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Building Resilience to Natural Hazards at a Local Level in Germany—Research Note on Dealing with Tensions at the Interface of Science and Practice

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Abstract: Building resilience is a core element of urban resilience that refers to both the (1) intended physical change of the building stock and the related blue, green, and grey infrastructure, as well as (2) the social process of increasing resilience through the goal-driven cooperation of scientists and practitioners. Building resilience at the interface of science and practice is characterized by tensions and a range of approaches to dealing with tensions. To specify this proposition, this research note adopts a strategic spatial planning perspective and introduces the typology of "motors of change" from organizational and management research. We focus on a goal-driven motor of change ("teleology") and highlight three approaches to dealing with tensions: developing a strategic focus of knowledge integration, setting priorities to enhance resilience as a pro-active ability of disaster risk reduction (DRR), and compromising in the management of trade-offs, such as those between the scales of resilience. For the purpose of illustration, this research note refers to examples of building resilience at a local level in Germany, dealing with heat stress in urban areas, managing the risk of extreme flood events, and analyzing the resilience of innovative infrastructure solutions.

Keywords: compromise; disaster risk reduction (DRR); motor of change; setting priorities; strategic focus; teleology

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1. Introduction

The decade from 2011 to 2020 was the "hottest" in history and the average global temperature by 2020 had risen by 1.2 °C since the start of the industrial era [1]. With extreme weather events becoming more frequent and the negative impacts of climate change intensifying, the need to enhance resilience seems to be clear. Around the globe, resilience has become the hope for many that cities and regions are increasingly capable of dealing with risks and uncertainties related to hazards in the context of climate change, especially extreme events and their potentially disastrous consequences (e.g., [2–7]).

Some scholars argue that the high diversity of resilience understandings provides the term with something of "poor scientific status" [8] (p. 15) or, even worse, something that is "vulnerable" to ideology-driven misuse and over-biased policy making (e.g., neoliberal policies of allocating responsibility to private actors, but *not* sufficient resources [2]). However, we suppose that the term "resilience" has some merit, if the multiplicity of meanings of the word is taken into due account [9] and if we consider the "messy history" [10] of the term. Meerow and colleagues [3] dealt with the messy history of resilience, especially urban resilience, and provided a definition as a starting point for our argument:

> *"Urban Resilience refers to the ability of an urban system—and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales—to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity"* [3] (p. 45).

We understand building resilience as a core element of urban resilience that refers to both the intended *physical* change of the building stock and the related blue, green, and grey infrastructure, as well as the *social process of increasing resilience through the goal-driven cooperation of scientists and practitioners*. Hence, building resilience is related to all four subsystems of urban resilience mentioned by Meerow and colleagues [3] (p. 45): urban form and infrastructure, networked material and energy flows, socio-economic dynamics, and governance networks.

Meerow and colleagues argue that scholars and practitioners need to address *tensions* in urban resilience [3] (p. 45). There are conceptual tensions, as well as tensions that specifically arise at the interface of science and practice, for translating the concept of resilience into an "implemented reality" in cities and regions. The consideration of tensions is also important to accomplish disaster risk reduction (DRR). For instance, DRR is rooted in general risk management concepts (e.g., acceptable risk, risk reduction plans [11,12]). The ideal type of risk management cycle of prevention, mitigation, preparedness, response, recovery, and rehabilitation emphasizes *anticipation and planning*. In contrast, there are resilience scholars who underline the limitations of effective planning in an uncertain world and who argue not to underestimate the need for *reactive* management [13]. Hence, if we address issues of building resilience and DRR, we should not omit tensions.

On a highly abstract level of argumentation, tension stands in contrast to incoherence and harmony. In the case of incoherence, elements of social relations and individual actions are *not* related. In the case of harmony, elements fit together without tensions like conflicts and dissonance. On a more specific level, tension is an umbrella term that covers different *kinds* of tensions (e.g., conflict, dilemma, dissonance, duality, paradox, and trade-off).

In this research note, we argue that tension is useful as an umbrella term, if multiple kinds of tensions and ways of dealing with them are considered (and not only through referring to different contents and context conditions of tensions). The overall research proposition is as follows: *Translating the concept of building resilience into practice is characterized by a multitude of tensions, and framing these as tensions of different kinds is crucial to analyze the effectiveness of dealing with such tensions.*

For instance, trying to negotiate compromise in the case of the diverging mindsets of people, with regard to the limitations of planning in an uncertain world, may be an ineffective way of dealing with this type of tension. Dealing with diverging mindsets often requires the justification of priorities, in order to regulate which mindset is more important in which situation and the reasons for this.

The purpose of this paper is to provide a conceptual, mainly descriptive, and process-oriented contribution to the research that deals with tensions at the interface of science and practice, especially in the form of collaborative projects between scientists and practitioners. Three comments on this purpose and how we accomplish it are in the following order:

(1) We label our contribution as a *research note*, because we expect that the note may be helpful as a conceptual input into more ambitious future research contributions (such as providing an extensive literature review of tensions in building resilience to natural hazards, conducting intensive comparative case study work to elaborate on causal research propositions, or testing specific hypotheses through the quantitative analysis of many cases [14,15]).

(2) To accomplish this purpose, we qualitatively analyzed a broad range of scientific publications covering conceptual, theoretical, and empirical contributions to the research. To achieve this, we used categories of strategic spatial planning [16–19]. We also referred to the *process-oriented* typology of "motors of change" as suggested by Andrew Van de Ven and Marshall Scott Poole [20,21] in organizational and management research. This helped to clarify the focus of the research note on the goal-driven processes of building resilience (teleology in contrast to social change as dialectical change, life-cycle change, or evolution). We "derived" three process patterns that are illustrated by results from our own completed empirical research projects (see [6] for a summary): developing a strategic focus, setting priorities, and negotiating compromise. The three project examples address

different contents of resilience building at a local level: dealing with heat stress and heat waves; managing flood risk, especially the risk of extreme flood events; and infrastructure resilience. In summary, this paper is the result of desktop research on a conceptual level based on our own previous empirical work.

(3) This research note seeks to address a specific and important *research gap*: dealing with tensions of building resilience at a local level and at the interface of science and practice requires "true" process-oriented research [22]. Even if there are many research contributions that address issues of dealing with tensions in resilience building, for instance [2,4,23], *process* research on building resilience through managing tensions still needs to be enhanced [6,24–27]. A strategic spatial planning perspective, as well as the typology of "motors of change", is an ideal goal for this research purpose.

The following is structured into two main sections. Section 2 presents the framework of our conceptual argumentation (strategic spatial planning, motors of change, especially goal-driven processes, and three process patterns of building resilience at local level and at the interface of science and practice: developing a strategic focus, setting priorities, negotiating compromise). Section 3 conceptually elaborates on the three process patterns of dealing with tensions, not least through referring to project examples of building resilience at a local level in Germany. Section 4 concludes the research note.

2. Strategic Spatial Planning in Projects at the Interface of Science and Practice

There are many different perspectives to approach the topic of building resilience to natural hazards at the interface of science and practice [28,29]. This research note is based on a strategic spatial planning perspective. Hence, we need to clarify what characterizes this perspective and how this relates to our topic. For our work, we adopt the widely acknowledged understanding of strategic planning proposed by Louis Albrechts:

> *"Strategic planning is selective and oriented to issues that really matter. As it is impossible to do everything that needs to be done, "strategic" implies that some decisions and actions are considered more important than others and that much of the process lies in making the tough decisions about what is most important for the purpose of producing fair, structural responses to problems, challenges, aspirations, and diversity."* [19] (pp. 751–752).

Planning scholars, such as Louis Albrechts and Patsy Healey, underline that strategic *spatial* planning should not be confounded with strategic planning *in business organizations*. Three reasons for this are especially noteworthy. Firstly, strategic spatial planning encompasses categories of spatiality at the core of strategy-making (e.g., spatial levels, node, territory, location). Secondly, this approach to planning is less characterized by analytical procedures, as in case of business organizations, and more by situational and value-laden decisions on how to make "the tough decisions about what is most important" [19] (p. 752). Thirdly, all three dimensions of strategic spatial planning—content, process, and context—are, in principle, equally relevant to accomplish planning efforts [17,18]. *This research note emphasizes the processual dimension of spatial strategy making in cities and regions.*

2.1. The Processual Dimension of Strategic Spatial Planning and the Focus of the Research Note

Based on deep theoretical and case study work, Patsy Healey provides a summary account of process patterns of strategic spatial planning. According to Healey [16], four processes characterize strategic spatial planning: scoping the situation, mobilizing attention *for change* in cities and regions, enlarging the "intelligence" of collective action (for instance, through new expert knowledge and the consideration of lay knowledge), as well as creating frames for collective action and selecting actions (e.g., joint projects at the interface of science and practice).

This research note focuses on how actors involved in building resilience *create frames and select actions*. Frames provide a direction in collective action. Action with tangible outcomes is important to facilitate a trust-based cooperation between actors with different perceptions, mindsets, and interests. Creating frames and selecting actions are necessary activities of strategic spatial planning [30] and are often characterized by tensions. The deliberation on options of dealing with tensions is a necessary condition of *successful* strategic spatial planning [17,18].

However, the conceptual element of "creating frames, selecting actions" remains rather abstract. Therefore, the following section specifies this element as a *goal-driven process of social change* in contrast to other types of social change (teleology in contrast to dialectics, evolution, and life-cycle change [20,21]). Social change and strategic spatial planning are closely related, because the latter is commonly understood as "transformative governance work" [16] (p. 440).

