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Review Article

The Role of Flood-adaptive Urban Design from the Perspective of Improving Risk Perception

(An Interdisciplinary Systematic Review)*

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Abstract | Following the culverting of rivers and the implementation of flood control infrastructure on riverbeds, people's perceptions regarding the ecological dynamics of rivers, as well as environmental safety have been widely disturbed. This lack of accurate flood risk perception can potentially lead to many casualties and damages during severe flood events. Therefore, to achieve flood resilience, in addition to structural criteria, the improvement of non-structural criteria such as risk perception to enhance adaptation and preparedness of communities against floods, is considered a challenging topic. Considering the transition of river management from structural approaches to integrated approaches, which emphasize the participation of related disciplines, and the capability of urban design to enhance people's perceptive experience of the environment, this study aims to conduct an interdisciplinary systematic review to investigate how urban design enters and integrates into the discussion of flood risk perception. By expanding the social-ecological model (SEM) of the study at different individual and environmental levels, three theoretical perspectives of environmental psychology, human geography, and nature conservation were selected as the foundation of the interdisciplinary study. Subsequently, by conducting a systematic review in the Scopus database in six steps, the role of urban design in improving flood risk perception was investigated. Urban design in the fields of environmental psychology, human geography, and nature conservation can play a critical role in expanding the perceptive experience of rivers and improving flood risk perception through perceived and aesthetic qualities, sense of place, and regulating ecosystem services, nevertheless urban design is facing many challenges in the mentioned fields. Therefore, as an initial step, urban design must determine how to adapt to these intervening factors and establish a balance with them.

Keywords | *Integrated Flood Management, Flood Risk, Environmental Perception, Social-ecological Model (SEM).*

Introduction | On a global scale, flood is one of the most widespread natural disasters that cities face (Dewan, 2013). It is considered a serious threat to the socio-economic structure of societies and affects the lives of millions of people in the world every year (Smith, 2013). In recent years, it has been predicted that the vulnerability to flooding is growing in most countries due to climate change, spatial expansion, and population growth (Mitchell, 2003).

Despite cities being equipped with extensive flood control infrastructures, they have remained

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vulnerable to extreme floods which exceed their capacity (Andersen & Shepherd, 2013). Flood control infrastructures not only have a limited capacity to deal with floods (Zevenbergen & Gersonius, 2007) but also degrade the ecological qualities of rivers and adjacent ecosystems in the long term (Everard & Moggridge, 2012). In addition, culverting streams and rivers (Chou, 2013), causes the extinction of nature experience among individuals (Soga et al., 2016). These interventions in human-nature relationships reduce the perception of ecological dynamics related to rivers and alternatively lead to a false sense of environmental safety (Liao, 2014; Ludy & Kondolf, 2012).

Therefore, the implementation of entirely structural solutions in flood-prone areas significantly affects flood risk perception in the long term and consequently, considering the reduction in the level of preparedness and adaptability of communities, the number of casualties intensely increases in severe flood events. In recent years, in addition to flood control structures, non-structural criteria such as risk perception have been underlined due to flood risk mitigation and improving the adaptive capacity of communities. In this regard, integrated flood risk management is transitioning from structural solutions to integrated and multifunctional approaches (structural and non-structural solutions) with the participation of related disciplines. Meanwhile, the role of urban design in the mentioned process is still uncertain and needs to be clarified. However, in non-structural approaches, urban design can play a significant role in expanding people's perceptive experience as well as improving flood risk perception by affecting the environmental perception factors and regulating the human-environment relationship.

One of the fundamental subjects of environmental design is associated with the human-environment relationship and its impact on human perception, cognition, and behavior, which have entered the field of urban design in the form of multiple theoretical perspectives including environmental psychology (Appleyard, 1976; Kaplan & Kaplan, 2009; Lynch, 1960; Nasar, 1989; Nasar,1990), human geography (Buttimer & Seamon, 2015; Relph, 1976; Seamon, 2014; Tuan, 1977) and nature conservation (De Groot & van den Born, 2003; Van den Born et al., 2001; Van Der Brugge et al., 2005). Considering the inclusion of non-structural measures within flood risk management provides an opportunity for participation across related disciplines (Klijn et al., 2015). Regarding the role of urban design in environmental perception, this study develops the hypothesis that in defining the role of urban design within integrated flood risk management, urban design is capable of improving flood risk perception and subsequently influencing flood-adaptive behaviors, which leads to the adaptation and preparation of communities.

In previous studies in this field, although factors influencing flood risk perception have been examined through cognitive, socio-cultural, and geographical approaches, the role of environmental design in people's flood risk perception has not been investigated so far. It can be acknowledged that there is a significant gap in understanding the role of environmental design in non-structural measures of integrated flood management, such as flood risk perception. Considering behavioral models in the field of natural disasters which emphasize humans and the environment separately, as well as neglecting human-environment interaction, which is a key factor in urban design, the SEM of study must be expanded to address this gap and provide a framework for integrating urban design with flood risk perception. Therefore, this study aims to first expand the SEM of study in the field of flood risk perception to address the existing gap and define the integration of urban design with this field using relevant theoretical perspectives. In further steps, by using the theoretical perspectives derived from SEM, an interdisciplinary systematic review is conducted in the Scopus database, following a six-step literature review process, subsequently, the integration of urban design with flood risk perception is examined.

Research Questions

Based on the primary hypothesis, this study aims to answer the following main question: How can urban design improve people's flood risk perception?

To answer the main research question, addressing the following sub-questions is significant:

1-Which theoretical perspectives related to urban design contribute to the field of flood risk perception?

2-Which perceptual factors of the environment affect flood risk perception in the process of environmental design?

3-What challenges do urban design encounter when integrating with the field of flood risk perception?

Research Background

Experts assess the disaster risk based on the probability of occurrence and the extent of damages and casualties caused by it, but laypeople evaluate it by subjective criteria. Therefore, the discrepancy between the objective assessment of experts and the subjective evaluation of laypeople has increased attention to the field of risk perception (Slovic, 1987). Various approaches identify different influencing factors on risk perception. Cognitive approaches consider psychological processes as the most relevant factor and seek to evaluate the effect of negative emotions on the level of risk perception

(Slovic & Peters, 2006). Socio-cultural approaches argue that risk perception is based on the surrounding environment and is socially constructed. In addition, these approaches highlight worldview, cultural norms, and social identity as significant factors of risk perception (Kahan et al., 2007). Geographical approaches consider the built and natural environment characteristics, such as openness of the environment and the distance to a hazard source, as the main predictors of risk perception (Botzen et al., 2009; O'Neil et al., 2016; Zhang et al., 2010). The role of environmental design and perceptual factors of the environment in people's flood risk perception has not been investigated. Therefore, this study can be an initial step in explaining the role of urban design in non-structural criteria for integrated flood management.

