land

Article

Developing an Integrative Theoretical Framework for Climate Proofing Spatial Planning across Sectors, Policy Levels, and Planning Areas

Maria Juschten [1], Florian Reinwald [2], Roswitha Weichselbaumer [2] and Alexandra Jiricka-Pürrer [1,*]

[1] Institute of Landscape Development, Recreation and Conservation Planning, University of Natural Resources and Life Sciences, 1190 Vienna, Austria; maria.juschten@boku.ac.at
[2] Institute of Landscape Planning, University of Natural Resources and Life Sciences, 1190 Vienna, Austria; florian.reinwald@boku.ac.at (F.R.); roswitha.weichselbaumer@boku.ac.at (R.W.)
* Correspondence: alexandra.jiricka@boku.ac.at; Tel.: +43-1-47654-85323

Abstract: Spatial planning holds a key role in preventing or mitigating the impacts of climate change on both cities and rural areas, taking a forward-thinking and holistic approach to urban and regional development. As such, spatial planning deals with challenges occurring at different scales and across sectors. The international literature points out the need for horizontal and vertical cooperation to tackle climate change impacts. This paper discusses the general challenges for climate proofing across planning levels, sectors, and areas and provides a systematic overview of challenges that would affect an integrative theoretical framework for climate proofing. Based on the latter, the study ultimately aims at presenting a novel theoretical framework for Climate Proofing specific to spatial planning involving a multi-sectoral perspective. An iterative process was used for conceptual development, based on a literature review followed by external feedback meetings with the core team of planning experts responsible for exchange across federal states and two workshops with focus groups of experts of planning departments responsible for federal, regional, and local spatial planning. Implementation and further development of the framework are planned as the second phase of this study. By specifically addressing the challenges relating to cross-regional and cross-sectoral planning, this novel framework attempts to discuss the (i) consideration of the hierarchy of climate proofing measures through enhanced vertical and horizontal cooperation as well as the (ii) long-term institutionalisation of integrative planning processes across planning borders. It attempts also to (iii) foster the consideration of co-benefits for joint adaptation purposes and climate change mitigation through encouraging multi-disciplinary perspectives

Keywords: climate proofing; spatial planning; climate change adaptation; framework; cross-regional; integral; co-benefits

check for updates

Citation: Juschten, M.; Reinwald, F.; Weichselbaumer, R.; Jiricka-Pürrer, A. Developing an Integrative Theoretical Framework for Climate Proofing Spatial Planning across Sectors, Policy Levels, and Planning Areas. *Land* **2021**, *10*, 772. https://doi.org/10.3390/land10080772

Academic Editor: Luís Carlos Loures

Received: 16 April 2021
Accepted: 19 July 2021
Published: 23 July 2021

1. Introduction

Climate change can bring about a change in the frequency and intensity of meteorological phenomena. These changes give rise to different thematic challenges which depend on geographical location, topographical and climatic conditions, as well as other influencing factors such as land use. While, in coastal areas, for example, protection against storm surges is the main concern [1–3], other areas primarily suffer from heatwaves and droughts, causing forest fires and/or water scarcity [4–6]. Alpine areas, on the other hand, have specific challenges primarily related to gravitational events such as erosion, landslide, and rockfall [7,8]. Their intensity also depends on other factors such as soil characteristics and the location of settlements [9]. Extreme events, in particular, can have a severe impact on settlement areas and their populations, transport infrastructure, energy supply, and other sectors [10–12]. Of particular relevance in this context is the impact on critical infrastructures such as power supply or transport links for places of major public significance or with important health or safety functions (e.g., hospitals). The interconnectedness of different critical infrastructures and interactions between them exacerbate this problem [13,14].

Spatial planning can contribute significantly to the prevention or mitigation of climate-related risks or damages, both through spatial research and the support of planning decisions [15]. Spatial planning decisions can determine developments for years or even decades. Land usage patterns and building developments are not only influenced by potential climate change impacts; they also hold the key to adapting to them. Therefore, forward-thinking planning practices have become the focus of spatial planning research in the last two decades. Such practices include, among other things, the increase of spatially-specific climate and adaptation knowledge, the development of scenarios for adaptation to climate change, the strategic promotion of nature-based solutions, and the monitoring of them [16].

In addition to strategic development, liability issues and financial risks have also become increasingly relevant. This is especially true at the municipal level, as planning decisions can have far-reaching consequences, depending on the longevity of the infrastructure following planning decisions or the impact on territorial systems. In this context, the possibility of adaptation, with the goal of preventing and/or reducing damages and business interruptions, has also become part of international research and planning practice. Numerous studies have addressed issues related to vulnerability or risk reduction in the context of spatial development [2,17–19].

Kruse and Pütz [20] emphasise the intrinsic long-term focus of planning processes that may be based on the precautionary principle [21]. In doing so, planners and policymakers try to avoid negative path dependencies while at the same time creating positive ones. Two aspects are important in this context: firstly, the proactive management of spaces, for instance through the preservation or expansion of green spaces or the designation of specific adaptation-relevant areas, and secondly, the identification of new risks that arise through the implementation of a plan/programme [22,23]. Over the decades, planning processes have paid much attention to some aspects of climate change, such as the risk of flooding [2,24]. However, awareness of and attention in the planning process to other aspects, such as the effects of heat and drought and response to them, have only grown recently.

In response to these different climatic changes, planners and decision-makers try to find long-term measures to reduce negative impacts, often referred to as "climate proofing". Swart et al. [2] define "climate proofing", in the context of spatial planning, as initiatives of different administrative or sectoral authorities aiming to "*integrate climate impacts concerns in land use, water management and other projects in order to make a location, a region, a district or an economic sector resilient to climate change (...)*", thereby reducing its vulnerability. This is to ensure that plans, programmes, and strategies, as well as associated investments, are resilient and adaptable both to the current and future impacts of climate change [25]. Given this definition, resilience, as the ability of urban/regional systems to adapt to external influences and to mitigate negative impacts, plays a central role in many climate proofing frameworks (see for example [14,26,27]). A systems-based approach to climate proofing would aim at increasing robustness and resilience. This would have the major advantage of maintaining the flexibility and agility of the planning instruments, allowing planners to adjust proactively to changing circumstances.

International science and governing institutions have been analysing opportunities for strengthening resilience to climate change in spatial planning for around 20 years now [2]. As part of this process, guiding concepts and frameworks have been developed to integrate climate proofing objectives at an early stage of the planning process and in a forward-looking manner. Within existing international studies and guidance documents, two particular challenges of spatial planning have only been addressed partially so far. One challenge refers to the importance of tiering between different spatial levels, which requires early consideration of planning alternatives in order to be able to specifically and appropriately implement further climate proofing measures at subsequent spatial levels. Another challenge relates to the difficulty of taking into account any changes in climatic conditions beyond the scope of the given planning areas [28].

In particular, the avoidance of "lock-in effects" [29,30], the lack of institutional flexibility in adapting policies to changing circumstances [3,31,32], as well as responses to increasing resource scarcities [31,33], are described as major challenges in both the international literature as well as in strategy documents and adaptation policies also in this context. These challenges can be addressed, among other options, by finding solutions that transcend spatial, policy level, and administrative boundaries. Several international studies highlight the importance of both integral and cross-regional climate proofing processes for diverse spatial conditions [13,21,28,34].

Next to the consideration of climate change along horizontal and vertical planning boundaries, the integration of sources of information and planning objectives from instruments of sectors complementary to spatial planning is highlighted by some studies. Kruse und Pütz [20], for instance, emphasised the importance of spatial planning for adaptation to climate change, especially with regard to sectoral dependencies (e.g., between water and soil).

This article, based on a large case study in the eastern part of Austria involving three different federal states—each with its own legal planning law and instruments—discusses a framework for an integrative systematic approach, across planning borders, to the complex challenges of climate proofing. In doing so, this communication addresses the following research question: how can a theoretical framework integrate the opportunities of climate proofing across sectors, policy levels, and planning areas?

Below, we will discuss this new framework concept that (i) integrates climate change impacts into spatial planning across planning levels and planning areas, including the longer-term reintegration of review steps at the different levels, and which also (ii) provides for the integral consideration of cross-sectoral approaches to climate proofing in different sub-steps. The implementation and further development of the framework are planned as the second phase of this initiative.

As such, the study aims at (1) discussing the general challenges for climate proofing across planning levels, sectors, and areas, (2) providing a systematic overview of challenges that would affect an integrative theoretical framework for climate proofing and based on the latter the study ultimately aspires to (3) present a novel theoretical framework for Climate Proofing specific to spatial planning involving a multi-sectoral perspective.

2. Background—Specific Challenges for Climate Proofing in Spatial Planning

2.1. Challenges for Climate Proofing in Spatial Planning Across Planning Levels and Areas (Scopes)

In many countries, the mainstreaming of climate proofing is based on National Adaptation Strategies, which identify impacts of climate change on a rather abstract scale and superior levels and introduce measures also for spatial planning and related sectors [34]. To implement these measures and redefine specific needs against the background of the specific spatial situation, downscaling and concretisation are necessary. Consideration of over-arching challenges can support these processes at the regional and local levels. For planning practice, some frameworks exist that aim to support the process of implementing climate proofing measures at different policy levels. While they often include processes of stakeholder involvement or cooperation with relevant sectoral or political stakeholders, they tend to focus on specific regional scales. The most frequently studied level of analysis is the urban level, where a wide range of planning or implementation frameworks is designed (see for example [35–37]). This imbalance may be attributed to data availability but also to the high sensitivity of urban areas to climate change, given their often increased exposure to the projected impacts of climate change (i.e., coastal locations or heat islands) as well as the large and often increasing size of the population affected [38,39].

