Four Clusters o fThought on Flood Resilience and Climate Adaptation
The state of the art and new directions for spatial planning

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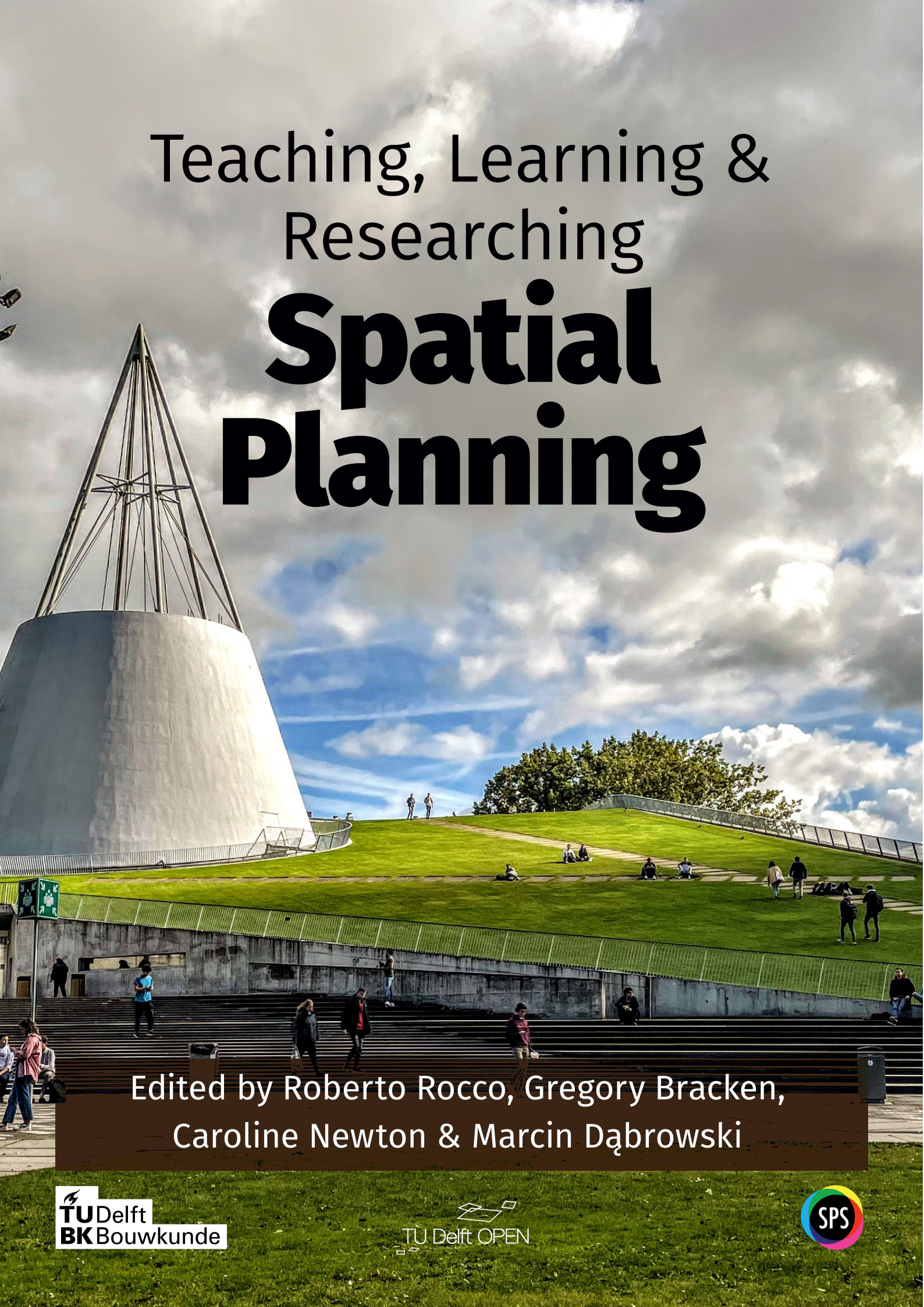

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Four Clusters of Thought on Flood Resilience and Climate Adaptation

The state of the art and new directions for spatial planning

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The need to respond to increasing flood risk, climate change, and rapid urban development has shaped innovative policies and practices of spatial planning in many countries over recent decades. As an instrumental–technical intervention, planning is mainly used to improve the physical environment (through concepts such as regulating waterproof facades of architecture, setting buffering zones, and designing green-blue corridors). However, the implementation of the proposed physical interventions is often challenging and necessitates assistance from practices such as climate assessment, policy disciplines, civil societies, and economic resources. These extensive perspectives have spawned many new research domains in the realm of spatial planning. This chapter provides a review of the recent developments in flood resilience, risk management, and climate adaptation; based on this, it positions planning research and practice within these works of literature. Four clusters of thought are identified, mainly in the European and American scholarship of the last two decades. They are environmental concerns, disaster management concerns, socio-economic concerns, and institutional concerns. Current planning research concentrates on disaster management in the underlying belief that planning is functionally efficient. The attention to environmental concerns, socio-economic concerns, and institutional concerns of planning research remains insufficient but has been growing. This, in turn, enlarges the scope of planning research and indicates future directions for study. These new concerns relate to spatial planning's ability to operate effectively in a multi-sectoral setting, despite limited resources and in the face of uncertain risk.