The importance of risk perception in the context of flood disasters is manifested in adopting adaptive behaviors (Weinstein et al., 1998). In this regard, several behavioral models have been introduced in natural hazards investigations to elucidate the causes affecting adaptive behaviors. The Protection Motivation Theory (PMT), with emphasis on cognitive processes (Rogers, 1975), and the Protective Action Decision Model (PADM), by considering socio-environmental processes (Lindell & Perry, 2012) are among the most widely used behavioral models in this field. Therefore, behavioral models in disaster contexts often focus on either cognitive processes (individual) or socio-environmental processes (individual's surroundings), thereby overlooking the interaction between humans and the environment, which is a key factor in urban design. The lack of attention to the interactive nature of the human-environment relationship in existing behavioral models pertaining to disasters is one of the gaps that can be examined through the lens of urban design.

This study expands SEM to address the interactive nature of human-environment relationships and provides a systematic approach to understanding the factors influencing flood risk perception and flood-adaptive behaviors. Developing SEM in the context of flood risk perception offers an opportunity to establish the integration of urban design with flood risk perception before initiating an interdisciplinary systematic review and identifying relevant theoretical perspectives in the field of urban design that can contribute to flood risk perception.

• Expanding the social-ecological model (SEM) of the study

While Social-ecological Models (SEM) have evolved in the context of behavioral sciences, in contrast with behavioral models, SEM simultaneously emphasizes both cognitive and socio-environmental processes and considers human-environment interactions (Barton & Grant, 2006; Bronfenbrenner, 1979; Dahlgren & Whitehead, 1991; McLeroy et al., 1988; Stokols et al., 2003). The ultimate goal of SEM in behavioral discussions is to develop a comprehensive approach which systematically creates or changes a specific behavior by altering influencing factors at different levels (Sallis et al., 2015). Hence, expanding SEM provides an opportunity to examine the effects of all individual and environmental levels on flood risk perception and flood-adaptive behaviors. Furthermore, at each level, the potential impact of urban design on influencing factors can be assessed, and ultimately, the most suitable factors can be selected.

In this study, in the first step, by considering the levels of authentic Social-ecological Models (Barton & Grant, 2006; Bronfenbrenner, 1979; Dahlgren & Whitehead, 1991; McLeroy et al., 1988; Stokols et al., 2003), intrapersonal environment, immediate environment, and indirect environment were selected as the main levels of the study's SEM. In the second step, the factors that can be examined at each level in relation to flood risk were explained. In the third step, taking into account the impact of urban design on the mentioned factors, the most effective factors at each level were determined. In the final step, by introducing the theoretical perspectives of urban design (nature conservation- human geography- environmental psychology) related to selected factors, a foundation was established for integrating urban design with flood risk perception, and subsequently conducting an interdisciplinary systematic review (Table 1).

Research Method

In this study, the qualitative review and content analysis of the articles have been done using the systematic review method. A systematic review is a structured approach including a set of predetermined steps which evaluate the existing literature on a specific topic or research question (Boland et al., 2017). Furthermore, it distinguishes from traditional review by identifying and screening relevant research and assessing each one based on predefined criteria (Jesson et al., 2011). In interdisciplinary research, a systematic review is a suitable starting point in the research process (Burgers et al., 2019). This study conducted an interdisciplinary systematic review in the Scopus database using the steps explained by Jesson and colleagues. The goal was to determine the role of urban design in improving flood risk perception through three theoretical perspectives (nature conservation- human geography- and environmental psychology) derived from the SEM of the study.

In the first step, the research question was defined, which plays an essential role in narrowing down the research focus. In the second step, the keywords related to risk perception and flood disaster were added. In the third

Table 1. Major steps for expanding SEM of study. Source: Authors.

	Intrapersonal environment	Immediate environment		Indirect environment	
		Perceptual environment	Behavioral environment	Physical environment	Socio-cultural environment
Step 1: Selecting the main levels of SEM	The intrapersonal environment including the individual and psychological characteristics, lies at the core of the model.	The immediate environment is the most profound and effective environment that surrounds individuals, including their activities, lifestyle and perceptual pattern.		The indirect environment refers to the various environments that encompass individuals and directly or indirectly impact their experience and subsequent behaviors.	
Step 2: Explaining the factors of each level considering the discussion of flood risk	-Demographic factors: age, gender, education, employment, etc. -Psychological factors: attitude, motivation, mental barriers, emotions, etc. (McLeroy et al. ,1988)	-Perceptual patterns: safety, security, comfort, satisfaction, etc. (Sallis et al., 2015)	-Mitigation measures -Preparedness measures -Response measures -Recovery measures (Lindell & Perry, 2003)	-Hydraulic effectiveness (the functional factors) -Ecological robustness (the environmental factors) -Cultural meaning and aesthetics (the perceived factors) (Busscher, Van Den Brink & Verweij, 2019)	-Social networks -Social identity -Sense of place -Social capitals (Kahan et al., 2007)
Step 3: Determining the most effective factor at each level according to the discussion of urban design	Vision of nature	Flood risk perception	Flood-adaptive behaviors (pre-disaster phase)	Perceived & aesthetic qualities of the environment	Sense of place
Step 4: Clarifying the theoretical perspectives of urban design related to selected factors	Nature conservation	Flood risk perception & flood-adaptive behaviors		Environmental psychology	Human geography

step, the inclusion criteria were determined, due to the interdisciplinary nature of the flood risk perception, a wide range of subjects are relevant to this discussion. Therefore, considering the impact of urban design, the subject area of research was restricted to environmental science, psychology, and social science. In the fourth step, keywords related to urban design were applied through three theoretical perspectives. In the fifth step, according to the eligibility criteria, the abstract and result of articles acquired from the previous step were assessed, and included articles were identified. In the sixth step, by analyzing the content of the included articles, the urban design impact on flood risk perception was investigated. Taking into account the PRISMA statement (Page et al., 2021), the systematic review steps were organized in a general classification including four steps of identification, screening, eligibility assessment, and included articles (Table 2).