While the literature pays some attention to such vertical levels of cooperation across different policy scales (national to regional to local, also framed as "mainstreaming") [40–42], little consideration is given to horizontal levels of cooperation, including the challenges of cross-regional or transboundary cooperation. This entails cooperation across different regions at the same administrative or hierarchical level [34,41]. Especially for the challenges of cross-regional planning within countries, linkages for their consideration would need to be created, again at different planning levels. So far, however, the procedural integration of cross-regional challenges has only been addressed within individual, often isolated, and project-based case studies on the implementation of climate change adaptation processes [43,44]. Many of them operate at the urban level while integrating surrounding regions or federal states (for example in the case of the joint river management of Berlin with the surrounding region Brandenburg, see [28], or in the case of adaptation of road infrastructure in the metropolitan region of Stuttgart, see [45]). International research on the matter, however, is currently scarce (see [46] for a noteworthy exception).

Van Eerd et al. [47] highlight the importance of this horizontal or cross-border cooperation by stating that "*Climate adaptation is inherently transboundary in character, as climate change effects do not stop at man-made borders*". This applies particularly to the effects of heat and drought as well as the ability to respond to them, which require consideration beyond singular planning structures such as one community and its planning boundaries [47]. Similarly, flooding and the response to it necessitate broader consideration as rivers and brooks involve large areas, influenced by the combination of land uses [28]. While van Eerd et al. [47], among others (see for example [48]), use this argument to justify the need for cooperation across national borders, the same argument can be used for cooperation across regional borders or planning areas, as emphasised by two publications on several geographical contexts in Europe, the US, and Australia [21,49]. Both negative effects, as well as potential co-benefits, are transboundary in nature, given their dynamic movement [47,50]. The UN Water Policy brief [50], among others, emphasises the importance of integrating transboundary cooperation at all stages of the climate proofing process, therefore affecting a range of different steps or aspects. While research has clearly stated the need for more integrated, cross-border planning practices [28], such processes also come with a number of challenges that ought to be addressed or at least considered by planning institutions.

Several suggestions as to how to overcome these challenges are made by international studies. Persson [51] distinguishes between three different approaches with regard to measures that aim to increase the integration of environmental policies at different levels and enhance more integrative perspectives. One possible (normative) approach refers to reforms or administrative restructuring processes in order to change the rules underlying existing cooperation processes. Another (organisational) approach focuses on administrative structures within the appropriate planning bodies and possible measures, which entail the re-allocation or new establishment of financial resources, staff, data access, or other resources crucially needed for enhanced cooperation. The last (procedural) approach focuses on processes of cooperation between different planning bodies, including new processes of joint decision making and information exchange between planning bodies. Ideally, such processes targeted at increased cooperation would be established long term. However, they often tend to be only voluntary or temporary [33]. Widmer [34] specifies that measures targeted towards the different approaches can entail varying levels or intensities of cooperation. They range from mere coordination of processes (low coordination) to harmonisation and prioritisation (highest level of cooperation).

To sum up, the literature reveals that, to date, a number of frameworks exist that outline essential climate proofing sub-steps (see for example [52,53]), often applied within specific planning areas (i.e., urban or regional contexts). However, the challenges related to spatial planning across policy levels and planning areas have not yet been explicitly integrated into the procedural approaches to climate proofing.

2.2. Integral Spatial Planning to Enhance Climate Proofing

At the policy and strategy levels, several authors stress the need for cross-sectoral adaptation [34,42,46,54]. Widmer [34] highlights the importance of addressing the "cross-cutting nature of adaptation" within planning processes, even though her work focuses on planning processes across different policy sectors rather than administrative boundaries. Similarly but with a sectoral focus on water management, Haaren and Moss [49] emphasise the need for more integrative planning across sectors, planning areas, and policy levels, which they attribute to the complexity of current challenges (i.e., climate change, technological and demographic changes), as well as the scarcity of public financial resources attributed to these tasks.

In this context particularly, conflicting interests, for example, due to the aggravating scarcity of resources, were highlighted [34] but also the ability to create positive synergies or co-benefits between multiple adaptation and even mitigation goals. In their analysis of 100 adaptation projects in the Netherlands, Swart et al. [2] provide examples of the possible co-benefits of climate adaptation with other sectoral goals from housing, transportation, and recreation among others.

At the local and regional levels, several challenges were identified, which often relate to sector-specific instruments and administrative boundaries across sectors as well. Next to institutional and process-related constraints, data, and the ability to include projections for various land uses are often mentioned as challenging. Harrison et al. [55], for instance, state that climate models often disregard interactions between different sectors with regard to short and long-term effects, which eventually may lead to misinterpretation of results (see also [56]). Particularly, resource consumption and competing interests, for example, regarding water usage for various adaptation purposes, can often not be considered transparently across planning boundaries and involving all relevant sectors accessing and impacting these resources.

While some initial research projects pointed out the limitations of spatial planning instruments in adapting to some impacts of climate change, others opted for a more integrative role for spatial planning in connecting necessary data, actors, and processes, to enable cross-sectoral climate change adaptation. One noteworthy example includes the study by Floater et al. [37], who developed a framework for assessing the possible co-benefits of climate proofing measures that extend to other sectors and may therefore increase support from and cooperation with other administrative bodies affected. In this respect, the City of Rotterdam and its "Climate Initiative" highlight the importance of ensuring cooperation and commitment from a range of different public and private stakeholders, although their perspective on cooperation only extends over various sectoral boundaries but not city boundaries [57]. A similar line of argument is followed by Kim and Lim [58], who highlight the relevance of interactions between sectors within their urban resilience framework, however focusing on sectors within city boundaries. While urban and suburban structures are more frequently and systematically assessed in cross-sectoral cooperation with regard to climate change impacts and their capacity to react to climate change, rural areas partly neglect the full potential of coping with climate change by means of integral planning across sector-specific instruments. However, positive examples exist, especially with regard to adaptation efforts to prevent flooding along riversides, where diverse cooperation between water management and spatial planning is often institutionalised for decades (see [2] for a list of projects and their geographical and sectoral focus).

2.3. Challenges of Climate Proofing Processes Across Sectors, Policy Levels, and Planning Areas

The previous sections discussed the importance but also the challenges of developing an integrative framework of climate proofing that fosters both vertical and horizontal cooperation by integrating stakeholders from different sectors, planning areas, and policy levels. Above all, such an approach to spatial planning allows planners to respond more effectively, rationally, and transparently to changing circumstances (i.e., technological, demographic, climatic changes) that affect land use and well-being across different sectors and planning areas [28,59]. For spatial planning, these aspects are highly relevant when discussing the benefits of involving a diverse set of other sectors such as water management, forestry, or geology during the preparation of new plans and programmes, as well as during the decision-making process. In order to develop a framework responsive to the specific challenges resulting from this integrative approach, a systematic review of the opportunities and challenges of integrative cooperation to achieve climate proofing targets is needed. Table 1 below provides this by subsuming the existing literature [28,59–61] and is loosely based on the categorisations used by Juhola and Westerhoff [61], which seem to relate well to procedural considerations of an integrative CP framework targeted at informing formal spatial planning processes.

Table 1. Opportunities and challenges of integrative cooperation in climate proofing.

Categories	Opportunities of Integrative Spatial Planning	Challenges of Integrative Spatial Planning
Institutionalisation of CP	More strategic, long-term coordination and increased level of harmonisation of processes/legal frameworks to avoid maladaptation [59]. Spatial Planning can act as a "hub" connecting different sectors and stakeholders [62].	Most current cooperation processes across planning areas are short-term/project-based, driven by individuals and not institutionalised [34,38], at least not during early stages [63].
Data	Data and knowledge exchange on the interpretation of data reduces uncertainties with regard to vulnerability assessments and increases the avoidance of conflicts as well as options for the identification of co-benefits [50,61,62].	Different data formats or analysis software impeding easy transfer. Lack of know-how regarding relevant indicators, analysis methods or analysed time frames/spatial scales represent further challenges [46,60]. Lack of knowledge or uncertainties regarding sectoral or regional climate change impacts [46,59,60], which is partly caused by inefficient use of available knowledge or insufficient inclusion of local knowledge [60].
Networks and Communication (internal and external)	The development of networks and continuous communication represents the basis for an improved exchange of knowledge, the identification of shared interests, and the building of (formalised) cooperation processes across scopes [62,63].	Stakeholders may display varying perceptions of risk related to climate change and trust related to scientific assessments [60]. Different regions may generally display competing interests caused by different local prerequisites, cultural differences (i.e., urban-rural), and traditions [60,63]. Different perceptions on acceptable measures and required burden-sharing (of costs and benefits) [60].
Commitment, motivation, and trust	The creation of a trustful atmosphere and mutual interests are crucial for cross-sectoral cooperation. Vital networks can enhance political commitment, despite lacking institutionalisations [61].	Personal, institutional, or structural inertia or resistance can repress CP initiatives/cooperation [60].
Visions, objectives, and consensus	Synchronised policy priorities and joint resources for thematic coordination and prioritisation allow the maximisation of co-benefits or synergies [28] and avoidance of lock-in effects, even though the role of consensus varies across different countries and institutional settings [61].	It may be hard to reach a consensus on the need for adaptation [60]. For some sectors, climate change adaptation is an "integral part of their agenda", for others it is not [41]. Differing interests or policy priorities (e.g., prioritisation of economic or specific sectoral objectives) [34,49,59]. Unclear guidance/goal-setting for mainstreaming of adaptation measures/integration into lower-level policies [60]. Lack of knowledge on synergies, co-benefits, and trade-offs of climate proofing measures across sectors [59].