FLOOD RESILIENCE, RISK MANAGEMENT, CLIMATE ADAPTATION, SPATIAL PLANNING

1. Introduction

There are lively scholarly and policy discussions on how to solve the growing flood threat and climate change, on which approaches are usable, and on how different actors can contribute to addressing these concerns (Vis et al., 2003; Economics of Climate Adaptation Working Group, 2009; Hegger et al., 2013; Löschner & Nordbeck, 2020). Although spatial planning has been recognised as a source of valuable tools to handle flooding hazards and make human settlements more resilient, most studies appraise its physical function, as an instrumental–technical intervention to arrange the spatial layout and land use, such as regulating waterproof façades of architecture, setting buffering zones, and designing rainfall gardens and green-blue corridors (Davoudi et al., 2009; Roggema, 2009; 2012). This chapter argues that the role of planning goes beyond this and can be extended into, for instance, environmental, social-economic, and institutional issues. To support it, the study reviews a wide range of literature to 1) outline the state of the art of the planning literature dealing with floods in policy, research, and practice, and 2) point out the progress and development of planning in different aspects. The aim here is to sketch out a wide landscape of scholarship from different research perspectives that can be used to understand and clarify the role of the planning field. This chapter concentrates on multiply source of flooding events, including: 1) fluvial floods (river floods), 2) pluvial floods (surface water floods occurring when rainfalls exceed the capacity of drainage systems), and 3) coastal floods (including extreme storm surges and gradually rising sea levels).

This chapter consists of three sections. Firstly, it introduces a four-pillar conceptual framework for the literature review developed in this chapter. Secondly, it applies this framework to review the planning literature of relevance in the recent 20 years (the 1990s–late 2010s). It explores the *status quo* in the spatial planning research in relation to each of the four clusters of thought to identify the well-developed and neglected perspectives. The latter create scope for planning to contribute to the advancement of scholarship on flood resilience. The study closes with an outline of future research directions and concluding remarks.

2. The four pillars of resilience agendas through the lens of sustainability

The starting point for organising the review is the literature on resilience and sustainability in urban development. The 17 Sustainable Development Goals (SDGs) associate resilience with sustainability in Goal 11 and propose to 'make cities and human settlements inclusive, safe, resilient, and sustainable' (United Nations, 2015: 24). Diverse actions are envisaged to reach this goal which can be summarised in five perspectives: environmental concerns (the reduction of the adverse environmental impact of cities); social concerns (the protection of poor or vulnerable people, including women, children, and elderly people); economic concerns (the decrease in financial loss); disaster management concerns (access to safety through, for instance, transport infrastructure and resilient buildings); and institution-

al concerns (participatory and integrated planning and management). Similar categories have been proposed, for example, a fourfold categorisation of benefits: environmental benefits (e.g. land, water, climate change), social benefits (e.g. safety, risk reduction, welfare), economic benefits (e.g. resources, payments), and institutional and governance benefits (e.g. stakeholders, institutions, networks) (Grafakos et al., 2016).

Inspired by these groups, we have adopted a four-pillar framework to organise the review of research and practice on the connection between flood resilience and spatial planning. These pillars are 1) environmental, 2) disaster management, 3) socio-economic, and 4) institutional (and governance) concerns. Social and economic perspectives are merged on account of the intertwined negative impacts caused by floods, for instance, the poor (a financial problem) having limited access to safe shelter (an inequity problem). A disaster management perspective is highlighted here referring to physical interventions (e.g., infrastructure layout designs, land use allocation) and related regulations that manage physical changes (e.g., building codes).

3. The development of spatial planning research, policy, and practice across the four pillars of flood resilience literature

This section provides a brief account of the development and challenges of spatial planning in relation to the proposed four pillars of flood resilience and climate adaptation, based on extensive (academic and grey) literature across the fields of literature from climate science, disaster mitigation, water management, flood risk management, hydrological engineering, economics, adaptation planning, public participation, administration, and governance. Here, the subtle difference between spatial planning and similar terms like land-use planning or urban planning is neglected for simplification. Some early research has indicated that these similar terms are more technical and concerned with zoning and setting parameters for land development, while spatial planning is broader, not only technical but also relating to the coordination of spatial activities (Fleischhauer, 2008; Stead, 2008).

3.1. Limited attention paid to environmental concerns

The literature focusing on environmental concerns aims to unpack how social-ecological systems—encompassing all ecological goods, (built) assets, services, and even populations—are threatened by flood hazards that can be exacerbated by climate change and human activities. These concerns arose from the uncertainty of climate change, extreme weather, and the risks they entail. At the global level, this strand was promoted by the projection of ecosystem-based risk such as the changes in precipitation and sea-level rise (Tegart et al., 1990) and the identification of the gains and losses (vulnerability) of human settlements in different regions, nations, and areas (Lehner et al., 2006; Intergovernmental Panel on Climate Change, 2007; Katsman et al., 2009; Forzieri et al., 2016; Jana & Hegde, 2016; Barnard et al., 2019).