Theoretical Foundations

Given the dynamic nature of natural disasters such as floods and the unpredictability of the intensity and consequences of these hazards, transitioning from a resistance approach to a resilience approach to flooding is essential to increase the survival of environmental systems under tension (Hemmati, 2015). Flood-resilient cities have the capacity to remain functional. Additionally, their built environments are adaptable to flood and capable of reorganizing the circumstances (Liao, 2012). While the flood control approach seeks to reduce the probability of flood occurrence and alter the flood regime, the resilience approach attempts to minimize the probability of flood damage and transform the lifestyle of societies to live with floods and utilize relevant ecosystem services (Liao et al., 2016). Resilience in the face of extreme and infrequent floods

Table 2. The steps for the interdisciplinary systematic review. Source: Authors.

General classification	Systematic review steps	Narrowing down process	Number of articles identified at each step
Identification	**Step 1:** Defining the research question	How can urban design improve people's flood risk perception?	-
	Step 2: Applying keywords in the field of "flood risk perception"	1-Applying keywords related to "risk perception": risk perception- public acceptance- public preference- public perception- landscape perception 2-Applying keywords related to "flood": flood- disaster- river	Records identified based on flood risk perception: 9513
Screening	**Step 3:** Determining the inclusion criteria	Language: English; Time period: 1990 to 2022 Document type: article/review; Source type: journal Subject area: environmental science/psychology/ social science	Articles identified by applying the inclusion criteria: 4709
	Step 4: Applying keywords in the field of "urban design"	1-Applying keywords related to "nature conservation": vision of nature- nature-based solutions 2-Applying keywords related to "human geography": sense of place- place attachment- place identity- place dependence 3-Applying keywords related to "environmental psychology": scenic beauty- aesthetic quality- river restoration/rehabilitation	Relevant articles to environmental psychology: 269 Relevant articles to human geography: 100 Relevant articles to nature conservation: 53
Eligibility	**Step 5:** Determining two eligibility criteria and assessing the quality of articles	Determining two eligibility criteria to eliminate irrelevant articles and identify selected articles: 1-The focus of the article must be on identifying the factors that affect the flood risk perception among residents living in flood-prone areas. 2-Influencing factors must include subjects related to "nature conservation/human geography/ environmental psychology".	Articles included in environmental psychology: 7 Articles included in human geography: 7 Articles included in nature conservation: 6
Included	**Step 6:** Analyzing the content of selected articles	Analyzing the content of 20 selected articles to identify the impact of urban design on flood risk perception	Articles included in review: 20

requires societies to adapt to frequent and smaller floods and learn from them (Liao, 2014). This perspective in the flood resilience discussion is associated with the latter approach to resilience, known as social-ecological resilience.

In social-ecological resilience, the objective is not to return the system to a single-state (or multi-states) equilibrium prior to the disturbance, but rather to emphasize the dynamic non-equilibrium state. Furthermore, the goal is to drive the system and achieve a better state compared to the past through learning and adaptation. In this definition, resilience is closely related to the concept of adaptive capacity (Adger et al., 2005; Pickett et al., 2004; Klein et al., 2003; Folke, 2006). Davoudi et al., (2013) refer to it as evolutionary resilience and introduce a forth component, preparedness, in addition to the three main resilience components (adaptability-persistence-transformability), to improve the adaptive capacity in the social-ecological system. Preparedness refers to the ability of systems to anticipate events and subsequently plan for dealing with them.

In socio-ecological systems, the artificial and excessive suppression of internal disturbances (the exclusive use of flood control infrastructure) increases the possibility of system collapse in the long term, while learning from these tensions and adapting to them (improving the preparedness and adaptation of local communities to floods) enhances system resilience (Berkes et al. 2003; Gunderson & Holling, 2002).This perspective has been reflected in integrated flood risk management. River management is now transitioning from a hard engineering approach to an integrated and multifunctional approach (Chou, 2016). Likewise, flood management, including structural measures, has evolved into flood risk management that incorporates both structural and non-structural measures concurrently (Klijn et al., 2015). Understanding how local communities perceive flood risk is one of the

non-structural measures which plays a key role in flood preparation, adaptation, and protection behaviors (O'Neil et al., 2016). Flood risk perception, rather than objective assessment of flood, emphasizes the subjective aspects of flood risk (Kellens et al., 2013). Individuals engage in precautionary behaviors when they assess hazard risk highly. Therefore, to trigger flood-adaptive behaviors, flood risk perception must occur first (Weinstein et al., 1998).

Perceptual factors of the environment, along with spatial qualities, significantly contribute to improving the perceptive experience of rivers and subsequently reinforcing flood risk perception within the multi-layered safety approach of flood risk management. This approach aims to reduce flood probability through the first layer of infrastructures, mitigate flood damages by the second layer of spatial interventions (environmental design), and facilitate recovery and evacuation through the third layer (Nillesen, 2019). Adopting this approach in recent years highlights the interdisciplinary nature of flood risk management. Therefore, defining the role of urban design in the second layer of this approach to improve flood risk perception plays a significant role in the process of flood risk reduction. Conducting an interdisciplinary systematic review in this field can be the initial step within the multi-layered safety approach to determine the role of urban design.

Discussion and Findings

According to the broad range of issues (such as the decline in perceived qualities of the environment, changes in cultural and social values toward natural river environments, and inconsistency of flood control infrastructure) which have emerged recently, many relevant interdisciplinary perspectives have been applied into integrated flood risk management to reduce the flood risk. Therefore, this study seeks to discuss the urban design impact on flood risk perception through the aforementioned theoretical perspectives.

• Environmental psychology- perceived and aesthetic qualities

The role of urban rivers within integrated flood risk management is considered a multifunctional open-space network. Flood risk reduction, ecological river rehabilitation, improvement in aesthetic and perceived quality, as well as enhancement of water resources, are among the multifunctional benefits associated with the recent approach to river management (Chou, 2016). Moreover, these functions are predominately carried out under river restoration/rehabilitation projects, focusing on restoring the natural function of rivers (Junker & Buchecker, 2008). While idealistic approaches to river restoration perceive any form of human influence on rivers as a negative effect and prioritize improving river ecology, pragmatic and realistic approaches advocate for maintaining a balance between human interests and ecological goals (Dufour & Piegay, 2009; Eden & Tunstall, 2006; Eden et al., 2000; Westling et al., 2014).