Table 1. *Cont.*

Categories	Opportunities of Integrative Spatial Planning	Challenges of Integrative Spatial Planning
Legal frameworks/instruments	Possibility of joint measures within similar legal structures/exchange of expertise on entry points for consideration of climate change adaptation [28].	Non-harmonised or non-binding planning frameworks or strategies may impede integrative climate proofing [59], as well as lacking or diverging levels of detail within specific planning instruments [28,59]. When regulations appear as "negotiable", higher risk may be taken by stakeholders in favour of construction/developments [60].
Resources	Shared cost burden, at least for parts of the risk assessment and adaptation process [50]. Possibility for efficient use of human and financial resources as well as space (in the case of multi-functional measures) [28].	Uncertainties/ambiguities regarding cost sharing [50] and limited financial resources in different regions [64]. Different internal structures, hierarchies, and responsibilities. Asymmetries in political commitment and cultures between different partners may impede uptake of administrative processes [59].

3. Methodological Approach

3.1. Description of the Case Study

The case study for this project and the resulting framework development is Eastern Austria, which is a very heterogeneous planning area that will be affected by a variety of meteorological and resulting planning challenges as climate change progresses. Three federal states—Vienna, Lower Austria, and Burgenland—founded the "Planungsgemeinschaft OST" (PGO), a joint organisation for the harmonisation, coordination, and preparation of questions relevant to spatial planning in the eastern region.

The area is characterised by strong contrasts. It includes a metropolitan region, as is Vienna with its population of nearly two million and is therefore characterised by the cross-sectoral pressure of land-use change in the vicinity of Vienna. It also includes numerous small communities in remote areas with structural difficulties and limited resources available for their adaptation to climate change. The urban region of Vienna is characterised by strong commuter links and many additional functional relationships between the core city and the surrounding area [65].

Due to the continental location, the PGO region is among the warmest regions in Austria with the lowest rainfall [66]. Longer dry periods are already observable and likely to increase in the future and despite no change in annual precipitation levels, a strong increase in evapotranspiration due to increasing heat effects is forecasted. Simulations show that this heat load will increase sharply [67], affecting especially densely-populated and urban areas [68]. Another key climatic change is the increase in heavy rainfall events, which leads to an increase in pluvial and fluvial flooding.

A central challenge is that planning law in Austria is a matter for the federal states, that is, all three federal states have different planning laws. The planning instruments and the administrative structures also differ. Different conceptual planning instruments, which are not legally binding (e.g., Strategy concepts, sectoral concepts), are used by federal states, regions, or municipalities for their spatial development. Hence, they vary greatly with regard to their key nature (strategic vs. policy-prescriptive) and their legal force (binding vs. non-binding).

The complex challenges of this case study area showcase the need for a robust framework for climate proofing which takes into consideration the cooperation of different federal states, the need for multidisciplinary perspectives, as well as implementation at various planning levels (federal, regional to local) and within different planning processes. A boundary organisation such as the PGO creates a novel opportunity to develop and discuss a new, integrative planning framework for climate proofing across sectors, planning areas, and policy levels that integrates this knowledge on potential barriers in order to enable planners to adequately address them early in the process.

3.2. Multi-Method Approach to the Development of the Framework

The project chose a multi-level methodological approach. It is based on the review of the current state of scientific knowledge, the indicative requirements of strategies and policies, as well as existing guidelines for national and international planning practice. Major opportunities and challenges relevant for integrative cooperation in climate proofing concluded from the literature were summarised in Table 1 (see Section 2.3.).

In the next step, several frameworks for climate proofing were screened and analysed with regard to relevant steps and content related to spatial planning. Many frameworks exist that try to mainstream climate proofing, including the well-established ones such as Willows' and Connell's decision-making framework [69] or the European Commission's Climate Adapt framework [70], among others [53,71,72]. What most of the climate proofing frameworks have in common is a division into different phases, such as the preparation or implementation phase (see [73]). In this regard, the illustrated processes within these existing frameworks show many similarities. Despite the fact that some frameworks focus on specific aspects of the process (such as monitoring and evaluation [74] or finances [75]), many have a similar procedural design. They include processes of stakeholder analyses or engagement, the definition of common objectives, the implementation of measures for climate proofing, or, in some cases, the monitoring and evaluation of these measures in relation to the objectives defined initially.

These frameworks cannot reflect the specifications of spatial planning, for example, the relevance of tiering among instruments of spatial planning to identify options for diverse types of climate proofing measures adequately or standardised elements of consultation in spatial planning determined through legal framing conditions or thematic limitations which require cooperation with other disciplines beyond spatial planning. Frameworks specific to spatial planning exist [16,53,76] but do not cover the three aspects of vertical, horizontal, and cross-sectional cooperation for the achievement of integrative climate proofing accordingly so far.

Coordination on the framework structure took place in several oral and written feedback loops with the core team of planning experts responsible for the exchange across federal states (PGO). Their feedback was obtained through multiple discussion sessions. Additionally, two focus group workshops took place virtually in mid-October 2020 and March 2021 with an extended group. This group included 12 experts from regional and local spatial planning units as well as landscape and nature conservation planning of the three federal states. After input from the project team, interactive discussions were carried out, supported by virtual tools such as "jambords" to promote an interactive exchange. Key questions comprised the following topics:

- Opportunities of multi-level CP across planning level (particularly regional and local levels) with focus on tiering of planning objectives, a hierarchy of measures for climate proofing, and coordination across sectors (e.g., for research "*Raumforschung*" and data acquisition).
- Need for improvement in horizontal cooperation, particularly across federal state borders with a focus on the compatibility of planning systems and differences in the application of planning instruments, as well as strategies to cope with these diverse preconditions.
- Entry points for climate proofing (spatial planning regulations and their implementation including recent amendments) as well as cross-sectoral opportunities (novel legal framing conditions and sectoral instruments delivering important information, data, or options for implementation of climate proofing measures).

4. Presentation of the Novel Theoretical and Methodological Framework

The framework presented in this paper integrates established procedural steps identified in the analysis of existing frameworks and amends them to create a more holistic, precautionary approach for climate proofing in spatial planning. The primary objectives of the framework concept developed were its applicability to and coordination between different planning levels and instruments. While for each planning level and instrument these steps differ regarding the scope and level of detail, central elements such as the opportunities for coordination and data collection from other departments or the public participation, which is determined by law as a period of open access to planning documents (to collect written statements), are similar. The aim of this novel framework was to intrinsically incorporate climate proofing into the core procedural steps in spatial planning.

The procedural steps presented fulfil two objectives: firstly, they help to identify the challenges resulting from climate change for different spatial planning levels (= vulnerability analysis). Secondly, they support the process of developing solutions that could be implemented by local and regional or, if relevant, cross-regional spatial planning institutions (= implementation and feedback). Figure 1 below represents the entire process and the links between the procedural steps.

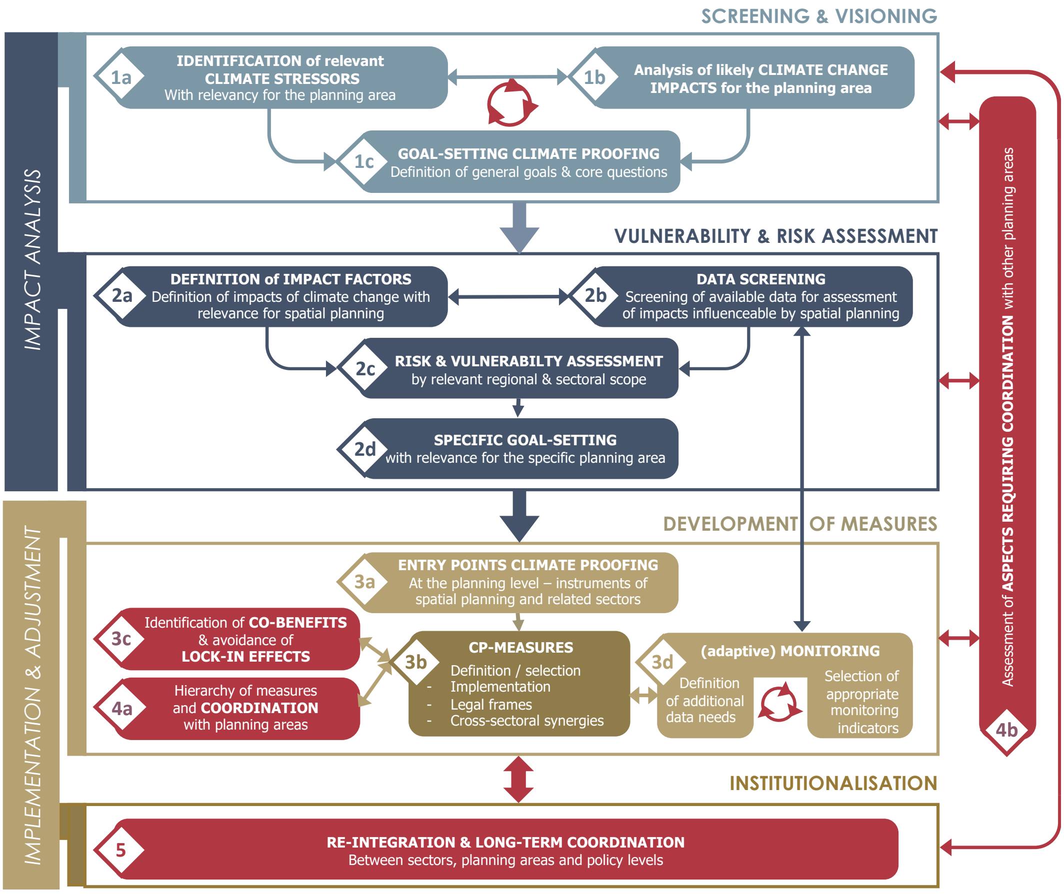

Figure 1. Framework concept for integrative "climate proofing" across planning areas and levels. Authors' illustration.