In terms of planning scholars and practitioners, environmental concerns have not been a main focus. In practice, agencies dealing with climate science, meteorology, environmental science, and hydrology

are forerunners in flood resilience, having more experience in monitoring, weather forecasting, and climatic assessment. As a result, these agents are mainly responsible for observing, modelling, and projecting climate change impacts and leading flood events. For instance, in the United Kingdom, the Environment Agency in England, the Natural Resources Wales, the Scottish Environment Protection Agency, and the Department of Infrastructure in Northern Ireland launched their flood maps within their jurisdictions (Department of Infrastructure in Northern Ireland, n.d.; Environment Agency in England, n.d.; Natural Resources Wales, n.d.; Scottish Environment Protection Agency, n.d.). Similarly, in the Netherlands, the Foundation Climate Adaptation Services launched the Climate Impact Atlas, which indicates the potential flooding areas (Foundation Climate Adaptation Services, n.d.).

Due to a lack of professionalised knowledge, planning institutions often step behind the above-mentioned institutions. Even so, they can still make a contribution to this stream by building strategic cooperation with those forerunners and overlaying hydrological maps (e.g. flooding maps) with socio-spatial data (e.g. age, incomes, land uses) to identify gains and losses of flood-exposed entities in different regions, nations, and areas. The findings then allow the planning sector to offer solutions to reduce flood loss. Typical cases are the Urban Waterfront Adaptive Strategies in New York (New York & Connecticut Sustainable Communities Consortium, 2013) and Climate Change Adaptation Strategies in Rotterdam (Rotterdam Climate Initiative, 2013), in which flooding maps and socio-spatial data were used to identify the vulnerabilities of communities and neighbourhoods caused by coastal floods and rainfalls and further develop strategies for flood resilience.

3.2. A focus on disaster management concerns

The literature focusing on disaster management concerns aims at identifying effective solutions to reduce the negative impacts of flood hazards. Since the early 2000s, this cluster witnessed a transition from hydrological engineering defences toward integrated solutions, considering the increasing damage potentiality in a basin where confidence in safety is miscreated by traditional flood control infrastructure (Takeuchi, 2001; Vis et al., 2003).

According to our observations, extensive planning literature has developed rich experience in disaster management concerns. The main aim of this literature is to identify and implement measures that planning can use to deal with floods. As with the former goal, the proposed measures in the more recent literature since the 1990s can be categorised into five aspects, based on the early study from Hegger et al. (2014), including avoidance, defence, mitigation, preparation, and recovery in terms of structural and non-structural interventions (see details in Table 1).

Nature-based infrastructure for flood mitigation has been a major solution widely promoted in the planning literature to decrease flood loss: ecological buffer zones at the macro-scale; mangroves, dunes, marshes, wetlands, lakes, and green-blue river/waterway/canal branches at the meso-scale; and rain gardens, permeable paving, green roofs at the micro-scale. They are proposed to protect shorelines, ensure drainage of excessive river waters as fast as possible or retain rainwater (Kang et al., 2009; Sayers et al., 2013; Wingfield et al., 2019).

Some measures adopted by planning can be de-

Measures	Statements in Planning Policies/Regulations	Affected (Non-) Structural Interventions in Practice	References
Avoidance/prevention	Floodplain zoning plans; land acquisition and relocation plans	- Watershed management and retreating from waters (avoiding urban development in flood-prone areas) - Function arrangement (economic enterprises, residential areas and recreations) - Population move and building (re)locations	(Thampapillai and Musgrave, 1985; Kang, Lee and Lee, 2009; Sayers et al., 2013)
Defence	Multipurpose/multifunctional engineering measures to deal with coastal and fluvial floods with the consideration of leisure, landscape, and commerce	- Dykes, floodwalls or quay walls (setting back, combined with residential buildings, commercial development, greening, and transportation) - Reservoirs (water storage, supply, natural landscape, and recreation)	(Van Veelen, Voorendt and Van Der Zwet, 2015; Voorendt, 2017; Wingfield et al., 2019)
Mitigation	Nature-based infrastructure for coastal flooding reduction, rainfalls detention, retention, and a river discharge passage	- Creation of green buffers and flood detention areas - Creation and preservation of mangroves, dunes, mashes wetlands, lakes, and green-blue corridors - Waterways and channels de-culverting, greening, and improvement - Sustainable Drainage Systems (SuDS)/Low impact development measures (rain gardens, permeable paving, green roofs)	(Kang, Lee and Lee, 2009; Sayers et al., 2013; Wingfield et al., 2019)
Preparation	Building codes and building controls; evacuation plans; safe havens arrangement	- Building waterproofing (removable stop logs, water-retaining walls, mobile barriers, the lowest flood elevation for footings, structural requirement to withstand water pressure, prohibiting basements, flood-proof facades, standards for buildings anchored to foundations) - Road networks optimization - Safe havens creation	(Water Resources Council, 1971; Elsergany et al., 2015; Coutinho-Rodrigues, Sousa and Natividade-Jesus, 2016; Voorendt, 2017; Jamrussri and Toda, 2018)
Recovery	Post-recovery plan; critical infrastructure protection	- Building reconstruction - Re(location) and reinforcement of supporting buildings such as power plants, healthcare centres, and police stations	(Olshansky et al., 2008; Sayers et al., 2013; World Health Organization (Regional Office for

Table 1: Five types of measures to deal with the flood risk when planning is taken into consideration.

batable and are not universally used. For instance, floodplain zoning plans in the avoidance category, which suggest retreating from waters (often coastal and fluvial floods), have faced criticism of losing valuable lands for urban development in countries and areas with high population density, like those that are members of the Organisation for Economic Cooperation and Development (OECD) (Sayers et al., 2013; Chiabai et al., 2015). Another case is the synergy of dyke systems and transportation or residential development in the defence category. This synergy has been a context-specific experience. In the Netherlands, this measure has been highly appraised, where the integration between planning and flood risk management and un-embanked area development (urban development beyond dykes) is well-established and rooted in deeply embedded traditions in water management and planning (van Veelen et al., 2015; Voorendt, 2017). Thus, these experiences cannot be used in other contexts without modification.