Over the recent decades, river restoration projects have encountered public non-acceptance and resistance due to the lack of attention given to the human aspects of these projects, such as flood risk perception and aesthetic preferences (Junker & Buchecker, 2008). While aesthetic preferences play a significant role in how people assess river corridors and can increase public acceptance in relation to restoration projects, these projects typically focus on flood protection measures and ecological restoration (Buijs, 2009; Junker et al., 2007). On the other hand, even though the restoration process is strongly connected to flood risk reduction, in most projects, addressing subjects like flood risk perception and water safety from the perspective of ordinary people and non-experts has become a major challenge (Buijs, 2009). Therefore, river restoration projects must simultaneously regard the ecological qualities of rivers, public aesthetic preferences, and measures of flood risk perception as essential factors (Seidl & Stauffacher, 2013).

Although many studies have claimed that basically, there are differences between the aesthetic preferences of lay people and the ecological and hydrological goals of experts (Parsons, 1995; Van Den Berg & Vlek, 1998; Williams & Cary, 2002), it is still possible to address these goals simultaneously through certain qualities, including naturalness of landscape, environmental maintenance, reduction of landscape disturbance, coherence, and variety. In the content analysis of the included articles, their viewpoints regarding the mentioned qualities were assessed (Table 3).

• Human geography- a sense of place

Sense of place and other place-based concepts (place attachment-place dependence-place identity) explain the relationship between human and place, as well as the meanings constructed in between. Therefore, considering the time required for the construction of these concepts, the meaning that people attach to a certain place in different ways plays a significant role in their flood risk perception (De Dominicis et al., 2015; Verbrugge & Van Den Born, 2018). Despite the fact that the livelihood status of local inhabitants undergoes many changes due to both flood occurrence and the implementation of protective measures (flood control infrastructures), the emotional connection that people hold with rivers is often overlooked within river management processes (ibid.).

Table 3. The impact of urban design on flood risk perception through theoretical perspectives derived from SEM. Source: Authors.

Theoretical perspective	Impact of environmental design	Content analysis	Included articles
Nature conservation	Vision of nature The role of environmental design in regulating ecosystem services (how to utilize nature's values) in line with perceived risk, as well as the efficiency and benefits of flood risk reduction solutions	**A vision of "master over nature" and supporting structural solutions** In the study of the relationship between one's vision of nature and their preference for flood solutions, the closer people's vision is to "master over nature", the more people tend to prefer grey solutions (De Groot, 2012). Additionally, in the areas where the level of perceived risk increases, the efficiency of these solutions to reduce flood risk is considered, and in this regard, structural solutions are faced with more trust and acceptance by individuals (Anderson & Renaud, 2021; Venkataramanan et al., 2020).	Santoro et al. (2019); Venkataramanan et al. (2020); De Groot & De Groot (2009); De Groot (2012); Anderson et al. (2022); Anderson & Renaud (2021)
		A vision of "stewardship and partnership in nature" and supporting hybrid solutions Anderson et al. (2022) acknowledge that although ecological restoration and benefits received (ecosystem services) around rivers have particular significance to people, disaster risk reduction is the primary concern of individuals, therefore the uncertainty in the effectiveness of NbS mostly leads public preferences to hybrid solutions.	
		A vision of "participant in nature" and supporting nature-based solutions In the study of the relationship between one's vision of nature and their preference for flood solutions, the closer people's vision is to "participant in nature", the more people tend to prefer green solutions (De Groot, 2012). The success of these solutions depends on people's perceptions and preferences, therefore paying attention to people's risk perception and providing a wide range of benefits are among the factors of their superiority over structural solutions (Anderson & Renaud, 2021; Santoro et al., 2019).Although people's visions are often ecocentric, in practice, absolute nature conservation standards, particularly in areas with high risk levels, are not acceptable to people (De Groot & De Groot, 2009).	
Human geography	Sense of place The role of environmental design in regulating individuals' affective bond with place based on context (strengthening or weakening people's sense of place) to possibly encourage the adoption of adaptive behaviors	**Sense of place as a functional mechanism** The meaning that people attribute to the environment (sense of place) affects public perception of river interventions, and subsequently their potential behavior in the environment. The sense of place serves as a functional mechanism through which residents can both maintain and adapt their residence in flood-prone areas (Anacio et al., 2016; Davenport & Anderson, 2005; Verbrugge & Van Den Born, 2018).	Verbrugge & Van Den Born (2018); Anacio et al. (2016); Van Heel & Van Den Born (2020); Daven-port & Anderson (2005); Bonaiuto et al. (2016); De Dominicis et al. (2015); Stancu et al. (2020)
		Sense of place as a restraining factor De Dominicis et al. (2015) highlight an optimistic bias toward the place of living, recognizing the strong bond between people and their surroundings as a restraining factor in adopting disaster-adaptive behaviors, even in cases of high perceived flood risk.	
		Sense of place as a concept dependent on geographical, social, and cultural contexts Bonaiuto et al. (2016) declare that there is fundamentally no definite relationship between place attachment and risk perception of disasters, and this relationship is based on the context, severity, and probability of hazards. In areas with a high level of risk but a low probability of flooding, if residents' risk perception is accompanied by a high attachment to the place, there is less possibility to adopt flood-adaptive behaviors (Stancu et al., 2020).Van Heel and van den Born (2020) among place-based concepts, exclusively recognize nature bonding in association with flood risk perception.	
Environmental psychology	Perceived & aesthetic qualities The role of environmental design in regulating the perceived qualities of the environment in line with the interaction and synergy of the ecological qualities and improving people's flood risk perception	**Naturalness**: The perceived and ecological qualities around rivers are most significantly influenced by naturalness, which is evaluated based on the level of human intervention in nature and the integration of biophysical elements of the landscape with the natural structure of the rivers (Buijs, 2009; Chou, 2013; Chou, 2016; Garcia et al., 2020; Junker & Buchecker, 2008; Seidle & Stauffacher, 2013; Westling et al., 2014).	Chou (2013); Chou (2016); Garcia, et al. (2020); Buijs (2009); Junker & Buchecker (2008); Seidl & Stauffacher (2013); Westling et al. (2014)
		Maintenance: Environmental cleanliness, the quality of river water, and the provision of services are among the examples of maintenance, the absence of which disturbs environmental safety and individuals' perception (Chou, 2013; Chou, 2016; Garcia et al., 2020; Westling et al., 2014).	
		Diversity: Diversity is manifested in different ways in the context of rivers, including the diversity of activities (the multi-functional role of rivers), biodiversity, and diversity of form (the way hard and soft edges are combined) (Buijs, 2009; Chou, 2013; Chou, 2016; Westling et al., 2014).	
		Coherence: The coherence of the environments around rivers relies on the structural-functional integrity and the continuity of the surrounding vegetation (Buijs, 2009; Westling et al., 2014).	
		Disturbance: While the presence of disturbances (floods, insects, and invasive species) around the rivers may contribute to a reduction in public perception, flood control structures, despite being a form of disturbance to the nature of rivers, are generally accepted by the public due to the enhanced perception of safety (Garcia et al., 2020; Seidle & Stauffacher, 2013; Westling et al., 2014).	

