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Urban Resilience
Evaluating the Adaptive Capacity of Cities Towards a Changing Climate
-
Case Study Vienna

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I. Abstract

Urbanisation and increasing risks for natural hazards due to Climate Change will lead to a large number of people to be threatened by natural disasters in the future (IPCC, 2013; United Nations, 2012; Dilley et al., 2005). It will therefore become increasingly necessary to make cities more "resilient" to those risks. This thesis will first look at the outcome of recent urban planning practices to show the need for the rather new concept of urban resilience. It will be seen that deregulation under the neoliberal agenda and the increasing pressure of globalisation have destroyed the urban system's self-regulating capacities and have led to high economic and social vulnerability (Eraydin, 2013). A new planning model should therefore aim at reducing these vulnerabilities by enhancing the system's adaptive capacity, self-organisation, and transformability. Furthermore, the concept of urban resilience is the first to acknowledge uncertainties and the fact that cities are dynamic, socio-ecological systems interacting with their environment. Second, to provide a sound basis for this new model of planning, it will be evaluated whether there is a way to assess urban resilience. To this end different existing approaches will be compared (U.S. Indian Ocean Tsunami Warning System Program, 2007; Asian Cities Climate Change Resilience Network (ACCCRN), 2009; Prasad et al., 2009; Normandin et al., 2009; Tanguay et al., 2010) and it will be shown that the Climate Disaster Resilience Index (CDRI) is the first comprehensive approach to deal with the issue (Shaw and Sharma, 2011a; Climate and Disaster Resilience Initiative, 2010; Shaw and Sharma, 2011b). A case study on the city of Vienna, Austria, will demonstrate how the CDRI assessment method can be applied in practise and how the findings will give guidance for further planning action in the sphere of disaster risk reduction (DRR). It will be shown that while Vienna is generally well-prepared to handle disturbances, there are certain areas which still need improvement and that problems need to be tackled comprehensively. The index will therefore prove to be a valuable tool to reveal strengths and weaknesses of an urban system and to provide guidance for future policy-making.

Keywords: urban resilience, disaster risk reduction, disaster management, Climate Disaster Resilience Index, Vienna

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IV. List of Abbreviations

ACCCRN	Asian Cities Climate Change Resilience Network
AR	Assessment Report
CAP	Climate Action Plan
CCCR	Canadian Centre for Community Renewal
CDRI	Climate Disaster Resilience Index
CIESIN	Center for International Earth Science Information Network
DRR	Disaster Risk Reduction
GHG	Greenhouse Gas
HDI	Human Development Index
HFA	Hyogo Framework for Action
GCM	Global Climate Model
IDNDR	International Decade for Natural Disaster Reduction
IPCC	Intergovernmental Panel on Climate Change
ISET	Institute for Social and Environmental Transition
PM	Particulate Matter
RCM	Regional Climate Model
SDI	Sustainable Development Indicator
SES	Socio-ecological System (or Social-ecological System)
SLD	Shared Learning Dialogue
UNDP	United Nations Development Programme
UNDRO	United Nations Disaster Relief Office
UNISDR	United Nations Office for Disaster Risk Reduction
UN WCDR	UN World Conference on Disaster Reduction
USAID	United States Agency for International Development
VOC	Volatile Organic Compounds
WCED	World Commission on Environment and Development

1 Introduction

Today, more than half of the world's total population lives in urban areas. By 2050, the ratio is projected to reach two-thirds and to continue to increase thereafter. (United Nations, 2012) At the same time, many cities are located in areas with high risks of natural hazards, such as earthquakes, landslides, volcano eruptions, droughts, floods, and cyclones (Dilley et al., 2005; United Nations, 2012). Climate Change will further contribute to those risks by giving rise to the occurrence of extreme weather events, such as heat waves, heavy precipitation events, droughts, and cyclone activity (IPCC, 2013). In combination with increasing urbanisation, the number of people threatened by natural disasters will therefore sharply increase in the future and it will become increasingly necessary to find ways to make cities more "resilient" to those risks. This basically means that it will not be sufficient to make a city more resistant to changes, but to increase a city's capacity to adapt to changes, internal or external to the system, responding to them, and recovering afterwards. Resilience therefore not only covers the timeframe of the duration of the perturbation but looks at the whole "stability landscape" (Gallopin, 2006) of the system – before, during, and after the perturbation. However, as the theory of resilience is rather new, starting only in the 1970s (Holling, 1973), and because it has been developed in the field of ecology (Holling, 1973; Folke, 2006), there is no consensus yet on how to transfer the meaning of resilience to the sphere of urban systems, as they are dynamic socio-ecological systems (SES), meaning systems, where humans interact with their ecological environment (Folke, 2006; Turner et al., 2003; Gallopin, 2006). At the same time, new concepts, such as vulnerability, and adaptive capacity have evolved in the study of SES (Adger, 2006; Gallopin, 2006; Smit and Wandel, 2006; Walker et al., 2004; Turner et al., 2003; Heylighen, 2001). Even though there seems to be general consensus that all those concepts are somehow related, there are different (and sometimes contradicting) definitions and uses of the terms in the academic literature, making it difficult to compare the research done in this field.

The aim of this thesis therefore is to answer two closely connected questions in the field of urban resilience research. First, it evaluates whether resilience is an adequate concept for future urban development and why the concept is actually needed in the sphere of city planning. To this end, the first section of the thesis will develop a definition of "urban resilience" corresponding to existing definitions of resilience in the research field of SES, but more precisely suitable for urban systems and perturbations coming mainly from the external environment. An analysis of past planning practises will explain their influence on the current status of cities and will show the need for a new planning model. It will also show that resilience is the only suitable concept to deal with urban development, as it is the first concept that acknowledges cities as dynamic systems and tries to deal with the problem of high uncertainty.

Second, the most important question will be whether the resilience status of a city can be properly assessed. This is important, as only a comprehensive assessment will provide a basis for future planning policy. Section two will therefore give an introduction to different approaches, which have been developed so far in the field of urban resilience assessment. It will show that this topic is very complex and that there is not yet general consensus on how an assessment should look like (Asian Cities Climate Change Resilience Network (ACCCRN), 2009; U.S. Indian Ocean Tsunami Warning System Program, 2007; Prasad et al., 2009). It will also show that the Climate Disaster Resilience Index (CDRI) is the first comprehensive approach, which has already been applied on a larger level in Asia (Shaw and Sharma, 2011a; Climate and Disaster Resilience Initiative, 2010; Shaw and Sharma, 2011b). This index will therefore be used in the case study in section three. The case study on Vienna will demonstrate, how this assessment method can be applied in practise and how the findings will give guidance for further planning action. Summarising, the thesis will contribute to the questions why urban resilience is a useful concept and how it can be assessed. It will also give a short outlook on how this assessment can directly contribute to future policy making.

2 Methodology

Based on the specific research question, different research methods will be required. The first and second question on whether urban resilience is a useful concept for urban systems and on why this concept is actually needed will be approached by a literature review of books and journal articles in the respective fields of study. The question on whether the resilience of a city can be properly assessed will also include review of literature and comparison of existing frameworks and indices but will mostly be answered by a case study for Vienna, using the Climate Disaster Resilience Index (CDRI), an evaluation method developed by the University of Kyoto.

As will be described in chapter 4, the index comprises 125 variables, or "questions", which have to be rated according to a given scheme. The questions will be either quantitative – requiring numbers and statistical data – or qualitative – requiring a "best answer" according to a personal evaluation of the situation. Quantitative answers will be answered using statistical primary data from the Austrian central statistical office or the statistical office of the city of Vienna, or by data found in respective scientific studies or reports. Qualitative answers require a much greater amount of information, as best answers need to be based on comprehensive knowledge on the topic. To this end, a wide array of sources, such as primary statistical data, studies, reports, newspaper articles, press releases, legal texts, and political correspondences will be used. Additionally, email correspondences and phone interviews, conducted with representatives of different departments within the local government, will serve as a tool to estimate the situation and give an appropriate best answer. However, it must be noted that the answers will always reflect the opinion of the author and that experts in this field might come to a different answer. The same is true for the necessary weighting of the parameters. While the weighting will always be based on the insights gained through thorough research, this is still a subjective process and other people might come to a different result.

3 Resilience Thinking in Urban Planning

3.1 Definition of the Main Keywords

3.1.1 Urbanisation

Today, 3.6 out of 7 billion people on this planet live in urban agglomerations. This accounts for more than half (52.1%) of the world's total population. While this ratio might not (yet) be true for every individual region, figures of world population growth over the last thirty years suggest that future population growth will be mainly absorbed by urban areas. This will lead to a further increase of people living in urban areas, while rural population is suspected to start declining in 2020 and will show lower figures in 2050 than today. While highly developed countries already show an urbanisation of 78%, Asia will reach today's global urbanisation ratio of 50% in 2020, Africa in 2035. Following today's projections, these trends will lead to a global population of 9.3 billion, 6.3 billion of which living in urban areas (67%), by the year 2050 - with urban population increase being most dominant in the developing world. (United Nations, 2012)

3.1.2 Urbanisation and Natural Hazards

The recent development of a database on the global spatial distribution of natural hazards by the Center for International Earth Science Information Network (CIESIN) at Columbia University "(…) will allow researchers to link demographic trends in urban agglomerations to various spatial and environmental characteristics (…) (United Nations, 2012: 17)." The database currently offers information on cyclones, droughts, earthquakes, floods, landslides, and volcano eruptions and provides a classification system about the risks of a particular area, depending on the frequency of occurrences and the scales of one or more specified natural hazards. (Dilley et al., 2005: 33-34; United Nations, 2012) While, according to this classification system, only 26% of Europe's and 37% of Africa's major cities are facing high risks of exposure to at least one natural hazard, in Asia, Latin America, North America, and the Caribbean 50-67% of the cities are at high risk. Globally, 60% of all urban areas (with more than 1 million inhabitants) are at high risk of exposure to natural hazards, which today accounts for 890 million people. (United Nations, 2012) With urban population increase being dominant in the most exposed areas, the number of people affected by natural disasters will sharply increase in the future. It will therefore be necessary to find a way to make cities more adaptive to risks posed by natural hazards.

3.1.3 Climate Change

The United Nations *Intergovernmental Panel on Climate Change (IPCC)* has recently published it's 5th Assessment Report (5AR) on the observable changes of the earth's climate and the suspected anthropogenic influences on this changes, as well as given prognosis for future developments of the climate. Their observations point to a further increase in global surface temperatures within a range of +1.5 to +2.0°C for most projection scenarios within this century. As natural solar irradiation changes have been too little to explain the global warming phenomena, it seems highly certain that anthropogenic emissions do contribute to the changing climate. Projections are difficult, however, as they depend on how much influence the respective models attach to the different emissions of greenhouse gases, VOCs (volatile organic compounds) and aerosols. Furthermore, it is still uncertain how much influence feedback mechanisms, such as cloud formation, changes in ocean currents, or albedo changes due to changes in land use, have, as to make certain predictions. (IPCC, 2013) At the moment, it can only be said with high certainty that global temperatures will rise in the future and that anthropogenic emissions do have an influence on this development.

This increase in global temperatures has had and will continue to have influence on the increase in extreme weather events, the global sea level rise, and the loss of polar ice sheets. These extreme weather events include heat waves, heavy precipitation events, droughts, and cyclone activity. (IPCC, 2013) It is therefore obvious that climate change will play a role in the future increase of natural hazards to cities and their inhabitants. As those changes vary greatly between different regions (IPCC, 2013), it will be necessary to evaluate the specific threats posed to different cities before taking appropriate adaptation steps.

3.1.4 Vulnerability – Resilience – Adaptive Capacity

The terms vulnerability, resilience and adaptive capacity are used by a wide variety of life sciences and social sciences. However, they often bear different meanings over the many disciplines, reflecting their respective intellectual tradition (Adger, 2006; Janssen et al., 2006). This plurality of definitions, however, may become a hindrance to communication and understanding across disciplines, and especially in research fields, where the interaction of both the social and biological sphere needs to be considered, such as global change research (Gallopin, 2006). Global change and sustainable development research can never be limited to either one of those research areas but must look at the whole socio-ecological system (SES) (Gallopin, 2006) – also called social-ecological system (Folke, 2006) or coupled human-environmental system (Turner et al., 2003). The socio-ecological system is defined as "… a system that includes societal (human) and ecological (biophysical) subsystems in mutual interaction (Gallopin, 2006: 294)" and therefore reflects the dynamic interplay between the components of the two disciplines.

3.1.4.1 Vulnerability

According to Adger (2006), "… vulnerability is most often conceptualized as being constituted by [a] components that include exposure and sensitivity to perturbations or external stresses, and the capacity to adapt (Adger, 2006: 270)." Vulnerability is therefore specific to perturbations, meaning that a system can be vulnerable to some perturbations and invulnerable to others. Furthermore, vulnerability is generally seen as a system's susceptibility to harm when encountering a perturbation, rather than the outcome of this confrontation. (Gallopin, 2006)

Hazard, perturbation, stress

Turner et. al (2003) define hazards as threats to a system, consisting of perturbations and stress (and stressors, which are the sources of stress), and their respective consequences. While "[a] perturbation is a major spike in pressure (e.g., a tidal wave or hurricane) beyond the normal range of variability in which the system operates (…)[,] [s]tress is a continuous or slowly increasing pressure (e.g., soil degradation), commonly within the range of normal variability (Turner et al., 2003: 8074)." They further argue that perturbations typically have external origins, while stress appears from within the system. However, Gallopin (2006) rightly argues that this will greatly depend on the definition of the system boundaries – while occurrences, such as earthquakes, or financial crisis are clearly internal phenomena of the global socio-ecological system, they might or might not be external to a specific city under review. This would qualify them in one case as stresses, in the other case as perturbations. I will therefore use the term perturbation for both, external and internal processes interacting with the system and will only classify them as external or internal, if it will be necessary for the understanding of a specific situation.