Preparation and recovery measures, such as evacuations and safe haven establishments, have received little attention in the planning literature (emergency response). A few papers based on Geographic Information System (GIS) methods, transportation, and urban simulation, opened windows for the domain of spatial planning to optimise evacuation plans and shelter locations arrangements in the face of coastal and fluvial floods (Tagg et al., 2013; Elsergany et al., 2015; Coutinho-Rodrigues et al., 2016; Jamrussri & Toda, 2018). Similarly, critical infrastructure protection is an under-researched issue in planning literature, which calls for paying more attention to protecting essential buildings in the flood events, such as power generation plants, healthcare centres, and police stations (Sayers et al., 2013; World Health Organization, 2017).

The implementation of the proposed measures, however, often faced challenges, given the enormous investment entailed, as well as data and predictive uncertainty in modelling (Vis et al., 2003). Additionally, current successful solutions may no longer be valid when hazards exceed a threshold (the maximum capacity of a system to keep safety, e.g., drainage systems) in the future. Thus, static or on-off resilient measures are not advisable in the face of the unpredictability of climate change, and the flexibility to shift from one to another alternative is significant (Reeder & Ranger, 2010; Barnett et al., 2014; Siebentritt et al., 2014; Buurman & Babovic, 2016).

As a result, since the 2010s, the planning literature has increasingly shifted its focus to the concept of 'adaptive planning,' taking into account the economic utility of resilient measures and wise funding allocation. This notion calls for 1) planning to keep options open to changing circumstances, avoiding locking in rigid decisions; and for 2) local societies and policymakers to remain flexible and adjust their strategies and measures in the face of the uncertainty of floods and climate change (Haasnoot et al., 2013; Walker et al., 2013). Even so, this literature has been criticised due to its idealised assumptions that decision-makers would like to make decisions based on long-term visions and seek opportunities to adjust plans and strategies in the face of the failure of some measures or their unintended negative effects ('maladaptation') (van Veelen, 2016).

3.3. A weak but emerging focus on socio-economic concerns

Despite the growing knowledge on the effects of climate change and flood hazards and available measures to deal with the effects, substantial economic uncertainties still hinder the design and implementation of adaptation measures in practice. These uncertainties include: 1) the potential loss of threatened systems under pressures (McCarthy et al., 2001), 2) the extent to which the resilient (or adaptation) measures could ameliorate the negative effects and enhance positive effects, and the extent of the cost of actions (de Bruin et al., 2009; Debels et al., 2009; Mechler et al., 2014), and 3) the distributional effects of the proposed resilience measures (Anguelovski et al., 2016). The literature focusing on socio-economic concerns, strongly supported by economic scientists and economic analysis institutions, provides some insights into these issues by 1) estimating financial losses of climate change and flood hazards (Stern, 2007), 2) calculating investment and payoff of flood resilience measures (Hallegatte et al., 2011), and 3) allocating the responsibilities of a flood (or pre-flood) loss compensation (Doorn-Hoekveld et al., 2016).

In the planning literature, the discussion of socio-economic features of resilience measures has been largely neglected. It has been partly covered in a few planning papers that concentrate on the economic issues of flood resilience measures in urban development projects, such as the calculation of investment and payoff (Raaijmakers et al., 2008). An early study from Bruin and Goosen (2014) used cost-benefit analysis (CBA) to verify the economic efficiency of flood resilience measures to deal with precipitation. They found that rainfall gardens, raised roads, and building codes were not economically efficient compared to ecological networks in a Dutch case. The institute Urban Floods Community of Practice confirmed the significance of regulatory instruments in Florida relying on cost-effectiveness analysis (CEA), where risk-based building codes reduced severe flood loss from Hurricane Charley by 42% (Urban Floods Community of Practice, 2017). Similar applications of cost-effectiveness analysis also appear in papers that confirm the effects of zoning plans and development controls in England, Colombia, Japan, New Orleans, Seoul, etc. (Urban Floods Community of Practice, 2017). Raaijmakers et al. explored ways of using multi-criteria analysis (MCA) to decide either a continuation of housing development in flood-prone areas for profits or a change of cultivated lands to natural lands to face the flood risk (coastal floods caused by storms) given the public and private stakeholders' worries and their individual risk perception (Raaijmakers et al., 2008).

Economic reports have given a more critical assessment of different flood resilience options available for planning and pointed out that the benefit-to-cost ratio is variable. For instance, mangroves as a natural option to create buffer zones to reduce coastal floods, supposed to have a high benefit-to-cost ratio by the Economics of Climate Adaptation Working Group (ECA) report (Economics of Climate Adaptation Working Group (ECA), 2009), was criticised by Sanghi et al. (2010) on account of an exponential increase in costs in high-income countries, like the United States. Similar discrepancies also appeared in options like retreating from low-lying areas, and building codes (see Table 2).

