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Towards a New Governance for Urban Heat Action Planning SMARTilience Real World Lab: Collection and Use of Urban Data to Manage Social Vulnerabilities Related to Extreme Weather Events

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Abstract

Human mortality and health problems linked to urban heat islands are emerging research topics in urban studies. To address the topic effectively a new governance model is needed to collect and use climate related data that give evidence for urban heat islands and weather-related vulnerabilities in cities. Visualization of data-based scenarios can offer opportunities for societal acceptance of data collection and for state intervention that addresses urban adaptation and heat action planning. The paper integrates social innovation, learning in cities and non-technical, nature-based solutions. The case study of Mannheim city illustrates how city administration actively bridge organizational silos to manage an open access GIS-data platform and participially develop new routines for an urban heat action plan. Data was obtained in a real-world lab design with universities, industry, and Fraunhofer research funded by the German ministry of education and research, BMBF.

Keywords: Urban GIS data; Heat action planning; Transformative governance; Climate change adaptation

Introduction

Climate change creates new risks for European cities: Heat islands effects bring higher number of cardio-vasculature diseases. Rising temperatures cause range shifts of fauna and flora. Non-native invasive species carry vectors and pathogenic agents which thrive in warm climates [1]. There is a high probability that Europe will see an increase in health problems related to rising temperature and extreme weather events (IPCC 2022) [2,3]. Therefore, adequate local adaptation strategies will become important to maintain the livability in urban agglomerations. The universal role of administrations is to provide for the protection of vulnerable citizens. Consequently, public funding for climate and vulnerability studies as well as for adaptation concepts is provided by the German Ministry of Environment for communities and smaller cities in the German Bundeslander. The protection schemes are either linked to climate mitigation and integrated action to cope with disaster recovery like heat action planning or to long-term urban adaptation of the built environment. However, do city administrations have the adequate response diversity (Walker et al. 2023) to switch from disaster mode to anticipatory urban adaptation? What is needed to adapt cities to changing climate conditions? We discuss the hypothesis that science-led climate action needs (1) clarification of organizational roles in the administration, (2) process governance for intervention as well as (3) KPI based-impact monitoring involving the citizens [4].

The analyses of social vulnerabilities in Mannheim are based on climate data of the German Weather Service and on Isotherm city maps of an external service provider (Figure 1). These visualizations provide common ground for joint decision making of city administration and citizens [6] and for the rapid implementation of actions in favour of those who cannot help

themselves and to protect critical infrastructure. Therefore, city administration must be reconsidered an important player that defines the legal and cultural frameworks to mitigate the dilemma of exclusion and provides new rules and routines for integration [7,8]. We discuss barriers and solutions for the collection and the use of data and show new digital developments and routines like the heat action plan. The case of Mannheim sheds light on a new governance for disaster recovery and climate change adaptation.

The research question: How are urban climate policies implemented and how can data-driven models, old and new players create a governance process to manage climate adaptation / transformation? Can system-thinking, co-creation, and integrated management lead to a better governance of impact pathways and to swifter action? The learning setting of the real-world lab is a new and important organizational element that contributes to a more effective and efficient governance for implementation and for protection of vulnerable groups in an urban context.

Structure of the Paper

We will present literature related to climate change, extreme weather events and climate urgency related to health and wellbeing in cities. Governance is discussed in the framing of ecological governance provided by Clement & Standish (2018) and linked to the debate of vulnerability in political ecology [9]. The case is presented with empirical data from the real-world lab Mannheim which includes interviews in the institutional ecosystem of data generation and use of data, matched with data obtained in interviews in the Mannheim city administration and workshops with German follower cities and the core team of the BMBF-funded resilient city program Smartilience (Izdebska et al. (2022)). We illustrate the situation in a problem tree and depict the impact pathway [10] from science-based evidence to city action planning. The practical findings are discussed in the context of a revised governance approach. The discussion links new data driven procedures to urban governance and outlines the management requirements. The study highlights the impact of technology, and citizen participation on urban administration.

Literature Review

Real world laboratories and system understanding for wicked problems

Real World Laboratories (RWL) are an experiential learning approach to test new methods, routines and solutions (Schäpke et al. 2018; Calzada 2020) beyond the rigid and dense framework of existing rules. RWL foresee the participation of different stakeholders and experts in transformational, interdisciplinary and translational development towards suitable and accepted actions for highly complex problems in the urban context [11]. Urban Living Labs test and transfer innovative solutions with the aim to transfer research to practice and create more resilient communities with a place-based approach (Singer-Brodowski, Beecroft, Parodi, 2018), [12,13]. RWL are employed to overcome limitations inherent in the Weberian bureaucratic model which is ill-suited for new problems and for swift adaptations in the public management [14].