Sensitivity

According to Adger (2006), "[s]ensitivity is the degree to which a system is modified or affected by perturbations (Adger, 2006: 270)." Specific to Climate Change, the IPCC defines sensitivity as

> (…) the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. (…) The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). (IPCC, 2001: 21)

This more generally means the amount of transformation of the system, per unit of change (increase or decrease) in the perturbation (Gallopin, 2006). Gallopin (2006) therefore argues that sensitivity must be an inherent property of the SES, which exists prior to a perturbation and is therefore independent from exposure.

Capacity to adapt

The capacity to adapt to (also called the capacity to respond to) perturbations can generally be defined as a system's "(…) ability to adjust to a disturbance, moderate potential damage, take advantage of opportunities, and cope with the consequences of a transformation that occurs (Gallopin, 2006: 296)." Smit and Wandel (2006) point out that some authors use the term "coping ability" to describe a system's ability to just survive a disturbance, whereas "adaptive capacity" for them means a more sustainable adjustment. In any case, similar to sensitivity, capacity to adapt clearly is an inherent attribute of the system, even in the absence of perturbations.

Exposure

Exposure generally means the degree, duration and extent to which a system experiences perturbations (Adger, 2006; Gallopin, 2006). There are two fundamental differences in the application of this meaning, however, as most authors see exposure as being a component of vulnerability, whereas some see it as a relation variable – necessary to evaluate vulnerability and therefore the changes caused to the system, but not its inherent attribute. If exposure were defined as a component of vulnerability, together with sensitivity and the capacity to adapt, a system not exposed to a perturbation would be defined as non-vulnerable. In climate modelling, this would mean that you would have to separately determine the vulnerability for all possible combinations of perturbations (= for all climate scenarios) and change them accordingly, if perturbations change.

However, if exposure is not seen as an attribute of the system itself, but of the relationship between the system and the perturbation, vulnerability became an inherent attribute of the system and the relationship to the exposure will determine the amount of change or damage to the system. In the climate-modelling example, this would mean that the vulnerability of a system stays constant and can be combined with the different scenarios to determine the amount of transformation. As this makes more sense in terms of efficiency of a study, I will adopt Gallopin's (2006) definition that

> (…) vulnerability is a function of the system's sensitivity and capacity of response, and the transformation suffered by the system is a function of its vulnerability, the properties of the perturbation, and the exposure of the system to the perturbation. (Gallopin, 2006)

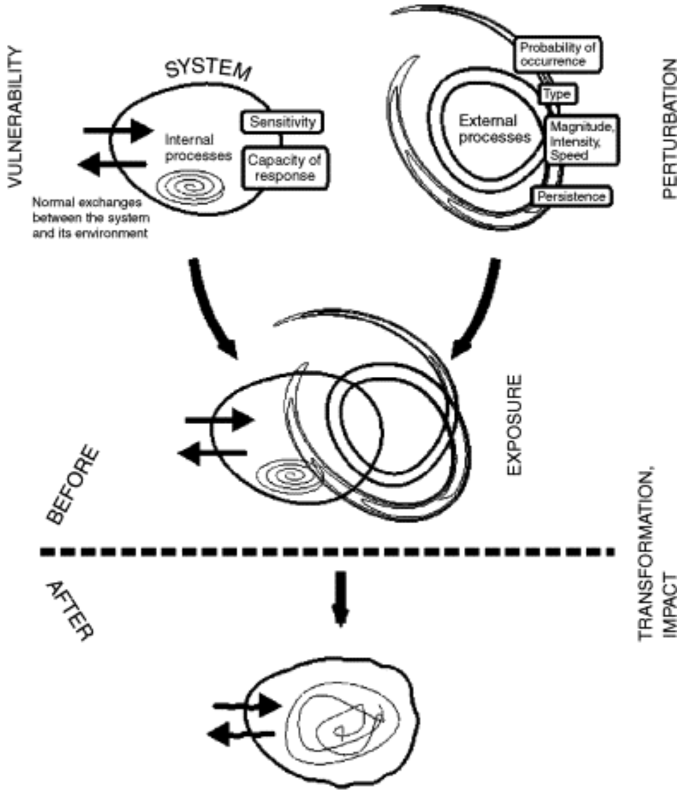

Fig. 3.1 Generic relations between vulnerability, threat, exposure, and impact or transformation of a system (social, natural, or SES) according to Gallopin. Time moves from top to bottom of the figure. (Gallopin, 2006: 296)

3.1.4.2 Resilience

The concept of resilience was originally developed in 1973 by C.S. Holling in the field of ecology and has thereafter found its way into various disciplines, sometimes with considerable deviation from its original meaning (Holling, 1973; Folke, 2006). The original definition sees resilience as "(...) a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables (Holling, 1973: 14)", while a more recent study by Walker et al. (2004) defines it as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks – in other words, stay in the same basin of attraction (Walker et al., 2004: 6)." The concept of domains or basins of attraction is a key feature of the resilience theory and will be explained in the following. The "state of a system" is comprised of all the variables of a system at a specific point in time. If this state changes over time, the succession of states through time is defined as the trajectory (or orbit) of the system. This trajectory itself moves in time toward a so-called "attractor". This attractor of the system can either be a specific point (a steady state), a closed cycle, an open-ended trajectory that never reaches a steady state, or an even more complicated geometric figure. The attributes of the attractor will determine the behaviour of a system in time. If the attractor is a fixed point (a steady state or dynamic equilibrium), the system will tend to reach that state and remain there after being pushed away from it by perturbations. Perturbations are assumed to be permanently occurring, so the system is not resting at the steady state for a very long time, but rather is in constant motion away from and towards this point. If the attractor is an open-ended trajectory, the system will tend to move towards this trajectory, but not to a fixed point and never reaching constancy.

The stability landscape of a system is comprised of the variables and all attractors within a given system, and the boundaries between them. (Gallopin, 2006) A system with only one attractor is called globally stable. However, systems with a non-linear relationship of their variables, such as socio-ecological systems, tend to have more than one attractor, therefore being "multistable". Within a basin of attraction, the system states may fluctuate widely, but the system will essentially retain the same functions. However, shifting between the basins of attraction of the different attractors can lead to fundamental changes in the functioning of a system (for example if a system shifts from a steady state attractor to an open-ended trajectory attractor). Therefore, resilience was defined as the ability of a system to stay within its current basin of attraction during and after a perturbation. It is not concerned with the stability and fluctuations within the given basin. Whereas stability can be measured by how fast a system returns to its attractor (stable point or trajectory) after a perturbation, resilience can be measured "by the magnitude of the perturbation that can be absorbed before the state of the system falls outside its domain of attraction (Gallopin, 2006: 299)." However, Holling (1986) shows that the evolution of parameters of a system can lead to the change of the domains of attractions themselves. "Thus, the stability domains themselves may expand, contract, and disappear in response to changes in slow variables, resulting in the loss of resilience of the system (Gallopin, 2006: 299)."

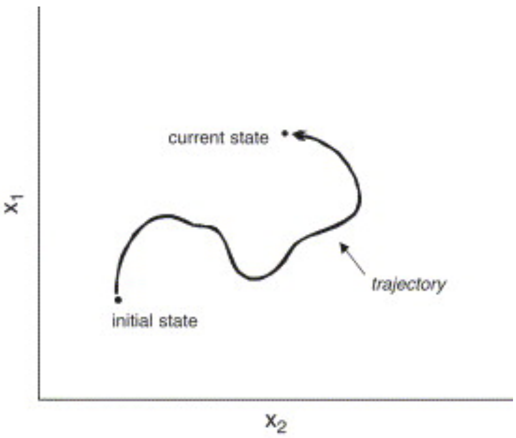

Fig. 3.2 A trajectory of a two-variable, dynamic system depicted in the state space (here, a plane defined by all possible values of state variables X1 and X2). (Gallopin, 2006: 297)

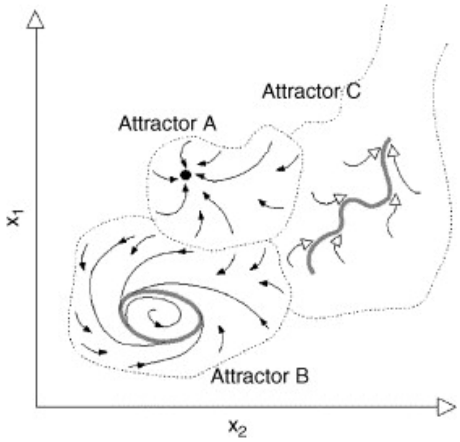

Fig. 3.3 State space of a two-variable system with three attractors, a steady state (A), a cycle (B), and an open-ended trajectory (C. The respective basins of attraction are indicated with dotted lines. (Gallopin, 2006: 298)

Following the arguments above, three different levels of stability can be defined: first, the local stability within a basin of attraction; second, the stability within the stability landscape of a system, meaning the movement of a system trajectory from one basin of attraction to another; and third, the structural stability of the stability landscape itself, meaning changes in the basins of attraction and the trajectory configuration. While resilience operates within the second level, only structural instability will transform a system into a different one. (Gallopin, 2006) Resilience therefore is related to the capacity of response component of vulnerability. However, while resilience is meant as the ability to preserve the functions of a system (by remaining within one basin of attraction), vulnerability may also lead to changes that cause a transformation from one basin to another. The term Urban Resilience can thereby be defined as the capacity of an urban socio-ecological system (a city) to absorb disturbance and reorganize/recover after perturbations so as to still retain essentially the same functions, structure, and feedbacks. With regards to Climate Change, these perturbations are defined as natural hazards, such as earthquakes, landslides, volcano eruptions, and extreme weather events. As taking into account a possible transformation of the urban system from one basin of attraction to another would lead to purely speculative outcomes, it will not be within the scope of this thesis and capacity of response will therefore be used synonymously with resilience.

3.1.4.3 Adaptive Capacity

Adaptive capacity (also called adaptability), generally has a similar meaning as the capacity to response. In the field of Climate Change, it is defined as "(…) the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001: 21)." This definition is more or less identical to this thesis' definition of urban resilience. However, as human systems are capable of learning, innovation and progress, the responses to perturbations may be reactive (as in the resilience and vulnerability concept), or proactive. This means that adaptive capacity is comprised of two different components: (1) the capacity of the SES to cope with perturbations from within the environment and (2) the capacity change (improve) its relation to its environment, even if the environment itself does not change. (Gallopin, 2006) This would mean that adaptive capacity has a broader meaning than capacity to respond or resilience, as human adaptations may alter the sensitivity to perturbations (the second component of vulnerability), increase the resilience of a system (by widening desirable basins of attraction), or reduce the exposure of the system to perturbations (through mitigation actions that operate upon the origin and attributes of a perturbation – i.e. reducing greenhouse gas emissions). Walker et al. (2204) state that "[a]daptability is the capacity of actors in a system to influence resilience. In a SES, this amounts to the capacity of humans to manage resilience (Walker et al., 2004: 3)." This thesis will therefore treat adaptive capacity as being comprised of the resilience of the system and the ability of the human part of the system to manage and alter this resilience. Adaptive capacity thus bears the important feature that the resilience can be shaped by the actions of human beings. Furthermore, by working also on the level of exposure and sensitivity, adaptive capacity can be seen as being part of vulnerability, by its ability of shaping all of its major subsystems.

Fig. 3.4 Relationship between the different terms as used by this thesis. (*Source*: author)

3.2 History of Planning Practice

3.2.1 Planning Models of the Recent Past

3.2.1.1 The Rational Model of Planning

The theory of the rational model of planning, developed in the 1950s, was mainly based upon a publication of Meyerson and Banfield (1955), called "Politics, Planning, and the Public Interest" (Schönwandt, 2008). In this publication, the two scholars, Meyerson being a city planner and Banfield a political scientist, describe the essential steps in planning as being

1. Analysis of the situation
2. Establishment of goals
3. Formulation of possible courses of action to achieve these goals
4. Comparison and evaluation of the consequences of these actions
   (Meyerson and Banfield, 1955)

Further development of those steps and their subdivision into sub-steps has subsequently led to the development of countless variations of the model, discussed and applied among planning theorists and practitioners. However, all models agree that the four steps are not meant to be applied in a hierarchic order but should rather be seen as parallel tools in mutual interaction. Also, there are no prescribed rules on how to achieve the different steps. Therefore, analysis of a situation may, for example, be achieved either through personal inspection and empirical investigations, by the use of secondary data, or by a combination of the two – depending on specific situation to be analysed and the amount of time available. (Schönwandt, 2008)

The most important aspect of the rational model is the emphasis laid on the "rational decision" of the planner. For Meyerson and Banfield, a "rational decision" is made in the following manner:

1. The decision-maker considers all of the alternatives (courses of action) open to him; i.e., he considers what courses of action are possible within the conditions of the situation and in light of the ends he seeks to attain;

2. he identifies and evaluates all of the consequences which would follow from the adoption of each alternative; i.e., he predicts how the total situation would be changes by the course of action he might adopt; and

3. he selects that alternative the probable consequences of which would be preferable in terms of his most valued ends.
   (Meyerson and Banfield, 1955: 314)

Following this line of thought, the planner in this model is an "(…) expert who relies on the objectivity of professional expertise to do what is in the public's best interest (Schönwandt, 2008: 5)." The expectations set upon the rational model of planning were considerable during the 1950s and 60s – it seemed that with the help of "careful planning", no goal was beyond reach.

