CHAPTER 1

Introduction

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1.1 Introduction

Dealing with climate-driven natural hazards like river or pluvial floods, droughts, heat waves or forest fires play a central role across the globe in the twenty-first century (Otto, 2016; Ray et al., 2017; Raymond et al., 2020). The frequency and magnitude of climate-driven natural hazards will increase in the next years (IPCC, 2021). At the same time, urban areas are increasingly vulnerable to the impact of such events. Residential and non-residential buildings will be more exposed to natural hazards and individuals are often ill-prepared for disasters. This will lead to more harm and damage in the future (Di Baldassarre et al., 2015;

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Papathoma-Köhle et al., 2021; Qiang et al., 2017; Tate et al., 2021). Nevertheless, due to population density and complex and interdependent infrastructures, urban areas are especially highly vulnerable to weather-related impacts (Markolf et al., 2019). In the past decades, we observed three main drastic changes across the globe. The first change reflects the increase of temperature and rise of natural hazards events, which we expect as extreme weather events increase (Raymond et al., 2020). The second key change reflects the land cover and land uses of our planet. We observe a rapid urbanization not only in the global south with an intensive increase of new megacities, but also in the global north, where large numbers of the citizens are moving from rural to urban areas (Chapman et al. 2017; Cullis et al. 2019; Zhang, 2016). However, the urbanization developed new and more residential and non-residential buildings in hazard-prone areas (de Moel et al., 2011; Qiang et al., 2017). A third change reflects the technological system; countries, particularly in the global north, are facing aging infrastructures which cannot respond adequately to the current and future climate-driven challenges, such as inadequate storm water systems in urban areas which cannot respond to the increase in intense pluvial floods (Chester et al., 2020; Markolf et al., 2021; Meerow et al., 2021). Therefore, aging infrastructure can often lead to higher damages. Based on these three challenges and developments, the annual losses will likely increase within the next decades (Dottori et al., 2018). Consequently, urban areas are highly affected by and prone to these three challenges. To maintain functional urban areas and quality of life in the future, urban areas in particular need to adapt and prepare for natural hazards. They need to become more resilient.

Urban resilience has become an important term in response to climate change. Resilience describes the ability of a system to absorb shocks. Resilience depends on the vulnerability and recovery time of a system.

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A shock affects a system to the extent that it becomes vulnerable to the event. The opposite of vulnerability is resistance. The part of a system that is resistant (e.g., by protective devices) remains unaffected. The less vulnerable or the more resistant a system, the higher the resilience. The second component of resilience is the recovery time. The shorter the time, the higher the resilience. Resilience can thus be increased by reducing vulnerability as well as recovery time. A resilience strategy can therefore address vulnerability and recovery time, or both.

Many cities have included resilience in urban land use planning and risk management strategies. The Resilient Cities Network understands and defines urban resilience as "the capacity of a city's systems, businesses, institutions, communities, and individuals to survive, adapt, and grow, no matter what chronic stresses and acute shocks they experience" (Resilient City Network, n.y.). Pathways to achieve resilient cities, however, remain blurred (Restemeyer et al., 2015).

Extensive research has been conducted on how urban resilience should look like and to what extent risk communication influences individual decision-making and the implementation of urban resilience policies. One of the findings that emerges over the last couple of years is that flood resilience needs to be realized not primarily and exclusively in public areas (Attems et al., 2020), but it requires action by individual homeowners and residents in potentially affected areas in particular. Flood resilience of private properties and privately owned lands play a crucial role in reaching urban resilience (Hartmann et al., 2019), as they often represent large parts of urban areas (Ferreira et al., 2021; Fuentalba & Verrest, 2020); though various types of property rights are present in cities. For example, squatter settlements are used privately, but the property right titles can lie in the hands of public administration (Porio & Crisol, 2004). Privately owned land plays a central role in natural hazard risk management to reach the goal of urban resilience, such as the implementation of Nature-based Solutions (NbS) strategies like green spaces, urban forests, woodlands or surface storages at privately owned buildings and land as a response to urban heat waves or flooding (Galderisi & Treccozzi, 2017). Another example is the implementation of property-level flood risk adaptation (PLFRA) measures at private residential and non-residential buildings as a strategy to reduce future losses caused by flood events, which brings homeowners in the core position of natural hazard risk management (Attems et al., 2020; Snel et al., 2020).