Sadly, climate urgency programs and the implementation of environmental policies in general are prone to blockages as goals are fuzzy and diverging, the roles of different stakeholders are not clear, and new processes contradict existing routines and practices. In these situations, effectiveness and efficiency of teams can be easily hampered by interpersonal conflicts and lack of trust [15] as well as conflicts of interest. Further, manifold causes and interrelations of topics trigger a crises mode behavior that overshadows long term risk planning. Hodkinson (2011) warns 'that the current climate crisis has coincided with a biodiversity crisis, which in turn has been met by a taxonomic crises' (Hodkinson et al. 2011). In climate change different topics and also high order interaction take place with unpredictable outcomes or with a certain degree of insecurity inherent in every modelled system.

To address the relationship between biodiversity, ecosystem stability and perturbations like climate change, and the effects of singular extreme weather "events", applied research does not only produce new data (Jentsch, Kreyling & Beierkuhnlein 2007; Maxwell et al. 2019) but engages in explaining and predicting patterns for range shifts of fauna and flora, the impact of nature based solutions, and altered human behavior [16]. Spatial mapping of GIS data can help to visualize hotspots and vulnerabilities to develop management schemes that support resilience through promotion of response diversity (Walker et al. 2023). Enabling stakeholders, and orchestrating systems are new roles of the administrative body to enable communities to cope with climate change adaptation in the urban context [14,17].

In that new understanding, variation of responses to environmental change, functional redundancy and response diversity "insure" cities and citizens against shocks, perturbations and long-term change (Response diversity: Mori, Furukawa and Sasaki, 2013M); (Insurance: Yachi and Loreau, 1999). Therefore, the question of stability has shifted to resilience of systems and variety of answers and different modes of governance [18]. Köhler et al. 2010 underline the importance of visible impact and the translation of real-world experiments and niche solutions into new standards and framework conditions for system behavior [18]. Niche solutions for wicked problems can be tested in real world labs and upscaling new socio-technical regimes is facilitated in this adaptative governance approach towards transformation .

Consequently, Holling & Meffee [19] emphasize the need for an altered management approach and discuss the pathologies of traditional command and control structures for addressing these environmental-social systems [19-21].

Value of data and intervention points

Climate urgency is a relatively new term to legitimize intervention and climate change is a long and lengthily discussed phenomenon based on different climate models. How can climate

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models help to protect vulnerable groups that are affected by extreme weather events? Will these models provide a legitimate basis for state intervention? Can task forces and administration be trained to manage these projects and to solve two sets of problems: how to organize and manage an interdisciplinary and intersectoral team of professionals in the administration and how to coordinate the actions and commitments of a larger network of citizens, experts and organizations in the city [21].

In the world of climate modelling different numerical climate models that use quantitative methods to simulate the interactions of drivers of climate atmosphere, oceans, land surface and ice to study the dynamics of the climate system rely on data that is either based on relatively stable climate conditions (recorded human history) - or on fossil records (Hodkinson et al. 2011) and on greenhouse gas levels stored in ice cores (BAS 2014). The latter show that severe climate changes took place with mass extinctions. That shows us that a. it is difficult to build a valid and accepted model (May, 1972; Donohue et al. 2016) and b. there must be tipping points where systems collide or change (Lenton, 2019). Furthermore, ecosystems and species can be lost, but they can also recover (or other species provide equal functional traits). Priming (stress caused by perturbations) might build better, more resilient species and also robust ecosystems (Hasanuzzaman and Fotopoulos, 2019). Biodiversity plays a crucial role (Folke et al. 2004), but the time factor (response time, transition time) and the change dimension in these models are critical points for research related to conservation plans. Prediction power of models is low in both points.

Furthermore, Maxwell et al. (2019) states that "(...) plans largely ignore another key factor of climate change—changes in the frequency and intensity of extreme weather and climate events". The IPCC report (2022) shows that in a simplistic perspective "hotter, drier, wetter" will be the new normal. As we encounter single extreme events with an increased frequency observation studies that focus on ecosystem and species responses to extreme events can detect potential risk and vulnerability for the selection of ecosystems and species for conservation and for the mitigation of risks. They can identify the current negative impacts (damage) and the most vulnerable persons. This can be done in a relatively simple research design and with good (valid and reliable) data.