Until the 1970s, the model had penetrated all parts of the planning community and found application not only in urban planning, but also in private ventures, in public administration, and in politics. However, important terms, such as "public interest", or "the public" in general, were rarely critically analysed but mostly presumed to consist of an undifferentiated, homogenous group – not taking into consideration social, ethnic or gender differences. Furthermore, critics of the model began to voice concern that this model of planning not only implies that the rational planner will always come to the right solution, but that it also gives planners sufficient power to implement those solutions. (Schönwandt, 2008)

New models started to develop in the late 1960s and early 1970s, driven by the understanding that there is a limit to solely technical models, not taking into consideration also socio-political aspects of the society. Many scholars pointed out that there is no such thing as a "rational" decision or an "optimal" solution, as all decisions are based on norms and values and all solutions may be only optimal for a defined group (March, 1978; March, 1982; Mandelbaum, 1979; Mandelbaum et al., 1996). By simply applying the norms and values formed by politics, the model was criticised as encouraging "(…) the acceptance of the *status quo*, support[ing] (…) the current political establishment, and maintain[ing] (…) the norms and values held by the upper and middle classes (Schönwandt, 2008: 6)." Also, the "top-down-approach" of the model was seen as being undemocratic. (Schönwandt, 2008)

3.2.1.2 The Advocacy Model of Planning

A first reaction to the rational model emerged by the publication of two articles by Paul Davidoff. "Advocacy and Pluralism in Planning" (Davidoff, 1965) and "A Choice Theory of Planning" (Davidoff and Reiner, 1962) deal with the notion that "the public" is not a homogenous group as implied by the rational model, but rather is made up of different interest groups and, above all, unequal power distributions. Also, as questions concerning the goals and interests of planning are mostly political rather then scientific, Davidoff urges planners to enter the political arena.

> (…) [P]lanners should be able to engage in the political process as advocates of the interests both of government and of such other groups, organizations, or individuals who are concerned with proposing policies for the future development of the community. (Davidoff, 1965: 332)

To serve the interests of all these different groups, the advocacy model propagates the development of several plans rather than only one single "master plan". All these plans should be created using extensive discussion about political values and interests and the question on how to distribute limited resources. (Davidoff, 1965; Davidoff and Reiner, 1962)

However, as everywhere else, also decisions in planning are influenced by political lobbies of the opposing interest groups and power distribution plays an important role. The model was therefore designed to work analogous to the legal system: "(…) a lawyer (advocate, in this case the planner) helps 'the weak' defend their own interests against 'the powerful' (Schönwandt, 2008: 8)." The planner is supposed to go into poor neighbourhoods, discover the "real needs" of their inhabitants, support their interests by providing his expertise and bring back and defend their interests in planning boards and council meetings. This lead to a change in the shape of planners' workaday lives. However, not before long it became apparent that disadvantages in specific neighbourhoods could not be contributed to a lack in technical expertise (which was, what planners were able to offer to them), but rather to a lack in political power to realise their ideas. As planners were not the ones holding the power in council meetings, the advocacy model was tested for its practical applicability. Unlike the legal system, where an independent third party passes the verdict based on established rules, political debates can solve conflicts only through compromise. As compromise often could not be accomplished, "(…) advocacy planners were accused of obstructing planning projects rather than offering useful alternatives (Schönwandt, 2008: 8)." The advocacy model of planning surely broadened the scope of the planner's role, but neither did it provide measures to change the established power structures, nor did it create mechanisms to solve disputes and bring about solutions. Therefore, planners developed several models to replace the advocacy model in the years to follow.

3.2.1.3 The (neo)Marxist Model of Planning

The so-called (neo)Marxist model of planning developed in the late 1960s and early 1970s to analyse the role of planning in a capitalist society. Most important are the works "Le Droite à la ville" and "The Urban Question" by Henri Lefebvre (1972) and Manuel Castells (1977), which both point to planning – in a capitalist state –being above all a political activity. The planner is therefore no longer seen as an expert, but rather as a "(…) handmaiden of capital with rather naïve ideas concerning actual power relationships – power relationships in which he himself is deeply and inescapably imbricated (Schönwandt, 2008: 10)." As a change in this situation can only be accomplished by a change in the system itself, the value of this model rather lies in the voicing of theoretical critique than on the level of the actual planning process. Again, the concept of "public interest" was questioned, however, no solutions to the problem or new definition of the tasks of the planner were offered.

3.2.1.4 The Model of Equity Planning

While advocacy planners operated mainly outside administration, decisions where still taken primarily within city councils. This new model therefore aimed at working with likeminded politicians to achieve change from within the system, thereby helping to reach justice for the disadvantaged. In their book "Making Equity Planning Work – Leadership in the Public Sector", planning theorists and practitioners Norman Krumholz and John Forester (1990) propagate the redistribution of power away from the powerful and towards the disadvantaged not by operating in opposition to official policy, but in concert with it. The planner once again acts as an expert who collects the necessary information (by talking to the people affected), analyses it, formulates the problem, and communicates everything to mayors, planning boards, and council members. "In this capacity, they have the power to guide attention towards specific issues and shape the discussion according to their own liking (Schönwandt, 2008: 11)." However, critics raised the concern that this model engaged too much in "top-down" politics and that planners may only work effectively as long as structures within the administration do not change. As it was acknowledged that neither party could have all the answers, the suggested solution was to bring these two parties together.

3.2.1.5 The Model of Social Learning and Communicative Action

The model of social learning ties in with the experiences advocacy planners had while working in poor neighbourhoods. While inhabitants of the planned regions clearly possessed the necessary technical abilities to engage in the planning process, there still was a wide gulf between the expert knowledge of the planner and the locally practiced knowledge. John Friedman, in his book "Retracking America: A Theory of Transactive Planning" (1973), described the social learning model as being based on dialogue, reflection of values, and mutual acceptance. By closely working together, the parties' interests will finally converge and conflicts can be resolved in concert. Forester (1989) points to self-reflectivity of the planner as being the decisive factor of the planning process. For him, the planner's primary task is to listen critically and find solutions by way of dialogue. Therefore, the planner does not need to be a value-neutral expert anymore, as the emphasis does not lie on the planner's knowledge but rather on how he utilise what he knows. Planning was "(…) no longer a matter of carefully analyzing the inhabitants and defining their needs and desires, but instead intensively involving them in the process of planning and incorporating their knowledge and abilities (Schönwandt, 2008: 13)."

However, also this planning model had to face critique in professional circles. First, it was pointed out that planners of this model are solely dealing with the social aspects of knowledge while neglecting work on conceptual content. Also, group dynamic processes may become a problem in this type of group-oriented planning process. Last, the five procedural demands of discursive ethic, developed by Flyvbjerg (1998), are highly unlikely to be fully met: while it might be possible to include all affected parties (requirement of generality), give them equal possibility to voice their ideas (autonomy), and engage them in the discourse (ideal role taking), it is very unlikely to eliminate differences in power (power neutrality), or establish full transparency of the parties' goals and intentions (transparency). As Schönwandt points out, "[t]here is (…) no space free of power, certainly not in planning (Schönwandt, 2008: 14)" – thereby pointing to the limits of this ambitious planning model.

3.2.1.6 The Radical Model of Planning

While supporters of the model of equity planning propagate the planner's involvement in the political arena (Krumholz and Forester, 1990), advocates of the radical model of planning point out that the close cooperation with decision makers might be the biggest weakness of this model, creating dependence on the existing power structure and administration. According to them, success in planning can only be reached from outside the administration, by working in clear opposition to it. Schönwandt (2008) explains the core points of this model to be (a) the clear opposition to governmental organisations; (b) the rejection of the domination of expert knowledge; (c) the possibility of learning through action and experience; and (d) the elimination of systemic inequities. This again leads to a new definition of the role of the planner: "(…) instead of working within the context of a professional community, the planner must relinquish his former status in order to lend his support to the disadvantaged (Schönwandt, 2008: 15)." While in the model of social learning, the planner is still a professional, however working in close contact and cooperation with his clients, here the planner denies his role as a professional and instead becomes part of, or at least shows solidarity with, the group in question.

The problems faced by the radical model are mostly connected to the size of the projects dealt with. Planning initiatives based on this model are rather suited to represent a transitional stage in the planning process. With increasing size, projects will encounter legal, financial, and political barriers, which mostly cannot be solved from a position outside the political system. The planning process will therefore not be able to avoid becoming part of the system at some point in time. Furthermore, also group-size is a decisive factor, as large groups require at least some form of internal structure, organisation, and distribution of responsibilities. The hierarchy within the group will then reflect the very weaknesses that are criticised in the system. (Schönwandt, 2008)

3.2.1.7 The Liberalistic Model of Planning

The liberalistic model of planning follows the concept of "laissez-faire" – it assumes that planning should only intervene if "free market"-mechanisms have failed and that resources used for planning should be limited as far as possible. According to Sorensen (1981, 1983), individual property rights, the individual's aim to maximise his wellbeing, and the power of contracts between individuals self-regulate the free market and empower self-realisation of the individual. Planning should only serve as a tool of avoiding unwanted consequences due to market failure, such as wrong behaviour of the individual, and infringements of (property) rights. Advocates of this model argue that expectations of what can be achieved through planning are often unreasonably high and that the free market is in fact better suited to deal with most problems. However, critics point to the fact that the concept of a "free market" is misleading and does not reflect reality. In reality, access to the free market is limited by certain entry-requirements, such as financial means and specific knowledge. To people not in possession of those means, the entry to the market is barred. (Schönwandt, 2008) Therefore, while propagating the protection of the individual's rights, this model is only conditionally able to realise its own goal, and might even lead to an increase in social inequality.

3.2.2 The development of Resilience-thinking in Urban Planning

3.2.2.1 Three Generations of Planning

While the "first generation" of planning models, consisting primarily of the rational model, saw its main tasks in analysing, comparing, developing, and applying scientific methods to support the planning process, it always defined the problems to be solved as "tame" problems. According to Rittel (1972) and Rittel and Webber (1973), "tame" problems can be defined as having a defined goal and a set of clearly defined rules and methods to achieve this goal – for example a game of chess or the solving of a mathematical equation. However, clearly not all problems can be put into this category. Therefore, "second generation" planning models were the first to acknowledge problems in planning as being "wicked" problems rather than "tame" problems. "Wicked" problems, or "ill-defined" problems, share the main characteristics that (a) each problem is essentially unique; (b) they neither have a quantifiable set of potential solutions nor a clearly defined set of measures to reach a solution; and (c) their solutions can be neither "right" nor "wrong" but only "better" or "worse". (Rittel, 1972; Rittel and Webber, 1973) While this certainly is a more accurate description of problems faced in planning processes, it would also mean that it would be basically impossible to systematise planning as no solutions could be transferred from one problem to another (Schönwandt, 2008).

Today, planning theorists are working towards a "third generation" of planning models based on systems theory. Classical systems theory describes systems as a set of interrelated components; however, this focuses solely on internal processes, not taking into consideration the system's interaction with its environment (Schönwandt, 2008). Therefore, newer research in systems theory sees the system as consisting of a system-core, which is embedded in a larger environment. To describe and understand the system, it is, however, not necessary to take into account the whole universe, but it suffices to focus on those parts of the system's environment, which either influence the system-core or are themselves influenced by it. (Mahner and Bunge, 1997) Furthermore, it is acknowledged that planners working within the system-core are always influenced by their selective perception, which is never complete and always theory-laden, and their limited ability to act. This third generation of planning models can therefore be described as follows:

> 'Agents', with their respective 'Cognitive Worlds', operate (usually as part of some organization) as the core of a system that exists in the context of an 'Environment'. Moreover, the 'Agents' that make up system-cores are constantly engaging in exchanges between themselves and various components of their 'Environment'. (Schönwandt, 2008: 28)

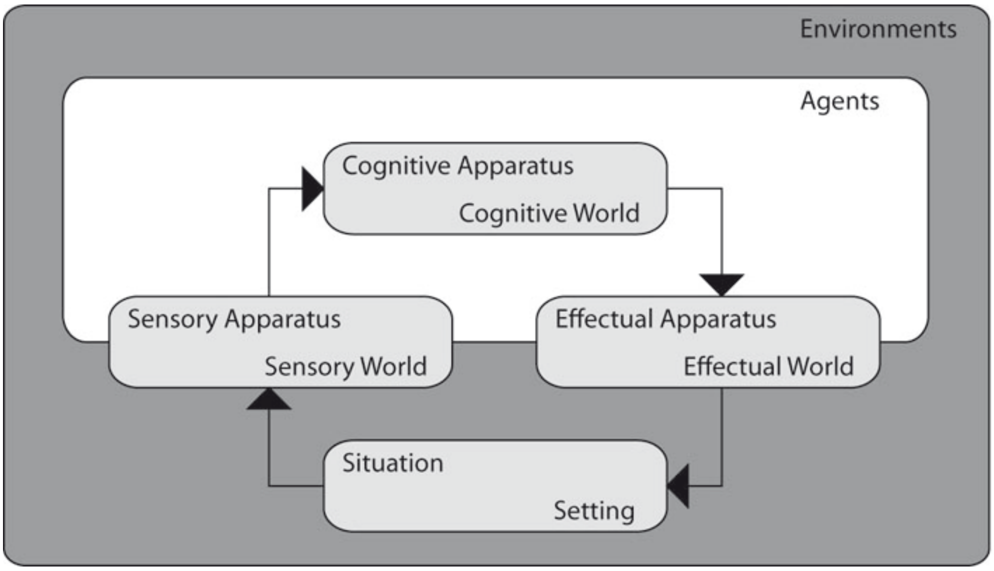

Fig. 3.5 The functional circle, modified after Schönwandt. (Schönwandt, 2008: 27)

3.2.2.2 Impacts of Previous Planning Models on the Urban System

Since the late 1970s, the neoliberal agenda has shaped the structure and functioning of urban systems. Deregulation and incorporation into the global economy under the pressure of increasing globalisation has destroyed the system's self-regulating capacities and has led to high economic and social vulnerability. This can easily be seen in many financial and economic crises within the last years and their domino effect among cities around the world. (Eraydin, 2013)

Neoliberalisation and market-oriented policies have also led to significant changes in the field of planning. Responsibilities of the former public sector have been decentralised or privatised, while consumerism and property-based developments have turned the property market into the key player in urban development (Eraydin, 2013). A fragmentation of the planning market into individual projects and plans has decreased the opportunity for sustainable long-term strategies in planning (Eraydin, 2013), and blurred boundaries between the public sector and private markets have caused a strong devaluation of planning institutions (Alexander, 2008) and an unequal redistribution of the benefits within the society (Purcell, 2009). The transfer of state functions to semi-public or private bodies has increased the number of stakeholders in the decision-making process (Albrechts, 2010; Purcell, 2009) and has therefore created the illusion of equal opportunities in this process. However, this only applies if power relations are not considered. Unfortunately, there is evidence that the transfer of responsibilities from the public to the private market has also caused a transfer of power from public institutions to corporations (Purcell, 2009).