Subsequently, we further differentiate the notion of a goal-driven process in three more specific process patterns at the interface of science and practice in the form of a project: (1) developing a strategic focus of collective action, especially with regard to tensions in knowledge integration; (2) setting a priority on building resilience and DRR as *pro-active* ability; and (3) negotiating compromise, if managing trade-offs is possible. We use project examples from our own recent empirical research in Dresden/the Free State of Saxony/Germany to illustrate these three process patterns (Table 1).

Table 1. Research focus on building resilience as a goal-driven process of social change and three process patterns that are illustrated through project examples at a local level in Germany.

Building Resilience as Goal-Driven Process	Illustration of Creating Frames and Selecting Actions through Project Examples at the Interface of Science and Practice
Developing strategic focus	The project example "HeatResilientCity" (HRC) in Dresden-Gorbitz illustrates tensions in knowledge integration at the interface of science and practice. Strategic focus on the common topic of dealing with heat stress and heat waves in urban areas facilitated an agreement between scientists and practitioners of which local measures to analyze and actually implement in the "real world".
Setting Priorities	The project example in Brockwitz/City of Coswig nearby the City of Dresden illustrates how to justify setting a priority on building resilience to *pro-actively* reduce disaster risk, for instance, through analyzing structural alternatives (dike construction vs. house lifting) to reduce the risk of extreme flood events and through using tools for visualizing the results of such analysis.
Negotiating compromise	The project example TRAFIS on creating a "sustainability check" illustrates that negotiating compromise is not only important to manage conflicts between interests, but also to manage trade-offs in analyzing the complexity of urban resilience to natural hazards (perturbations of infrastructure systems as part of urban systems).

Source: Project examples from our own empirical research (see [6] for a summary of contents and methods, see below Section 3 for how project examples are used to illustrate the three process patterns, and the acknowledgements for formal information).

2.2. *Dealing with Tensions in Goal-Driven Processes of Change*

Similar to strategic spatial planning, social change is also closely related to issues of building resilience. Currently, the challenges of urban transformation in developing sustainable solutions for pressing problems (such as, for instance, the potentially disastrous consequences of climate change in cities and regions) seem to reach the center stage of debates on urban resilience. Building resilience entails the vision of a better future through more resilient cities and regions. DRR entails the vision of a better future in which less disaster risk exists. Hence, both imply the imagination of a different future in relation to the present conditions.

In more general terms, change can be defined as a difference in properties (or attributes) of a focal unit (e.g., person, organization, network, urban system) over time, measured at a minimum at two time points. There is an abundance of concepts and theories to specify the focal unit, its properties, change as difference over time, as well as how and why change occurs. Under which conditions change is amenable to intentional change is also an important question [20,21].

Against this background, the following is based on two assumptions: (1) To conceptualize building resilience as social change in line with strategic spatial planning, it is useful to adopt the theoretical framework developed by Van de Ven and Poole [20,21] in organizational and management research. (2) This framework has not yet been adopted intensively to issues of building resilience.

Van de Ven and Poole [20] ground their theoretical framework to analyze social change in an extensive review of diverse literature. In order to analyze not only why this change occurs, but also *how* the process of change unfolds, they identify four "Families of Ideal-Type Theories of Social Change" [20] (p. 514). They label these families as "motors of change". Two of those motors are of special interest:

- *Teleology:* The key metaphors here are "purposeful cooperation" and "planned change". Social change is driven by a desired future in the sense of an envisioned end state ("goal"). Statements on goals do not only legitimize collective action; they actually motivate and guide the involved actors to initiate and implement change. There is a high consensus between the involved actors on the envisioned end state and on means that are judged to be effective and acceptable, in order to realize the common goal. There is a significant tension between the present and the future. Actors are (to some extent) dissatisfied with the status quo. They envision improvements and formulate goals. They undertake individual and collective efforts of knowledge integration and implementation, and they seek to learn from experience.
- *Dialectic:* The key metaphors are "opposition" and "conflict". Dialectical change is less future-oriented because change emerges in the present through the opposition between parties (agents) that follow different claims and interests. Whereas a teleological process is based on high goal-consensus, a dialectical process is characterized initially by contradictory forces and, hence, a low goal consensus. "Change occurs when … opposing values, forces, or events go out of balance. The relative strength, power, or legitimacy of an antithesis may emerge or mobilize to a sufficient degree of force to overthrow the current thesis or state of affairs and produce a synthesis, which then becomes the new thesis as the dialectical process recycles and continues" [31] (p. 204).

Van de Ven and Poole [20] (p. 522) identify two further motors of change (life cycle, evolution) that are omitted here, because both refer mainly to "prescribed" change processes in which the social construction of tensions and effective ways of dealing with them are less prominent than in the teleology and dialectic motors of change. Change simply occurs due to deterministic or probabilistic "laws" that are embedded in natural or institutional conditions. However, it is important to note that Van de Ven and Poole [20] argue for the consideration of social change, in principle, as *complex* change in which all four motors may play a role [32].

This research note conceptualizes the social process of building resilience mainly as a *goal-driven* process of social change (teleology). We know that the formulation of goals to build resilience as a contribution to climate change *adaptation* is different to quantitative goal-setting in climate change mitigation. However, teleological processes are not always driven only by quantitative goals (targets). The vision of a desired end state in the future may encompass a multitude of frames (e.g., a "Leitbild" as a visual representation of the desired future urban form and infrastructure of a city [16]).

We furthermore acknowledge that it is increasingly important to consider the "political nature" of building resilience in cities and regions; however, social change, in terms of future-oriented collective action motivated and guided by goals, is at the heart of building resilience as well as sustainable development in general. Additionally, before studying complex change processes that encompass multiple motors of change, especially planned change *and* dialectic change [21], we should understand in more detail how actors deal with tensions, if they follow common goals. *Tensions also arise in goal-driven processes that are* *based on a high consensus between the actors involved.* To show this in more depth, we need to consider the context conditions of social change.

2.3. Dealing with Tensions at the Interface of Science and Practice through Collaborative Projects

Goal-driven processes of social change to build resilience in cities and regions may encompass a multitude of tensions. Tensions may differ due to different contents and context conditions. For instance, in the context of climate change adaptation, there are different tensions involved in managing the risk of river floods due to well-known conditions, such as snowmelt in spring, in contrast to managing the risk of inundation due to torrential rain that affects only few localities (e.g., the tensions between measures upstream and their effects downstream in the case of the former, and tensions resulting from highly spatial selective torrential rainfall in case of the latter).

This research note elaborates on the contents of tensions of building resilience through referring to examples at a local level in Germany in the next section. Here, we focus on tensions that arise at the interface between conceptual resilience thinking and the translation of resilience concepts into the "real world" through implementation in practice. Of course, this note itself cannot go into the details of implementation (this would be an implementation study). Given that building resilience is a goal-driven process of social change that occurs at the interface of science and practice, we highlight three types of process patterns in dealing with tensions:

1. *Developing a strategic focus:* In principle, there is high complexity of goals and targets that are relevant for strategic spatial planning. If actors seek to consider as many goals and targets as possible, Wiechmann [18] (p. 143) labels this a synoptic approach to strategy development. In contrast, actors may also want to avoid overambitious and resource-demanding catalogues of goals and targets through focusing on only a handful of desired outcomes that are relevant in the specific situation of cities and regions. We argue that developing a strategic focus is especially important to accomplish knowledge integration at the interface of science and practice. Tensions arise not only with regard to the contents of knowledge integration, but also due to different *forms* of (or approaches to) integration.
2. *Setting priorities:* Setting priorities involves argumentation to justify explicitly why specific frames and actions of building resilience are more important than other frames and actions. There are also cases in which actors try to avoid explicit statements about the relative importance of frames and actions, because such statements may invite critics to question the priority setting. Healey [16] and others underline the value-laden "nature" of priority-setting in strategy development. In line with a strategic spatial planning perspective, we argue that it is by no means a trivial task to justify a priority of building resilience as *pro*-active ability in cities and regions.
3. *Negotiating compromise:* In the case of a trade-off, many "solutions are possible between two opposing poles" [33] (p. 309). Achtenhagen and Melin [33] (p. 309) highlight that finding a compromise in a specific situation "requires an understanding of the impact on both poles". The actors involved in urban resilience may determine through negotiation which solution between the two poles leads to a compromise that satisfies the claims and interests of the parties involved.

The purposeful cooperation of scientists and practitioners may happen in the form of a collaborative project. Projects are combinations of "people and other resources brought together in a temporary organization and process to achieve a specified goal. What distinguishes projects from all other organizational activities ... is that a project is finite in duration, lasting from hours, days, or weeks to years and in some cases decades ... a project organization is temporary and disposable by design. Each project brings together people and resources needed to accomplish a goal and disappears when the work is completed" [34] (p. 2).

The next section reports on examples of projects at the interface of science and practice to build resilience at a local level in Germany. The examples illustrate the three typical process patterns of dealing with tensions in goal-driven processes of social change: developing strategic focus, setting priorities, and negotiating compromise.

Developing focus is the most basic form of dealing with tensions [17,18]. It is difficult, if not impossible, to set priorities and work out a compromise without a strategic focus. Hence, we proceed with this process pattern first.