The inconclusive cost-benefit results are partly

Resilience Interventions		Calculation Methods	Findings	References
Watershed management and function arrangement	Retreating from low-lying areas *	CBA	A high benefit-to-cost ratio for hurricane protection and storm-surge; yet involving high opportunities in costs of lands, like OECD countries	(Economics of Climate Adaptation Working Group (ECA), 2009; Chiabai et al., 2015)
	Zoning plan with a functional arrangement	CEA	High benefits	(Urban Floods Community of Practice (UFCOP), 2017)
	A change of cultivated lands to natural lands to mitigate loss	MCA	High acceptance of public and private stakeholders in individual risk perception	(Raaijmakers, Krywkow and Veen, 2008)
Building codes/controls	Mobile barriers *	CBA	A high benefit-to-cost ratio	(Economics of Climate Adaptation Working Group (ECA), 2009)
	Houses with waterproof glass or windows *	CBA	A low benefit-to-cost ratio	(Bruin and Goosen, 2014)
	Retrofitting building materials against floods *	CBA	High/low benefit-to-cost ratio depending on differences in risk levels, the costs of resilience, existing costs and asset lifetimes, and assumed discount rates locally	(Hochrainer-Stigler et al., 2010)
	Residential building controls reducing severe flood loss from Hurricane Charley by 42%	CEA	High benefits	(Urban Floods Community of Practice (UFCOP), 2017)
Multi-purpose engineering measures	Construction of dykes combined with transportation	CBA	A low benefit-to-cost ratio	(Bruin and Goosen, 2014)
Natural coastal and waterfront buffer zones	A change of cultivated lands to ecological networks	CBA	A high benefit-to-cost ratio	(Bruin and Goosen, 2014)
	Mangroves *	CBA	A high benefit-to-cost ratio; yet an exponentially increase in costs due to land transformation and policy enforcement costs in high-income countries, like the US	(Economics of Climate Adaptation Working Group (ECA), 2009; Sanghi et al., 2010)
Water detention	Rainfall gardens for	CBA	A low benefit-to-cost ratio	(Bruin and Goosen, 2014)

Table 2: Economics of flood resilience measures available for spatial planning. Grey coloured blanks are the findings indicating variable benefit to cost ratios

CBA: cost-benefit analysis; CFA: Cost-effectiveness; MCA: multi-criteria analysis

* The findings come from economic reports

due to the uncertainties related to flooding extremes and the high site-specificity (Chiabai et al., 2015). Risk levels, the costs of resilience measures, land prices, policy enforcement costs, maintenance expenses, and asset lifetimes, etc., are different from a place to a place. It leads to a variation in cost-benefit ratios in different areas even for the same implemented measures (Hochrainer-Stigler et al., 2010; Sanghi et al., 2010). Also, the calculation can be affected by the definition of 'cost' and 'benefit' which can greatly alter the mathematical results (Sanghi et al., 2010; Chiabai et al., 2015). Even so, the analysis in the economic literature still provides insights for the planning literature on how to calculate the economic payoffs and profits of resilient measures that support option selection according to local conditions.

3.4. An increasing focus on institutional and governance concerns in the planning literature

The strand of the flood resilience scholarship concerned with institutional and governance issues is a mixed body of literature spanning across the disciplines of social science (Aylett, 2015), political science (Fraser and Kirbyshire, 2017), and policy studies (Keskitalo, 2010; Bulkeley, 2013). It explores how an institutional system at the national, regional urban, or community level responds to flood risk and natural hazards. The literature observes resilience policies and adaptation activities as a result of collective behaviours in multi-level, multi-domain, and multi-actor settings (Bulkeley, 2010; 2013; Keskitalo, 2010).

This strand has attracted a growing (albeit limited) number of planning researchers concerned with institutional and governance issues (Mileti, 1999; Storbjörk, 2007; Deyle, Chapin & Baker, 2008; White et al., 2016; Francesch-Huidobro et al., 2017). One stream of the literature suggests exploring the involvement of planning in flood affairs as a by-product of water management governance under the notions such as 'integrated water resources management' (Mostert, 2006), 'synergy between flood risk management and spatial planning' (Sayers et al., 2013; Ward et al., 2013; Ran & Nedovic-Budic, 2016; van Buren et al., 2016; Driessen et al., 2018), 'multi-level governance and boundary spanning planning for adaptation' (Dąbrowski, 2018a), and 'diversification of flood risk management with spatial planning's involvement' (Driessen et al., 2018). Another stream of research, although represented only in a few papers, positions planning at the centre of flood resilience and calls for the incorporation of flood risk management and climate adaptation in land use planning or spatial planning (Mileti, 1999; Storbjörk, 2007; Deyle et al., 2008; White et al., 2016; Francesch-Huidobro et al., 2017).