> On the whole, then, neoliberalization has increasingly shaped state policy to benefit capital rather than citizens. (Purcell, 2009: 143) The disciplinary forces of competitiveness and capital mobility give large corporations significant control over public policy. (Purcell, 2009: 144) The mass of people, insofar as they are represented by their government, are therefore significantly disempowered with respect to capital in setting the agenda for their local area. So (...) neoliberalization produces a democratic deficit because it transfers power from democratic citizens to corporations. (Purcell, 2009: 145)

This weakening of public institutions represents another aspect of increased vulnerability of contemporary cities towards crisis and external disturbances, as can be seen in the poor institutional performances and the correspondingly disastrous outcomes following Hurricane Katrina in the U.S. in 2005, and the tsunami in Japan in 2011 (Eraydin, 2013).

Another strong pressure on the performance of urban systems is the change in urban ecosystems. As neoliberal strategies have led to a dramatic increase in the demands for land and ecological services, this has created an immediate need for sustainable urban planning. Urban sprawl is the cause of higher amounts of air pollution (caused by the increased need of transportation), higher energy consumption, higher costs of infrastructure and the loss of resource land (Ewing, 1997). "In this respect, protecting the ecological balance and the efficient and sustainable use of land have become the main points of concern on the urban environmental agenda (…) (Eraydin, 2013: 23)." Low urban density, sprawl, and fragmentation are generally seen as disadvantages to sustainable development, whereas compactness, mixed land uses, and the recycling of urban vacant land are promoted as international goals in urban planning (Eraydin, 2013). However, while these are all internal processes of the urban system, recent years have introduced new aspects to the discussion on sustainable development. Climate change and global warming, increased probability of natural hazards, and the transboundary movement of pollution and wastes have increased the external pressures on the urban system, increasing the need for a planning model, which acknowledges the interdependence of the urban system and its environment. It is this necessity that has led to resilience thinking as the new paradigm in planning practice.

3.2.2.3 Resilience Thinking – Towards a new Planning Model

As mentioned above, increasing economic, social, institutional, and ecological vulnerabilities have called for a new model in urban planning. This is also due to the fact that various economic and environmental crisis experienced in the recent past have enhanced also our perceived sense of vulnerability and have "increased [the] sense of risk (economic and political as well as environmental) and (…) the perception that processes associated with globalization have made places and regions more permeable to the effects of what were once thought to be external processes (Christopherson et al., 2013: 3)." The new model should therefore be able to reduce these vulnerabilities by enhancing the adaptive capacity, self-organisation, and transformability of the urban system. Adaptive capacity, being the core of the new model, intends to make urban systems more capable in dealing with change, and sustain important ecosystem services in the face of internal and external disturbances. Self-organisation refers to the systems ability of internal organisation without management by an external agent (Heylighen, 2001). Transformability is the capacity to create a new system, when existing conditions make the current system unsustainable; "and planning may play a vital role within this process (Eraydin, 2013: 29)."

Under the pressure of globalisation, another major aspect of the new planning model must be the acceptance of the urban system as being a dynamic socio-ecological system with changing interrelations between the system variables and their environment. The concept of resilience acknowledges this concept and argues that there will never be a stable equilibrium to return to after a disturbance but that the system processes are constantly adapting and adjusting so as to preserve the system's main functions (Holling, 1973; Walker et al., 2004; Folke, 2006; Gallopin, 2006). Therefore, it will be necessary to focus on these processes, rather than on the structure of the system (Pickett et al., 2004). Last, the planning model will need to apply systems analysis to define the vulnerabilities of the specific urban system and thereby define the starting point of the planning process.

A planning model based on resilience will need to find a way to integrate the two dominating paradigms, rational planning and communicative planning. This can be explained by the use of Ernest Alexander's (2000) classification of rationality, as applied by different planning models. He mentions different types of rationalities:

1. *Instrumental Rationality*, which means to determine the optimal means to reach a defined goal
2. *Substantive Rationality*, which demands evaluation of the objectives and possible alternative goals
3. *Bounded Rationality*, which accounts for the sometimes morally questionable means to achieve a necessary goal in political decision-making
4. *Strategic Rationality*, which mentions the interdependence of the decision-maker and other actors and introduces the concept of power relations
5. *Communicative Rationality*, which shifts the focus away from the goal towards the value of social interaction

(Alexander, 2000)

As the concept of resilience clearly does not provide a defined goal for planning, but rather focuses on the means and maximum flexibility, neither instrumental, nor bounded or strategic rationality seem to work as a basis for resilience planning. Using substantive rationality would allow for more flexibility, but would also struggle with the problem of the value bias of the single expert planner. Communicative rationality would include different parts of the society and their perspectives, but would not create comprehensive long-term strategies but only case-specific solutions. Therefore, what is needed is an *integrated rationality* –

> (…) a complex construct, a recursive process deploying different forms of rationality at successive stages by various actors in changing roles. Sometimes these roles are individual or quasi-individual, applying forms of [substantive] rationality to evaluate alternative courses of action. In other stages, such a quasi-individual (a firm, organization, agency, or government) disaggregates into its relevant component actors, invoking an applied form of communicative rationality to address its interaction. At other times again, these rational agents interact as a collectivity in a process of communicative action. (Alexander, 2000: 247)

Different than the conventional planning models, this model aims at utilising actors as individuals (i.e. technical experts) as well as individuals in interactive and interdisciplinary teams. Which concept is used depends on the different stages of the planning process. In a first stage, the definition of the critical issues and their analysis should be accomplished by individual experts using instrumental and substantive rationality. For this stage, it will be crucial to define the main processes and structural constraints, as well as the impacts of possible disturbances and their effects on each other by the use of an integrative analysis of the urban system's socio-ecological dynamics. (Eraydin, 2013) The outcomes of this stage should then be used as inputs for the next stage, which comprises the definition of the problem-areas, using a decision making-process based on communicative action. To make this second stage most effective, Eraydin (2013) emphasises the importance of *commitment* of the actors involved, which ensures that the outcome will not be "based upon short-term expectations and socially constructed values (Eraydin, 2013: 31)" but will instead rather be focused on the long-term horizon.

Concluding, it can be said that planning theory of the recent past has mainly focused on the procedural side of planning. However, external developments and current problems of urban systems are taking place on the substantive side. This will continue to put pressure on the existing models, calling for answers and demanding responses. Resilience planning may offer answers by providing new *substance and context*, based upon the vulnerabilities of the urban system and the improvement of its adaptive capacities as the key goal of planning. (Eraydin, 2013) However, sustainable change in planning will not be accomplished without the accompanying development of a new value system. Without common expectations of the future, every decision will favour some, and not favour others – leading to inequalities in the society in the long run (Purcell, 2009). Decisions taken and agreements reached under this circumstances will be based on and even reinforce existing power relations, intensifying the democratic deficit of today's neoliberal system and thereby increasing its vulnerability. However, discussing the common value system necessary to achieve resilience is out of the scope of this paper. I will therefore assume this necessary requirement as given, albeit it's content might still be subject to future development.

4 Evaluating Urban Resilience

4.1 The Need for Indicators and Guide Values

According to Bossel (1998), human beings need symbols, so-called 'indicators', for their orientation in a complex world. These indicators help to reduce the complexity of the system to tangible and understandable information. To deal with complex systems, it is therefore necessary to observe a specific set of indicators and to identify the meaning of their current state to the system. What their current state implies for the system will, however, always depend on the determined "goal" for the system and is therefore closely linked to values and norms. Bossel (1998) identifies two essential information that can be derived from indicators: (1) the current state of the system and its functional capability, and (2) the system's 'position' in relation to predefined goals.

Systems theory uses two different types of indicators to describe a system: (1) indicators, which measure the current state of the system and (2) indicators, which compare those measurements to existing measurements and therefore describe the rate of change of the particular variable. The second type of indicators usually is the more valuable one, as it gives you information on possible future developments and trends. Furthermore, systems theory tells us that not each individual variable in the system might be used as an indicator. This is because some variables might only be a combination of other variables but do not give new information on the system. Therefore, according to Bossel (1998), only those variables giving fundamental information, which cannot be derived from any other variable, should be regarded as "indicators". Moreover, information derived from indicators may be either quantitative or qualitative. However, in the end, all information must be translated into a qualitative statement anyways, to assess its implications for the system.

4.2 Defining Indicators and Guide Values

4.2.1 Basic Concepts

4.2.1.1 Indicators vs. Indices

As already described above, not all variables observed may be suitable as an *indicator* (Bossel, 1998), and any suitable variable only becomes an indicator as soon as its meaning for the evaluation has been defined (Tanguay et al., 2010). For example, the unemployment rate of a country can only be used as an economic indicator once it has been determined that an increase in this number generally has a negative effect on a country's economic performance.

An *index*, on the other hand, is a synthesis of different indicators. Indices help to describe phenomena, which cannot be described by a single indicator. This concept is often used to make complex phenomena more easily understandable for the general public. (Tanguay et al., 2010) The *Human Development Index (HDI)*, for example, consists of three indices: life expectancy index, education index, and income index. Each of these indices is further described by a given set of indicators – the education index comprises the variables "mean years of schooling" and "expected years of schooling". The HDI was developed in 1990 by the United Nations Development Programme to raise the awareness that development politics should focus on the human being rather than solely on economic issues (United Nations Development Programme (UNDP), 2013), and is therefore a good example for the purpose and use of indices.

4.2.1.2 Aggregation, Weighting, and Threshold Values

Aggregation can be a concept to either compare the same indicator within different spatial or temporal scales (i.e. progression from a national to a regional scale, or from an annual to a monthly interval), or to combine thematically similar indicators to generate an index (Tanguay et al., 2010). By applying the concept of *weighting*, each indicator can then be attributed a different importance for the index. However, this approach has encountered a lot of criticism, as it is usually a rather "(…) arbitrary process and no weighting structure can rationally justify the attribution of a given weight (e.g. greater weight) to a given indicator (Tanguay et al., 2010: 408)."

The term *threshold value* mainly applies to environmental issues. It refers to a scientifically proven reference value, which causes the described phenomena to change or deteriorate (i.e. pollution of air, water, and soil). The term *critical value*, on the other hand, describes an arbitrary, yet generally recognised standard. For example, it is often stated that a 30% income allocation to housing constitutes a critical value for falling below the poverty line. Where indicators have neither a scientifically based threshold value, nor an agreed upon critical value, the thresholds are often determined based on the experience of other, similar, territories. This is then called *relative performance* and the indicator is evaluated in relation to the best and worst performers of the region. (Tanguay et al., 2010)

4.2.2 Sustainable Development Indicators

As described by the Brundtland Report (WCED, 1987), sustainable development is influenced by three different dimensions – the economic, the social, and the environmental dimension – and their interaction amongst each other. Accordingly, Tanguay (2010) follows that, to lead to sustainable development, those interactions must be

(1) *Equitable* (referring to the interaction between the economic and the social dimension),

(2) *Livable* (referring to the environment to provide services to meet social needs - corresponding to the concept of "quality of life"), and

(3) *Viable* (referring to the concept that economic development must not lead to environmental degradation through the depletion of non-renewable resources).

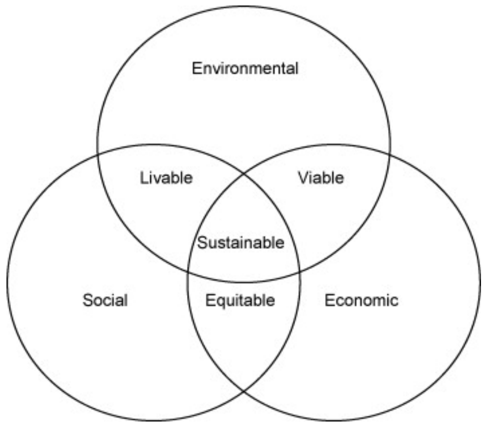

Fig. 4.1 Classic dimensions of sustainable development. (Tanguay et al., 2010: 408)

Sustainable Development Indicators (SDI) therefore usually comprise variables from these three dimensions to assess and monitor an urban system's sustainable development strategy and performance. However, a study by Tanguay (2010) shows that SDI are still far from being a generalized and not yet usable for comparing systems on an international level. His review of 17 studies dealing with the development of SDI for cities in western developed countries displays many of the problems with regards to the definition of indicators and the development of indices.