Nevertheless, there are many limitations and barriers to the implementation of respective measures, and research on how resilient measures are implemented on privately owned land as well as by individual homeowners is still intensely debated (Kuhlicke et al., 2020; Rufat et al., 2020). There are various reasons why individual homeowners or business-owners reject the targeted goal of implementing actions against future natural hazard events (for a detailed debate see for example Chapters 8 or 10).

Consequently, a key challenge poses the encouragement of private landowners to take a more active role in natural hazard risk management. Current findings show that their position is partly affected by perceived responsibility sharing (Slavikova, 2018), which is more or less successfully articulated as part of existing social contracts (Adger et al., 2013). Various instruments exist in land use and spatial planning (Gerber et al., 2018) that can encourage (or discourage) private landowners to change their individual awareness, motivation and behavior: land readjustment, transferable development rights, private law (such as contracts or land use restrictions) or strategic land banking. Additionally, economic policy such as subsidies, prices, taxes, etc., or socio-psychological instruments such as nudging, communication or social norms can steer toward different levels of involvement of private landowners in natural hazard risk management (see also further Chapters 2, 3, 4 and 5 within this edited volume).

Thus, this edited volume focuses on the implementation part of policies by providing insights from different case studies in combination with examples of various natural hazards to explore three related research questions:

- How do homeowners perceive (or reflect?) natural hazard events?
- Which measures can homeowners undertake?
- Which triggers activate homeowners to take action?

1.2 Urban Resilience

Urban resilience has become more dominant in policy strategy in the past decades. Various local, regional, national and international initiatives aim to reach the goal of urban resilience as a key response to future natural hazard events. International initiatives, like the 100 Resilient Cities concept or Smart Cities—Smart Living strategy, have received greater attention from decision-makers in urban areas (Moloney & Doyon, 2021;

Spaans & Waterhout, 2017). The City of Vienna, for example, has developed various programs such as the Smart Energy Vision 2050, Roadmap 2020 and Smart City Wien Framework Strategy 2019–2050, adopted in 2019 to reach the goal of urban resilience. These programs include various new modes of governance and the use of technologies in planning decisions (City of Vienna, 2021). Other examples, such as Toronto or New York, show that cities have worked closely with private companies like IBM Business Analytics Solution Center to create smart urban areas (Cohen, 2012). The City of Barcelona has mainly focused on the use of new computer technologies and to increase the efficient use of the city, particularly in terms of waste management and the implementation of the superblocks concept (Barcelona, 2021). The city has adopted the Smart City 3.0 concept, which includes strong collaboration with citizens in the overall urban planning process. These examples "offer promising new modes of governance and methods of collaboration between decision-makers, stakeholders and citizens" (Thaler et al., 2021, p. 224).

But what actually is urban resilience? The term resilience has a very long tradition. Alexander (2013), for example, states that the term resilience might actually appear in the ancient times for the first time. However, the term resilience first began to play a prominent role in the 1970s with the seminal paper by Crawford Stanley Holling in 1973. Holling (1973) uses the term to describe the point when an ecological system is able to absorb the changes or disturbances within an ecosystem. "Resilience, that is a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973, p. 14). More recently, the term resilience was used to describe the predominant goal in natural hazard risk management, as observed in an increasing number of academic and non-academic publications (Fekete et al., 2020). For example, the English and Welsh flood risk management strategy emphasized resilience in their flood risk management strategy in 2008 after the UK Summer Floods in 2007 (Cabinet Office, 2008), while the 2005 Defra program "Making Space for Water" mainly included sustainability goals in flood risk management and not resilience (DEFRA, 2005). Resilience to natural hazards includes various themes, such as psychological, institutional, engineering or financial resilience (Fuchs & Thaler, 2018). Psychological resilience, for example, assesses the individual behavior and response to natural hazard events, such as whether