3. Three Ways of Dealing with Tensions: Focus, Priority, and Compromise

3.1. Tensions in Knowledge Integration and Developing Strategic Focus

A goal-driven motor of change shows us why and how actors involved in building resilience initiate and implement change. Actors are motivated and guided by a common vision of a desired future end state to initiate change in the present and to use resources for measures to implement this envisioned end state. In the "real world", building resilience is, more often than not, *complex* change, in which many heterogeneous elements need to come together to generate the desired social change. The high complexity of elements is also implicit in the concept of urban resilience [3].

Consequently, to analyze and intentionally change urban systems, complex contents and forms of knowledge are relevant. At the interface of science and practice, efforts of knowledge integration are especially salient, for instance, to integrate the various contributions from different scientific disciplines and to integrate scientific knowledge with knowledge from practice (e.g., expert knowledge from public institutions, local knowledge of citizens and business organizations).

The knowledge integration for building resilience and DRR may be especially challenging. A disaster is defined as a "serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts . . . " [11] (p. 9). It seems plausible to expect that an actual disaster challenges the legitimacy, reputation, and effectiveness of those people (especially experts and further "knowledge workers") that have been involved, at central positions, in the various networks of urban systems in pre-disaster times. This should hold for an actual and, under specific circumstances, an anticipated disaster.

Hence, knowledge integration is not only a "technical exercise" that leads to "objective results", but also a highly political and contested endeavor. Tensions may emerge due to the contents and context conditions of building resilience. Tensions may also emerge because there are multiple approaches to knowledge integration. Following Tell [35], we distinguish between three approaches:

- *Sharing and transferring knowledge:* When two actors A and B share the same "body" of knowledge, this can be interpreted as redundancy in social action: A knows what B knows. Knowledge transfer is the process through which actors realize knowledge sharing. The main concern of transfer is matching message and medium [31]. After knowledge transfer, A knows what B already knew. Grant [36] points out that it is inefficient, if actors share *all* knowledge.
- *Using similar/related knowledge:* This approach is characterized by adopting a body of similar or related knowledge domains to accomplish a specific task. The term "integration" does not primarily refer to relations between the domains of knowledge involved, but to the common task and context of application. Efforts of integration are necessary and possible because the accomplishment of a specific task requires the application of already-related knowledge contents and forms.
- *Purposeful combination of specialized and complementary knowledge to accomplish specific tasks:* In this approach, actors combine highly different and hitherto unrelated knowledge by purpose and in regard to a specific task. For instance, A and B possess significantly different and unrelated, but potentially complementary knowledge. After knowledge integration, new knowledge emerges that is useful to accomplish a specific task that could not be accomplished with only the existing related or similar knowledge. Hence, knowledge integration in this third approach implies some degree

of innovation in the knowledge development. Tell [35] points out that knowledge combination is only possible if the involved actors also share some knowledge.

Knowledge integration is neither "one thing", nor is integration always a "good thing". There are different approaches such as knowledge sharing, using similar/related knowledge, and the purposeful combination of specialized knowledge; it is inefficient to share all knowledge. Efforts of combining specialized knowledge may fail because knowledge is not complementary. Knowledge integration often requires recurring cycles of co-operation and trust-building between the people involved. Trust is quickly "destroyed" but only emerges over time. This is also applicable in the goal-driven processes of social change.

It is important to consider both (1) tensions within and (2) tensions between the three approaches to knowledge integration:

- *Tensions within approaches to knowledge integration:* For instance, the third approach seeks to combine specialized and complementary knowledge. This requires that such knowledge is *available* for combination and that combinatory efforts are successful in the generation of new knowledge. The availability of specialized knowledge is based on in-depth experiences in a certain specialized knowledge domain, whereas efforts of combination need to draw "golden threads" through the complexity of specialized knowledge inputs. Van de Ven and Zahra [37] argue that both *too much* cognitive distance between actors, as well as *too little* cognitive distance, is negatively related to knowledge combination and innovation. Cognitive distance is one manifestation of tension between project partners. Knowledge integration at the interface of science and practice is facilitated if project partners follow a strategic focus that is positioned between too much and too little distance (see project example below).
- *Tensions between approaches to knowledge integration:* By definition, sharing and combining knowledge have tensions. Knowledge sharing means that actors have identical knowledge. Knowledge combination means that actors are able to combine knowledge that is different at the beginning and synthesized after combination. Hence, sharing thrives on homogeneity and the combination of heterogeneity. Tensions between sharing and combination are especially relevant at the interface of science and practice. In this context, it is plausible to assume that the actors involved in a collaborative project for building resilience have heterogeneous knowledge. Therefore, knowledge sharing may be the "bottleneck" for finding solutions to the pressing problems of building resilience. The project example below shows that this was actually the case in Dresden-Gorbitz.

As stated above, with regard to strategic spatial planning, developing a strategic focus is by no means primarily an exercise in strategic analysis, but a synergetic exercise that leads to collective action in urban areas, motivates people to participate in governance networks of urban systems, and facilitates knowledge integration at the interface of science and practice [16,17,38]. The project example "HeatResilientCity" (HRC), on dealing with summer heat stress and heat waves in the City of Dresden, illustrates this proposition.

The inter- and transdisciplinary project HRC is of medium size and involved both scientists and practitioners with a focus on the topic of heat stress in two cities: Dresden and Erfurt. The project lasted from 2017 to January 2021. Project partners applied a complex mix of methods to accomplish the project goal. Particularly noteworthy is the linking of measurement and simulation data across the scale levels of urban districts and buildings in order to map the effects of adaptation measures for resilience building, as well as the inclusion of the stakeholder perspective by means of surveys. A summary of the project goal, the constellation of partners, applied methods and results can be found in [39].

Summer heat is one of the most serious environmental impacts of climate change. Climate projections show a clear trend towards summer heat (e.g., an increase in both the mean and maximum temperatures, IPCC 2018). The projections for the Free State of Saxony also show an increase in temperatures. In addition to rising mean temperatures, especially in spring and summer, increased maximum temperatures are projected. The frequency of summer days (Tmax ≥ 25 °C), hot days (Tmax ≥ 30 °C) and warm general weather conditions, such as in the summers of 2003 and 2018, will increase.

This applies in particular to dense urban neighborhoods without networked green corridors and ventilation strips. The performance and the so-called thermal comfort of people are significantly affected, both inside and outside buildings in their neighborhood. In order to maintain or even improve the quality of life of people in the context of climate change, it is necessary to focus on ensuring their coping capacity, and thus focus on resilience. The built environment—buildings and open spaces in the neighborhood as well as blue and grey infrastructures—can be intentionally adapted to absorb thermal effects to a certain extent, and thus reduce the exposure of people to heat stress and heat waves.

Against this background, some authors of this paper were involved in developing and implementing the project HRC [39]. In HRC, measures of climate change adaptation were implemented to intentionally change buildings and open spaces in two selected sample quarters in Dresden-Gorbitz and Erfurt-Oststadt each with a different urban structure and building types that are characteristic of many cities in Germany and Europe.

In the following, we focus on the project work completed in Dresden-Gorbitz. The most visible and largest part of the example quarter Dresden-Gorbitz is predominantly built up with industrial prefabricated concrete apartment buildings (so-called, post-war large-panel construction), which were constructed in the early 1980s. A large part of these buildings are owned by the housing cooperative "Eisenbahner-Wohnungsbaugenossenschaft Dresden eG" (EWG). Slightly more than twenty thousand people live on an area of about 200 hectares. Compared to the whole city, the district has a higher spatial concentration of socially and economically disadvantaged people. However, Dresden-Gorbitz has a relatively high proportion of green spaces.

HRC aimed to develop and implement innovative, socially equitable, and user-acceptable adaptation measures that supported the reduction in summer heat stress on people in buildings and open spaces. Selected measures were *physically implemented* in the sample neighborhoods. A quantitative and qualitative assessment of effectiveness served as the basis for the selection of suitable adaptation measures. The evaluation of measures was carried out using effectiveness analysis methods based on indicators that were suitable for measuring heat stress, in combination with user surveys on their perception [39].

In this paper, we do *not* report in detail the methods and results of the comparative analysis and evaluation of measures with regard to the buildings and open spaces in the sample quarter in the City of Dresden (see [39] for a summary). Our issue is the issue of dealing with tensions for building resilience, especially in terms of knowledge integration. *The development and implementation of HRC illustrates both dealing with tensions within and between approaches to knowledge integration.*

From 2013 to 2017, HRC developed as a *follow-up activity* of the large climate change adaptation project REGKLAM in the Dresden region, which lasted from 2008 to 2013. REGKLAM was characterized by a very broad and complex agenda of regional climate change adaptation topics. The agenda encompassed issues of adapting urban open space and built structures, economic relations, and policies related to health, biodiversity, agriculture, and forestry.

We hypothesize that the integration capabilities of the REGKLAM partners did not match this broad agenda [40]. Dealing with tensions was difficult, because too many topics were involved and the cognitive distance between many REGKLAM partners was too high. As a consequence, REGKLAM partners formulated a climate change adaptation program that lacked a strategic focus [40]. The climate change program is characterized as a complex catalogue of statements on goals, targets, and measures of planned climate change adaptation in the Dresden region. However, at present, the program seems to have had only an insignificant impact on the strategy development in the Dresden region [30].