First, it can be seen that there is a clear lack in consensus on the optimal number of indicators to be used, ranging from only 10 up to 86 indicators used within one study. This is often due to the problem of data availability. Constraints of availability and accessibility of data often "(…) dictate[ ] the use of less than maximally efficient indicators to capture sustainable development on the municipal scale (Tanguay et al., 2010: 413). "

Second, also the indicators themselves widely differ between the studies. While altogether the 17 studies use 188 different indicators, only 28% of the indicators are used in three studies or more. (Tanguay et al., 2010) This can be explained by the lack in consensus concerning the definition of the term "sustainable development" (Tanguay et al., 2010; Levett, 1998). Definitions are commonly rather broad and interpretations develop over time. This can easily be seen by the fact that institutional sustainability has only recently been adopted as a fourth dimension (Spangenberg, 2007). However, there is still no general consensus on this issue and some studies still treat institutional indicators within the social domain. Levett (1998) addresses this problem by stating that "[t]he struggle to find and use indicators of sustainable development is intimately bound up with the process of deciding what we mean by sustainable development and what we shall do about it (Levett, 1998: 291)." This problem is also reflected in Tanguay's study (2010), where he shows that the approaches on how to define the indicators strongly depend on the objective of the respective study. These objectives are often specified to fit a specific city and/or target audience rather than aiming at generalized indicators for enhanced comparability between cities. Indicators customized to a specific city clearly do have certain advantages, as the unique properties of a city can be taken into account. However there is a clear

> (…) tradeoff between consideration of specific factors for each city or municipality and the need to homogenize the indicators such that they allow a fairer comparison between municipal jurisdictions of the same stature. (…) [C]omparability and the adoption of common SDI is necessary to avoid that SDI become marketing tools for cities tempted by choosing indicators that make them look good only. (Tanguay et al., 2010: 411-412)

Third, it can be said that the indicators of all compared studies cover the three dimensions of sustainable development as defined above. However, while social and economic indicators show higher consensus between the studies, environmental indicators differ widely (see Fig. 4.2 and 4.3) and are generally fewer in number than those of the other categories. According to Tanguay (2010), this can be attributed to the fact that qualitative and quantitative data on social and economic variables (such as household assets, employment, education, income, etc.) are more easily accessible at a municipal level than are environmental data (such as GHG emissions, air quality, energy consumption, etc.).

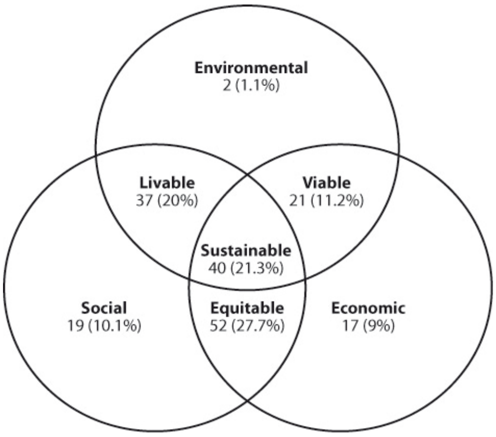

Fig. 4.2 Classification of the 188 indicators counted by Tanguay. (Tanguay et al., 2010: 411)

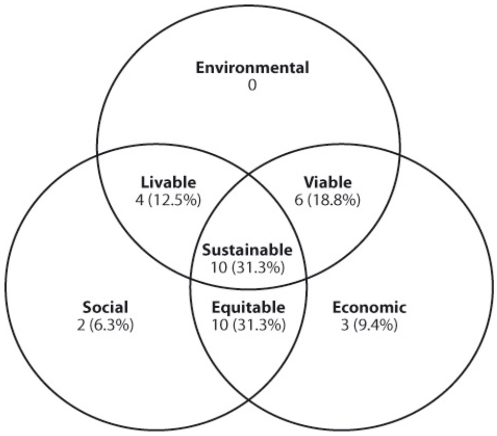

Fig. 4.3 Indicators used four times or more. (Tanguay et al., 2010: 413)

In his study, Tanguay (2010) identifies 29 indicators of sustainable development (see Table 4.1). He does this by applying a Survey-based selection strategy (SuBSelec), selecting those indicators, which (1) are used most often, (2) best cover all components of sustainable development, and (3) are most easily obtained by data collection.

Table 4.1 The 29 indicators developed by Tanguay. (Tanguay et al., 2010: 415)

Indicator	Description	Dimension of sustainable development	Category
SD policies or strategies	Absence or presence of political initiatives supporting sustainable development	Sustainable	Administration, public expendiures
Density of urban population	Density of population per square kilometre in urban areas	Sustainable	Demographics
Daily water consumption per person	Average daily water consumption per person per year	Sustainable	Water
Ecological footprint	Ecological footprint	Sustainable	Unclassified indicator
State of health reported by population	Percentage of people claiming that they feel well or very well	Sustainable	Health
Users of mass transit (MT)	Percentage of users of MT vs other means of transport	Sustainable	Transport
Space alloted to nature conservation relative to area of territory	Space alloted to nature conservation relative to area of territory	Sustainable	Ecosystem, heritage, green space
Cost of living	Cost of living in $ per person	Economic	Well being
Participation rate for all sectors	Change in participation rate	Economic	Employment
Job creation for all sectors combined	Number of new jobs per year for all sectors	Economic	Employment
Mean or median household income per year	Mean/median household income ($ per year)	Economic	Income and expenses
Households spending 30% or more of income on housing	Percentage of Households spending 30% or more of income on housing	Equitable	Housing conditions
Population aged 18 and over with less than a high school diploma	Percentage of population aged 18 and over with less than a high school diploma	Equitable	Education
Unemployment rate	Unemployment rate of the workforce	Equitable	Employment
Ratio, population with high income–low income	Ratio of population with income over $80,000 to population with income below $20,000	Equitable	Income and expenses
Population receiving social assistance	Percentage of workforce receiving social assistance	Equitable	Income and expenses
Low income households	Households with income below $10,000 per year	Equitable	Income and expenses
Crime rate	Crime rate per 100,000 inhabitants	Equitable	Security
Rate of participation in municipal elections	Rate of participation in municipal elections	Social	Governance
CItizen participation in public affairs	Rate of participation in public hearings	Social	Governance
Annual consumption of energy from renewable sources	Annual consumption of energy from renewable sources per inhabitant in kWh	Viable	Energy
Businesses with environmental certification	Percentage of businesses with environmental certification	Viable	Businesses
Quantity of waste recycled	Quantity of waste recycled in tonnes/inhabitant/year	Viable	Waste
Concentration of PM10 particles	Average annual concentration in designated residential zones	Livable	Air
GHG emissions (excluding transport)	GHG emissions in tonnes of CO_2 per year (excluding transport)	Livable	Air
Population exposed to Lnigh > 55 dB (A)	% of total population exposed to Lnight > 55 dB (A)	Livable	Noise
Quality of waterways	Percentage of waterways with excellent water quality	Livable	Ecosystem, heritage, green space
Quantity of household waste	Quantity of household waste sent to landfills (tonnage per year)	Livable	Waste
Participation in sports in parks and swimming pools	Number of participants as percentage of total population	Livable	Social and community services

4.2.3 Resilience Indicators

In a subsequent study, Normandin et al (2009) used a similar approach to define indicators for urban resilience and then compared these indicators with the sustainable development indicators derived by Tanguay (2010). They used nine studies on urban resilience and made similar findings:

First, the studies used a large variety of indicators - only 31 out of the 273 indicators used, were present in two studies or more (11%). Normandin et al. (2009) account this to the fact that there is still no general consensus on the definition of and on how to measure "(…) the risk, vulnerability and/or resilience of cities, which results in a large variety of indicators (Normandin et al., 2009: 7)." He also mentions that the compared studies were developed for assessing the resilience status of cities in different parts of the world and that local characteristics apparently play a large role in the development of indicators.

Second, Normandin et al. (2009) are able to show that, similar to the studies on sustainable development, all studies on urban resilience use indicators, which equally cover all four dimensions of urban resilience as developed by the Resilience Alliance (2007), although none of the studies explicitly refers to this specific concept. This implies that, although there is no general consensus yet on precise definitions of resilience and vulnerability, there seems to be consensus on the different aspects of resilience. These aspects – or dimensions – are defined as

1. **Metabolic flows**
   One of the main functions of urban systems is to sustain human wellbeing and quality of life by maintaining the various flows of material goods, services, and energy, which often come in from ecosystems outside the city boundary (Folke et al., 1997). Flows into the city can enter either actively (transport into the city by human effort) or passively through natural processes (i.e. solar radiation and hydrological processes) (Decker et al., 2000). All this makes a city very dependent on its surroundings and the following considerations must be made if the city wants to increase its resilience. First, cities relying on only one or a very limited number of suppliers for their goods and services are far more vulnerable towards impacts affecting this supplier (i.e. ecological change, natural hazards, or geopolitical instability) than cities who have a higher *diversity* in their supply portfolio. Second, *connectivity* between regions and globalisation in general implies that the resilience of one city might be indirectly dependent on the resilience of another city and that transregional and global efforts should be

taken to enhance the resilience of all cities. Third, *urban metabolism* itself needs to be adapted. Increasing the recycling rates, for example, could reduce the dependency on external resources and thus might enhance the systems resilience. (The Resilience Alliance, 2007)

2. **Social Dynamics**

   Future population growth will be almost solely absorbed by urban areas (United Nations, 2012). The urban population itself will, however, not only be influenced by natural population growth, but will additionally increase by rural-to-urban migration and the incorporation of surrounding rural areas into the city boundaries. This often fast increase can lead to or deepen existing problems of unemployment (and therefore poverty), missing infrastructure and housing, deficiencies in social services, as well as degradation of the environment. This leads to changes in social dynamics, which become increasingly important. For example, Olsson et. al (2004) found out that communities with strong social networks are far more resilient as they are better able to adapt to and respond to changes in their environment. Generally, it can be said that not only *demographic* changes should be observed when assessing a city's resilience, but also issues of *distribution* of economic and environmental resources within the communities. Another aspect often mentioned in resilience research is the issue of *diversity*, as it might be possible that "populations with a mix of cultures, age groups and education levels, for example, have a higher level of social capital in terms of organisational knowledge and life experience to withstand rapid-onset shocks (The Resilience Alliance, 2007: 14)."

3. **Governance networks**

   As described in a previous chapter, planning models of the recent past and the increasing pressure of globalisation have led to privatisations of traditional functions of the government, decentralisation of public institutions, as well as a strong devaluation of planning institutions (Alexander, 2008) and an unequal redistribution of the benefits within the society (Purcell, 2009). In the field of land-use planning, this has led to overlapping and often competing jurisdictions between the national, regional, and local level and an inability to act and distribute financial resources in times of crisis, when fast action would be most needed. 'Good governance' is therefore often mentioned as a precondition to ensure equal distribution of resources and enhance urban resilience (Pirez, 2002). According to the United States' National Academy of Science's Panel on Urban Population Dynamics, urban governance comprises five key dimensions:

(1) The *capacity* to provide the required serviced
(2) The ability to raise and conscientiously manage sufficient *financial* capital
(3) The ability to deal with urban *diversity* and inequality
(4) The capacity to cope with rising urban *security* threats
(5) The ability to manage the increasing complexity of *authority* and to mediate across jurisdictions
(National Research Council - Panel on Urban Population Dynamics, 2003)

4. Built environment

Urban landscapes often show a diverse mixture of different land-uses and habitats. However, whereas urban landscapes are highly dynamic systems – experiencing rapid rates of change, perpetual disturbances, and complex interactions between the environment and its inhabitants – urban planning is relatively static. This is due to the different timescales on which the two operate: while urban landscapes are constantly forced to cope with and adapt to ongoing changes in the environment, urban planning is based on building codes and legislation, which has developed over a long time span and has been agreed upon a long time ago. "Thus to a large extend, we live in 'yesterday's cities' in the sense that many of the urban patterns we see today – roads, buildings, land ownership, etc – reflect decision making periods of the past (The Resilience Alliance, 2007: 17)." This is important as the special organisation of a city highly influences its internal processes. For example, the physical location of mobility infrastructure (such as roads, railway stations, and airports) directly controls the flow of goods and people in and out of the city. (Garmestani et al., 2005) The built environment therefore plays a large role in shaping the organisational principles of a city and thus contributes to a city's resilience. Further research will be necessary to clarify the role of different *patterns, sizes, and diversity* (i.e. the role of 'greenspace', or the optimal density) towards urban resilience, and to investigate upon how urban *planning culture* can be made compatible with the speed of urban system change and how a system's self-organisation capacity may be included in the planning process. (The Resilience Alliance, 2007)

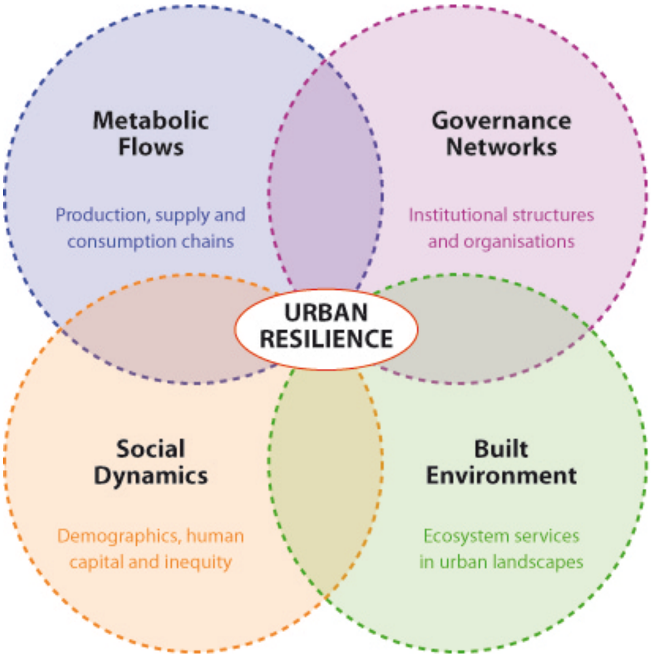

Fig. 4.4 The four dimensions of urban resilience, modified after The Resilience Alliance. (The Resilience Alliance, 2007: 10)

By analysing the 31 most used indicators (see Fig. 4.5 and 4.6), Normandin et al. (2009) found that, regardless of the four dimensions of resilience, all of the indicators belong to one of three categories: (1) characteristics of the situation, (2) tools for prevention, mitigation or crisis management, or (3) critical infrastructure[1]. (Normandin et al., 2009: 11) However, they also found that while all four dimensions of resilience are equally represented in the studies, the 31 most commonly used indicators show an under-representation of the institutional dimension. This clearly shows the lack of consensus and the difficulties in defining meaningful indicators in the governmental/policy-making area.