natural hazard events might cause post-flood traumas (Babcicky et al., 2021; Tapsell & Tunstall, 2008; Viavattene & Priest, 2020). Institutional resilience understands the role of formal and informal institutions to natural hazard events; for example, institutional vulnerability caused by economic and financial crises can increase the social and physical vulnerability of a country (Papathoma-Köhle et al., 2021). Engineering resilience focuses on the question of timing, for example, how fast a bridge can be rebuilt after an event (Ayyub, 2014). Finally, financial or economic resilience assesses the question of how financial resources influence the recovery phase (Kousky et al., 2020). The lack of financial security can cause large negative implications to individuals or communities (Slavikova et al., 2021).

1.3 Private-Owned Land

Natural hazards and property rights in land have a twofold relationship. On the one side, "changing environmental conditions […] have an impact on land use" (van Straalen et al., 2018, p. 1). The mere fact that land uses are positioned in harm's way creates damages in the first place. The impact of natural hazards on land use and property rights can be long-term and gradual, as for example in avulsion of coastlines (Hunter, 2013; Norton & Meadows, 2014), beach erosion (Gibbs et al., 2013), land subsidence (Saputra et al., 2017), or farmland alteration (Pellissery & Sridhar, 2018), or the changes can be sudden and temporal, such as flooding, earthquakes or landslides (van Straalen et al., 2018). Because land is an immobile resource, adaptation is needed to prevent or reduce the impact of natural hazards. On the other hand, management of natural hazards requires access to land to implement measures to mitigate natural hazards. Recent trends in natural hazard management toward a more risk-based approach and toward more nature-based solutions increase the need for land (Hartmann et al., 2019). Adaptation and mitigation as part of natural hazard management need to influence land and its use.

Land use is regulated by public policy, such as land policy (Gerber et al., 2018), spatial planning or sectoral planning (Needham et al., 2018; Spit & Zoete, 2016). However, any intervention in land use affects property rights in land in one way or another (Buitelaar, 2012; Needham, 2006). Property rights can be characterized as a robust institution (Hartmann & Needham, 2012; Tarlock & Albrecht, 2016). They cannot

be changed or adapted swiftly and easily. This makes adaptation and mitigation on private land challenging.

So, the robustness of property in land on the one side and the need for adaptation and mitigation measures on land create a tension that is not easily resolved. While many academics and professionals discuss financial instruments to compensate or incentivize certain actions of landowners (Crabbé & Coppens, 2019; Kis & Ungvári, 2019; Löschner et al., 2021; McCarthy et al., 2018; Suykens et al., 2019), experience from various natural hazards, but foremost from flood risk management, shows that financials means can only partly resolve the issues. Land, it seems, is a more complicated matter, where specific governance schemes (Löschner et al., 2019) and multiple perspectives of property (Davy, 2012) need to be taken into account at various levels of scale (Raska et al., 2019). Understanding the fraught relationship between changing environmental conditions and property rights—or in other words: the relation between land and natural hazards—is essential for successful natural hazard management.

1.4 Structure of the Book

The core question of this book is how to reach private property-owners to implement such measures or to improve their individual coping and adaptive capacity to respond to future events. In overall, there exist various planning (Chapter 2), legal (Chapter 3), psychological (Chapter 4) and financial incentives (Chapter 5) factors to encourage individuals to take an active role in natural hazard risk management with the goal to reach urban resilience. The book presents theoretical discussions and empirical cases of how to reach urban resilience. The book guides the reader through different conceptual frameworks as well as by showing how urban regions are actually trying to reach urban resilience on privately owned land. This will be shown on different cultural, socio-economic and political backgrounds to see how different institutional frameworks (formal and informal rules) have an impact.