For the planning area in Eastern Austria, a detailed analysis was also carried out to point out the procedural entry points for each planning level and instrument exploring specific foci and tiering throughout the various steps of the framework. One core objective was also to analyse the role of complementary instruments such as the Strategic Environmental Assessment to enhance a more multidisciplinary perspective at the different scales. While these results are more specific to the Austrian planning system, the core steps of the framework and implications for spatial planning practice are discussed in a more abstract way having an international audience in mind.

In order to estimate the vulnerability of specific planning areas to the consequences of climate change, it is necessary to define the meteorological parameters and indicators to which special attention should be paid (steps 1a and 1b). Possible indicators could be both current or expected change in frequency or intensity of the phenomenon under observation. Depending on the planning scale, existing adaptation strategies and policies already indicate the most spatially relevant challenges for climate proofing. According to the scale of planning or the meteorological phenomena to be included, the need for precise small-scale consideration can vary greatly.

The identification of specific climate proofing goals (step 1c) is done with respect to challenges in the specific planning area and should account for the following aspects:

- existing (overarching/superordinate) policies and goals,
- specific climatic, geographical, and territorial conditions,
- other active "drivers of change" (land-use changes, population dynamics, economic aspects, etc.),
- intermediary goals achieved hitherto regarding climate change adaptation or climate proofing,
- state of integration of relevant institutions for cross-sectoral coordination.

The initial definition of objectives and indicators by which to measure existing processes is a crucial preparatory step, especially with regard to the efficient use of resources and the feasibility of integrating climate proofing into spatial planning. It helps to identify the specific challenges of the planning area including social indicators and, in doing so, allows a focus on existing efforts and resources for the selected indicators (steps 2a and 2b).

For many possible climate change impacts, interrelationships with other land-use changes are crucial. Therefore, the analysis of impact factors is an essential sub-step of this climate proofing framework, as also highlighted by Houghton and Castillo-Salgado [19] and Rannow et al. [38] (step 2a). Changes in vegetation with regard to water retention capacity, for example, can mitigate or intensify the impacts of climate change both by themselves and in combination with other factors [77]. Another example of these interrelationships is the changes in soil cover that affect the evaporation of water from the soil [78,79]. From a spatial planning perspective, particular focus may be placed on all those factors that can be actively influenced by planning decisions. Examples of this are the creation of fresh-air corridors by focusing on the appropriate layout of building structures, which in turn requires a forward-thinking approach to zoning determinations. Parameters such as the green space factor can be important in this context, depending on the specific planning level involved [80,81]. Especially with regard to the consideration of impact factors, it is indispensable to consider, at an early stage, which planning decisions are indicative for the subsequent planning levels (see step 3).

In contrast to the initial identification of targets (step 1), only a detailed analysis of projected impacts for the specific area under consideration (step 2) allows more precise subsequent determination of the level of local/regional vulnerability, taking into account both the appropriate climatic changes (step 2b), as well as the spatial impact factors (step 2a). For step 2b, again, climate change impact models from other planning units such as geology, water management, or forestry can add important sources of information. The final assessment of the remaining vulnerability can be repeated at a later stage, after considering possible procedural and legal possibilities to implement "climate proofing" measures. In this regard, cross-sectoral coordination and cooperation can support the process of defining specific climate proofing targets for the planning area under consideration. Based on vulnerability analysis, specific goals can be defined with relevance for the specific planning area (step 2d).

While the first steps (as displayed in the vulnerability analysis) are part of many frameworks for climate change adaptation and climate proofing (see for example [37,74,82,83]), the newly presented framework integrates the following new approaches, particularly throughout the development of measures to reduce negative impacts of climate change, to foster positive co-benefits for climate change mitigation and encourage learning loops also concerning vertical and horizontal cooperation. These aspects will be discussed in greater detail below.

4.1. Cross-Level Coordination of Climate Proofing Options

In order to be able to counter climate change impacts strategically and proactively through climate proofing, it is essential to reflect on which challenges can be countered at which planning level or from which level onwards.

An assessment across different levels is particularly relevant for the following four steps within spatial planning. Combined, they represent a large part of the overall planning process:

Firstly, cross-level tiering enhances the integration and coordination of goals across planning levels. In this way, it attempts to contribute to the consistency of planning instruments between different sectors and planning levels and their respective goals. Integrating goals and information on climate change impacts from superior levels can, in particular, inform the definition of specific climate proofing objectives.

Secondly, the multi-scale perspective can facilitate the impact analysis process as well as the analysis of vulnerability (step 2). In this context, determination of the appropriate scale for identifying potential impacts (databases, indicators, tiering of the level of detail) (steps 2a, 2b, 2c, and 2d) is a crucial aspect that can be facilitated by integrating higher-planning-level outcome documents, as well as by considering follow-up planning processes at a more detailed planning scale.

Thirdly, tiering allows exploitation of the full potential of the hierarchy of measures, starting with the identification of planning alternatives. The incremental examination of suitable measures for climate proofing is particularly important. Climate proofing measures in spatial planning have three main objectives:

- Securing of areas (risk or favourable areas or those with regulatory functions),
- Reduction of damage to buildings and infrastructure as well as risks to their users or inhabitants (technical and nature-based approaches),
- Securing the continuation of operational processes (especially with respect to critical infrastructure or transport-related accessibility).

Figure 2 shows the four principal fields of climate proofing measures particularly relevant for spatial planning to achieve the objectives specified above.

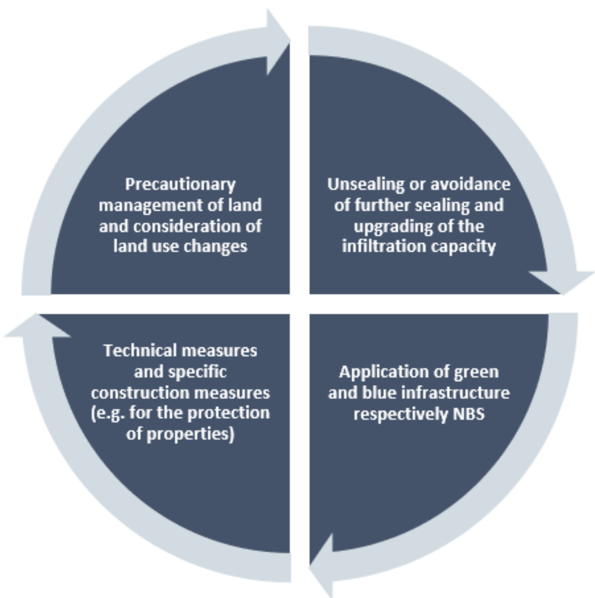

Figure 2. Central options for enhancing climate proofing in spatial planning considered in this project.

The identification of the appropriate level for the implementation of climate proofing measures in connection with specific planning instruments (step 3a) allows precautionary planning at the appropriate level and concretisation according to legal entry points at each level [84]. Figure 3 illustrates this process of the Austrian planning system involving instruments of federal, regional spatial planning, and local land-use planning as well construction plans.

Central field of measures	Heat waves	Drought	Small-scale heavy rainfall	Large-scale heavy rainfall	**Instruments regional and and supra-local spatial planning** (Federal programme, regional development programmes and small-scale regional development programmes for spatial planning) ***Objectives for planning and indicaton of measures***	**Instruments regional and and supra-local spatial planning** (Federal programme, regional development programmes and small-scale regional development programmes for spatial planning) ***Detailed planning and implementation of measures for climate proofing***	**Instruments local spatial planning** (Local development concept, zoning plan, construction plan) ***Objectives for planning and indicaton of measures***	**Instruments local spatial planning** (Local development concept, zoning plan, construction plan) ***Detailed planning and implementation of measures for climate proofing***
Steering or development of a climate-sensitive settlement structure (settlement expansion and stock)	x	(x)			FP/RDP/SSRDP		LDC/DC	ZP/ CP
Position of buildings and fresh air corridors	x	(x)			RDP/SSRDP		LDC/DC	ZP/ CP
Road orientation and cross-sections	x	x			RDP/SSRDP		LDC/DC	ZP/ CP
Securing the areas for green spaces (GI) in and between settlement structures	x	x	x	(x)	RDP/SSRDP	(FP)/RDP/SSRDP	LDC/DC	ZP
Increase in the proportion of greenery of sealed (built-up) or buildable parcels/ areas	x	x	x	(x)	FP/RDP/SSRDP		LDC/DC	CP

Figure 3. Example of the application of a hierarchy principle of targeting and implementing climate proofing considering legal entry points in different spatial planning instruments in Austria.

This tiering or gradual assessment of the various available planning instruments (3a and continuation in 3b) across different planning levels results in the possibility of developing climate proofing measures at an early stage and at an agreed level of detail. While, for example, the retention of fresh air corridors and production areas for cold air must already be ensured at a superordinate level, the small-scale and meso-climatic influence of different nature-related measures can only be specified in relation to local planning decisions [85].

Fourthly, cross-scale climate proofing can support the promotion of synergies between various adaptation goals and climate protection targets (steps 3b, 3c, 4a, and 4b) and even more importantly prevent "lock-in effects" and CO_2 sinks. In the newly developed regional spatial planning programmes in one of the three federal states (Lower Austria) carbon sinks will be explicitly addressed in the future, for instance. This was encouraged also by the newly developed climate change adaptation strategy of the federal state [86]. In some cases, however, it may also be necessary to examine impacts across different planning areas.

Especially when identifying suitable measures across sectors and aiming to foster synergies between them, a planning approach spanning planning areas may be essential as well deserving horizontal cooperation. This may be the case, for example, in protecting against the impacts of heavy rainfall, where such an approach can yield potential for an early reduction of negative effects of climate change, implying co-benefits for other adaptation targets but also human health, tourism, and recreation or biodiversity. This can be promoted both through planning at subordinate levels and through exchange or coordination at the immediate planning level within the individual steps of the framework, for example, through inter-community planning exchange and specifications.