As shown so far, the approaches in, as well as the problems related to developing indicators for sustainable development and resilience are quite similar. Both fields cover similar dimensions of urban development and share problems of consensus-building in defining indicators as well as problems of data availability. It is thus not surprising that many scholars see a close relationship between resilience and sustainable development

[1] "Critical infrastructures are those physical and cyber-based systems essential to the minimum operations of the economy and government. They include, but are not limited to, telecommunications, energy, banking and finance, transportation, water systems and emergency services, both governmental and private. (…) As a result of advances in information technology and the necessity of improved efficiency, (…) these infrastructures have become increasingly automated and interlinked. These same advances have created new vulnerabilities to equipment failure, human error, weather and other natural causes, and physical and cyber attacks." (Clinton, 1998: 1-2)

and advocate the linkage of the two fields for future research (Adger, 2000; Pelling, 2003; Berkes and Folke, 1998). Adger (2000), for example, states that "(…) resilience, in both its social and ecological manifestations, is an important aspect of the sustainability of development and resource utilization (Adger, 2000: 357)."

It would therefore not be surprising to find similar indicators for the two fields. However, when comparing the 31 resilience indicators with the 39 sustainable development indicators derived by Tanguay (2010), Normandin et al. (2009) found that only a small minority of less than 5 indicators overlap. So while scientific literature tries to develop the linkages between resilience and sustainable development, the "(…) analysis shows a lack of transportation of this idea in the indicators (Normandin et al., 2009: 16)." This will most certainly lead to future difficulties in the development of globally applicable indices and the comparability of cities.

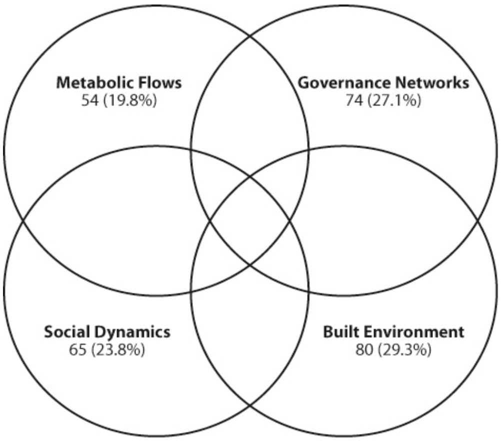

Fig. 4.5 Classification of the 273 indicators counted by Normandin, modified after Normandin et al. (Normandin et al., 2009: 11)

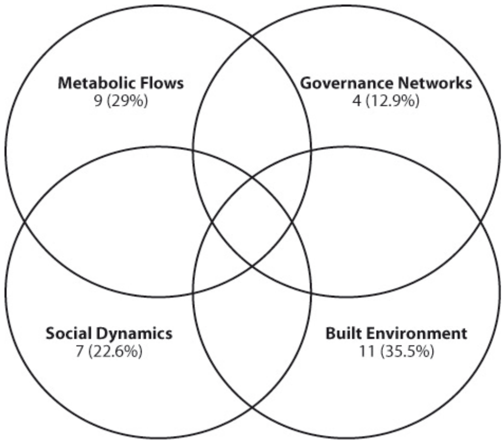

Fig. 4.6 Indicators used two times or more, modified after Normandin et al. (Normandin et al., 2009: 16)

4.3 Existing Resilience Frameworks

Assessing and monitoring urban resilience has become an increasingly popular topic in urban research. This can be seen by an increasing number of initiatives proposed by the academic community, private businesses and international organisations, on how to address the issue of urban resilience. The following paragraphs will give a short overview on some of the larger frameworks and approaches.

4.3.1 The RA's Urban Resilience Research Initiative

In 2007, the Resilience Alliance published a Research Prospectus on Urban Resilience, which "(…) serves to prioritise research over the next 3-5 years and provides a framework (…) to guide the preparation of integrated and coordinated new research proposals, (…) and will act as an umbrella initiative for engaging with related global research activity (…) (The Resilience Alliance, 2007)." The framework should build on the four dimensions of urban resilience – Metabolic Flows, Governance Networks, Social Dynamics, and Built Environment – as already described in more detail in the previous section. Although since then the Alliance published a new document on how to assess resilience (The Resilience Alliance, 2010) as part of there ongoing research on resilience in general, there has not yet been issued a follow up publication on the progress of the urban resilience research programme.

4.3.2 The ACCCRN's Shared Learning Dialogue (SLD) Process

The Asian Cities Climate Change Resilience Network (ACCCRN) was founded in 2008 as a means to address Climate Change related risks to urban areas and to develop effective response strategies. The network consists of 10 cities from four different countries (India, Indonesia, Thailand, and Vietnam) and is funded by the Rockefeller Foundation as part of their nine-year Climate Change Resilience initiative. (ACCCRN, 2013)

The ACCCRN approach towards urban resilience emphasises the "(…) collaboration between outside experts, national partners, local governments, and other organizations (…) (Asian Cities Climate Change Resilience Network (ACCCRN), 2009: 2)", which is why they developed the Shared Learning Dialogue (SLD), a framework, lead by the Institute for Social and Environmental Transition (ISET), to implement "(…) iterative, transparent group discussions with local actors in communities, government agencies, and specific organizations designed to bring together available information on climate change with local knowledge and perceptions (Asian Cities Climate Change Resilience Network (ACCCRN), 2009: 8)." The objective of this approach is to integrate vulnerable population groups into the urban resilience planning process, which makes it comparable to the planning model of social learning and communicative action, as described in the previous chapter. However, this framework takes it one step further by including not only actors from all levels within the city, but also tries to establish a planning cooperation between cities with similar challenges. While the framework explicitly acknowledges the uncertainties of climate projections and the complexity of adaptive socio-ecological systems, the outcome of the SLD still aims at more than just common understanding between the groups and tries to deliver concrete actions for responding to future climate change related challenges. (Asian Cities Climate Change Resilience Network (ACCCRN), 2009)

The SLD Process can therefore be seen as a new approach in urban resilience planning, as it includes actors and stakeholders from different levels and aims at increasing the adaptive capacity of the most vulnerable groups. However, they do not address the problem of assessing a cities resilience status systematically. While the vulnerability is been assessed in the course of the SLD process, there is no general framework or index, all participating cities use, but the "ACCCR partners adapt existing tools and methodologies for conducting vulnerability assessments to their specific contexts (Asian Cities Climate Change Resilience Network (ACCCRN), 2009: 9)." This decreases transparency and makes it difficult to compare the outcomes of different cities' planning processes. Therefore, the goal of cooperation between multiple cities might be difficult to achieve.

4.3.3 The USAID's Coastal Community Resilience Guide

In 2007, the U. S. Agency for International Development (USAID) published the "How Resilient is Your Coastal Community? A Guide for Evaluating Coastal Community Resilience to Tsunamis and Other Coastal Hazards" (U.S. Indian Ocean Tsunami Warning System Program, 2007). The guide aims at utilising the experiences gained from the 2004 tsunami to reduce the vulnerability of coastal communities to natural hazards. It does so by providing a framework for the assessment of Coastal Community Resilience (CCR) and thereby complementing further planning processes. Similar to the ACCCR process, the CCR assessment should be "(…) conducted as a collaborative and participatory undertaking by coastal communities, national and local government agencies, NGOs, the private sector, and other key stakeholders to identify strengths, weaknesses, and opportunities to enhance resilience at local and national levels (U.S. Indian Ocean Tsunami Warning System Program, 2007: 1-3)." To assess the vulnerability, the guide addresses 11 different coastal hazards – such as (but not limited to) tsunamis, earthquakes, storms, flooding, oil spills or chronic pollution, shoreline erosion, and sea level rise – but also places importance on internal vulnerabilities of coastal communities, such as environmental degradation due to increasing coastal populations, or insufficient disaster warning systems. Furthermore, the guide aims at integrating the three often separately treated domains of coastal resilience planning into one single framework:

(1) Community development (governance, social & economic conditions) (IMM Ltd., n.d.; Canadian Centre for Community Renewal (CCCR), 2000)

(2) Coastal management (human resource use & ecosystem management) (White et al., 2005)

(3) Disaster management (preparedness, response, recovery, mitigation) (Asian Disaster Preparedness Center (ADPC), 2005)

Also the assessment of the resilience status reflects the attributes of these three dimensions. USAID developed 8 categories and corresponding benchmarks to "(…) characterize the desired conditions for each resilience element (U.S. Indian Ocean Tsunami Warning System Program, 2007: 1-4)." (see Fig. 4.8 and Appendix I) However, the guide does not introduce a generalised system for rating the benchmarks but rather suggests to use one of two different approaches – first, a numerical rating system, rating the conditions from 0 (condition absent) to 5 ("Excellent" - 81 to 100 % fulfilled, sustainable), and second, a trend rating system, stating whether the conditions are "poor", "fair", or "good" and whether they have been "stable", "declining", or "improving" over the recent past. (U.S. Indian Ocean Tsunami Warning System Program, 2007)

Fig. 4.7 Resilience as an Integrating Framework for Community Development, Coastal Management, and Disaster Management Domains.
(U.S. Indian Ocean Tsunami Warning System Program, 2007: 3-3)

Fig. 4.8 Elements of Coastal Community Resilience
(U.S. Indian Ocean Tsunami Warning System Program, 2007: 3-3)

Summarising, it can be said that this guide gives a more comprehensive understanding of how resilience could be assessed and the result integrated into the planning process. The eight categories of coastal community resilience developed in the guide overlap with the resilience domains established by the Resilience Alliance. The CCR guide even further extends the general definition by including benchmarks connected to disaster management. The establishment of common benchmarks offers the opportunity to compare different coastal communities. However, the lack of a common rating system makes comparisons difficult. Moreover, the benchmarks are defined rather vaguely, which only allows for a qualitative rating rather than a real numerical rating based on actual numbers. However, the guide acknowledges these problems and suggests the application of a multi-step data collection process, including interviews, group discussions, and participatory mapping with multiple stakeholders from different levels of the community (U.S. Indian Ocean Tsunami Warning System Program, 2007), to minimize errors and lopsidedness of the result.

4.3.4 The World Bank's Climate Resilient Cities Approach

In 2009, the World Bank published a

> (…) guide for local governments in the East Asia Region to better understand the concepts and consequences of climate change; how climate change consequences contribute to urban vulnerabilities; and what is being done by city governments in East Asia and around the world to actively engage in learning, capacity building, and capital investment programs for building sustainable, resilient communities. (Prasad et al., 2009: XIII)

The guide suggests a three-step process, starting with a vulnerability assessment. The assessment should be conducted by a *City Climate Change Team*, consisting of members from different governmental departments dealing with climate change issues (such as, for example, environment, spatial planning, transportation, infrastructure, etc.), but "[t]he cities are also encouraged to include other stakeholders from the scientific and technical institutions and from civil society (Prasad et al., 2009: 42)." Through a series of workshops, the City Climate Change Team should then collect enough information to complete a *City Typology and Risk Characterization Matrix*, consisting of 11 categories in 6 key areas (see Appendix II). The outcome of the assessment then states whether the city is a "Hot Spot", meaning very vulnerable to climate change risks, whether it is "Resilient", or somewhere in between.

As a second step, the guide proposes to use the Matrix to establish a City Information Base, called the *Climate Change Impacts and Disaster Risk Management Workbook*, as "(…) a useful record and tool of the process and results of addressing impacts and hazards that lead to policy and [priority] plan development and implementation (Prasad et al., 2009: 55)." The third step in the process is to develop a *Climate Change Impacts and Disaster Risk Management Framework* to define priority actions and strategies for the future planning process. However, while the guide offers example questions to be addressed while developing the framework, the guidance on the issue is not very detailed and lacks information on how exactly this framework should look like and how its implementation should be accomplished.