Based on the REGKLAM project, the partners of HRC were able to establish a strategic focus on urban heat stress *at an early time point in project development*. Discussions on joint follow-up activities began immediately after the completion of REGKLAM and involved a core of partners, now implementing HRC. The project partners of HRC agreed to focus on such issues of climate change adaptation that were related to strong and relatively robust climate change "signals" such as rising mean temperatures, a higher frequency of hot days and an increasing probability and duration of heat waves especially in urban areas.

The agenda of HRC was also focused in terms of addressing a complex set of measures for intended incremental change (not transformative change of the urban region). *We hypothesize that developing a strategic focus within HRC was a necessary precondition for knowledge combination at the interface of science and practice* (this was evident in the agreement of measures that were analyzed scientifically and actually implemented in the example quarter Dresden-Gorbitz).

HRC also illustrates tensions *between* the approaches to knowledge integration. Among the project partners from practice, HRC included the housing cooperative EWG as a formal partner, with its own budget provided by the federal government and allocated towards investment expenditures of the cooperative. Project implementation in Dresden-Gorbitz functioned "smoothly" not least due to the ownership structure of the EWG, which is a housing cooperative whose representatives can make their own direct decisions about their building stock.

Shortly after the start of the project, the selection of the buildings and a first presentation of the planned renovation measures by EWG took place at the end of 2017. Immediately afterwards, the EWG provided planning documents, such as plans of the existing buildings and renovation plans, so that researchers could work out specific concepts for measures. On-site inspections of the selected buildings and a comparable building that had already been renovated were carried out. As early as spring 2018, possible adaptation measures were coordinated between project researchers and the EWG. In summer, the tender documents were published and tenders were obtained from construction companies.

Adaptation measures were implemented in connection with EWG's existing renovation concepts on and in the buildings between 2019 and 2020 on a pilot basis. Communication processes between scientists and the housing cooperative could be managed without an intermediary property management company. The housing cooperative was interested in strengthening the future attractiveness of its rental flats, thereby, taking into account the affordability for the socially and economically disadvantaged people living there [39].

However, including a large organization with its own interests and resources may significantly limit the innovation potential of a project. For instance, in HRC, concepts for the optimization of summer thermal insulation were developed under the consideration of the *existing* renovation concepts of the EWG. Due to this fact, some potential adaptation measures were only partially considered or rejected under the time restrictions of the project duration.

Other measures required additional project-budget resources of the EWG due to the declared additional costs or caused higher rents, and thus potentially exacerbated social injustice. With regard to long-term planning, the economic evaluation of maintenance was of great importance in the selection of suitable adaptation measures. A preference was given to technically resilient measures that involved as little maintenance-intensive, failure-prone technical systems as possible.

In summary, a stable relationship between only a few partners from science and practice may help to specify the strategic focus on dealing with heat stress and heat waves in an urban area. However, this fit between strategic focus and social relations comes at a "cost". Innovative and transformative-oriented efforts to build resilience may require a more open and inclusive approach towards the selection, analysis, evaluation, and implementation of measures that refer to the mid- to long-term.

Hence, the example of implementing the project HRC in Dresden illustrates a tension in knowledge integration between short-term *knowledge sharing and knowledge combination* and facing the challenges of the mid- to long-term future. This also illustrates the proposition that developing a strategic focus is by no means sufficient for successful strategic spatial planning in general, particularly for building resilience at a local level.

Further process patterns in goal-driven social change are necessary for setting priorities and selecting actions.

3.2. Setting a Priority on Building Resilience and DRR as Pro-Active Ability

More implicit than explicit in the definition of urban resilience provided by Meerow and colleagues [3] (p. 45), are the tensions between resilience as a pro-active *and* reactive ability. Urban resilience is defined as the ability of an urban system to rapidly return to the desired functions in the face of disturbance. It remains open whether this is an *actual* disturbance of urban systems or a disturbance *anticipated* by actors that is pro-actively involved in the development of an urban area. It is possible that Meerow and colleagues [3] had the former in mind more than the latter. In contrast, the ability to transform urban systems to increase their future adaptive capacity explicitly points to anticipation and pro-action. However, pro- and reactive efforts of building resilience do not always fit together easily. This becomes clearer through considering in more detail different kinds and conditions of disturbance.

In a complex, uncertain, and turbulent world, some disturbance of urban systems is inevitable and increasingly "the new normal" (see [41] on "surprise management" and [42] on "Governance in turbulent times"). There are different kinds of disturbance. The nature of some disturbances is well-known in advance ("usual" or "known unknowns"). Still, when they happen and exactly how they happen may unsettle the lives of the affected actors. Other disturbances are less known ("unusual") or even completely outside the range of experiences and expectations of an actor ("black swans" or "unknown unknowns").

In a similar vein, in his seminal book on "Searching for safety", Wildavsky [43] (p. 93) distinguishes between "quantitative (expected) surprise" and "qualitative (unexpected) surprise". The nature of the former is known, but its specific manifestation when it occurs is unknown; the latter is impossible to expect in qualitative, and thus quantitative, terms. Otherwise, by definition, such a manifestation of surprise is classified as "expected surprise". Wildavsky [43] (p. 93) highlights the unexpected surprise as "true" surprise.

The terms "disturbance" and "surprise" highlight the different conditions for building resilience and DRR. The term "disturbance" is more action-oriented, whereas the term "surprise" points to cognition about the future. If there is a disturbance, something that could have been undisturbed is present. In the social sciences, disturbance is often related to institutionalized action. The term "surprise" focuses attention on the cognitive–cultural representations of future action and on the fact that expectations do not necessarily become "true" when the future unfolds in the present.

When an actor experiences surprise, there are, by definition [6], two relevant approaches to explaining the unexpected [13]: (1) an explanation through referring to the external context conditions of action (e.g., the change in socio-economic conditions, action of other actors) and (2) an explanation through the relatively appropriate expectations of an actor as internal context conditions.

Weick and Sutcliffe [13] argue that resilience requires that actors resist the temptation to attribute *success* mainly to *internal* conditions and *failure* to *external* circumstances. The actors interested in building resilience and especially DRR consider the full range of options: internal conditions as causes of success and failure (e.g., appropriate and inappropriate expectations) and external conditions of success and failure (e.g., good luck and bad luck).

Against this background, we argue that *building resilience as a pro and reactive ability has tension*. This tension may have many sources and manifestations which will be elaborated in the project example below. However, inspired by the work of Weick and Sutcliffe on "Managing the unexpected" [13], it is plausible to expect that tensions are related to governance networks of urban systems and that they are characterized by how actors involved in urban systems perceive and interpret the "world" around them. Weick and Sutcliffe explain:

> *"Notice that in the reactive world of the unexpected, the ability to make sense of an emerging pattern is just as important as is anticipation and planning. And the ability to*

cope with the unexpected requires a different mindset than to anticipate its occurrence. The mindset for anticipation is one that favors precise identification of possible difficulties so that specific remedies can be designed. A commitment to resilience is quite different. Resilience is a combination of keeping errors small, of improvising work-arounds that keep the system functioning, and of absorbing change while persisting" [13] (p. 97).

Dealing with tensions is especially challenging when it comes to governance networks and people *with diverging mindsets*. Differences between mindsets cannot be easily resolved through the searching and finding of compromise because mindsets are (among others) complex, internally structured phenomena (e.g., a cognitive hierarchy of terms that shape the perception, interpretation, and action of human agents in urban systems; these are basic assumptions about crucial cause–effect relations). Some actors involved in urban systems may have a strong preference for anticipation and planned pro-action, despite experiences of the limitations of planning complex urban systems. Others may mainly follow a reactive and opportunity-driven strategy with an emphasis on short-term results and gains. There may also be actors that seek to strike a balance between pro- and reactive efforts of building resilience for DRR, but this then needs to be strengthened through political support and an appropriate resource base for action.

Hence, actors involved in building resilience and DRR need to consider the possibility of setting priorities that clarify the relations between different mindsets and beliefs in anticipation and planning. We propose that building resilience and DRR are related to a high priority of anticipation and planning, despite well-known voices that underline the limitations of effective planning in a complex, uncertain, and ambiguous world [13,43]. The following project example on managing extreme flood events in the Dresden region illustrates this proposition.

Disastrous flood events, such as the flood disaster related to the Elbe River and its tributaries in August 2002, as well as multi-level governance processes, led to changes in how flood risk was managed in European Member States. In summary terms, this change is described as a change from "conventional flood protection" to "flood risk management" [44] (p. 309).

This disaster-induced change in policies and practices also led to more attention towards managing the risk of extreme flood events [40]. Managing extreme events and their potential consequences is an important topic in many research fields and practices of designing resilience [2,45]. Not surprisingly, the notion of resilience was also discussed on managing the risk of extreme flood events (among other reasons for addressing issues of resilience in flood risk management [46]).

Scholars and practitioners alike emphasize that managing the risk of extreme flood events requires a pro-active approach towards risk reduction that highlights a comprehensive analysis, anticipation, evaluation, and planning [47]. Managing the risk of extreme floods as a contribution to DRR also seems to place a priority on prevention, mitigation, and preparedness.

As stated above, we argue that there are tensions between pro- and reactive efforts of building resilience that need to be considered. The following project example shows that this may justify a priority on anticipation and planning, *if the specific implications of considering extreme events are systematically worked out in strategic spatial planning.* In other words, an emphasis on pro-action requires justification based on a conceptual framework that is able to consider tensions between pro- and reactive efforts of building resilience. Adopting a tension-oriented perspective does *not generally* imply that a high priority for anticipation and planning is avoided (this would resemble the positions taken by [43] and [13] that are rather critical of planning).