Consequently, many studies have emphasized the importance of considering these place-based meanings within flood risk management (Agyeman et al., 2009; Davenport & Anderson, 2005; Jacobs & Buijs, 2011).

The relationship between sense of place (or other place-based concepts) and flood risk perception is still unclear and associated with disparate results. Some studies have declared that a strong affective bond to place provides a sense of safety to people, and subsequently, people are inclined to ignore the hazards of disasters (Armas, 2006). On the other hand, some studies have demonstrated that in areas where the flood frequency is higher, and consequently the flood severity is lower, the high level of neighborhood attachment increases flood risk perception (Bonaiuto et al., 2011).

In this regard, Bernardo (2013) claims that the effect of place attachment varies according to the severity and probability of hazards. In the presence of high risk with a low probability of occurrence, the place attachment reduces the perception of risk. However, in the case of disasters with low severity and high probability of occurrence, the place attachment augments the perception of risk. By contrast, van Heel and van den Born (2020) claim that among place-based concepts, apart from nature bonding which is considered attachment to nature, other concepts do not have a remarkable impact on flood risk perception. In other words, residents who have a stronger connection with nature and a better understanding of river dynamics, subsequently have a higher flood risk perception.

Some studies have assessed sense of place and other place-based concepts as moderator variables in the relationship between flood risk perception and flood-adaptive behaviors. In this regard, Stancu et al. (2020) emphasize that in high-risk areas, if residents' risk perception is accompanied by a strong attachment to the place, there is a higher possibility of feeling distressed and less possibility of adopting flood-adaptive behaviors. In addition, De Dominicis et al. (2015) claim that although a high level of flood risk perception can lead to flood-adaptive behaviors, this effect is weaker if there is a strong attachment to the place. In the content analysis of the included articles, their viewpoints on the relationship between sense of place (or other place-based concepts) and flood risk perception were investigated (Table 3).

• Nature conservation- vision of nature

In water management, the shift is taking place from battling against water to embracing a vision of living with water (Wiering & Arts, 2006). The evolution of the vision of nature is the main driver behind these procedural changes and now the public vision toward water as a hostile entity is transforming into a compatible partnership with water (De Groot & De Groot, 2009). To the extent that people's vision shifts from "master over nature" to "participant in nature", instead of nature's instrumental values, they focus on nature's intrinsic values as well as mutual interaction with nature (De Groot & Van Den Born, 2003). The emergence of a "participant in nature" vision within Nature-based Solutions (NbS) is evident. The primary goal of NbS is to provide solutions based on the natural ecosystem of cities to improve resilience against natural disasters such as floods (Kabisch et al., 2016). Moreover, with the emergence of a broad ra nge of green and blue infrastructures and their ecosystem services, other social, economic, and ecological goals can also be achievable (Moosavi et al., 2021). Many studies have highlighted that the public vision of nature can remarkably affect human-nature relationships and serves as an appropriate criterion to predict and evaluate public preferences and perceptions in relation to nature, including flood risk perception (De Groot & De Groot, 2009; De Groot & Van Den Born, 2003; Van Den Born et al., 2001). Additionally, Individuals' perceptions and preferences regarding the adopted solutions (green solutions-grey solutions) within flood risk management are influenced not only by their vision of nature but also by the level of perceived risk and the effectiveness and benefits of these solutions (Santoro et al., 2019; Venkataramanan et al., 2020). In areas with a low probability of flood occurrence, due to the low-risk perception, the perceived benefits of adopted solutions become remarkable. In these contexts, NbS meet more acceptance since it provide a broad range of ecosystem services (Kim & Petrolia, 2013). However, in areas with a higher perceived risk, the efficacy of the adopted solutions in flood risk reduction is considered (Anderson & Renaud, 2021). Therefore, NbS receive less acceptance due to the lack of sufficient evidence for flood prevention (Esteves & Thomas, 2014), moreover, people are still concerned about flood mitigation measures with Nbs and place more trust in flood control structures (Chou, 2016). In operational areas, the adopted approaches are not categorized as either entirely green or grey. Generally, the solutions are greener or grayer. Meanwhile, hybrid approaches, by combining the natural and built infrastructures, attempt to enhance the resilience of cities to floods and address the drawbacks of the mentioned two approaches (Naylor et al., 2017; Sutton-Grier et al., 2015). In the content analysis of the included articles, their viewpoints regarding the effect of human-nature relationship (NbS) and vision of nature on flood risk perception were evaluated (Table 3).

Conclusion

Although in the last decade, flood risk management approaches have been shifting from unidimensional and structural solutions to integrated approaches which facilitate opportunities for cooperation across relevant disciplines, defining and clarifying how to integrate relevant disciplines into flood risk is a time-consuming process that requires numerous interdisciplinary research. In this study, considering the existing gap in the research background, SEM was expanded to address the interactive nature of human-environment relationship and to adopt a comprehensive approach in relation to the factors influencing flood risk perception. Expanding SEM provided an opportunity to examine the influence of all individual and environmental levels on flood risk perception and to assess the potential impact of urban design on the influencing factors at each level. According to the mentioned model, the integration of urban design with the discussion of flood risk perception could be achieved through three theoretical perspectives of environmental psychology, human geography, and nature conservation.

In the intrapersonal environment, the influence of environmental design on flood risk perception is achievable through the theoretical perspective of nature conservation. Within this theoretical perspective, the vision of nature constitutes one of the perceptual factors of the environment, enabling environmental design to affect flood risk perception. Vision of nature is a valid criterion for predicting people's preferences and perceptions in relation to nature. Moreover, environmental design can effectively respond to the level of perceived risk and people's preferences by adjusting ecosystem services within the environment. In the socio-cultural environment, the theoretical perspective of human geography facilitates the interaction between urban design and the field of risk perception. Within this perspective, a sense of place emerges as a significant perceptual factor of the environment through which urban design can influence people's flood risk perception. At this level, environmental design can have a favorable effect on flood risk perception by adjusting the affective bond between humans and place in accordance with the socio-geographic context of the environment, as well as the severity and probability of hazard. In the physical environment, environmental design has the potential to address flood risk perception through the lens of environmental psychology. In this perspective, the aesthetic and experiential qualities of the environment enable environmental design to affect flood risk perception. Environmental design can play an effective role in enhancing individuals' flood risk perception by constructing or modifying the aforementioned qualities in line with the interaction and synergy with the ecological qualities of the environment.