These emerging studies share a focus on identifying the facilitators and barriers for planning institutions to play a meaningful role in flood governance and exploring how and why they emerge. The main points include four aspects (see Table 3). The first aspect is about the products of flood governance. Some studies reported that policies, strategies, codes, standards, and planning rules provided legal supports and frameworks for planning to be involved in flood agendas (Wilby & Keenan, 2012). Empirically, policymakers and researchers argued that planning for adaptation can be impaired by 'fragmented and convoluted' frameworks and legislation (Wamsler & Pauleit, 2016). They believe

that the ways of framing or interpreting climate adaptation and flooding in planning discourse are significant (Brouwer et al., 2013), which is relevant not only to the definitions of problems and intentions of acts but also to the expected means to do so (Foxell & Cooper, 2015). However, in practice, it is still not easy to avoid insufficient framing (for example, no detailed guidelines for local practice and the lack of corresponding explanations at the regional and national levels), incomplete framing (for example, thinking merely flood defence in flood risks management) and disconnected framing (for example, initiating detached policies failing to mainstream adaptation) (Storbjörk, 2007; Ward et al., 2013; Wamsler & Pauleit, 2016; Driessen et al., 2018; Runhaar et al., 2018). More empirical knowledge is needed of how framing works in practice.

The second aspect is about the collaborative process between divergent agencies. Increasing numbers of planning studies stress the joint work between planning and extensive actors in the formulation and implementation of resilience and adaptation policies, albeit pointing out that trade-offs are difficult between governments, planning agencies, hydrological engineers, scientists, civil society, and markets due to divergent interests and political positions (Storbjörk, 2007; Francesch-Huidobro et al., 2017; Dąbrowski, 2018b; Driessen et al., 2018). A few papers added to this line of argument and reported that mismatches in time-spans and procedures between professions could impair the transboundary cooperation between the planning sector and other sectors (Mostert, 2006; Davidse et al., 2015; Ran & Nedovic-Budic, 2016). More research is needed to explore the means to facilitate these co-determined processes.

The third aspect is about the start-conditions for planning to participate in flood governance: A small number of studies have cast light on the complexity of the collaborative process in terms of authority, resource and organisation conditions and indicated these pre-sets could affect planning's performance in the collaborative governance (Mileti, 1999; Deyle et al., 2008; Driessen et al., 2018). For example, the legal clarity and versatility of planning tools may affect land use restrictions and policy changes in response to climatic uncertainty (Mileti, 1999; Deyle et al., 2008; Driessen et al., 2018). Also, suitable allocation of finance and access to information in relation to planning is required to deal with distributional effects of floods (fairness), information sharing between sectors, and the public's right to be informed (Intergovernmental Panel on Climate Change, 2014; Driessen et al., 2018). Last but not least, the establishment of technical co-working platforms, clarification of planning's accountability (or responsibilities), and the planners' knowledge determine the planning agencies' capacities in flood governance (Mileti, 1999; Storbjörk, 2007; Ward et al., 2013; Ran & Nedovic-Budic, 2016; Driessen et al., 2018). However, the means to improve these start-conditions remain an under-researched issue.

The fourth aspect is about the contextual factors shaping the start conditions for planning in flood governance: This stream of research on the contextual factors that could affect the pre-conditions for planning in flood governance—from the fixed administrative structures and shared perceptions, to notions, values, and traditions embedded in history—is limited in the planning literature. Early studies reported that fragmented structures in political administration, asymmetries of powers, and persistence in the old paradigms in flood governance could weaken the capacities of planning agencies in