The book consists of two parts. The first part presents a conceptual debate about the barriers and drivers in reaching the goal of urban resilience. The second part discusses various examples across the globe on how different urban regions focus on the goal of urban resilience, using different types of natural hazards. The examples are from Africa

(Uganda), America (United States of America), Asia (China), Australia and Europe (Belgium and Germany).

Chapter 2—written by Barbara Tempels—with the title *Resilient Cities and Homeowners Action: Governing for Flood Resilience Through Homeowner Contributions* shows the possibility of homeowners in reaching the goal of urban resilience from a spatial governance perspective. It explores the rationales for homeowner involvement in flood risk management, the challenges and dilemmas that arise, and the technical, economic, legal and social conditions and triggers within flood risk governance that might encourage increased homeowner involvement in achieving flood resilience.

Chapter 3—written by Marleen van Rijswick and Willemijn van Doorn-Hoekveld—with the title *Property, Property Rights, Natural Hazards and Beyond* provides an overview on the legal dimensions on reaching urban resilience on private-owned land and provides an overview on the legal dimensions of reaching urban resilience on privately owned land. Land use is regulated by public policy, such as land policy (Gerber et al., 2018), spatial planning or sectoral planning (Needham et al., 2018; Spit & Zoete, 2016). However, any intervention in land use affects property rights in land in one way or another (Buitelaar, 2012; Needham, 2006). Property rights can be characterized as a robust institution (Hartmann & Needham, 2012; Tarlock & Albrecht, 2016). They cannot be changed or adapted swiftly and easily. This makes adaptation and mitigation on private land challenging.

Chapter 4—written by Thomas Thaler and Elisabetta Genovese—with the title *Individual Behaviour in Disaster Risk Reduction* focuses on the question of the behavioral turn in natural hazard risk management to reach urban resilience. The chapter provides an overview about which factors influence (positively or negatively) a change in individual behavior to take actions against future natural hazards events. The objective of the chapter is to provide a theoretical discussion about how psychological variables influence individual risk behavior.

Chapter 5—written by Lenka Slavíková and Thomas Hartmann—entitled *Resilient Flood Recovery—Financial Schemes for the Recovery–Mitigation Nexus* Public and private financial schemes are used for the recovery from natural hazards event. The chapter shows how financial schemes might be used to stimulate urban resilience.

Part II reflects on the role of homeowners to reach the goal of urban resilience across the globe based on seven case studies.

Chapter 6—written by Shaofeng Jia and Dalong Li with the title *Resident's Role in Sponge City Construction and Urban Flood Disaster Relief of China*—focuses on the resident's role in the current sponge city flood risk management strategy in China with a special focus on Beijing (China). The chapter shows the role of homeowners in the Chinese urban areas and how the sponge city concept can be implemented to reach urban resilience. The chapter focusses especially on incentives and barriers of implementation.

Chapter 7—written by Simbarashe Chereni et al. with the title *Factors Influencing Flood-Related Coping Appraisal Among Homeowners and Rsidents in Kampala, Uganda*—assesses the factors that influence flood-related coping appraisal among homeowners in Kampala (Uganda). The chapter used survey data from 612 householders to understand their coping appraisal elements to reach urban resilience.

Chapter 8—written by Peter Davids with the title *Addressing the Homeowners' Barriers to Property-Level Flood Risk Adaption: A Case Study of Tailored Expert Advice in Belgium*—focuses on the encouragement of homeowners in the Belgium region Flanders (Belgium). The chapter analyzes how private homeowners are encouraged to implement PLFRA measures to flood hazards through tailor-made flood risk advice provided by the regional authority.