4.2. Integration of Cross-Sectoral Perspectives

In addition to spatial planning instruments, climate proofing can also benefit from planning in other sectors. Coordinated efforts can lead to synergies between suitable instruments. Cross-sectoral cooperation, as a need for effective climate change adaptation, has been described in several studies [59,87–89]. An exchange with other sectoral planning institutions may be beneficial or even necessary with regard to several parts of the planning process. This includes both the examination of challenges that may arise due to changing meteorological phenomena, as well as their impact on the planning area and the definition of specific climate proofing targets and related uncertainties [46,59].

To sum up, an integrative assessment of challenges and opportunities for climate proofing can inform steps 1c, 2b, c and d, 3a, b and c, and 5 of the framework, in particular:

- When defining climate proofing objectives and identifying possible areas of conflict,
- When aiming to obtain and coordinate spatially appropriate data,
- For narrowing down the spatial "focus areas" to be considered for the particular climate proofing measures,
- Throughout the analysis of planning alternatives,
- In the process of identifying measures,
- When monitoring the effects of climate change impacts on different spatial contexts and in the assessment of the achievement of objectives of the gradual measures implemented.

Climate service centres and/or scientific institutions can also provide relevant assistance, particularly in the case of strategic issues. They can support the interpretation of climate projections and may provide foresighted advice on which impact models or data sets are available to estimate the specific spatial impacts of climate change in the medium and/or long term.

Coordination with other sectoral spatial planning programmes can help to identify possible conflicts with regard to the predefined climate proofing objectives at an early stage. Concrete and very topical examples with strong relevance for spatial planning include the demand of space relate to climate change mitigation, for example, for the production of renewable energy through photovoltaic and concurrence with other land uses or the conversion of small-scale forests for this purpose. This could, among other things, require the exchange of instruments of nature conservation and green space or forest planning (e.g., forest development plans) and integration of relevant information with spatial planning.

Such processes can also help to utilise existing synergies based on a shared set of objectives between different planning sectors, which in turn allows broader positive outcomes of the measures to be achieved across different sectors [59].

4.3. Re-Integration and Long-Term Coordination across Planning Levels and Planning Areas

While often efforts for climate change adaptation are started dynamically, the long-term surveillance of their implementation as well as the effectiveness of the measures undertaken deserves institutionalisation. According to some researchers [34,47,90], institutionalised long-term cooperation in climate adaptation (and the related processes such as knowledge exchange) are at the heart of successful long-term climate proofing policies. However, attempts of institutionalisation have been complicated by the shift from a centralised government to more inclusive and open governance structures [88].

As is evident from the previous sub-sections, both the definition and the achievement of objectives are influenced by the extent of coordination between different planning levels. Especially when surveying the implementation of measures, namely during monitoring, the interaction between planning levels can be another influential factor. Feedback regarding the efficiency and effectiveness of measures at each level (step 5) can provide important guidance for future revisions. Furthermore, it can ensure that future targeting processes are aligned with newer, spatially resolved impact assessment models (step 3c).

Similarly, long-term coordination with adjacent planning areas also plays an important role in successful climate proofing. Combination with other land-use changes and changes affecting spatial developments—in particular strategic processes in urban/sub-urban areas—can offer important incentives for transformation. These may also be relevant across administrative or planning boundaries.

The framework presented offers a number of novel aspects that have not yet been part of common climate proofing frameworks. Referring to the categories used in Table 1, these novel aspects are displayed in Table 2. The role of resources throughout the overall framework process but in particular at certain resource-intensive steps—such as data compilation and interpretation, implementation of climate proofing measures, or long-term institutionalisation of integrative climate proofing and its inclusion in (adaptive) monitoring of spatial plans and programmes—will be examined in detail in the follow-up research. The diverse dimensions of resources and their influence as both enablers and barriers for implementation of climate proofing will be discussed therewith based on additional actors-based empirical research.

Table 2. Novel aspects of the presented integrative climate proofing framework.

Categories	Novel Aspects of the Presented Integrative Framework	Steps of the Framework Process (See Figure 1)
Data	Integration of a recursive knowledge exchange process across stakeholders at different levels regarding relevant impact factors and available databases; feedback loops through monitoring (of climate change impacts and the implementation of climate proofing measures).	1a, 1b, and 2a, 2b, 2c, 3d
Visioning	Integration of an inclusive and iterative process of goal setting/visioning with regard to both: general climate proofing objectives and sectoral and regional spatial planning objectives; Additional process to strengthen knowledge and exchange among stakeholders regarding the co-benefits and lock-in effects of sectoral measures.	1c and 2d, 3b
Commitment, motivation, and trust	Established cross-sectoral cooperation at various planning levels can foster the commitment for the implementation of climate proofing measures; institutionalised feedback loops (established monitoring) allow multi-sectoral perspectives for balanced goal-setting and identification of the future need for climate proofing in a more integrative manner to create confidence in the relevance and at the same time survey the actual success (achievement of objectives) of these measures.	1b, c, 2d, 3a, 3b, 5
Communication (internal and external)	This involves the exchange regarding data mentioned initially and above but also the joint identification of synergistic goals and conflicting interests, as well as the maximisation of co-benefits along the hierarchy of measures for climate proofing.	2b and d, 3a-c, 4b, 5
Legal frameworks/instruments	Integration of an analysis and subsequent consideration of the current state of harmonisation and overlaps between different planning instruments across planning areas and sectors, serves as a basis for the definition of possible entry points for climate proofing within different planning institutions.	3a
Institutionalisation of CP	Integration of an institutionalised and systematic process of cooperation across different spatial planning institutions across sectors, policy levels, and planning areas, taking into account different co-benefits and interaction effects across sectors.	Entire framework, especially 4a, 4b, and 5

5. Discussion

The framework presented shows a novel and integrative approach to climate proofing across sectors, planning areas, and policy levels by combining academic insights on the inherent challenges of such complex planning processes with knowledge of various involved stakeholders.

A particular challenge addressed by the new framework concept is the proactive approach intended to foster synergies for different goals of climate proofing as well as climate change mitigation. "Nature-based solutions" as one of the four core fields of climate proofing measures can particularly contribute to these achievements. These measures can, for example, include the strategic and multifunctional implementation of green infrastructure [91]. The European Commission was also quick to emphasise the potential that this could represent. They also highlighted the benefits of combining climate change adaptation (e.g., in response to heatwaves, droughts, and heavy rainfall) and climate change mitigation objectives by stating that this combined perspective could also bring other benefits, such as the conservation or restoration of biodiversity [92].

Another strength of the framework presented is its ability to counteract the occurrence of conflicting goals and interests. For spatial planning, strategic land management is an opportunity to consider potential synergies in order to ensure the best possible coordination of adaptation to heavy rainfall events and heat, for example. Likewise, objectives of nature conservation as well as agriculture (long-term land appraisal, irrigation needs, etc.) can be included in this context, at least indirectly. At the level of spatial research—both regional and local—an initial analysis of objectives would already be desirable. This would help to counteract possible conflict potentials and to include longer-term developments in land-use planning and land-use management.

In the case of cross-sectoral cooperation projects including a range of public and private stakeholders from different sectors, the asymmetry in understanding of climate change projections or differing awareness of its severity was mentioned as a barrier in both a UK and a Zambia-based case study [93,94]. Widmer [34] also highlights the risk that the sectoral adaptation strategies mandated by planning authorities may be developed by existing staff members who lack specific climate knowledge, or that they may lack coherence in terms of content, structure, or technical language. Another barrier their study identified is uncertainty related to the potential future economic benefits of investing in climate proofing measures [93], which may be a particularly relevant barrier when private stakeholders are involved, for whom such investments need to be met by tangible economic benefits. Linked to this was the threat of adaptation measures bringing about increasing long-term utilities for different sectoral departments (e.g., for maintaining green infrastructure) that are often avoided due to limited financial resources and project evaluations that disregard the non-monetary benefits of green spaces, for example. In this regard, conflicts of interest between different planning institutions were mentioned as a threat to forward-thinking planning approaches, especially when priority is given to economic and development aims rather than environment- and health-focused aims within different sectoral planning agendas [34,93].

Given these conflicts of interest that may occur across sectors (especially those with a smaller overlap of sectoral goals with climate change considerations), several studies highlight the need for a leading or main coordinating department with a clear mandate for advancing the climate proofing of cities or regions [34,93].

In the case of climate proofing across administrative boundaries or planning areas, divergent administrative or legal structures or different departmental responsibilities can create problems. According to Widmer [34], this risk of differences in departmental structures and responsibilities also applies to collaboration across sectors. While some case studies exist that operate across planning areas, opportunities, challenges, and corresponding solutions have not received much attention in the academic literature so far, creating a distinct research gap (see [28]). The framework presented, as well as its implementation in the case study of Eastern Austria, can help to close this gap by providing an overarching structure to facilitate the systematic analysis of processes.

For vertical cooperation across different policy levels, diverging proximity to the results of climate change, or differing degrees of being directly affected by it represent a challenge to cooperation. While superordinate levels (i.e., national, or federal state level) are needed to provide overarching guidelines, strategies and, in most cases, financial and other resources, actual implementation takes place at the local level, where a certain degree of autonomy is required to adjust policy measures to specific local circumstances. Wamsler et al. [95] argue that the power struggles involved across different policy levels in Sweden result in a lack of coordination between their efforts. These misdirected efforts have great potential to negatively impact local adaptation capacities, which is why the authors suggest that countries should aim at linking policies across various policy scales rather than continuing with isolated efforts. Steurer et al. [96], in cases of the building sector in Switzerland and Austria, also highlight the risk of policies or strategies being "watered down" to the smallest common denominator by federal state/regional policy-makers, partly in response to power struggles and lack of representation in the strategy development process.