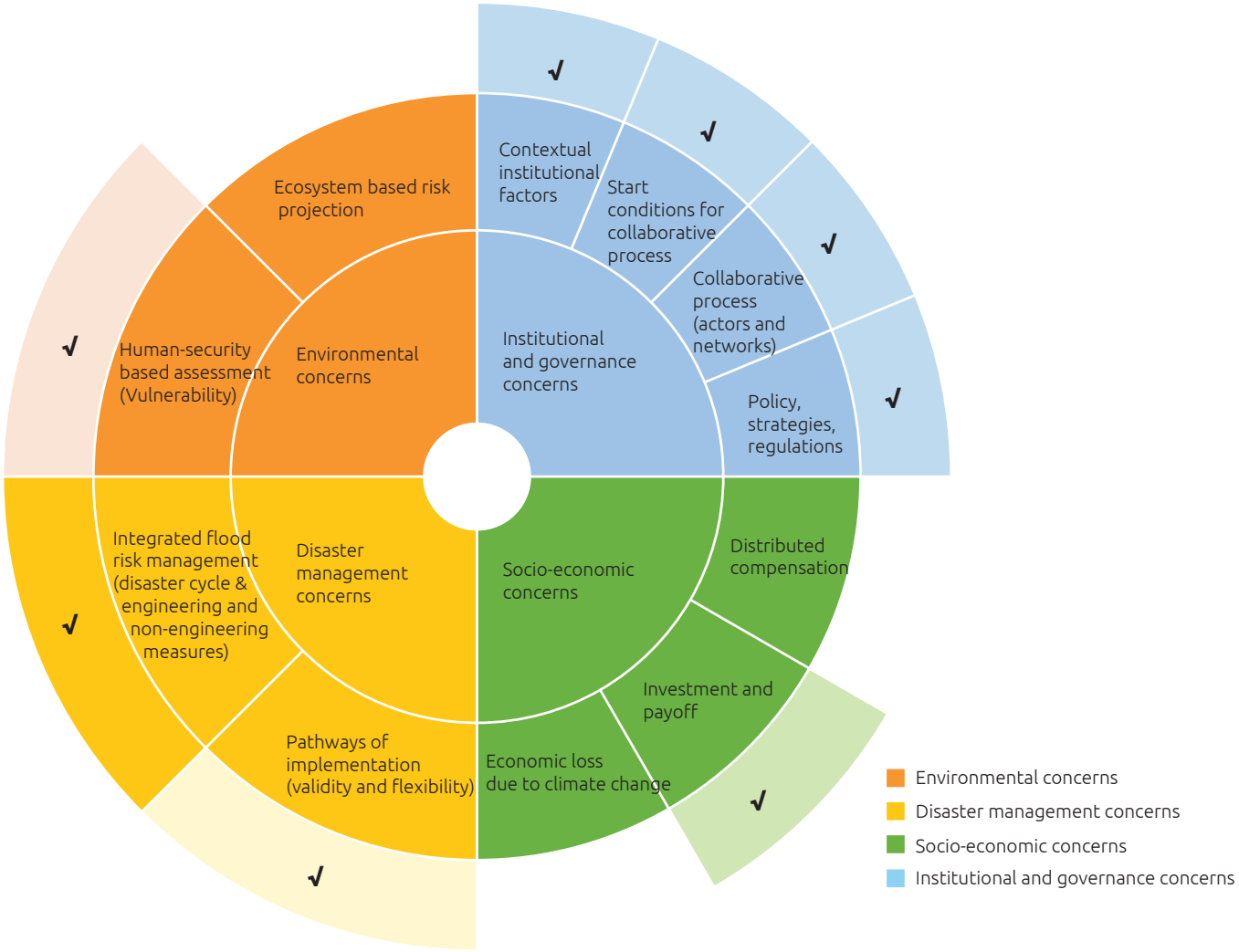

Figure 1: The developments of planning literature in the four pillars (the third ring).
Note: The dark colours mean that there are many studies, pale colours mean that there is a limited but increasing amount of studies, and white means that there is a gap here and the topic is under-researched in planning literature

implementing a broader set of adaptation measures in flood agendas (Mileti, 1999; Ward et al., 2013; van Buren et al., 2016). However, to change these contextual factors is often difficult, which need more explorations about their continuity and way out. See Table 3 on the next page.

4. Discussion

As an indispensable approach for flood resilience, planning makes a contribution through a broad range of inter-disciplinary experience. Figure 1 present planning's recent roles in environmental concerns, disaster management concerns, socio-economic concerns, and institutional and governance concerns. The darker the colours are, the deeper the relative

Key Topics	Sub-Topics	Challenges for Spatial Planning	References
Outputs of flood governance	Policies, strategies, codes, standards, planning rules	- Mainstreaming flood risk issues in local agendas - Diversifying adaptation measures in discourse such as non-structural measures - Aligning the mismatches between local, regional, and national policy discourse - Short-term vs. long-term benefits	(Storbjörk, 200
Collaborative process	Actors/ stakeholders	- Enhancing the roles of planning in the decision-making process (proactive participation) - Resolving misaligned interests of parties, - Converging conflicting understanding of parties in flood resilience and climate adaptation (awareness of risk, cognitions of adaptation measures, priorities on short- and long-term benefits), - Strengthening the weak abilities in using climatic knowledge to predict future scenarios	(Storbjörk, 200 et al., 2018)
	Networks	- Aligning the conflicting timespans and planning procedures in contrast to water management and environmental planning - Strengthening communications and cooperation between governmental and private actors in planning and flood-risk management	(Mostert, 2006; Budic, 2016)
Start conditions for planning to participate in flood governance	Authority condition	- Balancing legal certainty and flexibility to regulate restrictions or change land-use functions for flood resilience	(Mileti, 1999; D
	Resource condition	- Adopting appropriate principles in dealing with distributional effects of planning layouts (fairness in the distribution of cost and benefit), - Enabling information sharing and knowledge communications between governmental sectors - Facilitating public access to spatial planning information.	(IPCC, 2014; Dri
	Organisation condition	- Establishing a technical information platform for interactions between territorial, institutional, and policy cooperation - Clarifying blurred accountability (responsibilities) and powers between national authorities, local planning actors, and other stakeholders for flood events - Personnel skills	(Mileti, 1999; St Driessen et al.,
Contextual factors shaping the start conditions for planning in flood governance	Institutional design	- Facing fragmented administrative and political structures	(Mileti, 1999; W
	Notions, values, and traditions embedded in history and traditions	- Facing the persistence in the old paradigms (institutional inertia and path divergence) - Facing the asymmetries of powers	(Van Buren, Ell

Table 3: Key challenges for planning to play a role in flood governance.

07; Ward et al., 2013; Driessen et al., 2018; Runhaar et al., 2018)

07; Francesch-Huidobro et al., 2017; Dąbrowski, 2018b; Driessen

; Davidse, Othengrafen and Deppisch, 2015; Ran and Nedovic-

eyle, Chapin and Baker, 2008; Driessen et al., 2018)

essen et al., 2018)

torbjörk, 2007; Ward et al., 2013; Ran and Nedovic-Budic, 2016;
, 2018)

Ward et al., 2013)

en and Warner, 2016)

exploration by the publications in relation to spatial planning. The four-pillar model indicates that the planning literature pays more attention to disaster management concerns. This reflects the perspective on planning as a design approach, technically efficient in dealing with floods, which corresponds to one origin of planning as a physical intervention approach organising city development and property.