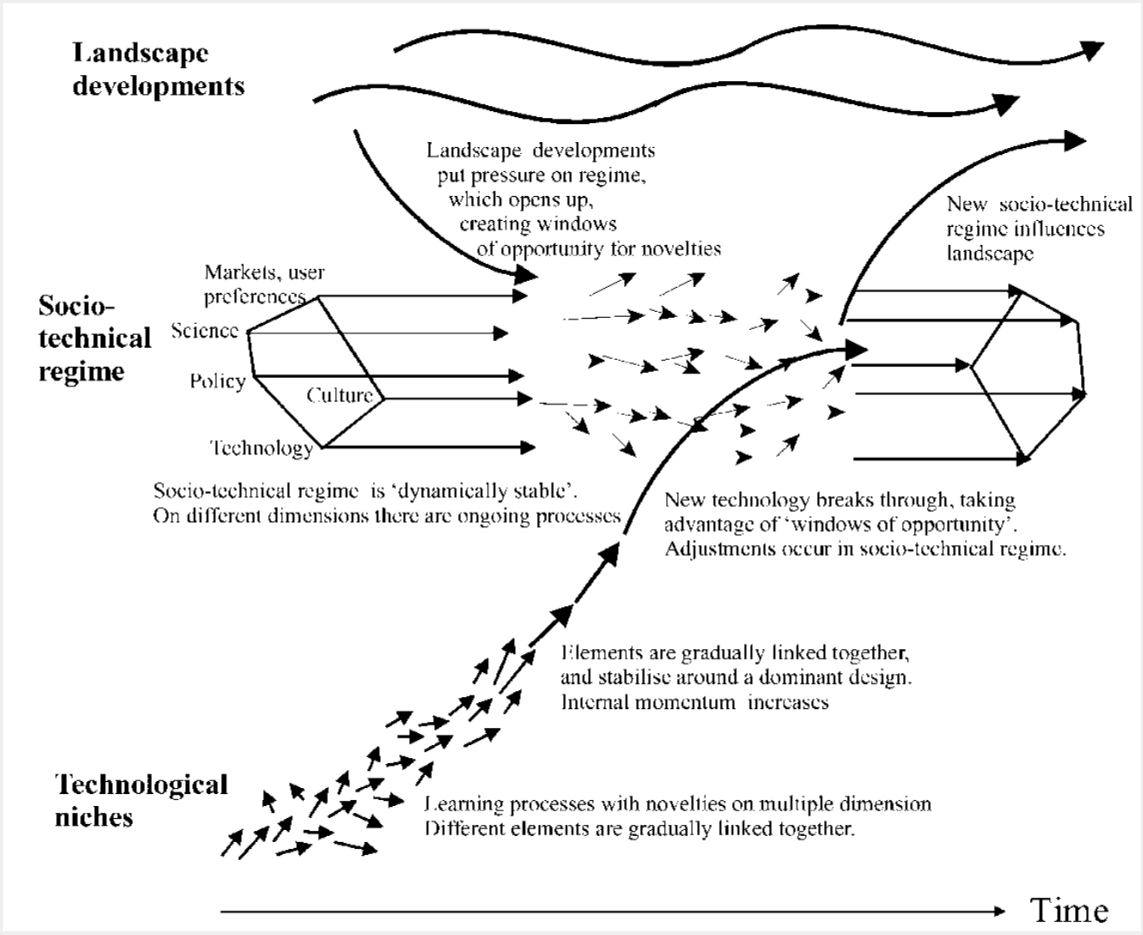

Figure 1: LEED scorecard [4].

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Governance

The transition towards a smart and sustainable city is a complex process. Although public targets have substantial impacts on the everyday lives of individuals and local communities the buy-in is facilitated or hampered through beliefs and behavioral patterns. Scientifically framed issues remain unclear if they are not assigned to a specific place and community [22]. From the urban thinker's campus standpoint, co-creation is the ultimate form of participation [23] Co-creation is linked to the mutual understanding of a relevant problem, joint definition of feasible pathways and learnings in the implementation process [24]. Theory of Change [10] and the way from understanding to action [25] can help to manage stakeholders through difficult transitions. The impact pathways (Figure 1) sheds light on actions and related assumptions that might lead to desired outcomes via capacity and behavioral changes. It is transparent in the way that it allows for testing of assumptions or the rationale for actions. Barcelona has applied the method to the air pollution problem with affected communities [26].

Following the literature, the starting point for the research are the altered responsibilities of the administration in coping with climate change mitigation and urban adaptation. The specific framework conditions posed by climate change are the uncertainty that goes with it, the long -time perspective and the need for action, and the interconnectedness of topics and governmental levels.

Research Design/Methods

For the analysis we use a case study of the city Mannheim carried out from 2017- 2020 with the administration and the climate agency and action research [27]. The case study offers learnings in terms of impact pathways or patterns that can be generalized [28]. The review of the literature indicates that in the nexus of environment/nature and society in the urban several problems have to be addressed in the real-world lab:

1. How does problem definition and goal setting take place?

2. How is data generated or collected, and data gaps identified and closed. How can data silos be bridged to build reliable information platforms and to allow for information exchange and monitoring of climate goals and actions?

3. Will platforms and models lead to new communication pattern and interaction channels for a joint learning and city development of administration and urban society.

4. How are real-world labs results integrated in bureaucratic routines?

5. Will the approach lead to a new discussion of the socio-economic dimension of climate change and to a legitimate (accepted) intervention?