We provide an example of analyzing and evaluating the advantages and disadvantages of two (planned) structural measures in a local case: the conventional measure of dike construction and the measure of house lifting in the village of Brockwitz in the City of Coswig/Saxony nearby the City of Dresden. The inter- and transdisciplinary project "House lifting in flood-prone areas based on the example of the Elbe village Brockwitz"

(2017–2019) was designed in the sense of a feasibility study using a mix of methods ranging from spatial hydrologic, hydraulic, and potential building damage modelling, analyzing the impacts on nature and landscape, the benefit–cost analysis, citizens and property owners involvement, as well as a general consequences assessment of action alternatives [47].

The Free State of Saxony has invested around EUR 2.6 billion in flood protection and in the elimination of flood damage to existing protection systems since the major flood event in 2002. The prioritization of new flood protection measures was based on the application of criteria that took into account the extent of the damage potential, the cost–benefit ratio, water management aspects, as well as particular impacts, consequential hazards and protection requirements. Based on these evaluations, many priority projects were established. However, the assessment also revealed that there were projects with a low priority and, consequently, cannot be implemented in the near future. The main reasons for this are often local or small-scale projects in combination with less favorable benefit–cost ratios.

Brockwitz, a village within the City of Coswig (with about 21,000 inhabitants) and located on the Elbe River, was also severely affected by flood events, especially those in 2002 and 2013. Due to local conditions, a stationary flood protection facility (dike) is contested here, as it represents a significant intervention in the cultural landscape and the historic townscape with a 1000-year history. At the same time, it is possible to protect only a relatively small number of buildings (affecting about 100 people), so that this project, from the perspective of the Free State of Saxony, had a low priority and the implementation of the measure in the near future is questionable.

This prompted the identification of suitable alternatives for risk reduction, an assessment of their feasibility, and an evaluation of the consequences for the village, its residents, and the surrounding area. Therefore, to maintain or even improve the attractiveness, as well as the quality of life, of the town and the natural functions of the Elbe floodplain, the City of Coswig was (and still is) pursuing the (potentially) innovative solution of house lifting for the flood-affected houses in order to mitigate flood risk in accordance with principles of sustainability while avoiding the subsequent costs. The following focuses on the comparison of house lifting and dike construction as alternatives for reducing the risk of extreme flood events, in terms of the potential damage to buildings in the relevant local area, in the village of Brockwitz. The complex issues of evaluating measures under a comprehensive and context-specific set of sustainability criteria (including issues of cultural heritage, and so forth) can be found in [47].

The aim was to investigate the key issues for building resilience and sustainable development with regard to the appropriate flood mitigation measures. Among others, the investigation encompassed the following components:

- Analysis of the building stock focused on three aspects: (1) A building typological differentiation of the settlement structure, as well as the incorporation of object-specific building parameters as a basis for damage modeling and the assignment of vulnerability information; (2) an assessment of the building stock, including the existing cultural monuments and the historic settlement with regard to their significance for the preservation of monuments, cultural history and the view of the place, as well as (3) an initial structural assessment with regard to technologically relevant boundary conditions for house lifting.
- A damage analysis was conducted through applying the model HOWAD/GRUWAD, which is characterized by (i) a multi-scale approach analyzing risks and risk mitigation, (ii) innovative methods to describe the urban structure and the vulnerability as well as (iii) a high spatial and contextual resolution of the resulting risks [48].
- Investigations were based on on-site inspections, individual case studies and archival research. Emphasis was also given to involve the affected citizens and property owners.

Inter- and transdisciplinary investigations were used as a basis for a comparative assessment between house lifting and conventional dike construction. Even though the assessment was still tentative and was carried out in the sense of a feasibility study, some results can already be highlighted here: In the context of the conceptual framework outlined in the previous section, the most relevant result is that the protective effect of both measures, dike and house lifting, are somehow similar (approximately) up to a protection level of a flood event with an "Average Recurrence Interval (ARI)" of 100 years. For events with a higher ARI (a higher ARI corresponds to a lower probability of occurrence and, generally, a higher ARI corresponds with a lower flood probability and vice versa), the protective effect of house lifting exceeds that of the dike, while both measures achieve a similar cost–benefit ratio.

Figure 1 displays this result and illustrates how managing the risk of extreme flood events may contribute to building resilience and DRR.

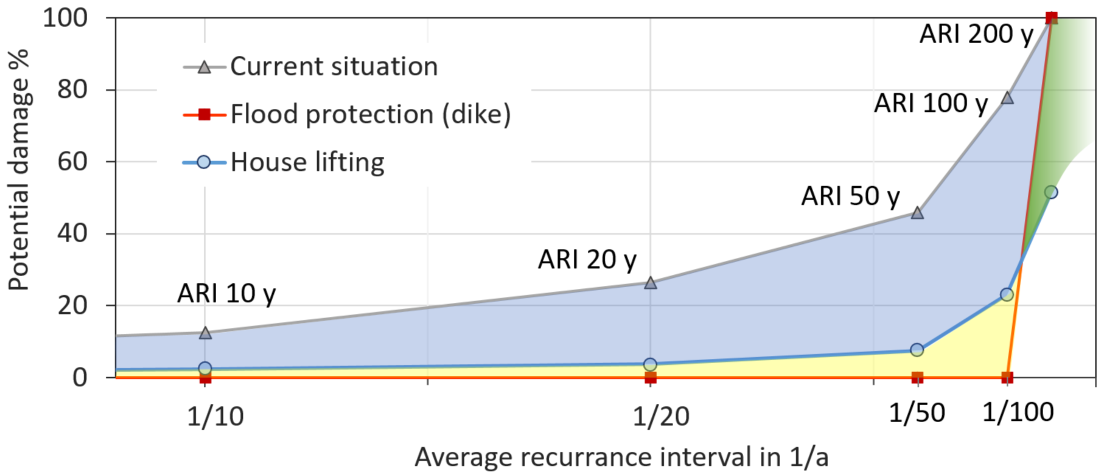

Figure 1. Risk curves for the case study area Brockwitz (Source: Author's own).

The risk curves in Figure 1 show the expected, potential damage to buildings depending on the ARI of the flood events. The expected damage values are displayed in percent related to the current situation. The colored, differential area between the curves of the current situation and the planned alternatives with mitigation measures indicates the prevented damage to buildings, respectively [49]:

- In case of a flood event with ARI between 10 and 50 y, both the construction of a dike and the measure of house lifting lead to a similar reduction in the expected potential damage.
- In case of ARI 100 y, the construction of a dike with this design standard will prevent all damage behind the dike. If the measure of house lifting refers to the same protected area, then, in this specific case, some damage to buildings is to be expected (about 20% potential damage).
- If a flood event exceeds the ARI 100 y, then the dike will provide no protection. In case of an uncontrolled, fast overtopping of the dike, this event could lead to a catastrophic situation, destroying parts of the dike structure and several buildings, via the flooding of their ground floors, and endangering life due to a potentially delayed evacuation. For this reason, areas protected by a dike are referred to as "risk areas outside floodplains" according to the German Water Management Act since 2018. In contrast, an extreme flood event with ARI 200 y will lead to only moderate flood levels for the lifted buildings and there is the possibility of preventing damage by mobile systems.

Figure 1 highlights these differences between dike construction and house lifting in terms of the expected damage potentials by the green color between the relevant curves and illustrates that house lifting improves building resilience with regard to extreme flood events.

It is worthwhile repeating that the measure of dike construction leads to the avoidance of potential damage up to a flood event with ARI 100 y, the design standard of the dike, whereas choosing the measure of house lifting could imply the pro-active acceptance of an increasingly higher damage potential relative to the dike construction up to its design level.

This is to say: In terms of the reduced damage potential, the advantage of house lifting becomes obvious only if decision makers consider extreme flood events for analyzing and evaluating measures ("outcome efficacy", [50] (p. 159)) beyond the typical German design standard of events with ARI 100 y.

The construction of a dike refers to two very different states of conditions that lead to flood damage potential in the case study area: (1) no damage potential up to the design level of the dike (flood event with ARI 100 y); (2) beyond the design level, the possibility of a local flood disaster. In contrast, the measure of house lifting aims to reduce damage for all recurrence intervals including water levels *above* the design water level of ARI 100 y. We hypothesize that the latter facilitates a stable and relatively high local flood (risk) awareness, whereas constructing a dike could tempt residents to develop a "false sense of security" behind the dike and to forget the possibility of extreme flood events in their local area.

In summary, the project example illustrates that setting a priority on building resilience as a pro-active ability through anticipatory analysis is well-justified, *because such a priority does not necessarily undermine* a strategic spatial planning perspective that pays due attention to the limits of effective anticipation and planning in an uncertain world. An anticipatory analysis enables actors interested in building resilience to calculate the specific implications of managing the risk of extreme (flood) events and to display them through means of visualization in the present. Of course, "good" anticipation and planning do not ensure successful efforts of building resilience [13]. This proposition may be applicable, especially with regard to managing extreme events in the context of climate change adaptation. Further processes of strategic spatial planning are needed "on the ground" in cities and regions.