6. Concluding Thoughts and Outlook

The conceptual approach, despite being thoroughly discussed in workshops with the relevant actors from all three regions and tested for its applicability, faces possible limiting conditions in terms of practical implementation. As such, numerous studies have identified both drivers and barriers to climate change adaptation [2,97,98], some of which have specifically been analysed in the context of multi-level, integrative approaches [34,93]. According to Swart et al. [2], not all characteristics are necessarily present in every process, but they may be interrelated and, as a result, present difficult challenges. Some of the barriers are particularly relevant for structures that extend planning areas if they require different planning systems to interact with each other.

To examine whether and to what extent the challenges mentioned above could impede the implementation of the framework concept, empirical studies have been carried out in the planning area of Eastern Austria. This includes interviews with experts from spatial planning but also with sectors relevant to spatial interaction with climate proofing such as forestry, water management, or geology, in order to find out more about potential drivers and barriers to achieving an integrative climate proofing approach. To address the complex and interdependent urban and sub-urban context—particularly for the implementation of climate proofing measures—additional departments such as those of nature conservation and green area management were involved.

The interviews have been analysed and will be published in the next phase of the project in order to allow adjustment of the framework presented to the specific challenges of the given planning context. The results are expected to foster processes of institutionalising climate proofing across different sectors as well as policy and planning levels.

In light of the various challenges to climate proofing that integrates actors from various sectors and policy levels, this paper emphasises the key role of spatial planning in fostering an integrative climate proofing and its core duty to consider and resolve conflicts of interest. The framework presented including the explanations and illustrations from the Austrian planning practice can help to encourage awareness of such problems by targeting the inclusion of different sectors early in the planning process and focusing on aligning their planning objectives and institutionalising joint planning processes. With an increasing amount of (semi-institutionalised) cooperation taking place between various planning levels and institutions, such a systematic and integrative approach seems highly relevant.

Author Contributions: Conceptualisation, A.J.-P.; investigation, A.J.-P., M.J., F.R.; Authors; writing—original draft preparation, A.J.-P., M.J., F.R.; writing—review and editing, A.J.-P., M.J., R.W.; visualisation, F.R., M.J.; project administration, A.J.-P., F.R.; funding acquisition, A.J.-P., F.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Planungsgemeinschaft OST, whose purpose is to coordinate and prepare spatial planning activities between the three federal Austrian states of Vienna, Lower Austria, and Burgenland.

Acknowledgments: We particularly thank the involved members of the PGO office, as well as all members of the project steering group.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Goosen, H.; de Groot-Reichwein, M.A.M.; Masselink, L.; Koekoek, A.; Swart, R.; Bessembinder, J.; Witte, J.M.P.; Stuyt, L.; Blom-Zandstra, G.; Immerzeel, W. Climate Adaptation Services for the Netherlands: An operational approach to support spatial adaptation planning. *Reg. Environ. Chang.* **2014**, *14*, 1035–1048. [CrossRef]
2. Swart, R.; Sedee, A.G.J.; de Pater, F.; Goosen, H.; Pijnappels, M.; Vellinga, P. Climate-Proofing Spatial Planning and Water Management Projects: An Analysis of 100 Local and Regional Projects in the Netherlands. *J. Environ. Policy Plan.* **2014**, *16*, 55–74. [CrossRef]
3. Van den Brink, M.; Meijerink, S.; Termeer, C.; Gupta, J. Climate-proof planning for flood-prone areas: Assessing the adaptive capacity of planning institutions in the Netherlands. *Reg. Environ. Chang.* **2014**, *14*, 981–995. [CrossRef]
4. Labedens, S.; Scartezzini, J.; Mauree, D. Modeling the effects of future urban planning scenarios on the Urban Heat Island in a complex region. *Submitted to Urban Clim.* **2018**, 1–41. Available online: https://eartharxiv.org/repository/view/1204/ (accessed on 15 March 2021).
5. Morabito, M.; Crisci, A.; Guerri, G.; Messeri, A.; Congedo, L.; Munafò, M. Surface urban heat islands in Italian metropolitan cities: Tree cover and impervious surface influences. *Sci. Total Environ.* **2021**, *751*, 142334. [CrossRef] [PubMed]
6. Alcoforado, M.J.; Andrade, H.; Lopes, A.; Vasconcelos, J. Application of climatic guidelines to urban planning. The example of Lisbon (Portugal). *Landsc. Urban Plan.* **2009**, *90*, 56–65. [CrossRef]
7. Stoffel, M.; Tiranti, D.; Huggel, C. Climate change impacts on mass movements—Case studies from the European Alps. *Sci. Total Environ.* **2014**, *493*, 1255–1266. [CrossRef]
8. Schlögel, R.; Kofler, C.; Gariano, S.L.; Van Campenhout, J.; Plummer, S. Changes in climate patterns and their association to natural hazard distribution in South Tyrol (Eastern Italian Alps). *Sci. Rep.* **2020**, *10*, 5022. [CrossRef]
9. Gruber, M.; Kanonier, A.; Pohn-Weidinger, S.; Schindelegger, A. *Spatial Planning in Austria with References to Spatial Development and Regional Policy*; ÖROK: Vienna, Austria, 2018; ISBN 9783950414639.
10. BMU. *Dem Klimawandel Begegnen. Die Deutsche Anpassungsstrategie*; Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit: Berlin, Germany, 2009.
11. BMU. Aktionsplan Anpassung der Deutschen Anpassungsstrategie an den Klimawandel. Available online: https://www.bmu.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/aktionsplan_anpassung_klimawandel_bf.pdf (accessed on 5 April 2021).
12. Altvater, S.; van de Sandt, K.; Marinova, N.; de Block, D.; Klostermann, J.; Swart, R.; Bouwma, I.; McCallum, S.; Dworak, T.; Osberghaus, D. *Assessment of the Most Significant Threats to the EU Posed by the Changing Climate in the Short, Medium and Long Term—Task 1 Report*; Ecologic: Berlin, Germany, 2011.
13. Bollinger, L.A.; Bogmans, C.W.J.; Chappin, E.J.L.; Dijkema, G.P.J.; Huibregtse, J.N.; Maas, N.; Schenk, T.; Snelder, M.; van Thienen, P.; de Wit, S.; et al. Climate adaptation of interconnected infrastructures: A framework for supporting governance. *Reg. Environ. Chang.* **2014**, *14*, 919–931. [CrossRef]
14. Lomba-Fernández, C.; Hernantes, J.; Labaka, L. Guide for climate-resilient cities: An urban critical infrastructures approach. *Sustainability* **2019**, *11*, 4727. [CrossRef]
15. Hurlimann, A.C.; March, A.P. The role of spatial planning in adapting to climate change. *Wiley Interdiscip. Rev. Clim. Chang.* **2012**, *3*, 477–488. [CrossRef]
16. Pütz, M.; Kruse, S.; Butterling, M. *Bewertung der Klimawandel-Fitness der Raumplanung: Ein Leitfaden für PlanerInnen*; Projekt CLISP, ETC Alpine Space Programm: Birmendorf/Bern, Switzerland, 2011; pp. 1–43.
17. De Groot-Reichwein, M.A.M.; Goosen, H.; van Steekelenburg, M.G.N. Climate proofing the Zuidplaspolder: A guiding model approach to climate adaptation. *Reg. Environ. Chang.* **2014**, *14*, 909–918. [CrossRef]
18. Birkmann, J.; Greiving, S.; Serdeczny, O.M. Das Assessment von Vulnerabilitäten, Risiken und Unsicherheiten. In *Klimawandel in Deutschland: Entwicklung, Folgen, Risiken und Perspektiven*; Brasseur, G.P., Jacob, D., Schuck-Zöller, S., Eds.; Springer: Berlin/Heidelberg, Germany, 2017; pp. 267–276. ISBN 978-3-662-50397-3.
19. Houghton, A.; Castillo-Salgado, C. Analysis of correlations between neighborhood-level vulnerability to climate change and protective green building design strategies: A spatial and ecological analysis. *Build. Environ.* **2020**, *168*, 106523. [CrossRef]
20. Kruse, S.; Pütz, M. Adaptive Capacities of Spatial Planning in the Context of Climate Change in the European Alps. *Eur. Plan. Stud.* **2014**, *22*, 2620–2638. [CrossRef]
21. Saunders, F.; Gilek, M.; Day, J.; Hassler, B.; McCann, J.; Smythe, T. Examining the role of integration in marine spatial planning: Towards an analytical framework to understand challenges in diverse settings. *Ocean Coast. Manag.* **2019**, *169*, 1–9. [CrossRef]