6. How will capacity building in the use of data be addressed?

7. How are expectations and conflicts managed and mediated? Is there a continuous reflection on goals, roles and processes in the system?

8. What patterns evolve in terms of coping with financial constraints and the use of program funding?

The following tools were employed in the living lab to identify topics and objectives and design the impact pathway:

Phase 1 based on interviews with the representatives of the consortia members the biggest concerns related to climate resilience were addressed and analyzed with the Sensitivity Analysis [29]. The preliminary chart was validated in a participatory process with representatives of the two cities, the Fraunhofer Institute IAO and The University of Stuttgart and Hafen City University Hamburg, Malik Management Consulting and Drees & Sommer Real Estate Management (Consortia Member of the Smartilience FONA Program). The results were tested in the Mannheim living lab during a co-creation process with 42 experts in urban climate research, other city administrations, and business.

Phase 2 The causes and effects of heat related health problems were depicted and mapped to prepare for a workshop with different departments in the City of Mannheim that resulted in a ranking of urban pressures related to climate change and the identification of heat related problems as a major topic. The identification of the most pressing problem – heat waves and the impact on vulnerable groups were identified in a focus group workshop with different departments of the administration (Mannheim). Data protection and ethical issues were considered and respected. The vulnerability analysis relies on open street map data.

Phase 3 The implementation pathway [10] for the heat action map was created by the project team to show the governance approach in terms of tools, stakeholders and benefits. We used it to identify blockages and success factor for a rapid implementation and concretization of science-based evidence to city action planning. The practical findings are discussed in the context of a revised governance approach that includes data platforms, modelling and change elements in a participatory process.

Findings

SMARTilience research had the objective to provide peer-to-peer practical advisory and support for German administrations in form of an open access platform and a formative project design, and to test real cases for action planning. To meet that goal existing routines were discussed with the administration in Mannheim before new administrative routines were tested in a real-world lab – again with the administration.

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Phase 1: The biggest concerns of city administration related to climate change adaptation

The Sensitivity chart (Figure 2) shows the relevant topics that were named by the consortia members cities of Mannheim and Halle. The system in focus and the trigger question for the interview was How to achieve urban climate resilience. In the impact matrices the research team jointly estimated the impact of each topic on the others in a focus group which resulted in the model of interdependency Figure 2 shows the aggregated data of the estimations. Virtuous and vicious circles become prominent through cross linking density of topics (percentages) and effective controls are visible. The administration of the two cities identifies participation (85%), viable targets (62%) as main levers to initiate a virtual circle and lack of strategy as the biggest blockage and main element in the vicious circle that prevents solution building and impact in the city in terms of climate resilience.