3.3. Tensions in Analyzing Building Resilience and Negotiating Compromise

If actors agree on which future end state they want to realize through joint action, this does not mean that they also agree on every implementation detail to realize their desired common future. More often than not, there are differences in perceptions, interpretations, interests, knowledge and expertise between actors. Especially at the interface of science and practice in the form of a project, researchers with various disciplinary backgrounds and practitioners with different responsibilities, experiences, and expertise need to deal with tensions during the implementation of common goals.

At first sight, negotiating a compromise seems to be a widely applicable way of handling tensions during goal implementation. At second sight, we need to consider that compromise is effective if specific preconditions of dealing with a tension are provided. *Compromise is possible, if a problem has many feasible and acceptable solutions.* A spectrum of many solutions is based on the underlying dimensions of the problem that are characterized by scales that allow the continuous exchange of values ("trade-off"; the collective bargaining to reach a compromise between representatives of capital and labor being the typical example).

The following wants to show that dealing with tension through compromise is not only important when it comes to trade-offs between actors with different interests, but also with regard to the joint activities of scientists and practitioners to understand, describe, or analyze urban and building resilience.

Urban resilience is a highly differentiated and dynamically related complex phenomenon. Meerow and colleagues [3] (p. 45) provide a "simplified conceptual schematic of the urban 'system'" in which they distinguish four subsystems (as indicated above): governance networks, networked material and energy flows, urban infrastructure and form, as well as socio-economic dynamics. Meerow and colleagues [3] (p. 45) use the summarizing term "urban infrastructure and form" that emphasizes *relations* between buildings, utilities, ecological greenspace, and transportation networks (see Figure 3 in [3] (p. 45)).

From the viewpoint of engineering, architecture, and urban analysis, it is important to accomplish a due disaggregation of urban infrastructure and form into the detailed analysis of single components, for instance, various types of residential buildings in cities based on selected dimensions of the building stock (e.g., building structure types and periods of construction [48]). The knowledge of the relations between the details of building types is then aggregated to the knowledge of the vulnerability (e.g., operationalized as damage potential, [48]) and resilience of spatial units within urban systems.

Hence, there is a tension, with regard to the object of interest, between generalization (urban resilience) and specification (building resilience), not as a fundamental conflict or dilemma, but as tensions in terms of manifold trade-offs in research and practice. Scholars and practitioners alike need to find ways to address this tension between specification and generalization in order to understand urban resilience [6]. The results of the analysis should be instructive to guide decisions, but still remain feasible while considering internal or external conditions which lie in the future. Here, the tension between general and specific resilience is no academic discussion but must respond to very practical questions of existing urban systems.

We claim that the positioning of the resilience perspective *in between* the poles of extreme specification and extreme generalization is in accordance with the different opportunities and limitations of the different working levels for yielding operational results and, as a consequence, is important for selecting a working level for producing the desired instructions for building resilience at a local level [51]. Researchers and practitioners may search for a compromise by combining levels of specification, with regard to the most important dimensions of building resilience.

In between strong arguments for the maximum specification or the search for general resilience, we perceive an "analytical space" (see Figure 2 below) to consider *trade-offs between specification and generalization*. Framing a tension as a trade-off facilitates the search for a compromise that satisfies the proponents of specification *and* general resilience. The following project example TRAFIS illustrates this through reporting on a "sustainability check" as a tool for local infrastructure development, in which the concept of resilience was included to address issues of infrastructure service supply security [51].

The inter- and transdisciplinary project TRAFIS (2017–2019) was dedicated to questions around the sustainability transformation of local and regional infrastructure systems. TRAFIS involved various, mainly qualitative, methods of transformation and transformative research. The development of the sustainability check was accomplished through a mix of methods, especially a literature analysis, the practical application of the sustainability and resilience check, and interviews with the managers of local infrastructure systems. For the application of the sustainability check with 115 German experts, the Delphi-method was applied [51].

Blue, green, and grey infrastructure are crucial systems within the larger urban systems. Where infrastructure services are disrupted, economic and social activities lose momentum and safety is endangered. As a result, the provision of infrastructure services has become a central topic of resilience research on infrastructure [52]. Generally, the resilience of infrastructure systems has long been a core feature of infrastructure operation. However, the attempts to explicitly differentiate the various facets of resilience, which might be of relevance for the operation and transformation of urban infrastructure systems, are relatively new.

Currently, this issue receives increasing attention due to two overlapping processes which are able to challenge, on a global scale, the high levels of security of supply of infrastructure in the Western world [51]:

- A highly dynamic transformation of infrastructure systems involving new technologies, structures, interconnections, and resources.

- The potentially increasing pressure on systems due to various perturbations (disturbances) from natural, climate-related hazards (inundations, heavy precipitation, heat, etc.), new dependencies within coupled systems and changing demand patterns.

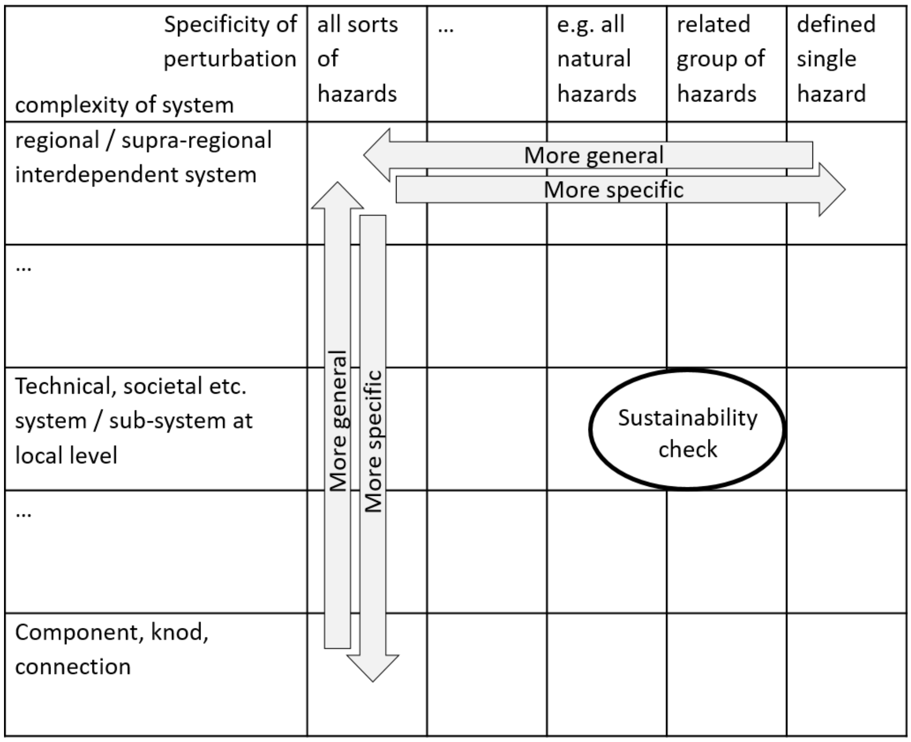

Figure 2. Locating the "sustainability check" through the specification of the focal infrastructure system and perturbation (own illustration based on [51]).

Innovative infrastructure solutions are, on the one hand, a challenge to the resilience of systems due to higher complexities, as well as new uncertainties and dependencies. On the other hand, they also are an opportunity for a more explicit and differentiated consideration of resilience in infrastructure development. Early phases in the development of new infrastructure solutions for urban systems are particularly promising for the consideration of resilience aspects, as the openness and scope for design may be relatively high with low sunk costs ("path dependency" in the context of urban development).

Therefore, the "sustainability check" aims to help "keep an eye" on the various infrastructure-specific aspects of sustainability before formal decisions create path dependencies. Given this challenge and based on multiple research projects, a team of scholars developed (on behalf of the German Environment Agency) the "sustainability check" for an in-process sustainability assessment of local infrastructure innovation projects [51].

The check helps to understand the sustainability effects of a new infrastructure solution. Thus, the check is a *screening instrument* that also provides indications of potential challenges, which require special attention in the development of the solution in order to minimize undesired effects.

Currently, the "sustainability check" includes over 30 criteria to operationalize the assessment of the sustainability of innovative infrastructure solutions at an early stage of development. Three dimensions form the basic framework for making the sustainability concept operational by providing criteria that can be applied at an operational "real world" project level [51]:

- Security of supply (performance and resilience) (14 criteria);
- Natural resources (14 criteria);
- Economic viability and social justice (six criteria).

In this context, an operational stability-oriented understanding of resilience ("bounce back") based on "engineering resilience" is mainly adopted [51]. To assess resilience, system properties describing the structure, resources, and abilities of the regarded system are differentiated by using ordinal scales. Bearing local level community resilience in mind, the work mainly addresses the operation and administration of local level infrastructure utilities engaged in short- and middle-term innovation processes as a part of a local sustainability transition.

However, even in case of a focus on local infrastructure development, questions arise on how to deal with the tension of specification and generalization, not in the sense of a dilemma or indivisible conflict, but as a trade-off. In order to achieve this, the "sustainability check" is located in relation to two dimensions of specification and generalization (Figure 2).