While the guide offers a definition of resilience comparable to the one presented in chapter one of this thesis, the Hot Spot Assessment more or less equates vulnerability with resilience without explaining the reasons for that. While this clearly lacks consistency, the assessment itself covers similar categories as the resilience assessment described in the USAID guide and can therefore generally be seen as a resilience assessment rather than a mere vulnerability assessment. The World Bank guide uses an equal amount of questions, or "benchmarks", as the USAID guide, yet, it offers a less comprehensive explanation on the role of the different categories and why they are important for urban resilience. However, the guide touches upon the important issue of developing a knowledge base, which, while maybe indirectly implied, is not explicitly mentioned in the other popular guides or frameworks, although USAID suggests that "[e]ffective practices in CCR need to be documented, evaluated, and shared (U.S. Indian Ocean Tsunami Warning System Program, 2007: 5-3)." Developing a workbook should be part of every resilience planning since only "[a]n updated, working information base is key to sound urban management" as "[i]t will explain the city context and the 'why' behind the plans (…) (Prasad et al., 2009: 55)."

4.4 The Hyogo Framework for Action and the Climate Disaster Resilience Index (CDRI)

Starting in the 1960s, natural disasters and disaster risk reduction (DRR) became increasingly important on the international agenda (UNISDR, 2014). Loss of human lives and economic losses challenging economic development gains lead to different UN resolutions targeting the assistance in case of natural disasters and finally lead to the establishment of the *United Nations Disaster Relief Office (UNDRO)* in 1971 (UNISDR, 2014), to "promote the study, prevention, control and prediction of natural disasters (UN Resolution 2816: Assistance in case of natural disaster and other disaster situations, 1971: 1(f))." In 1990, the UN declared the *International Decade for Natural Disaster Reduction (IDNDR)*, leading to the adoption of the *Yokohama Strategy and Plan of Action* at the first *UN World Conference on Disaster Reduction (UN WCDR)*, held at Yokohama, Japan from 23 to 27 May 1994 (UNISDR, 2014; Matsuoka and Shaw, 2011). At the end of the decade, the *International Strategy for Disaster Reduction (ISDR)* was established (UN General Assembly Resolution 56/195: International Strategy for Disaster Reduction, 2001) "(…) as the successor mechanism of IDNDR within the United Nations to promote increased commitment to DRR and strong linkages to sustainable development (Matsuoka and Shaw, 2011: 129)." The "ISDR system consists of governments, intergovernmental and nongovernmental organizations (NGOs), international financial institutions, scientific and technical bodies, and specialized networks as well as civil society and the private sector (Matsuoka and Shaw, 2011: 130)", working together on global, regional, national, and different thematic platforms.

Based on the ISDR, a comprehensive policy guidance was developed and adopted by 168 UN member states at the second UN WCDR, held in Kobe City, Hyogo Prefecture, Japan in December 2005 – the *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA)* (UNISDR, 2014; Matsuoka and Shaw, 2011; International Strategy for Disaster Reduction (ISDR), 2005). The severe Indian Ocean tsunami that struck Southeast Asia only three weeks before the conference was probably one of the reasons that disaster risk reduction shifted away from the solely scientific sphere to find its way into the political agenda and gain increased political commitment around the world (Matsuoka and Shaw, 2011). The *United Nations Office for Disaster Risk Reduction (UNISDR)* secretariat supports countries in their efforts to implement the Hyogo Framework for Action and advocates DRR efforts on the international level to strengthen global political commitment.

4.4.1 The Hyogo Framework for Action

The HFA was developed to serve as policy guidance to all stakeholders involved in DRR. It consists of three strategic goals, five priorities for action, and the corresponding actions. The strategic goals target capacity-building to strengthen the role of DRR in national policies, and are as follows:

> (a) The more effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels, with a special emphasis on disaster prevention, mitigation, preparedness and vulnerability reduction;
>
> (b) The development and strengthening of institutions, mechanisms and capacities at all levels, in particular at the community level, that can systematically contribute to building resilience7 to hazards;
>
> (c) The systematic incorporation of risk reduction approaches into the design and implementation of emergency preparedness, response and recovery programmes in the reconstruction of affected communities.
>
> (International Strategy for Disaster Reduction (ISDR), 2005: 3-4)

To achieve these goals, the HFA suggests five priorities of action:

1. **Making DRR a national and a local priority** (by establishing institutional and legislative frameworks, allocating necessary resources, and enabling community participation);
2. **Improve disaster risk information and enhance early warning** (by conducting risk assessments, developing early warning systems, and building the capacity to process and interpret information on possible risks);
3. **Build a culture of safety and resilience at all levels** (by exchanging information, providing education and training, promoting research, and fostering public awareness)
4. **Reduce the underlying risk factors** (through sound environmental and natural resource management and land-use planning, and through sustainable social and economic development practices)
5. **Strengthen disaster preparedness for effective response at all levels** (by promoting dialogue and exchange of information, coordinating regional approaches, establishing funds, providing for periodical reviews of disaster management plans, and supporting community participation)

(International Strategy for Disaster Reduction (ISDR), 2005: 6-13)

(For further detail on the actions defined by the HFA, please refer to Appendix III.)

In 2007, UNISDR developed a guideline for implementation of the HFA on the national level, called *Words Into Action: A Guide for Implementing the Hyogo Framework* (UNISDR, 2007; Matsuoka and Shaw, 2011). The guide defines 22 tasks to be performed by national governments to ensure implementation of DRR (UNISDR, 2007). However, while this guide was developed for stakeholders at national level, the most effective process in which the HFA could be implemented is at local level (Matsuoka and Shaw, 2011). "This is because impacts of disasters are most immediately felt and intensely felt at the local level. (…) Each local entity/city is unique in its immediate and long-term needs for DRR [and] [a]ll people and entities have a stake in DRR to protect their lives and livelihoods (Matsuoka and Shaw, 2011: 135)", which is why their participation in the implementation of the HFA should be encouraged. Following this argumentation, one of the thematic platforms of the ISDR system, the Asia Regional Task Force on Urban Risk Reduction (RTF-URR) developed *A guide for implementing the Hyogo Framework for Action by Local Stakeholders*, published in 2010 by UNISDR (UNISDR, RTF-URR & Kyoto University, 2010).

This guide adapts the 22 tasks developed for the national level to fit local requirements on city-level and comes up with a modified version of 20 tasks and corresponding tools, appropriate to execute the tasks (see Appendix IV). Implementation of the HFA on the local level, using this guide, shall be the responsibility of a multistakeholder platform, which shall ensure streamlining of the process within the local government. "Each [stakeholder] will assess their own context and recall relevant local actors, which will also help to identify the strengths and weaknesses unique to him or her (Matsuoka and Shaw, 2011: 137)." The 20 tasks thereby serve as indicators of the progress achieved in implementation of the HFA (Matsuoka and Shaw, 2011).

4.4.2 The Climate Disaster Resilience Index (CDRI)

As can be seen by the Hyogo Framework Action no. 3, achieving resilience is an integral part of DRR (International Strategy for Disaster Reduction (ISDR), 2005). To implement the HFA, it will therefore be necessary to conduct periodical assessment of a city's current resilience status. While there are already approaches on how to measure a city's vulnerability to disasters, as described in the previous section, the *Climate Disaster Resilience Index (CDRI)* goes a step further by including important aspects of urban resilience, such as the capacity to adapt after a disaster (Joerin and Shaw, 2011). It includes basic services provided by cities (such as electricity, water, solid waste disposal, and road networks) and the linkages that are there between those services and a city's vulnerability and responsive capacity. Therefore, the CDRI provides "(…) a comprehensive baseline assessment that addresses these linkages between various actors, aspects of the physical, economic, institutional, and natural components of a city or and urban area (Joerin and Shaw, 2011: 51)", and acts as "(…) a planning tool that has the objective to disclose sectors that are least resilient or not capable of responding adequately in the event of a climate-related disaster (Joerin and Shaw, 2011: 51)."

The CDRI consists of five dimensions – a physical, social, economic, institutional, and natural dimension – each of them split into 5 parameters, depicting different topics, which are important for the respective dimension. Each parameter itself, is again split into five variables ($x_1, x_2, \ldots, x_5$). Consequently, the CDRI consists of 125 variables, based on the five priorities of action as defined by the HFA, all of which have to be ranked from (1) "not available/very poor" to (5) "best", either based on a numerical value, or based on a qualitative assessment according to a provided guidance sheet (see Appendix V). The variables are defined by a set of 125 questions. Additionally, all variables within a parameter, have to be weighted between each other ($w_1, w_2, \ldots, w_5$) from (1) "not important" to (5) "very important". This allows for the calculation of a weighted mean of each parameter, according to the formula:

$$\frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} = \frac{w_1 x_1 + w_2 x_2 + w_3 x_3 + w_4 x_4 + w_5 x_5}{w_1 + w_2 + w_3 + w_4 + w_5}$$

(Joerin and Shaw, 2011)

To calculate the score for an overall dimension, the parameters (p_1, p_2, ..., p_5) are then weighted against each other and basically the same formula is applied:

$$\frac{\sum_{i=1}^{n} w_i p_i}{\sum_{i=1}^{n} w_i} = \frac{w_1 p_1 + w_2 p_2 + w_3 p_3 + w_4 p_4 + w_5 p_5}{w_1 + w_2 + w_3 + w_4 + w_5}$$

Spider diagrams are then used to depict the score of the parameters within a specific dimension, as well as to show the score of the dimensions within the overall resilience. (Joerin and Shaw, 2011) Regarding the interpretation of the CDRI scores, the authors point out that "(...) the numerical value itself is not the most important aspect in understanding the overall CDRI or dimension-wise results (Joerin and Shaw, 2011: 55)." Rather should the CDRI help to identify variables, which are particularly high or low "(...) in order to take action in those sectors where needed most (Joerin and Shaw, 2011: 55)." Quantitative interpretation is difficult as the geographical and historical context for each city is different and weighting is thus applied differently for each city. Additionally, weighting is always subjective to the person filling in the questionnaire, which makes standardisation of CDRI scores difficult. However, as the index should be a tool to help implementation of HFA at the local level, a qualitative interpretation of the strengths and weaknesses should be sufficient (Joerin and Shaw, 2011). Furthermore, detecting correlation in the results for different variables has the potential to show connections between different aspects of resilience and to target DRR more effectively (Joerin and Shaw, 2011).

4.4.3 From Resilience Mapping to Implementation of the HFA

Although the CDRI is still in its pilot phase, it may prove to be an extremely useful tool to implement the HFA at the local level. The HFA is a low-resolution guidance tool for application on the national level, "(...) designed to be generic and [not including] too much detail (Matsuoka and Shaw, 2011: 141)" so as to be applicable in all UN member states. The CDRI, on the other hand, is a high-resolution tool to depict the local characteristics of resilience in great detail. Combining the localised HFA tasks with the CDRI in form of a matrix (see Appendix IV) will reveal linkages and will show which tasks are needed to implement the HFA and to increase resilience and improve DRR policies of the city (Matsuoka and Shaw, 2011). Using this approach, the different tasks can be rated as having short-term, mid-term, or long-term priority, giving local governments the possibility to further customise their *Climate Action Plans (CAP)*. At the same time, the matrix approach ensures that efforts made on a local level will contribute towards the global strategic goals as defined by the HFA. However,

> [b]ecause the tools and guidelines provided through the HFA and its related documents are not one-size-fits-all (and it may never be), countries themselves need to adapt and learn from the guidelines and capacity development programs as well as partnerships they build through implementation process in order to increase awareness among its citizens and strengthen the culture of resilience that is most relevant to their context. An international and regional organization's initiatives and guidance can only facilitate and support these activities, but it heavily replies on capacities of the individual governments, both national and local, and its people to prepare and reduce risks to protect itself from future disasters. (Matsuoka and Shaw, 2011: 146)

5 Case Study Vienna

5.1 Climate Change projections for Vienna

The research project reclip:more (Research for Climate Protection: Model Run Evaluation) – a joint programme of the BOKU Vienna, the University of Vienna, the Wegener Center for Climate and Global Change in Graz, the Austrian Institute of Technology (AIT), and the ZAMG – was initiated to develop regional climate projections for Austria for the period until 2050. This is done by the downscaling of global climate models to a resolution of a 10 km grid, using different climate scenarios. (Kromp-Kolb et al., 2007; Frank et al., 2004) Simultaneously, the BOKU Vienna conducted a study on the impacts of Climate Change on the city of Vienna, also under consideration of different climate scenarios (Kromp-Kolb et al., 2007). The following section will give a short summery of the main findings, as this will give an insight into the future climate risks posed to the city, which will make disaster reduction measures necessary. It should be pointed out that while temperature and precipitation measurements show actual trends, future projections are based on numerical climate models, which still bear large uncertainties.

5.1.1 Temperature

Temperature measurements show an increase in annual average temperatures of 1,5°C for the period 1971-2000 compared to the long time average (Kromp-Kolb et al., 2007). Also temperature extremes changed. While frost days (*Frosttage*[2]) show a significant decrease from 92 to 60 for the period 1872-2000 (Auer et al., 2003: 14), the number of heat days (*Hitzetage*[3]) has increased by 15 days since 1900 (Auer et al., 2003: 18) – see Fig. 5.1-5.2. Furthermore, the yearly amount of heat waves4 show an exponential increase since 1970, increasing from an annual average of 5,1 days between 1961 and 1990, to 9,1 days between 1976 and 2005 (Kromp-Kolb, 2005: 17; Kromp-Kolb et al., 2007: 10) (see Fig. 5.3).