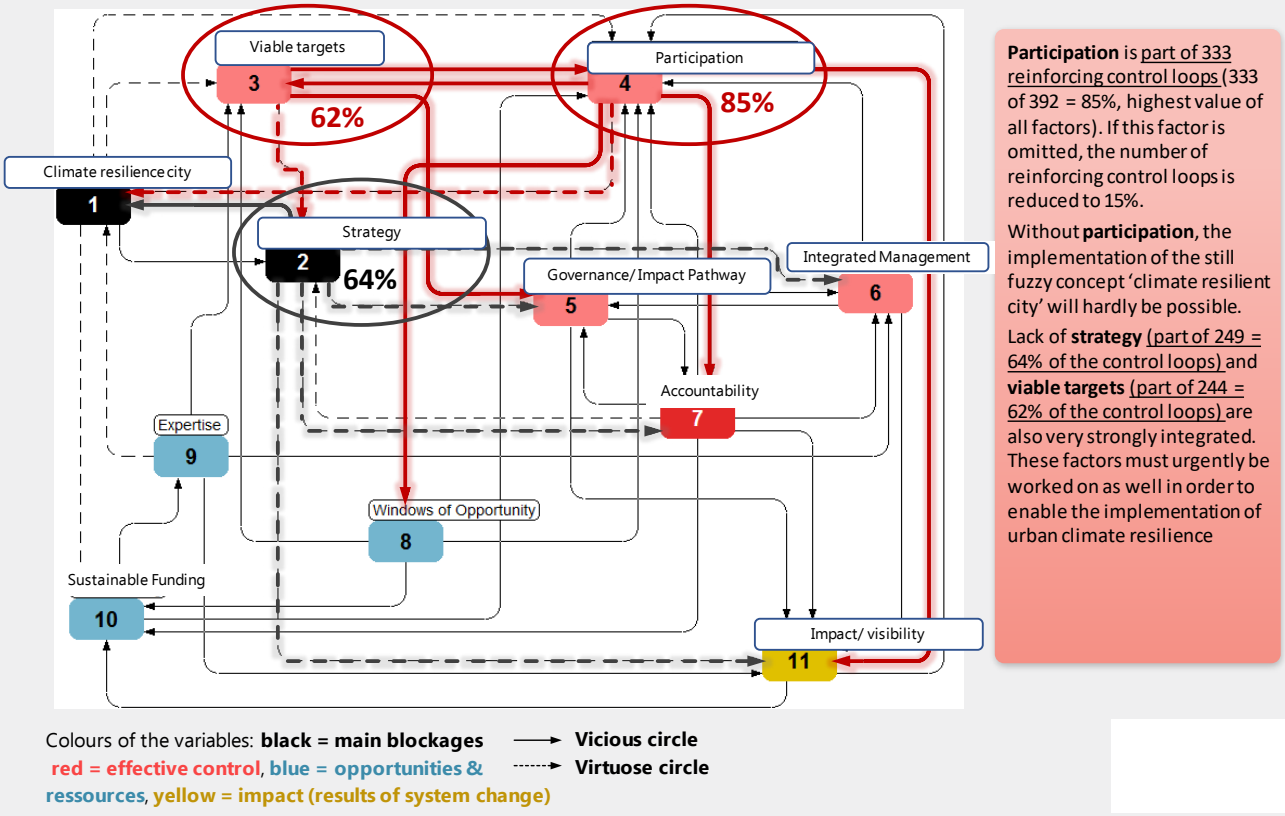

Figure 2: Sensitivity Map: Core Challenges of Climate Resilience, adapted from [29] Source: Author, 2023.

Lack of strategy (2), viable targets as well as participation (4), governance of the impact pathway (5), integrated management (6) and accountability (7) are critical drivers. They have a strong impact on many other factors but are also strongly influenced - they can drive system changes forward. However, it is crucial to work simultaneously on other factors in an integrated way, as otherwise their effects dissipate.

Variables as Windows of Opportunity (8) relate to a sense of climate urgency and sustainable funding (10) both fall under the neutral range. They are less suitable as active levers for system change but they stabilize the system. An undesired manifestation of these factors can, however, decisively slow down system change. Climate resilience is the impact the system is striving for (11) and an indicator of system change.

Phase 2 Starting point: Clarifying the concept of climate resilience for the city administration

The sensitivity analysis revealed that in a first step the fuzzy concept of urban climate resilience has to be discussed and further clarified to understand the challenge. Both city administrations decided to focus on climate adaptation to face long-term climate change rather than climate mitigation to mitigate GHG which was already installed and monitored in Mannheim [30]. Extreme weather events were identified as a core problem by the two cities, Mannheim and Halle, consortia members of SMARTilience. To start with, the new phenomenon of heat waves and management of rising urban temperatures were selected as main topics. Hard

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rain and floodings were considered equally important challenges but they were better under control in terms of human health and routines involving fire brigades and city departments already existed.

The living lab selected 5 heat related restrictions on living conditions and 8 heat related health problems to take the SMARTilience program to the next step (Figure 3).