Each infrastructure is in itself a complex system. By providing essential services, infrastructure systems are deeply interwoven into society. Most infrastructure is enabled by a densely related interplay of technological, socio-economic, and ecological elements and conditions. The functioning of such socio-technical [53] or better socio-eco-technical systems [54] integrates physical artefacts, technologies, societal expectations and behavior, market patterns, institutional structures, knowledge and skills, legal regulations, technical standards and natural resources. To consider this complexity and to be specific about its relevance for the "sustainability check", five levels of specification describe the analytical space:

- Single components,
- Artefacts (meaning a functional agglomeration of components);
- Sub-systems that include various artefacts connected by communication and control to form the first complex functional units (the "sustainability check" focuses on this level of specification);
- Interconnected and interdependent (sub-)systems from different domains, focusing on socio-technical or socio-eco-technical systems;
- A regional-supra-regional level of interwoven cross-domain systems.

Furthermore, Figure 2 describes a continuum of perturbations from a focus on a single hazard to the extreme of considering all uncertainties related to natural and man-made hazards as envisioned by the concept of general resilience [55]. As the "sustainability check" is an instrument of screening, it is often plausible to consider multiple, but related, types of perturbations (e.g., climate-change-related hazards such as weather extremes). Specific infrastructures may face disturbances from only one hazard or very few.

Based on the analytical space depicted in Figure 2, scientists and practitioners are able to agree on multiple compromises to specify the level of infrastructure complexity and the spectrum of disturbances (or perturbations) that they wish to consider in a joint project:

- They may jointly work on only one component of a focal infrastructure system, while paying apt attention to all possible hazards;
- They may jointly focus on a very complex regional infrastructure system that is embedded in international relations. Only a few and very specific perturbations that challenge the security of the system are taken into consideration;
- Seemingly, the "sustainability check" has a different aim to these two possibilities. The check integrates information on complex local infrastructure solutions that are (potentially) innovative and at an early stage of development. Further, the check considers multiple, but not all possible, perturbations to a secure infrastructure service provision.

In summary, the check illustrates how a compromise can be found based on the levels of specification (generalization) with regard to the relevant dimensions of building resilience. This project example also illustrates the proposition that negotiating compromise is, in case of concluding negotiations that lead to compromise, contingent on complex success factors. In the face of the high complexity of urban systems, scientists and practitioners need to agree on an "analytical space", such as proposed in Figure 2, to jointly determine a spectrum of the possible options for collaborative work. In turn, the positioning of the resilience focus in the analytical space can be adapted to the specific needs in collaborative projects at the interface of science and practice in the sense of data, methods, and the financial resources available for the analysis. This again underlines the proposition that negotiating a compromise is based on developing the strategic focus of scientists and practitioners and the ability to set priorities in the face of tough decision demands.

4. Conclusions

It is the aim of this research note to argue that the umbrella term "tension" is useful if different kinds of tensions and the ways of dealing with them are considered. Based on a strategic spatial planning perspective and an understanding of social change as a goal-driven process ("planned change"), we highlighted three kinds of tensions and ways of dealing with them:

- *Dealing with complexity in knowledge integration through developing a strategic focus:* Especially at the interface of science and practice, knowledge integration is characterized by the complexity of contents, frames, and approaches to integration. We differentiated tensions within and between approaches to knowledge integration (knowledge sharing, application, and combination). Developing a strategic focus is crucial in the face of increasingly high expectations of how knowledge on building resilience in the context of climate change is generated and transferred into practice. In conclusion, we argue that strategic focus must be understood as a *necessary* condition for a successful knowledge integration to build resilience to natural hazards at the interface of science and practice.
- *Dealing with diverging mindsets towards planned change through setting priorities:* Even if the scientists and actors involved in urban systems follow a common goal for building resilience, they will often approach goal accomplishment with different mindsets. This is due to various reasons (e.g., variations in institutional constraints of action, different "logics" of scientific disciplines and practice fields). Therefore, goal-driven processes of building resilience are characterized by the demands of setting priorities, and this is exactly what a strategic spatial planning perspective attempts to achieve. Thereby, setting priorities entails both (1) the statement that A is more important than B and (2) the justification of why this is the case, with regard to a specific situation and frame of justification. We conclude that this understanding of setting priorities is important for dealing with building resilience and DRR in the face of voices that highlight the limitations of planned change in an uncertain world and especially the limits of planning for extreme events [56].
- *Dealing with trade-offs in analyzing the contents of building resilience through negotiating compromise:* Trade-offs are often conceptualized as trade-offs between the interests of agents involved in urban systems. By contrast, in this research note, we argue that trade-offs also arise at the interface of science and practice with regard to the complexity of urban systems and the spectrum of possible natural hazards. Based on the strategic focus for building resilience and the agreement on how to set priorities, scientists and practitioners may be able to work out a complex "analytical space" (see Figure 2 above) in which a multitude of specific compromises serves as a frame of negotiations for scientists and practitioners, regarding how to develop innovative solutions to the pressing problems of climate change adaptation in cities and regions.

The three kinds of tensions and the ways of dealing with them through focus, priorities, and compromise indicate that the efforts of resilience building are as much about dealing with the complexities of frames as they are about motivations, interests, power, and institutional constraints of action. This also indicates that our research note is written from a micro-perspective on building resilience to natural hazards. Such a perspective needs to be combined with meso- and macro-oriented approaches that highlight the complexities of institutionalized action and institutional change. This brings us back to the typology of motors of social change: Building resilience is a complex change that encompasses multiple motors. Future research and practice need to consider both the interplay between planned change and the politics of pluralistic, as well as the highly confrontational ways of adapting to climate change [57].

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References

1. Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, S.L.; Péan, C.; Berger, S.; Caud, N.; Chen, Y.; Goldfarb, L.; Gomis, M.I.; et al. (Eds.) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, 2021; in press.
2. Coaffee, J.; Lee, P. *Urban Resilience. Planning for Risk, Crisis, and Uncertainty*; Palgrave: London, UK, 2016.
3. Meerow, S.; Newell, J.P.; Stults, M. Defining urban resilience: A review. *Landsc. Urban Plan.* **2016**, *147*, 38–49. [CrossRef]
4. Elmqvist, T.; Andersson, E.; Frantzeskaki, N.; McPhearson, T.; Olsson, P.; Gaffney, O.; Takeuchi, K.; Folke, C. Sustainability and resilience for transformation in the urban century. *Nat. Sustain.* **2019**, *2*, 267–273. [CrossRef]
5. Zhang, Q.; Hu, J.; Song, X.; Li, Z.; Yang, K.; Sha, Y. How does social learning facilitate urban disaster resilience? A systematic review. *Environ. Hazards* **2020**, *19*, 107–129. [CrossRef]
6. Hutter, G.; Neubert, M.; Ortlepp, R. (Eds.) *Building Resilience to Natural Hazards in the Context of Climate Change. Knowledge Integration, Implementation and Learning*; Springer: Wiesbaden, Germany, 2021.
7. Sapountzaki, K.; Chalkias, C. Urban geographies of vulnerability and resilience in the economic crisis era—The case of Athens. *ITU AZ* **2014**, *11*, 59–75.
8. Jore, S.H. Is resilience a good concept in terrorism research? A conceptual adequacy analysis of terrorism resilience. *Stud. Confl. Terror.* **2020**, 1–20. [CrossRef]
9. Davoudi, S. Just resilience. *City Community* **2018**, *17*, 3–7. [CrossRef]
10. Ansell, C. Coping with conceptual pluralism: Reflections on concept formation. *Public Perform. Manag. Rev.* **2021**, *44*, 1118–1139. [CrossRef]
11. United Nations (UN). *2009 UNISDR Terminology on Disaster Risk Reduction*; UN: Geneva, Switzerland, 2009.
12. United Nations (UN). *Sendai Framework for Disaster Risk Reduction 2015–2030*; UN: Sendai, Japan, 2015.