While environmental design, within the mentioned theoretical perspectives, can be efficient in expanding the perceptive experience of rivers, and subsequently improving flood risk perception through various perceptual factors of the environment, urban design is confronted with numerous challenges in each of these domains. Therefore, as a first step, urban design must realize how to adapt to the aforementioned intervening factors. On the intrapersonal level, urban design can contribute to changing the public vision of nature by regulating ecosystem services and promoting the conservative utilization of nature's values within flood risk management. However, on the other hand, the high level of perceived risk in the context can shift public attitude and preference from the perceived benefits of NbS (ecosystem services) to the effectiveness of structural solutions (flood protection). Therefore, one of the challenges facing urban design in this field is to identify a balance between the benefits of green solutions and the efficacy of gray solutions with regard to the level of flood risk. In the socio-cultural environment, urban design has a powerful tool, a sense of place, which can influence flood risk perception. Since this effect is based on the socio-cultural context, as well as the severity and probability of flooding, a sense of place may occasionally have a negative effect on people's perception or behavior. Therefore, determining how to incorporate the sense of place into the mentioned process, or attempting to strengthen or weaken the sense of place to achieve the best result are among the issues which require further consideration. In the physical environment, urban design can enhance public perception regarding the ecological dynamic and potential risk of rivers by modifying the aesthetic and perceived qualities of river landscapes. However, considering the emphasis of river restoration projects on natural ecosystems and ecological qualities, how maintaining a balance between the ecological qualities of rivers and public aesthetic preferences is one of the obstacles which urban design encounters.

Therefore, although integrating urban design with flood risk perception through the relevant perceptual factors is feasible, as indicated by expanding SEM and conducting an interdisciplinary systematic review, further and specialized research in the relevant fields is necessary to address the challenges urban design encounters and this study serves as starting point for future studies in this field.

Endnotes

This paper is extracted from part of the thesis of "Alaleh Toossi Ardekani" entitled "Flood-adaptive urban design - The role of urban design in improving flood risk perception" which is being conducting under supervision of Dr. "Koroush Golkar" and consultation of Dr. "Alireza Fallahi" at Shahid Beheshti University, Faculty of Architecture and Urbanism.

References list

- Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockstrom, J. (2005). Social-ecological resilience to coastal disasters. *Science, 309*(5737), 1036-1039.
- Agyeman, J., Devine-Wright, P., & Prange, J. (2009). Close to the edge, down by the river? Joining up managed retreat and place attachment in a climate changed world. *Environment and Planning A, 41*(3), 509-513.
- Anacio, D. B., Hilvano, N. F., Burias, I. C., Pine, C., Nelson, G. L. M., & Ancog, R. C. (2016). Dwelling structures in a flood-prone area in the Philippines: Sense of place and its functions for mitigating flood experiences. *International Journal of Disaster Risk Reduction, 15*, 108-115.
- Andersen, T. K., & Shepherd, J. M. (2013). Floods in a changing climate. *Geography Compass, 7*(2), 95-115.
- Anderson, C. C., & Renaud, F. G. (2021). A review of public acceptance of nature-based solutions: The 'why', 'when', and 'how 'of success for disaster risk reduction measures. *Ambio, 50*(8), 1552-1573.
- Anderson, C. C., Renaud, F. G., Hanscomb, S., & Gonzalez-Ollauri, A. (2022). Green, hybrid, or grey disaster risk reduction measures: What shapes public preferences for nature-based solutions? *Journal of Environmental Management, 310*, 114727.
- Appleyard, D. (1976). *Planning a pluralist city: Conflicting realities in Ciudad Guayana*. MIT Press.
- Armas, I. (2006). Earthquake risk perception in Bucharest, Romania. *Risk Analysis, 26*(5), 1223-1234.
- Barton, H., & Grant, M. (2006). A health map for the local human habitat. *The Journal of the Royal Society for the Promotion of Health, 126*(6), 252-253.
- Berkes, F., Colding, J., & Folke, C. (2003). *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press.
- Bernardo, F. (2013). Impact of place attachment on risk perception: Exploring the multidimensionality of risk and its magnitude. *Estudios de Psicología, 34*(3), 323-329.
- Boland, A., Cherry, G., & Dickson, R. (2017). *Doing a systematic review: A student's guide*. SAGE.
- Bonaiuto, M., De Dominicis, S., Fornara, F., Ganucci Cancellieri, U., & Mosco, B. (2011). Flood risk: the role of neighborhood attachment. In G. Zenz, & R. Hornich (Eds.), *Proceedings of the international symposium UFRIM. Urban flood risk managementApproaches to enhance resilience of communities*. Verlag der Technischen Universitat Graz.
- Botzen, W. J., Aerts, J. C. J. H., & Van Den Bergh, J. C. (2009). Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water Resources Research, 45*(10).
- Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press.
- Buijs, A. E. (2009). Public support for river restoration. A mixed-method study into local residents' support for and framing of river management and ecological restoration in the Dutch floodplains. *Journal of Environmental Management, 90*(8), 2680-2689.
- Burgers, C., Brugman, B. C., & Boeynaems, A. (2019). Systematic literature reviews: Four applications for interdisciplinary research. *Journal of Pragmatics, 145*, 102-109.
- Busscher, T., Van Den Brink, M., & Verweij, S. (2019). Strategies for integrating water management and spatial planning: Organising for spatial quality in the Dutch "Room for the River" program. *Journal of Flood Risk Management, 12*(1), 12448.
- Buttimer, A., & Seamon, D. (2015). *The human experience of space and place*. Routledge.
- Chou, R. J. (2013). Exploring the quasi-naturalistic landscaping design of a Taiwanese culverted urban stream. *Landscape Research, 38*(3), 347-367.
- Chou, R. J. (2016). Achieving successful river restoration in dense urban areas: Lessons from Taiwan. *Sustainability, 8*(11), 1159.
- Dahlgren, G., & Whitehead, M. (1991). *Policies and strategies to promote social equity in health*. Background document to WHO-Strategy paper for Europe (No. 2007: 14). Institute for Futures Studies.
- Davenport, M. A., & Anderson, D. H. (2005). Getting from sense of place to place-based management: An interpretive investigation of place meanings and perceptions of landscape change. *Society and Natural Resources, 18*(7), 625-641.
- Davoudi, S., Brooks, E., & Mehmood, A. (2013). Evolutionary resilience and strategies for climate adaptation. *Planning Practice & Research, 28*(3), 307-322.
- De Dominicis, S., Fornara, F., Cancellieri, U. G., Twigger-Ross, C., & Bonaiuto, M. (2015). We are at risk, and so what? Place attachment, environmental risk perceptions and preventive coping behaviors. *Journal of Environmental Psychology, 43*, 66-78.
- De Groot, M. (2012). Exploring the relationship between public environmental ethics and river flood policies in Western Europe. *Journal of Environmental Management, 93*(1), 1-9.
- De Groot, M., & De Groot, W. T. (2009). "Room for river" measures and public visions in the Netherlands: A survey on river perceptions among riverside residents. *Water Resources Research, 45*(7).
- De Groot, W. T., & Van Den Born, R. J. (2003). Visions of nature and landscape type preferences: an exploration in The Netherlands. *Landscape and Urban Planning, 63*(3), 127-138.
- Dewan, A. (2013). *Floods in a megacity: Geospatial techniques in assessing hazards, risk and vulnerability*. Springer.
- Dufour, S., & Piegay, H. (2009). From the myth of a lost paradise to targeted river restoration: forget natural references and focus on human benefits. *River Research and Applications, 25*(5), 568-581.
- Eden, S., Tunstall, S. M., & Tapsell, S. M. (2000). Translating nature: river restoration as nature-culture. *Environment and Planning D: Society and Space, 18*(2), 258-273.
- Eden, S., & Tunstall, S. (2006). Ecological versus social restoration? How urban river restoration challenges but also fails to challenge the science–policy nexus in the United Kingdom. *Environment and Planning C: Government and Policy, 24*(5), 661-680.
- Esteves, L. S., & Thomas, K. (2014). Managed realignment in practice in the UK: results from two independent surveys. *Journal of Coastal Research, (70 (10070))* 407-413.
- Everard, M., & Moggridge, H. L. (2012). Rediscovering the value of urban rivers. *Urban Ecosystems, 15*(2), 293-314.
- Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change, 16*(3), 253-267.
- Garcia, X., Benages-Albert, M., Buchecker, M., & Vall-Casas, P. (2020). River rehabilitation: Preference factors and public participation implications. *Journal of Environmental Planning and Management, 63*(9), 1528-1549.
- Gunderson, L. H., & Holling, C. S. (2002). *Panarchy: Understanding transformations in human and natural systems*. Island Press.
- Hemmati, M. (2015). Resilience: A design approach in chaotic environment. *Manzar, 7*(32), 74-81.