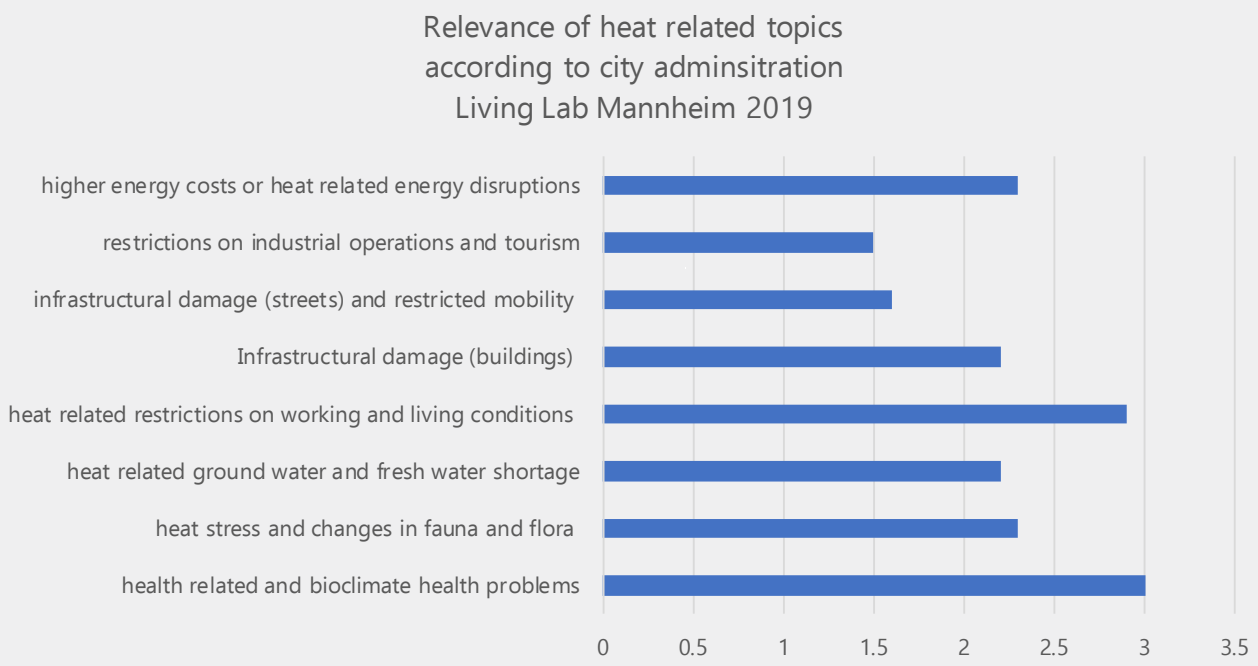

Figure 3: Relevance of heat related topics according to city administration. Source: Mentimeter survey of a workshop with different departments. Living Lab Mannheim 201.

Following the focus group vulnerable groups were mapped on the isotherm map of Mannheim to show the spots where help is needed in terms of heat waves and administration is accountable (Figure 2). The researchers looked at elderly people, children and people with disabilities. The map shows the social hotspots for heat action planning and for urban adaptation. In the following geo-referential data was used to create new layers in the urban GIS-portal to make decision for a new heat action plan. The mapping of the vulnerable groups in Mannheim was done with open street data (OSD). Data protection limited the selection and set the focus on institutions of young children and old and disabled people. The mapping allowed for identification of hotspots as a basis for interdepartmental decision making in the administrative process (Figure 4 & 5) (Table 1).

Phase 3 The implementation pathway for the heat action map

On the premises of the decisions and actions outlined in the findings, the city of Mannheim developed a blueprint for urban heat related actions on the premises of analysis and action planning in the real laboratory. Heat action planning considers the steps in the impact pathway in Figure 6 to avoid blockages [10]. The urban heat is a volunteering obligation not a binding rule. Objectives are to avoid health problems and mortality caused by heat and heat waves, install a support and risk management system of mutual to protect vulnerable groups, help to avoid overload of the health system, activate NGOs like Caritas, and old people homes, associations for homeless and to create risk awareness of heat related health disorders, (kidney problems, mental disorder, skin protection, etc.) cool locations and drinking fountains to enforce heat resilience in citizens.

The action plan follows the logic of the impact pathways proposed by Mayne [10].

In addition, Mannheim city lists the following actions to cool the city in a long-term perspective:

a) Creation of new green space and cold islands and protect existing ones.

b) No densification of the build environment.

c) removal of buildings that block ventilation corridors and develop new corridors that allow cold air to enter the inner-city during the night.

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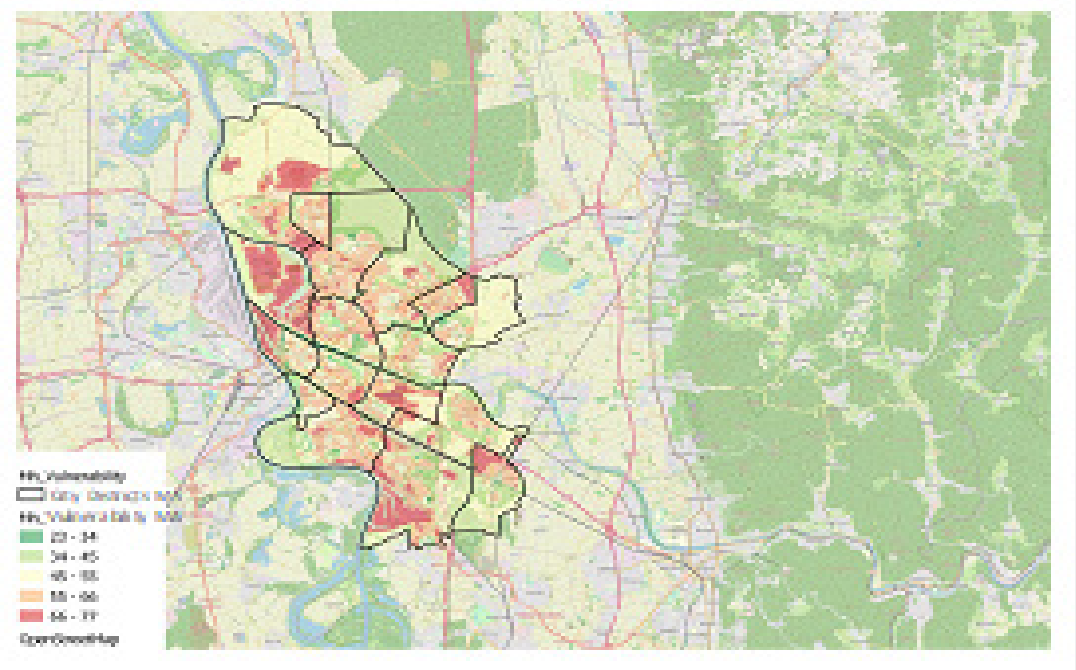

Figure 4: Vulnerability Map (left).