Chapter 9—written by Alfred Olfert and Gerard Hutter with the title *Strategic Risk Communication to Increase the Climate Resilience of Households—Conceptual Insights and a Strategy Example from Germany*—focuses on the role of risk communication to reach urban resilience in Germany. The chapter addresses communicative measures to increase the resilience of private households in small and medium-sized towns in the Free State of Saxony in the east of Germany.

Chapter 10—written by Thomas Jacobson with the title *Government, Homeowners, and Wildfire: What Can We Learn from California's Resilience Planning Experience?*—shows the role of homeowners in California's urban resilience strategy against wildfires. In particular, wildfires demonstrate an increased threat to the population in California since the fire season has doubled and more people are living in hazard-prone areas. The chapter shows different policy instruments and their influence on individual adaptation behavior.

Chapter 11—written by Fünfgeld et al. with the title *Supporting Stakeholder-Based Adaptation to Climate Change: Experiences in the City of Melbourne*—focuses on the challenge of how to engage private

actors and stakeholders to adapt to natural hazard events in the case of Melbourne (Australia). The city of Melbourne developed various strategies to improve the city resilience in close collaboration with public and private stakeholders. The chapter shows the challenges, but especially positive lessons learn from early adopters at local level.

References

Adger, W. N., Quinn, T., Lorenzoni, I., Murphy, C., & Sweeney, J. (2013). Changing social contracts in climate-change adaptation. *Nature Climate Change, 3*(4), 330–333.

Alexander, D. E. (2013). Resilience and disaster risk reduction: An etymological journey. *Natural Hazards and Earth System Sciences, 13*(11), 2707–2716.

Attems, M.-S., Thaler, T., Genovese, E., & Fuchs, S. (2020). Implementation of property-level flood risk adaptation (PLFRA) measures: Choices and decisions. *Wires Water, 7*(1), e1404.

Ayyub, B. M. (2014). Systems resilience for multihazard environments. Definition, metrics, and valuation for decision making. *Risk Analysis, 34*(2), 340–355.

Babcicky, P., Seebauer, S., & Thaler, T. (2021). Make it personal: Introducing intangible outcomes and psychological sources to flood vulnerability and policy. *International Journal of Disaster Risk Reduction, 58*, 102169.

Barcelona. (2021). *Smart City—Info Barcelona*. https://www.barcelona.cat/infobarcelona/en/tema/smart-city. Last access: 26 July 2021.

Buitelaar, E. (2012). The fraught relationship between planning and regulation: Land use plans and the conflicts in dealing with uncertainty. In T. Hartmann & B. Needham (Eds.), *Planning by law and property rights reconsidered* (pp. 207–218). Ashgate.

Cabinet Office. (2008). *The Pitt review—Learning lessons from the 2007 floods*. Cabinet Office.

Chapman, S., Watson, J. E. M., Salazar, A., Thatcher, M., & McAlpine, C. A. (2017). The impact of urbanization and climate change on urban temperatures: A systematic review. *Landscape Ecology*, 32, 1921–1935.

Chester, M. V., Underwood, B. S., & Samaras, C. (2020). Keeping infrastructure reliable under climate uncertainty. *Nature Climate Change*, *10*, 488–490.

Cohen, B. (2012). *The top 10 smart cities on the planet*. https://www.fastcompany.com/90186037/the-top-10-smart-cities-on-the-planet. Last access: 26 June 2021.

Crabbé, A., & Coppens, T. (2019). Swapping development rights in swampy land: Strategic instruments to prevent floodplain development in Flanders. In

T. Hartmann, L. Slavíková, & S. S. McCarthy (Eds.), *Nature-based flood risk management on private land* (pp. 85–97). Springer International Publishing.

Cullis, J. D. S., Horn, A., Rossouw, N., Fisher-Jeffers, L., Kunneke, M. M., & Hoffman, W. (2019). Urbanisation, climate change and its impact on water quality and economic risks in a water scarce and rapidly urbanising catchment: Case study of the Berg River Catchment. *H2Open Journal*, *2*(1), 146–167.