22. UBA. *Klimaanpassung in der Räumlichen Planung Starkregen, Hochwasser, Massenbewegungen, Hitze, Dürre*; Umweltbundesamt: Dessau-Rößlau, Germany, 2016.
23. UBA. *Klimaanpassung im Raumordnungs-, Städtebau- und Umweltfachplanungsrecht Sowie im Recht der Kommunalen Daseinsvorsorge-Grundlagen, Aktuelle Entwicklungen und Perpektiven*; Umweltbundesamt: Dessau-Rößlau, Germany, 2018.
24. Hurlimann, A.; Wilson, E. Sustainable urban water management under a changing climate: The role of spatial planning. *Water* **2018**, *10*, 546. [CrossRef]
25. Birkmann, J.; Fleischhauer, M. Anpassungsstrategien der Raumentwicklung an den Klimawandel: "Climate Proofing"-Konturen eines neuen Instruments. *Raumforsch. Raumordn.* **2009**, *67*, 114–127. [CrossRef]
26. Pieterse, A.; Van Niekerk, W.; du Toit, J. Creating Resilient Settlements through Climate Change Adaptation Planning. In Proceedings of the Planning Africa Conference 2018, Cape Town, South Africa, 15–17 October 2018.
27. Bush, J.; Doyon, A. Building urban resilience with nature-based solutions: How can urban planning contribute? *Cities* **2019**, *95*, 102483. [CrossRef]
28. Von Haaren, C.; Haller, C. Einleitung. In *Zukunftsfähiger Umgang mit Wasser im Raum*; von Haaren, C., Haller, C., Eds.; VSB Verlagsservice Braunschweig GmbH: Hannover, Germany, 2011; pp. 11–15. ISBN 9783888380631.
29. Grafakos, S.; Pacteau, C.; Delgado, M.; Landauer, M.; Lucon, O.; Driscoll, P. Integrating Mitigation and Adaptation Opportunities and Challenges. In *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network*; Rosenzweig, C., Solecki, W., Romero-Lankao, P., Mehrotra, S., Dhakal, S., Ibrahim, S.A., Eds.; Cambridge University Press: New York, NY, USA, 2018; pp. 101–138. ISBN 978-1316603338.
30. Landauer, M.; Juhola, S.; Klein, J. The role of scale in integrating climate change adaptation and mitigation in cities. *J. Environ. Plan. Manag.* **2019**, *62*, 741–765. [CrossRef]
31. Probst, T.; Hohmann, R. Climate Adaptation Governance in Switzerland Final Country Report. 2018. Available online: https://www.alpine-space.eu/projects/goapply/results/results_revised/goapply_d.t1.2.1_d.t1.3.1_wp1_transntional-synthesis-report_foen-wsl_final.pdf (accessed on 13 March 2021).
32. Van Buuren, A.; van Buuren, A.; Driessen, P.P.J.; van Buuren, A.; Driessen, P.P.J.; van Rijswick, M.; van Buuren, A.; Driessen, P.P.J.; van Rijswick, M.; Rietveld, P.; et al. Towards Adaptive Spatial Planning for Climate Change: Balancing Between Robustness and Flexibility. *J. Eur. Environ. Plan. Law* **2013**, *10*, 29–53. [CrossRef]
33. Bauer, A.; Feichtinger, J.; Steurer, R. The Governance of Climate Change Adaptation in 10 OECD Countries: Challenges and Approaches. *J. Environ. Policy Plan.* **2012**, *14*, 279–304. [CrossRef]
34. Widmer, A.M. Mainstreaming climate adaptation in Switzerland: How the national adaptation strategy is implemented differently across sectors. *Environ. Sci. Policy* **2018**, *82*, 71–78. [CrossRef]
35. GIZ. *Guiding Urban Concepts and Climate Change in Germany's Urban Planning Practice: A Review of the Recent Academic Discourse*; Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ): Bonn, Germany, 2018.
36. Pietrapertosa, F.; Salvia, M.; De Gregorio Hurtado, S.; D'Alonzo, V.; Church, J.M.; Geneletti, D.; Musco, F.; Reckien, D. Urban climate change mitigation and adaptation planning: Are Italian cities ready? *Cities* **2019**, *91*, 93–105. [CrossRef]
37. Floater, G.; Heeckt, C.; Ulterino, M.; Mackie, L.; Rode, P.; Bhardwaj, A.; Carvalho, M.; Gill, D.; Bailey, T.; Huxley, R.; et al. Co-Benefits of Urban Climate Action: A Framework for Cities. 2016. Available online: https://www.c40.org/researches/c40-lse-cobenefits (accessed on 12 June 2021).
38. Rannow, S.; Loibl, W.; Greiving, S.; Gruehn, D.; Meyer, B.C. Potential impacts of climate change in Germany-Identifying regional priorities for adaptation activities in spatial planning. *Landsc. Urban Plan.* **2010**, *98*, 160–171. [CrossRef]
39. Araos, M.; Berrang-Ford, L.; Ford, J.D.; Austin, S.E.; Biesbroek, R.; Lesnikowski, A. Climate change adaptation planning in large cities: A systematic global assessment. *Environ. Sci. Policy* **2016**, *66*, 375–382. [CrossRef]
40. Widmer, A.M. The Governance of Climate Change Adaption in Switzerland Issues, Actors, and Processes at the National and Cantonal Level and in Land-Use Relevant Policies. Ph.D. Thesis, ETH Zürich, Zurich, Switzerland, 2014.
41. Widmer, A.M. Integrating Climate Change Adaptation Policy in Switzerland. In Proceedings of the ECPR General Conference, Prague, Czech Republic, 7–10 September 2016; pp. 1–32.
42. Scheltema, M. Mainstreaming Urban Climate Adaptation into Urban Planning and Design. Master's Thesis, Wageningen University, Wageningen, The Netherlands, 2017.
43. Rechid, D.; Petersen, J.; Schoetter, R.; Jacob, D. *Klimaprojektionen für Die Metropolregion Hamburg*; TuTech Verlag: Hamburg, Germany, 2014; Volume 1.
44. InKoKa Leitfaden zur Klimaanpassung: Ein Nachschlagewerk für Kommunen der Metropolregion Nordwest. Metropolregion Metropolregion Bremen-Oldenburg im Nordwesten e. V., Delmenhorst, Germany. 2016. Available online: https://www.metropolregion-nordwest.de/downloads/datei/OTAwMDAwNTg3Oy07L3Vzci9sb2NhbC9odHRwZC92aHRkb2NzL2Ntc3gvbWV0cm9wb2xyZWdpb24vbWVkaWVuL2Rva3VtZW50ZS9sZWl0ZmFkZW5fenVyX2tsaW1hYW5wYXNzdW5nX3dlYi5wZGY%3D (accessed on 8 March 2021).
45. Vogt, V.; Atzl, S.; Klimopass, F. Entwicklung Modellhafter Anpassungsstrategien der Regionalen Straßeninfrastruktur in der Metropolregion Stuttgart an den Klimawandel. Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg (LUBW), Karlsruhe, Germany. 2016. Available online: https://pudi.lubw.de/detailseite/-/publication/57980 (accessed on 2 April 2021).

46. Wachsmuth, J. Cross-sectoral integration in regional adaptation to climate change via participatory scenario development. *Clim. Chang.* **2015**, *132*, 387–400. [CrossRef]
47. Van Eerd, M.C.J.; Wiering, M.A.; Dieperink, C. Exploring the prospects for cross-border climate change adaptation between North Rhine-Westphalia and the Netherlands. *Utr. Law Rev.* **2014**, *10*, 91–106. [CrossRef]
48. Vinke-de Kruijf, J.; Pahl-Wostl, C. A multi-level perspective on learning about climate change adaptation through international cooperation. *Environ. Sci. Policy* **2016**, *66*, 242–249. [CrossRef]
49. Von Haaren, C.; Moss, T. Voraussetzungen für ein integriertes Management: Koordination und Kooperation der wasserrelevanten Akteure und Organisationen in Deutschland. In *Zukunftsfähiger Umgang mit Wasser im Raum*; von Haaren, C., Haller, C., Eds.; VSB Verlagsservice Braunschweig GmbH: Hannover, Germany, 2011; pp. 67–81. ISBN 9783888380631.
50. UN Water. Climate Change and Water—UN-Water Policy Briefs. UN-Water Technical Advisory Unit, Geneva. 2019, pp. 1–28. Available online: https://www.unwater.org/publications/un-water-policy-brief-on-climate-change-and-water/ (accessed on 11 March 2021).
51. Persson, Å. *Environmental Policy Integration: An Introduction*; Stockholm Environmental Institute (SEI): Stockholm, Sweden, 2004.
52. Ingram, J.; Hamilton, C. *Planning for Climate Change: A Strategic, Values-Based Approach For Urban Planners*; UN-Habitat: Nairobi, Kenya, 2012; ISBN 9789211324006.
53. Calliari, E.; Staccione, A.; Mysiak, J. An assessment framework for climate-proof nature-based solutions. *Sci. Total Environ.* **2019**, *656*, 691–700. [CrossRef] [PubMed]
54. Aguiar, F.C.; Bentz, J.; Silva, J.M.N.; Fonseca, A.L.; Swart, R.; Santos, F.D.; Penha-Lopes, G. Adaptation to climate change at local level in Europe: An overview. *Environ. Sci. Policy* **2018**, *86*, 38–63. [CrossRef]
55. Harrison, P.A.; Dunford, R.W.; Holman, I.P.; Rounsevell, M.D.A. Climate change impact modelling needs to include cross-sectoral interactions. *Nat. Clim. Chang.* **2016**, *6*, 885–890. [CrossRef]
56. IPCC. *Climate Change 2014: Synthesis Report*; Intergovernmental Panel on Climate Change (IPCC): Geneva, Switzerland, 2015; ISBN 9789291691432.
57. Rotterdam Climate Initiative. Rotterdam: Climate Change Adaptation Strategy; Rotterdam, The Netherlands. 2013. Available online: http://www.urbanisten.nl/wp/wp-content/uploads/UB_RAS_EN_lr.pdf (accessed on 27 March 2021).
58. Kim, D.; Lim, U. Urban resilience in climate change adaptation: A conceptual framework. *Sustainability* **2016**, *8*, 405. [CrossRef]
59. Serrao-Neumann, S.; Crick, F.; Harman, B.; Sano, M.; Sahin, O.; van Staden, R.; Schuch, G.; Baum, S.; Low Choy, D. Improving cross-sectoral climate change adaptation for coastal settlements: Insights from South East Queensland, Australia. *Reg. Environ. Chang.* **2014**, *14*, 489–500. [CrossRef]
60. Valente, S.; Veloso-Gomes, F. Coastal climate adaptation in port-cities: Adaptation deficits, barriers, and challenges ahead. *J. Environ. Plan. Manag.* **2020**, *63*, 389–414. [CrossRef]
61. Juhola, S.; Westerhoff, L. Challenges of adaptation to climate change across multiple scales: A case study of network governance in two European countries. *Environ. Sci. Policy* **2011**, *14*, 239–247. [CrossRef]
62. Van Eerd, M.C.J.; Wiering, M.A.; Meijerink, S. *Integrated, Transboundary Climate-Adaptation Governance: Exploring Essential Steps for the Development of a Cross-Border and Integrated Climate Adaptation Strategy*; National Research Programme Knowledge for Climate: Nijmegen, The Netherlands, 2014; ISBN 9789492100115.
63. Steele, W.; Sporne, I.; Dale, P.; Shearer, S.; Singh-Peterson, L.; Serrao-Neumann, S.; Crick, F.; Choy, D.L.; Eslami-Andargoli, L. Learning from cross-border arrangements to support climate change adaptation in Australia. *J. Environ. Plan. Manag.* **2014**, *57*, 682–703. [CrossRef]
64. Ledda, A.; Di Cesare, E.A.; Satta, G.; Cocco, G.; Calia, G.; Arras, F.; Congiu, A.; Manca, E.; De Montis, A. Adaptation to climate change and regional planning: A scrutiny of sectoral instruments. *Sustainability* **2020**, *12*, 3804. [CrossRef]
65. PGO. Zwischenbericht Stadtregion+ (SRO+); Vienna. 2011. Available online: https://www.planungsgemeinschaft-ost.at/no_cache/studien/ansicht/detail/studie/zwischenbericht-stadtregion-sro/ (accessed on 5 April 2021).
66. Reniu, M.G. Evapotranspiration Projections in Austria under Different Climate Change Scenarios. Master's Thesis, University of Natural Resources and Life Sciences, Vienna, Austria, 2017.
67. Žuvela-Aloise, M.; Koch, R.; Buchholz, S.; Früh, B. Modelling the potential of green and blue infrastructure to reduce urban heat load in the city of Vienna. *Clim. Chang.* **2016**, *135*, 425–438. [CrossRef]
68. Stadt Wien-MA 22 Urban Heat Island Strategy City of Vienna, Stadt Wien. 2018. Available online: https://www.wien.gv.at/umweltschutz/raum/pdf/uhi-strategieplan-englisch.pdf (accessed on 5 April 2021).
69. Willows, R.I.; Reynard, N.; Meadowcroft, I.; Connell, R.K. Climate adaptation: Risk, uncertainty and decisionmaking. In *UKCIP Technical Report*; Willows, R.I., Connell, R.K., Eds.; Climate Impacts Programme: Uxford, UK, 2003; pp. 41–87.
70. EC. *Guidelines on Developing Adaptation Strategies*; European Commission: Brussels, Belgium, 2013; Available online: https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/swd_2013_134_en.pdf (accessed on 27 March 2021).
71. UN-Habitat. *Planning for Climate Change: A Strategic, Values-Based Approach for Urban Planners-Toolkit*; United Nations Human Settlements Programme (UN-Habitat): Nairobi, Kenya, 2014; ISBN 978-92-1-132597-3.
72. Raymond, C.M.; Frantzeskaki, N.; Kabisch, N.; Berry, P.; Breil, M.; Nita, M.R.; Geneletti, D.; Calfapietra, C. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environ. Sci. Policy* **2017**, *77*, 15–24. [CrossRef]