Source: Velankar, Madhulika (2021), Open Street Map Analysis City of Mannheim 2021, adapted by the author. Red colour shows the highest density of vulnerabilities in the city correlating with high summer temperatures and recurring heat islands. Drees & Sommer 2021.

Table 1: Categories and indicators for Mapping Vulnerabilities. Source: [31] Adapted by the author 2023.

Categories	Indicators
Heat Island and high temperatures over a long-time probability (and potential for nature-based solutions)	Trees / Green Parks (cooling from canopy shadow evaporation)
	Soil Sealing / house, streets, places (prevent cooling or add to heat island effects)
Vulnerable Groups (based on mobility)	Elderly (nursing and retirement homes) Percentage of inhabitants over 65 years
	Very Young (schools, children day care) Percentage of inhabitants over 65 years
Exposure (based on easy access to services)	Walking distance to primary services, emergency medical services hospitals, Food Shops, freshwater fountains
	Para medical services, doctors, community centers, cool and freely accessible buildings

Discussion of Findings: Towards a New Data-Based Governance

The proceedings of the real-world lab show a decision-making process that developed with the framing of a governance model that is consensual, transformative and participative in a way that interdepartmental silos were bridged and data was used for the visualization. The new approach took the socio-economic change dimension of climate change into account. It gives answers to the points raised in research section of the paper (Table 2) [32-38].

Outlook and Recommendations

SMARTilience illustrates how administrations can manage the insecurities and blockages inherent in climate change adaptation. System awareness and discussion of interconnected topics in the administration help to create new routines in a joint attempt to speed up the process and revise solutions. Extreme weather events like the hot summer in 2018 and the flooding in the German Ahrtal (2021) have urged the topics of climate resilience and urban adaptation to climate change. Both are now firmly anchored in the political agenda in Germany. The use of digital maps and geo-referential data have gathered importance in German administrations. The real-world lab approach and peer-to-peer learnings have facilitated digitalization and visualization in urban decision-making and the approach created new routines like the heat action plan.

To effectively anticipate climate change and to prevent social, financial and technical damages caused by extreme weather events digital mapping, open access platforms for interdepartmental collaboration in city administration become a conditio sine qua non. They are a new governance element that allows for real time monitoring, citizen sciences, and better urban disaster management.

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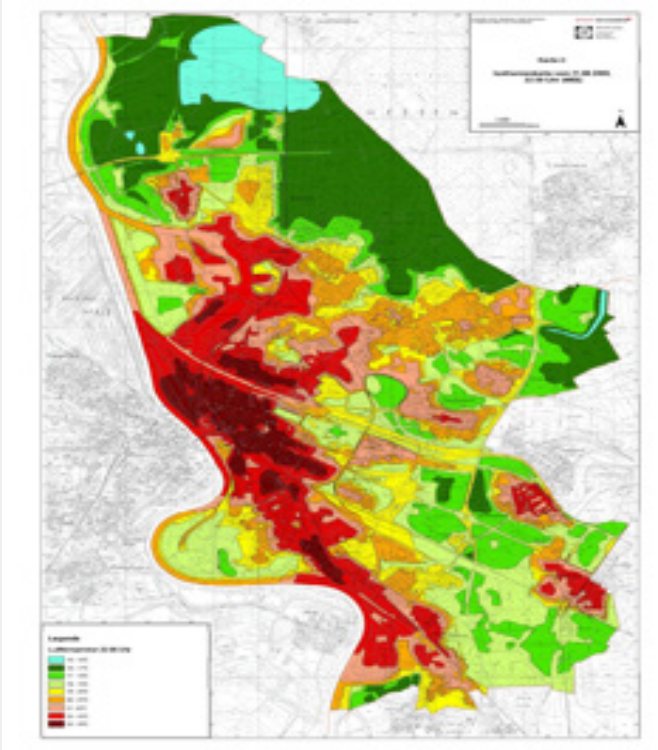

Figure 5: Isotherme Map Annual mean Day Temperature (right).

Source: Klimaanalyse 2010. Stadt Mannheim https://www.mannheim.de/de/stadt-gestalten/planungskonzepte/stadtklima/stadtklimaanalyse-2010.

Table 2: Overview topics and solutions. Source: Author, 2023.