Meanwhile, the influence of climate, economic, social, and policy sciences on planning is emerging, even though few planning studies investigate these concerns. They inspired planning research, policy, and practice to broaden their scopes to include new topics such as vulnerability identification, investment and payoff, and governance. Planning, thus, is adapting its role as an integrated approach to contribute to flood resilience.

5. Conclusions and 'opening up'

The growing threats of floods and climate change necessitate long-term safe, fair, economically efficient, and institutionally coordinated circumstances for human settlements. For this goal, this chapter proposes a four-pillar framework to understand environmental, disaster management, socio-economic, and institutional challenges that need to be considered in flood resilience and climate adaptation. It is applied here to conduct an extensive literature review spanning across the fields of climate science, disaster mitigation, water management, flood risk management, hydrological engineering, economics, climate policy, adaptation planning, public participation, administration, and governance. The proposed framework aids in identifying and assessing spatial planning trends concerning flood resilience and climate adaptation against the disciplines listed above.

Our analysis of the literature indicates that the domain of planning concentrates on improving the physical environment mainly in relation to disaster management concerns, in the belief that planning is an instrumental–technical

intervention shaping human settlement patterns. However, planning is a broad discipline increasingly including the environmental, socio-economic, and institutional topics in the wider policy context. This trend is spurred by insights from climate change analysis, economic analysis, social science, governance and policy studies, and promoted by pioneering planning scholars.

Our analysis also indicates that emerging topics could bring valuable insights informing the implementation of physical planning in practice, which remains challenging due to uncertainty about the future risks, limited resources, and complex social and institutional relations. Relevant research can add to spatial planning's ability to 1) enhance the evidence-based evaluations of flood hazards and evidence-based strategies for resilience, 2) act on uncertainty in the face of a shortage of financial resources, 3) address the unfair distributional effects of flood damages with adequate and equitable compensation, 4) manage societal concerns and divergent interests, 5) improve the coordination of resilience measures across sectors and spatial scales, and finally, 6) propose spatial resilience strategies that respect and take advantage of knowledge and values embedded in local history and traditions.

6. References

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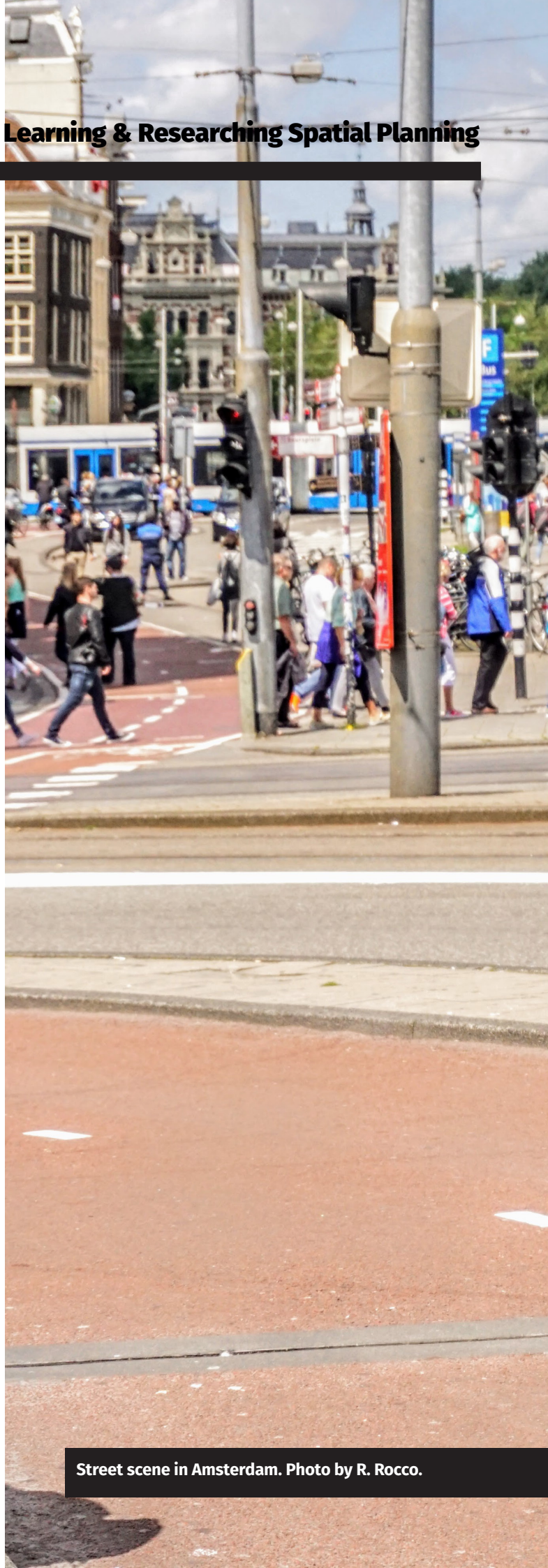

Street scene in Amsterdam. Photo by R. Rocco.