73. Neely, B.; Mccarthy, P.; Cross, M.; Enquist, C.; Garfin, G.; Gori, D.; Hayward, G.; Schulz, T. *Climate Change Adaptation Workshop for Natural Resource Managers in the Gunnison Basin: Summary*; Southwest Climate Change Initiative: Gunnison, CO, USA, 2010.
74. GIZ; UNEP-WCMC; FEBA. *Guidebook for Monitoring and Evaluating Ecosystem-Based Adaptation Interventions*; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH: Bonn, Germany, 2020.
75. World Bank. *Implementing Nature Based Flood Protection: Principles and Implementation Guidance*; The World Bank Group: Washington, DC, USA, 2017.
76. GIZ; CMP. *Conservation Standards Applied to Ecosystem-based Adaptation*; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH: Bonn, Germany, 2020.
77. Gan, G.; Liu, Y.; Sun, G. Understanding interactions among climate, water, and vegetation with the Budyko framework. *Earth Sci. Rev.* **2021**, *212*, 103451. [CrossRef]
78. Fini, A.; Frangi, P.; Mori, J.; Donzelli, D.; Ferrini, F. Nature based solutions to mitigate soil sealing in urban areas: Results from a 4-year study comparing permeable, porous, and impermeable pavements. *Environ. Res.* **2017**, *156*, 443–454. [CrossRef] [PubMed]
79. Podhrázská, J.; Kučera, J.; Karásek, P.; Szturc, J.; Konečná, J. The Effect of Land Management on the Retention Capacity of Agricultural Land in the Conditions of Climate Change—Case Study. *J. Ecol. Eng.* **2020**, *22*, 258–266. [CrossRef]
80. Reinwald, F.; Ring, Z.; Kraus, F.; Kainz, A.; Tötzer, T.; Damyanovic, D. Green Resilient City—A framework to integrate the Green and Open Space Factor and climate simulations into everyday planning to support a green and climate-sensitive landscape and urban development. In *IOP Conference Series: Earth and Environmental Science, Vol. 323: Sustainable Built Environment Conference 2019, 11–14 September 2019, Graz, Austria*; IOP Publishing Ltd: Bristol, UK, 2019.
81. Vartholomaios, A.; Kalogirou, N.; Athanassiou, E.; Papadopoulou, M. The green space factor as a tool for regulating the urban microclimate in vegetation-deprived Greek cities. In Proceedings of the International Conference on "Changing Cities": Spatial, Morphological, Formal & Socio-Economic Dimensions, Skiathos Island, Greece, 18–21 June 2013. [CrossRef]
82. UNISDR. *How To Make Cities More Resilient. A Handbook For Local Government Leaders*; United Nations International Strategy for Disaster Risk Reduction: Geneva, Switzerland, 2012; ISBN 978-92-1-101496-9.
83. Chapman, E.; Nieuwenhuijs, A. User Guide: The Resin Decision Support Tools for Climate Change Adaption; Freiburg, Germany. 2018. Available online: https://resin-cities.eu/fileadmin/user_upload/Handbooks/RESIN-D4-3-guide-ENGLISH-www.pdf (accessed on 5 April 2021).
84. Nalau, J.; Preston, B.L.; Maloney, M.C. Is adaptation a local responsibility? *Environ. Sci. Policy* **2015**, *48*, 89–98. [CrossRef]
85. Damyanovic, D.; Reinwald, F.; Brandenburg, C.; Allex, B.; Gantner, B.; Morawetz, U.; Preiss, J. Pilot Action City of Vienna—UHI-STRAT Vienna. In *Counteracting Urban Heat Island Effects in a Global Climate Change Scenario*; Musco, F., Ed.; Springer International Publishing: Cham, Germany, 2016; pp. 257–280. ISBN 978-3-319-10425-6.
86. Amt der NÖ Landesregierung. NÖ Klima- und Energiefahrplan 2020 bis 2030. 2020. Available online: https://www.noe.gv.at/noe/Energie/Energiefahrplan_2030.html (accessed on 5 April 2021).
87. England, M.I.; Dougill, A.J.; Stringer, L.C.; Vincent, K.E.; Pardoe, J.; Kalaba, F.K.; Mkwambisi, D.D.; Namaganda, E.; Afionis, S. Climate change adaptation and cross-sectoral policy coherence in southern Africa. *Reg. Environ. Chang.* **2018**, *18*, 2059–2071. [CrossRef]
88. Biesbroek, G.R.; Swart, R.J.; Knaap, W.G.M. Van Der The mitigation—Adaptation dichotomy and the role of spatial planning. *Habitat Int.* **2009**, *33*, 230–237. [CrossRef]
89. Adger, W.N.; Arnell, N.W.; Tompkins, E.L. Successful adaptation to climate change across scales. *Glob. Environ. Chang.* **2005**, *15*, 77–86. [CrossRef]
90. Vitale, C.; Meijerink, S.; Moccia, F.D.; Ache, P. Urban flood resilience, a discursive-institutional analysis of planning practices in the Metropolitan City of Milan. *Land Use Policy* **2020**, *95*, 104575. [CrossRef]
91. Gill, S.; Forest, T.M.; Ennos, R. Adapting Cities for Climate Change: The Role of the Green Infrastructure. *Built Environ.* **2007**, *33*, 115–133. [CrossRef]
92. EC. *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment*; European Commission: Brussels, Belgium, 2013; Available online: http://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf (accessed on 5 April 2021).
93. Carter, J.G.; Cavan, G.; Connelly, A.; Guy, S.; Handley, J.; Kazmierczak, A. Climate change and the city: Building capacity for urban adaptation. *Prog. Plann.* **2015**, *95*, 1–66. [CrossRef]
94. Vincent, K.; Colenbrander, W. Developing and applying a five step process for mainstreaming climate change into local development plans: A case study from Zambia. *Clim. Risk Manag.* **2018**, *21*, 26–38. [CrossRef]
95. Wamsler, C.; Johannessen, Å. Meeting at the crossroads? Developing national strategies for disaster risk reduction and resilience: Relevance, scope for, and challenges to, integration. *Int. J. Disaster Risk Reduct.* **2020**, *45*. [CrossRef]
96. Steurer, R.; Clar, C.; Casado-Asensio, J. Climate change mitigation in Austria and Switzerland: The pitfalls of federalism in greening decentralized building policies. *Nat. Resour. Forum* **2020**, *44*, 89–108. [CrossRef]
97. Biesbroek, G.R.; Klostermann, J.E.M.; Termeer, C.J.A.M.; Kabat, P. On the nature of barriers to climate change adaptation. *Reg. Environ. Chang.* **2013**, *13*, 1119–1129. [CrossRef]
98. Simonet, G.; Leseur, A. Barriers and drivers to adaptation to climate change—A field study of ten French local authorities. *Clim. Chang.* **2019**, *155*, 621–637. [CrossRef]