13. Weick, K.E.; Sutcliffe, K.M. *Managing the Unexpected. Sustained Performance in a Complex World*; Wiley: Hoboken, NJ, USA, 2015.
14. Gerring, J. *Case Study Research. Principles and Practices*; Cambridge University Press: Cambridge, UK, 2017.
15. Gerring, J.; Christenson, D. *Applied Social Science Methodology: An Introductory Guide*; Cambridge University Press: Cambridge, UK, 2017.
16. Healey, P. In Search of the "Strategic" in Spatial Strategy Making. *Plan. Theory Pract.* **2009**, *10*, 439–457. [CrossRef]
17. Hutter, G.; Wiechmann, T.; Krüger, T. Strategische Planung. In *ARL Reader Planungstheorie. Band 2. Strategische Planung—Planungskultur*; Wiechmann, T., Ed.; Springer: Heidelberg, Germany, 2019; pp. 13–25.
18. Wiechmann, T. *Planung und Adaptation. Strategieentwicklung in Regionen, Organisationen und Netzwerken*; Rohn Verlag: Dortmund, Germany, 2008.
19. Albrechts, L. Strategic (spatial) planning reexamined. *Environ. Plan. B Plan. Des.* **2004**, *31*, 743–758. [CrossRef]
20. Van de Ven, A.H.; Poole, M.S. Explaining development and change in organizations. *Acad. Manag. Rev.* **1995**, *20*, 510–540. [CrossRef]
21. Poole, M.S.; Van de Ven, A.H. (Eds.) *The Oxford Handbook of Organizational Change and Innovation*; Oxford University Press: Oxford, UK, 2021.
22. Hutter, G.; Wiechmann, T. Time, temporality, and planning—Comments on the state of art in strategic spatial planning research. *Plan. Theory Pract.* **2022**, *23*. in press.
23. Chelleri, L.; Waters, J.J.; Olazabal, M.; Minucci, G. Resilience Trade-offs: Addressing Multiple Scales and Temporal Aspects of Urban Resilience. *Environ. Urban.* **2015**, *27*, 181–198. [CrossRef]
24. Seidler, R.; Dietrich, K.; Schweizer, S.; Bawa, K.S.; Chopde, S.; Zaman, F.; Sharma, A.; Bhattacharya, S.; Devkota, L.P.; Khaling, S. Progress on integrating climate change adaptation and disaster risk reduction for sustainable development pathways in South Asia: Evidence from six research projects. *Int. J. Disaster Risk Reduct.* **2018**, *31*, 92–101. [CrossRef]
25. Termeer, C.J.A.M.; Dewulf, A.; Biesbroek, G.R. Transformational change: Governance interventions for climate change adaptation from a continuous change perspective. *J. Environ. Plan. Manag.* **2017**, *60*, 558–576. [CrossRef]
26. Parker, J.; Crona, B. On being all things to all people: Boundary organizations and the contemporary research university. *Soc. Stud. Sci.* **2012**, *42*, 262–289. [CrossRef]
27. Schipper, E.L.F.; Eriksen, S.E.; Fernandez Carril, L.R.; Glavovic, B.C.; Shawoo, Z. Turbulent transformation: Abrupt societal disruption and climate resilient development. *Clim. Dev.* **2021**, *13*, 467–474. [CrossRef]
28. Wiechmann, T. (Ed.) *ARL Reader Planungstheorie. Band 1. Kommunikative Planung—Neoinstitutionalismus und Governance*; Springer: Heidelberg, Germany, 2019.
29. Wiechmann, T. (Ed.) *ARL Reader Planungstheorie. Band 2. Strategische Planung—Planungskultur*; Springer: Heidelberg, Germany, 2019.
30. Hutter, G.; Olfert, A. *Project-Based Learning for Building Urban Resilience—Reflecting on Project Examples of Climate Change Adaptation in the Dresden Region in Building Resilience to Natural Hazards in the Context of Climate Change. Knowledge Integration, Implementation and Learning*; Hutter, G., Neubert, M., Ortlepp, R., Eds.; Springer: Wiesbaden, Germany, 2021; pp. 229–250.
31. Van de Ven, A.H. *Engaged Scholarship. A Guide for Organizational and Social Research*; Oxford University Press: Oxford, UK, 2007.
32. Scott, W.R. *Institutions and Organizations. Ideas and Interests*; SAGE: Thousand Oaks, CA, USA, 2014.
33. Achtenhagen, L.; Melin, L. Managing the homogeneity-heterogeneity duality. In *Innovative Forms of Organizing*; Pettigrew, A.M., Whittington, R., Melin, L., Sánchez-Runde, C., Van den Bosch, F.A.J., Ruigrok, W., Numagami, T., Eds.; Sage: London, UK; Thousand Oaks, CA, USA; New Dehli, India, 2003; pp. 301–327.
34. Davies, A. *Projects. A Very Short Introduction*; Oxford University Press: Oxford, UK, 2017.
35. Tell, F. Knowledge integration and innovation: A survey of the field. In *Knowledge Integration and Innovation. Critical Challenges Facing International Technology-Based Firms*; Berggren, C., Bergek, A., Bengtsson, L., Hobday, M., Söderlund, J., Eds.; Oxford University Press: Oxford, UK, 2011; pp. 20–38.
36. Grant, R.M. Toward a knowledge-based theory of the firm. *Strateg. Manag. J.* **1996**, *17*, 109–122. [CrossRef]
37. Van de Ven, A.H.; Zahra, S.A. Boundary spanning, boundary objects, and innovation. In *Managing Knowledge Integration Across Boundaries*; Tell, F., Berggren, C., Brusoni, S., Van de Ven, A.H., Eds.; Oxford University Press: Oxford, UK, 2017; pp. 241–254.
38. Greiving, S.; Pratzler-Wanczura, S.; Sapountzaki, K.; Ferri, F.; Grifoni, P.; Firus, K.; Xanthopolous, G. Linking the actors and policies throughout the disaster management cycle by "Agreement on Objectives"—A new output-oriented management approach. *Nat. Hazards Earth Syst. Sci.* **2012**, *12*, 1085–1107. [CrossRef]
39. Ortlepp, R.; Schünemann, C.; Brzoska, P.; Schiela, D.; Westermann, J.; Richter, B.; Kunze, S.; Sinning, H. Building heat-resilient neighborhoods—Testing the implementation on buildings and in open spaces in two sample quarters Dresden and Erfurt. In *Building Resilience to Natural Hazards in the Context of Climate Change. Knowledge Integration, Implementation and Learning*; Hutter, G., Neubert, M., Ortlepp, R., Eds.; Springer: Wiesbaden, Germany, 2021; pp. 113–156.
40. Hutter, G. Goal-oriented networks and capacity building for natural hazards—Examples in the Dresden region. *Nat. Hazards Earth Syst. Sci.* **2014**, *14*, 81–94. [CrossRef]
41. Farazmand, A. Hurricane Katrina, the crisis of leadership, and chaos management: Time for trying the 'surprise management theory in action'. *Public Organ. Rev.* **2009**, *9*, 399–412. [CrossRef]
42. Ansell, C.; Trondal, J.; Ogard, M. (Eds.) *Governance in Turbulent Times*; Oxford University Press: Oxford, UK, 2017.
43. Wildavsky, A. *Searching for Safety*; Transaction: New Brunswick, NJ, USA; London, UK, 1988.

44. Klijn, F.; Samuels, P.; Van Os, A. Towards flood risk management in the EU: State of affairs with examples from various European countries. *Int. J. River Basin Manag.* **2008**, *6*, 307–321. [CrossRef]
45. Comfort, L.K.; Boin, A.; Demchak, C.C. (Eds.) *Designing resilience. Preparing for Extreme Events*; University of Pittsburgh Press: Pittsburgh, PA, USA, 2010.
46. Disse, M.; Johnsona, T.G.; Leandroa, J.; Hartmann, T. Exploring the relation between flood risk management and flood resilience. *Water Secur.* **2020**, *9*, 1–9. [CrossRef]
47. Neubert, M.; Schinke, R. House lifting to improve flood resilience in settlement areas—An example of the Elbe village Brockwitz (Saxony, Germany). In *Building Resilience to Natural Hazards in the Context of Climate Change. Knowledge Integration, Implementation and Learning*; Hutter, G., Neubert, M., Ortlepp, R., Eds.; Springer: Wiesbaden, Germany, 2021; pp. 55–73.
48. Neubert, M.; Naumann, T.; Hennersdorf, J.; Nikolowski, J. The geographic information system-based flood damage simulation model HOWAD. *J. Flood Risk Manag.* **2016**, *9*, 36–49. [CrossRef]
49. Schinke, R.; Schwarze, R.; Carstensen, D.; Neubert, M.; Schinker, N.; Schade, C.; Melenhorst, M.; Lier, O. Haushebung, eine geeignete Maßnahme zur Hochwasservorsorge?—Das Fallbeispiel Brockwitz. In *Komplexe Planungsaufgaben im Wasserbau und ihre Lösungen*; Technische Universität Dresden, Institut für Wasserbau und Technische Hydromechanik, Ed.; TU Dresden: Dresden, Germany, 2019; pp. 373–382.
50. Van Valkengoed, A.M.; Steg, L. Meta-analyses of factors motivating climate change adaptation behaviour. *Nat. Clim. Chang.* **2019**, *9*, 158–163. [CrossRef]
51. Olfert, A.; Walther, J.; Hirschnitz-Garbers, M.; Hölscher, K.; Schiller, G. Sustainability and resilience—A practical approach to assessing sustainability in innovative infrastructure projects. In *Building Resilience to Natural Hazards in the Context of Climate Change. Knowledge Integration, Implementation and Learning*; Hutter, G., Neubert, M., Ortlepp, R., Eds.; Springer: Wiesbaden, Germany, 2021; pp. 75–111.
52. Shafiee, M. Modelling and analysis of availability for critical interdependent infrastructures. *Int. J. Risk Assess. Manag.* **2016**, *19*, 299–314. [CrossRef]
53. Frantzeskaki, N.; Loorbach, D. Towards governing infrasystem transitions: Reinforcing lock-in or facilitating change? *Technol. Forecast. Soc. Chang.* **2010**, *77*, 1292–1301. [CrossRef]
54. Chester, M.V.; Markolf, S.; Allenby, B. Infrastructure and the environment in the Anthropocene. *J. Ind. Ecol.* **2019**, *23*, 1006–1015. [CrossRef]
55. Folke, C.; Carpenter, S.R.; Walker, B.; Scheffer, M.; Chapin, T.; Rockström, J. Resilience thinking: Integrating resilience, adaptability and transformability. *Ecol. Soc.* **2010**, *15*, 1–9. [CrossRef]
56. Birkmann, J.; Wenzel, F.; Greiving, S.; Garschagen, M.; Vallée, D.; Nowak, W.; Welle, T.; Fina, S.; Goris, A.; Rilling, B.; et al. Extreme events, critical infrastructures, human vulnerability and strategic planning: Emerging research issues. *J. Extrem. Events* **2016**, *3*, 1–25. [CrossRef]
57. Pelling, M. *Adaptation to Climate Change. From Resilience to Transformation*; Routledge: London, UK; New York, NY, USA, 2011.