Davy, B. (2012). *Land policy: A German perspective on planning and property*. Ashgate.

De Moel, H., Aerts, J. C. J. H., & Koomen, E. (2011). Development of flood exposure in the Netherlands during the 20th and 21st century. *Global Environmental Change*, *21*(2), 620–627.

DEFRA. (2005). *Making space for water*. Department for Environment, Food and Rural Affairs.

Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Yan, K., Brandimarte, L., & Blöschl, G. (2015). Debates—Perspectives on socio-hydrology: Capturing feedbacks between physical and social processes. *Water Resources Research, 51*(6), 4770–4781.

Dottori, F., Szewczyk, W., Ciscar, J.-C., Zhao, F., Alfieri, L., Hirabayashi, Y., Bianchi, A., Mongelli, I., Frieler, K., Betts, R. A., & Feyen, L. (2018). Increased human and economic losses from river flooding with anthropogenic warming. *Nature Climate Change*, *8*, 781–786.

Fekete, A., Hartmann, T., & Jüpner, R. (2020). Resilience: On-going wave or subsiding trend in flood risk research and practice? *Wires Water, 7*(1), e1397.

Ferreira C. S. S., Potočki, K., Kapović-Solomun, M., & Kalantari, Z. (2021). Nature-Based Solutions for Flood Mitigation and Resilience in Urban Areas. In *The handbook of environmental chemistry*. Springer.

Fuchs, S., & Thaler, T. (Eds.). (2018). *Vulnerability and resilience to natural hazards*. Cambridge University Press.

Fuentalba, R., & Verrest, H. (2020). Disrupting risk governance? A post-disaster politics of inclusion in the urban margins. *Urban Planning, 5*(3), 274–287.

Galderisi, A., & Treccozzi, E. (2017). Green strategies for flood resilient cities: The Benevento case study. *Procedia Environmental Sciences, 37*, 655–666.

Gerber, J.-D., Hartmann, T., & Hengstermann, A. (Eds.). (2018). *Instruments of land policy: Dealing with scarcity of land*. Routledge.

Gibbs, M. T., Thébaud, O., & Lorenz, D. (2013). A risk model to describe the behaviours of actors in the houses falling into the sea problem. *Ocean & Coastal Management, 80*, 73–79.

Hartmann, T., & Needham, B. (2012). Introduction: Why reconsider planning by law and property rights? In T. Hartmann & B. Needham (Eds.), *Planning by law and property rights reconsidered* (pp. 1–23). Ashgate.

Hartmann, T., Slavíková, L., & McCarthy, S. S. (Eds.). (2019). *Nature-based flood risk management on private land: Disciplinary perspectives on a multidisciplinary challenge*. Springer International Publishing.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics, 4*, 1–23.

Hunter, G. (2013). Severance v. Patterson: How do property rights move when the dynamic sea meets the static shore? *Ecology Law Quarterly, 40*(2), 271–295.

IPCC. (2021). *AR6 climate change 2021: The physical science basis*. https://www.ipcc.ch/report/ar6/wg1/. Last access: 25 Nov 2021.

Kis, A., & Ungvári, G. (2019). Commentary: An economic view on the prospects of a flood defense related development rights market in Flanders. In T. Hartmann, L. Slavíková, & S. S. McCarthy (Eds.), *Nature-based flood risk management on private land* (pp. 105–108). Springer International Publishing.

Kousky, C., Wiley, H., & Shabman, L. (2020). *Can parametric microinsurance improve the financial resilience of low income households in the United States?* Wharton Risk Center, University of Pennsylvania.