• Jacobs, M. H., & Buijs, A. E. (2011). Understanding stakeholders' attitudes toward water management interventions: Role of place meanings. *Water Resources Research, 47*(1).

• Jesson, J., Matheson, L., & Lacey, F. M. (2011). *Doing your literature review: Traditional and systematic techniques*. SAGE Publications.

• Junker, B., & Buchecker, M. (2008). Aesthetic preferences versus ecological objectives in river restorations. *Landscape and Urban Planning, 85*(3-4), 141-154.

• Junker, B., Buchecker, M., & Müller-Böker, U. (2007). Objectives of public participation: which actors should be involved in the decision making for river restorations? *Water Resources Research, 43*(10).

• Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., & Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society, 21*(2).

• Kahan, D. M., Braman, D., Gastil, J., Slovic, P., & Mertz, C. K. (2007). Culture and identity-protective cognition: Explaining the white-male effect in risk perception. *Journal of Empirical Legal Studies, 4*(3), 465-505.

• Kaplan, S., & Kaplan, R. (2009). Creating a larger role for environmental psychology: The Reasonable Person Model as an integrative framework. *Journal of Environmental Psychology, 29*(3), 329-339.

• Kellens, W., Terpstra, T., & De Maeyer, P. (2013). Perception and communication of flood risks: A systematic review of empirical research. *Risk Analysis: An International Journal, 33*(1), 24-49.

• Kim, T. G., & Petrolia, D. R. (2013). Public perceptions of wetland restoration benefits in Louisiana. *ICES Journal of Marine Science, 70*(5), 1045-1054.

• Klein, R. J., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: How useful is this concept? *Environmental Hazards, 5*(1), 35-45.

• Klijn, F., Merz, B., Penning-Rowsell, E. C., & Kundzewicz, Z. W. (2015). Preface: climate change proof flood risk management. *Mitigation and Adaptation Strategies for Global Change, 20*(6), 837-843.

• Liao, K. H., Le, T. A., & Van Nguyen, K. (2016). Urban design principles for flood resilience: Learning from the ecological wisdom of living with floods in the Vietnamese Mekong Delta. *Landscape and Urban Planning, 155*, 69-78.

• Liao, K. H. (2014). From flood control to flood adaptation: a case study on the Lower Green River Valley and the City of Kent in King County, Washington. *Natural Hazards, 71*(1), 723-750.

• Liao, K. H. (2012). A theory on urban resilience to floods-a basis for alternative planning practices. *Ecology and Society, 17*(4).

• Lindell, M. K., & Perry, R. W. (2012). The protective action decision model: Theoretical modifications and additional evidence. *Risk Analysis: An International Journal, 32*(4), 616-632.

• Lindell, M. K., & Perry, R. W. (2003). *Communicating environmental risk in multiethnic communities*. Sage Publications.

• Ludy, J., & Kondolf, G. M. (2012). Flood risk perception in lands "protected" by 100-year levees. *Natural Hazards, 61*(2), 829-842.

• Lynch, K. (1960). *The image of the city*. MIT Press.

• McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education Quarterly, 15*(4), 351-377.

• Mitchell, J. K. (2003). European river floods in a changing world. *Risk Analysis: An International Journal, 23*(3), 567-574.

• Moosavi, S., Browne, G. R., & Bush, J. (2021). Perceptions of nature-based solutions for Urban Water challenges: Insights from Australian researchers and practitioners. *Urban Forestry & Urban Greening, 57*, 126937.

• Nasar, J. L. (1990). The evaluative image of the city. *Journal of the American Planning Association, 56*(1), 41-53.