Topics	Solutions
How does problem definition and goal setting take place?	Living lab and place-based approach as an experimental test bed for new administrative routines
	Use of Data to support interdepartmental cooperation and action planning to address an important topic (Health of Citizens / climate protection and climate adaptation)
How is data generated or collected, and data gaps identified and closed. How can data silos be bridged to build reliable information platforms and to allow for information exchange and monitoring of climate goals and action?	Easy and free access to open street map data for the digital mapping of vulnerabilities. GIS portal managed by a new entity in the city that collects and distributes decentralized data of different departments
Will platforms and models lead to new communication pattern and interaction channels for a joint learning and city development of administration and urban society	The platform is a learning platform. It is planned to add another layer for city planners. Citizens engage in city action but not on the platform
How are real-world labs results integrated in bureaucratic routines?	The lessons learned and impact pathways are already copied in other cities and funded by regional and national agencies.
Will the approach lead to new discussion of the socio-economic dimension of climate change and to a legitimate (accepted) intervention?	The living lab addressed a wicked problem with an action plan related to human health and climate change. The socio-economic change dimension of climate change was addressed
How will capacity building in the use of data be addressed?	Peer-to peer learnings in city administrations Open access Urban governance tool box to share the results
How are expectations and conflicts managed and mediated? Is there a continuous reflection on goals, roles and processes in the system?	The steps in the governance models and the living lab format allows for reflection of findings and revisions if new facts occur
What patterns evolve in terms of coping with financial constraints and the use of program funding?	Sustainable funding is a topic that has to be further addressed. Mannheim is involved in matching funding and succession programs to take the topic of urban climate adaptation further

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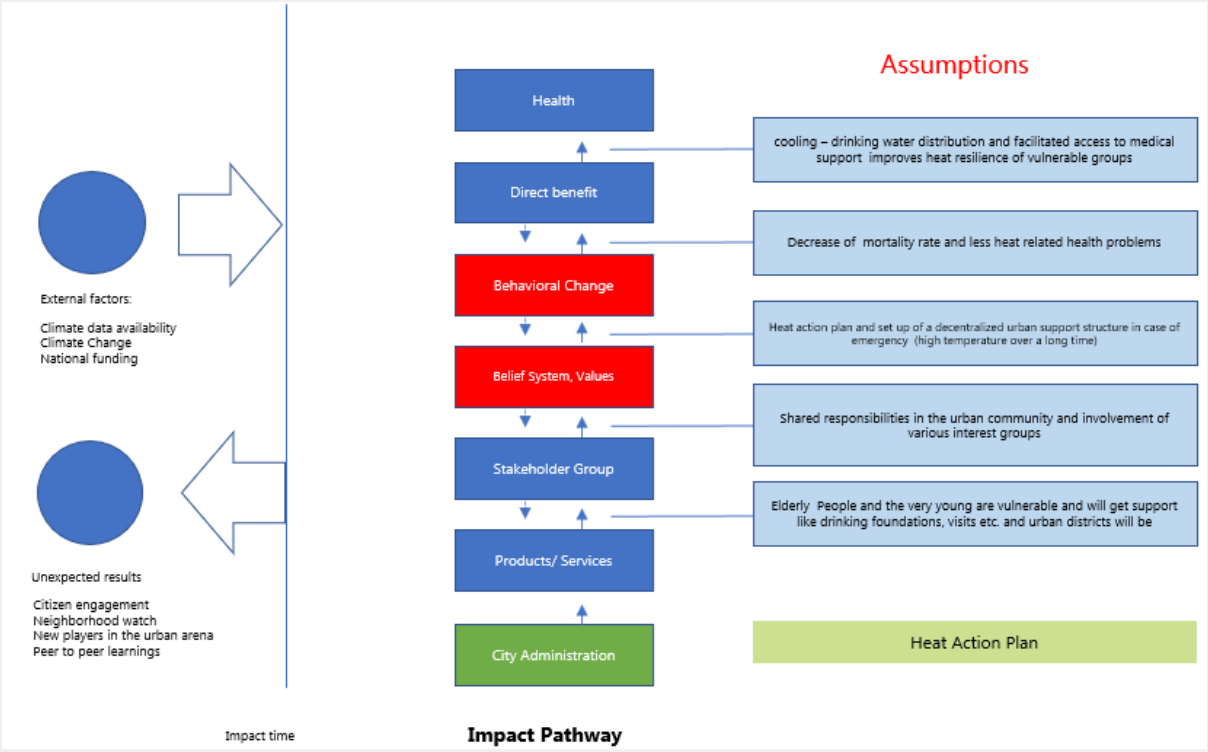

Figure 6: Implementation Pathway: Heat action plan Mannheim, adapted from [10] Source: Author, 2023.

However, heat action planning is only a first step to prevent health problems for vulnerable groups and to show the use of data to protect the elderly and the very young. In the long term perspective the revised city governance must create fresh air corridors and mitigate land use conflicts between cooling effects of nature-based solutions and the need for new construction development. The new data and integrated management expertise on how to design new routines may help to provide digital models for re-zoning and climate resilient rebuilding of districts.

The research shows that integration of technology (satellite data, and other data sources), GIS data modelling and imaging procedures are more effective and efficient than traditional paper-based administration of land registries. Participation of citizens is important to co-create this new role of city administration and share responsibilities to develop new swifter behavioural repertoires and routines.

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