Kuhlicke, C., Seebauer, S., Hudson, P., Begg, C., Bubeck, P., Dittme, C., Grothmann, T., Heidenreich, A., Kreibich, H., Lorenz, D. F., Masson, T., Reiter, J., Thaler, T., Thieken, A. H., & Bamberg, S. (2020). The behavioral turn in flood risk management, its assumptions and potential implications. *Wires Water, 7*(3), e1418.

Löschner, L., Hartmann, T., Priest, S., & Collentine, D. (2021). Editorial: Strategic use of instruments of land policy for mobilising private land for flood risk management. *Environmental Science & Policy, 118*, 45–48.

Löschner, L., Seher, W., Nordbeck, R., & Kopf, M. (2019). Blauzone Rheintal: A regional planning instrument for future-oriented flood management in a dynamic risk environment. In T. Hartmann, L. Slavíková, & S. S. McCarthy (Eds.), *Nature-based flood risk management on private land* (pp. 141–154). Springer International Publishing.

Markolf, S. A., Hoehne, C., Fraser, A., Chester, M. V., & Underwood, B. S. (2019). Transportation resilience to climate change and extreme weather events – Beyond risk and robustness. *Transport Policy*, *74*, 174–186.

Markolf, S. A., Chester, M. V., Helmrich, A. M., & Shannon, K. (2021). Re-imagining design storm criteria for the challenges of the 21st century. *Cities*, *109*, 102981.

McCarthy, S. S., Viavattene, C., Sheehan, J. J., & Green, C. (2018). Compensatory approaches and engagement techniques to gain flood storage in England and Wales. *Journal of Flood Risk Management, 11*(1), 85–94.

Meerow, S., Helmrich, A. M., Andrade, R., & Larson, K. L. (2021). How do heat and flood risk drive residential green infrastructure implementation in Phoenix. *Arizona? Urban Ecosystems*, *24*, 989–1000.

Moloney, S., & Doyon, A. (2021). The Resilient Melbourne experiment: Analyzing the conditions for transformative urban resilience implementation. *Cities, 110*, 103017.

Needham, B. (2006). *Planning, law, and economics: The rules we make for using land*. Routledge.

Needham, B., Buitelaar, E., & Hartmann, T. (2018). *Planning, law and economics: The rules we make for using land* (2nd ed.). Routledge.

Norton, R. K., & Meadows, G. A. (2014). Land and water governance on the shores of the Laurentian Great Lakes. *Water International, 39*(6), 901–920.

Otto, F. E. L. (2016). The art of attribution. *Nature Climate Change, 6*, 342–343.

Papathoma-Köhle, M., Thaler, T., & Fuchs, S. (2021). An institutional approach to vulnerability: Evidence from natural hazard management in Europe. *Environmental Research Letters, 16*, 0414056.

Pellissery, S., & Sridhar, P. (2018). Climate change-induced property re-evaluation in agrarian contexts. In F. van Straalen, T. Hartmann, & J. J. Sheehan (Eds.), *Property rights and climate change: Land-use under changing environmental conditions* (pp. 13–24). Routledge.

Porio, E., & Crisol, C. (2004). Property rights, security of tenure and the urban poor in Metro Manila. *Habitat International, 28*(2), 203–219.

Qiang, V., Lam, N. S. N., Cai, H., & Zou, L. (2017). Changes in Exposure to flood hazards in the United States. *Annals of the American Association of Geographers, 107*, 1332–1350.

Raska, P., Slavíková, L., & Sheehan, J. J. (2019). Scale in nature-based solutions for flood risk management. In T. Hartmann, L. Slavíková, & S. S. McCarthy (Eds.), *Nature-based flood risk management on private land* (pp. 9–20). Springer International Publishing.

Ray, A., Hughes, L., Konisky, D. M., & Kaylor, C. (2017). Extreme weather exposure and support for climate change adaptation. *Global Environmental Change, 46*, 104–113.