• Nasar, J. L. (1989). Perception, Cognition, and Evaluation of Urban Places. In I. Altman & E. H. Zube (Eds.), *Public Places and Spaces. Human Behavior and Environment (Advances in Theory and Research)*. Springer.

• Nillesen, A. L. (2019). Spatial Quality as a decisive criterion in flood risk strategies: an integrated approach for flood risk management strategy development, with spatial quality as an ex-ante criterion. *A+ BE| Architecture and the Built Environment, (1)*, 1-200.

• Naylor, L. A., Kippen, H., Coombes, M. A., Horton, B., MacArthur, M., & Jackson, N. (2017). *Greening the Grey: a framework for integrated green grey infrastructure (IGGI)*. Technical Report. University of Glasgow.

• O'Neill, E., Brereton, F., Shahumyan, H., & Clinch, J. P. (2016). The impact of perceived flood exposure on flood-risk perception: The role of distance. *Risk Analysis, 36*(11), 2158-2186.

• Parsons, R. (1995). Conflict between ecological sustainability and environmental aesthetics: Conundrum, canard or curiosity. *Landscape and Urban Planning, 32*(3), 227-244.

• Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *International Journal of Surgery, 88*, 105906.

• Pickett, S. T., Cadenasso, M. L., & Grove, J. M. (2004). Resilient cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. *Landscape and Urban Planning, 69*(4), 369-384.

• Relph, E. (1976). *Place and Placelessness*. Pion.

• Rogers, R. W. (1975). A protection motivation theory of fear appeals and attitude change. *The Journal of Psychology, 91*(1), 93-114.

• Sallis, J. F., Owen, N., & Fisher, E. (2015). Ecological models of health behavior. In K. Glanz, B. Rimer, & K. Viswanath (Eds.), *Health Behavior: Theory, Research, and Practice*. Jossey-Bass.

• Santoro, S., Pluchinotta, I., Pagano, A., Pengal, P., Cokan, B., & Giordano, R. (2019). Assessing stakeholders' risk perception to promote Nature Based Solutions as flood protection strategies: The case of the Glinščica River (Slovenia). *Science of the Total Environment, 655*, 188-201.

• Seamon, D. (2014). Place attachment and phenomenology: The Synergistic Dynamism of Place. In L. Manzo & P. Devine-Wright (Eds.), *Place Attachment*. Routledge.

• Seidl, R., & Stauffacher, M. (2013). Evaluation of river restoration by local residents. *Water Resources Research, 49*(10), 7077-7087.

• Slovic, P. (1987). Perception of risk. *Science, 236*(4799), 280-285.

• Slovic, P., & Peters, E. (2006). Risk perception and affect. *Current Directions in Psychological Science, 15*(6), 322-325.

• Smith, K. (2013). *Environmental Hazards: Assessing Risk and Reducing Disaster* (6th ed.). Routledge.

• Soga, M., Gaston, K. J., Koyanagi, T. F., Kurisu, K., & Hanaki, K. (2016). Urban residents' perceptions of neighborhood nature: Does the extinction of experience matter? *Biological Conservation, 203*, 143-150.

• Stancu, A., Ariccio, S., De Dominicis, S., Cancellieri, U. G., Petruccelli, I., Ilin, C., & Bonaiuto, M. (2020). The better the bond, the better we cope. The effects of place attachment intensity and place attachment styles on the link between perception of risk and emotional and behavioral coping. *International Journal of Disaster Risk Reduction, 51*, 101771.

• Stokols, D., Grzywacz, J. G., McMahan, S., & Phillips, K. (2003). Increasing the health promotive capacity of human environments. *American Journal of Health Promotion, 18*(1), 4-13.

• Sutton-Grier, A. E., Wowk, K., & Bamford, H. (2015). Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. *Environmental Science & Policy, 51*, 137-148.

• Tuan, Y. F. (1977). *Space and Place: The Perspective of Experience*. University of Minnesota Press.

• Van Den Berg, A. E., & Vlek, C. A. (1998). The influence of planned-change context on the evaluation of natural landscapes. *Landscape and Urban Planning, 43*(1-3), 1-10.

• Van Den Born, R. J., Lenders, R. H., De Groot, W. T., & Huijsman, E. (2001). The new biophilia: an exploration of visions of nature in Western countries. *Environmental Conservation, 28*(1), 65-75.
• Van Der Brugge, R., Rotmans, J., & Loorbach, D. (2005). The transition in Dutch water management. *Regional Environmental Change, 5*(4), 164-176.
• Van Heel, B. F., & Van Den Born, R. J. (2020). Studying residents' flood risk perceptions and sense of place to inform public participation in a Dutch river restoration project. *Journal of Integrative Environmental Sciences, 17*(1), 35-55.
• Venkataramanan, V., Lopez, D., McCuskey, D. J., Kiefus, D., McDonald, R. I., Miller, W. M., & Young, S. L. (2020). Knowledge, attitudes, intentions, and behavior related to green infrastructure for flood management: A systematic literature review. *Science of the Total Environment, 720*, 137606.
• Verbrugge, L., & Van Den Born, R. (2018). The role of place attachment in public perceptions of a re-landscaping intervention in the river Waal (The Netherlands). *Landscape and Urban Planning, 177*, 241-250.
• Weinstein, N. D., Rothman, A. J., & Nicolich, M. (1998). Use of correlational data to examine the effects of risk perceptions on precautionary behavior. *Psychology and Health, 13*(3), 479-501.
• Westling, E. L., Surridge, B. W., Sharp, L., & Lerner, D. N. (2014). Making sense of landscape change: Long-term perceptions among local residents following river restoration. *Journal of Hydrology, 519*, 2613-2623.
• Wiering, M. A., & Arts, B. J. M. (2006). Discursive shifts in Dutch river management: deep institutional change or adaptation strategy? In *Living Rivers: Trends and Challenges in Science and Management* (pp. 327-338). Springer.
• Williams, K. J., & Cary, J. (2002). Landscape preferences, ecological quality, and biodiversity protection. *Environment and Behavior, 34*(2), 257-274.
• Zevenbergen, C., & Gersonius, B. (2007). Challenges in urban flood management. In R. Ashley, S. Garvin, E. Pasche, A. Vassilopoulos, & C. Zevenbergen (Eds.), *Advances in Urban Flood Management*. Taylor & Francis.
• Zhang, Y., Hwang, S. N., & Lindell, M. K. (2010). Hazard proximity or risk perception? Evaluating effects of natural and technological hazards on housing values. *Environment and Behavior, 42*(5), 597-624.

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