Raymond, C., Horton, R. M., Zscheischler, J., Martius, O., Agha Kouchak, A., Balch, J., Bowen, S. G., Camargo, S. J., Hess, J., Kornhuber, K., Oppenheimer, M., Ruane, A. C., Wahl, T., & White, K. (2020). Understanding and managing connected extreme events. *Nature Climate Change, 10*, 611–621.

Resilient City Network. (n.y.). *What is urban resilience?* https://resilientcitiesnetwork.org/what-is-resilience/. Last access: 26 July 2021.

Restemeyer, B., Woltjer, J., & van den Brink, M. (2015). A strategy-based framework for assessing the flood resilience of cities—A Hamburg case study. *Planning Theory & Practice, 16*(1), 45–62.

Rufat, S., Fekete, A., Armas, I., Hartmann, T., Kuhlicke, C., Prior, T., Thaler, T., & Wisner, B. (2020). Swimming alone? Why linking flood risk perception and behavior requires more than "it's the individual, stupid." *Wires Water, 7*(5), e1462.

Saputra, E., Hartmann, T., Zoomers, A., & Spit, T. (2017). Fighting the ignorance: Public authorities' and land users' responses to land subsidence in Indonesia. *American Journal of Climate Change, 06*(01), 1–21.

Slavikova, L. (2018). Effects of government flood expenditures: The problem of crowding-out. *Journal of Flood Risk Management, 11*(1), 95–104.

Slavikova, L., Hartmann, T., & Thaler, T. (2021). Paradoxes of financial schemes for resilient flood recovery of households. *Wires Water, 8*(2), e1497.

Snel, K. A. W., Witte, P. A., Hartmann, T., & Geertman, S. C. M. (2020). The shifting position of homeowners in flood resilience: From recipients to key-stakeholders. *Wires Water, 7*(4), e1451.

Spaans, M., & Waterhout, B. (2017). Building up resilience in cities worldwide—Rotterdam as participant in the 100 Resilient Cities Programme. *Cities, 61*, 109–116.

Spit, T., & Zoete, P. R. (2016). *Planologie: Een wetenschappelijke introductie in de ruimtelijke ordening in Nederland*. Coöperatie in Planning UA.

Suykens, C. B. R., Tarlock, D. D., Priest, S. J., Doorn-Hoekveld, W. J., & van Rijswick, H. F. M. W. (2019). Sticks and carrots for reducing property-level risks from floods: An EU–US comparative perspective. *Water International, 44*(5), 622–639.

Tapsell, S. M., & Tunstall, S. M. (2008). "I wish I'd never heard of Banbury": The relationship between "place" and the health impacts from flooding. *Health & Place, 14*(2), 133–154.

Tarlock, D. D., & Albrecht, J. (2016). Potential constitutional constraints on the regulation of flood plain development: Three case studies. *Journal of Flood Risk Management, 13*(11), 2379.

Tate, E., Rahman, M. A., Emrich, C. T., & Sampson, C. C. (2021). Flood exposure and social vulnerability in the United States. *Natural Hazards, 106*, 435–457.

Thaler, T., Witte, P. A., Hartmann, T., & Geertman, S. C. M. (2021). Editorial: Smart urban governance for climate change adaptation. *Urban Planning, 6*(3), 223–226.

The City of Vienna. (2021). *The smart city Wien framework strategy*. https://smartcity.wien.gv.at/en/approach/framework-strategy/. Last access: 26 July 2021.

van Straalen, F. M., Hartmann, T., & Sheehan, J. J. (2018). Changing environmental conditions, property rights and land use planning. In F. van Straalen, T. Hartmann, & J. J. Sheehan (Eds.), *Property rights and climate change: Land-use under changing environmental conditions* (pp. 1–10). Routledge.

Viavattene, C., & Priest, S. J. (2020). *A method for monetising the mental health costs of flooding*. Environment Agency.
Zhang, X. Q. (2016). The trends, promises and challenges of urbanisation in the world. *Habitat International*, *54*(3), 241–252.