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[2] *Frosttage* are defined as days with a minimum temperature below 0°C

[3] *Hitzetage* are defined as days with a maximum temperature above 30°C

[4] Heat waves or *Kyselý days* are defined as 3 or more consecutive days with a max. temp. above 30°C

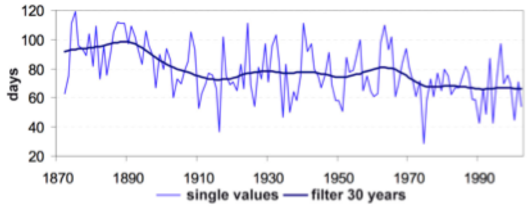

Fig. 5.1 Annual amount of frost days at Hohe Warte, Vienna. (Auer et al., 2003: 14)

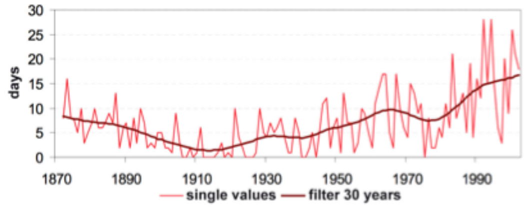

Fig. 5.2 Annual amount of heat days at Hohe Warte, Vienna. (Auer et al., 2003: 18)

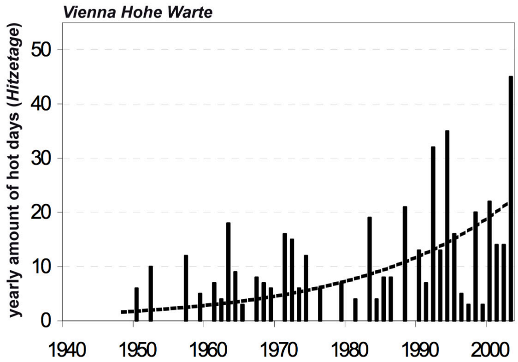

Fig. 5.3 Annual amount of heat waves after Kyselý at Hohe Warte, Vienna. (Kromp-Kolb et al., 2007: 11).

Reclip:more projections show that increase of average temperatures for the period 2041-2050 largely vary with the seasons (Loibl et al., 2007; Kromp-Kolb et al., 2007) (see Fig. 5.4). In eastern Austria, the winter months (December-February) will experience temperature increases of 1,3-1,8°C, while spring (March-May) temperatures will increase by 1,8-2,5°C, and summer (June-August) temperatures by 2-2,5°C. The highest increase will be experienced for autumn months (September-November), showing values of plus 2,5-3°C. (Kromp-Kolb et al., 2007: 21) The higher increases in summer and autumn can be explained by the decrease in precipitation for these seasons (see next section) (Kromp-Kolb et al., 2007: 21). Also the frequency of heat waves is projected to increase from around 9,8% between 1961-1990, to 15,9% in 2001-2026, and to 24,1% in 2016-2049 (Kromp-Kolb et al., 2007: 23). Furthermore, a study concerning the amount of nights without significant cooling (*Warme Nächte*[4]) shows that warm nights will increase from 6,4 between 1985 and 2005 to 13,2 for the scenario period 2019-2048 (Gerersdorfer et al., 2009).

[4] *Warme Nächte* are defined as nights with a minimum temperature above 18°C

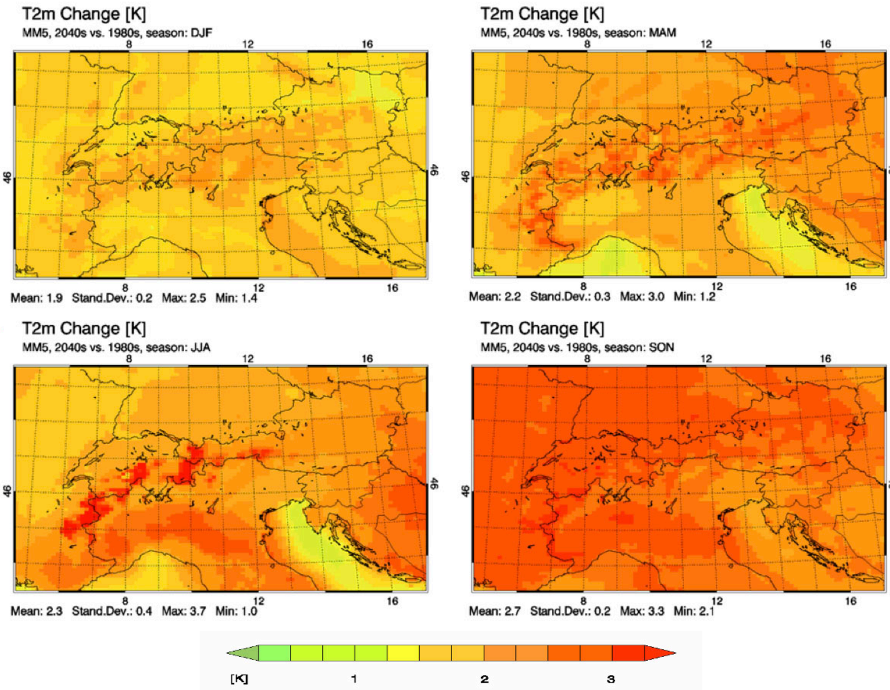

Fig. 5.4 Seasonal mean temperature differences [°C] between WegCenter's MM5 scenario (2041 to 2050) and control simulation (1981 to 1990). (Loibl et al., 2007: 68)

5.1.2 Precipitation

Precipitation measurements for Vienna show a high annual variability, which makes it impossible to define a clear trend (Kromp-Kolb et al., 2007: 10). Measurements since 1840 show a high variability between 404 mm and 988 mm annual precipitation between 1932 and 1941, an increase in precipitation from 1860 to 1920, and a rapid decrease thereafter, slowing down to a slight decrease up until 1980 (see Fig. 5.5) (Auer et al., 2003: 20). Also events of heavy precipitation (*Starkregen*) with more than 20 mm show no varying trend for the period 1948-2005 (Kromp-Kolb et al., 2007: 11). Most years show an average of 4-6 events (Kromp-Kolb et al., 2007: 11) (see Fig. 5.6).

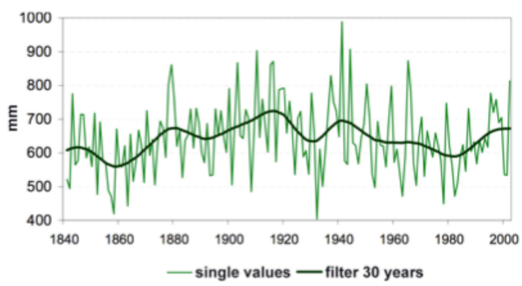

Fig. 5.5 Annual precipitation 1841-2000. (Auer et al., 2003: 14)

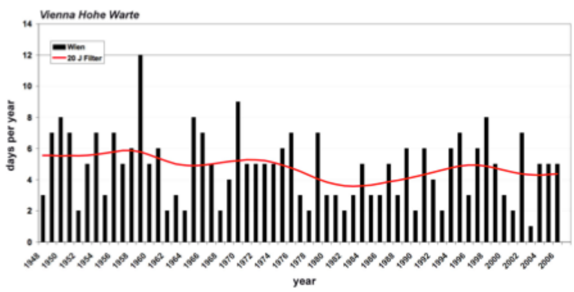

Fig. 5.6 Amount of days with heavy precipitation 1948-2006. (Kromp-Kolb et al., 2007: 11)

Projections for precipitation have shown to be more difficult than temperature projections (Kromp-Kolb et al., 2007). However, a trend towards a general decrease in precipitation for eastern Austria can be identified (Kromp-Kolb et al., 2007: 21). Reclip:more projections show an increase of 15-30% for the winter months, while spring shows a decrease of 15%. Summer and autumn show different trends, ranging from -5% to +30% between June and August, and from -25% to +35% between September and November (see Fig. 5.7). (Kromp-Kolb et al., 2007: 22)

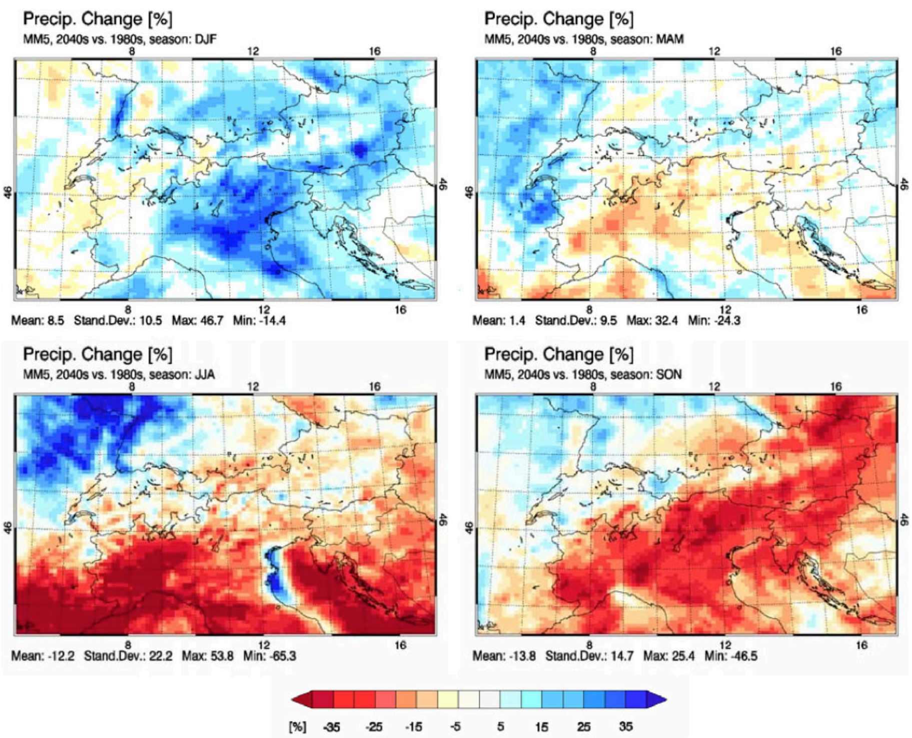

Fig. 5.7 Relative differences [%] of mean seasonal precipitation between the WegCenter MM5 scenario (2041 to 2050) and control simulation (1981 to 1990). (Loibl et al., 2007: 72)

5.1.3 Wind

Similar to precipitation, also wind records do not show a significant trend towards one direction (Matulla et al., 2008: 125). The number of storm events rather seemed to level off to an average value of one event per year within the last half of the 20th century (Matulla et al., 2008: 125) (see Fig. 5.8). Projections have proven to be very difficult as winds in Vienna can either be influenced by large-scale Atlantic low-pressure fields, or by local strong winds (*Starkwinde*) caused by thunderstorms (Kromp-Kolb et al., 2007: 28). Global Climate Models (GCM) show a future increase in Atlantic low-pressure systems. However, they also show a shift of these systems towards Northern Europe, which would mean less impact on Vienna. (Kromp-Kolb et al., 2007: 28) Strong winds on a local level cannot be sufficiently covered by today's Regional Climate Models' (RCM) resolutions. However, evidence points in the direction that Climate Change will not significantly influence the storm situation in Vienna. (Kromp-Kolb et al., 2007: 28)

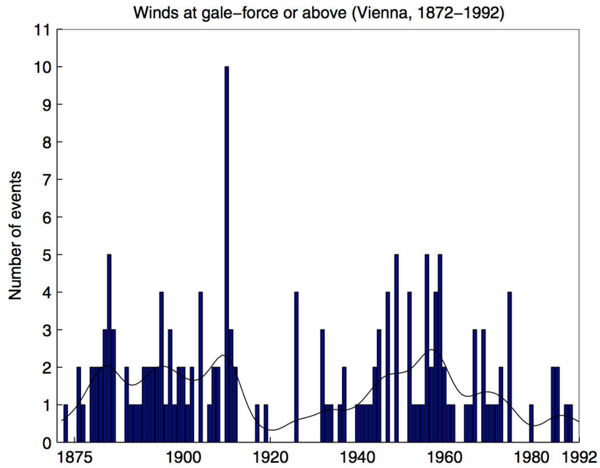

Fig. 5.8 Number of annual storm events in Vienna 1872-1992. (Matulla et al., 2008: 126)

5.1.4 Potential Evaporation

Potential evaporation shows a significant increase of 25 mm per decade since 1970 (Kromp-Kolb et al., 2007: 13; Formayer, 2006: 2-3). According to Formayer (2006), this can be attributed to the increase in temperatures and global irradiation. Projections show that the increase in hot and dry periods combined with the increase in evaporation will lead to a significant decrease of soil moisture within the next century (Kromp-Kolb et al., 2007: 15).

5.1.5 Possible Impacts

A recent study by Krüger et al. (2009) shows that the atmospheric mixing layer experienced an increase from around 800 m in 1975 to around 1.000 m in 2008, which can be attributed to the increase in temperatures within this period (Krüger et al., 2009). The height of the mixing layer has direct influence on air quality, as a higher mixing layer leads to better dilution of pollutants. Consequently, Krüger et al. project a decrease in PM concentrations and better air quality for the city of Vienna within the next century.

There are no studies available yet on the influence of Climate Change on the water gauge of the Danube or on the springs supplying Vienna's drinking water. Also urban biodiversity has not yet been targeted by Climate Change research. However, projects are currently developed in these fields and first results are expected to be published within the first quarter of this century. (Kromp-Kolb et al., 2007: 31-32)

Similarly, there are no studies yet on the impact of Climate Change on Vienna's built environment. However, adapting buildings to rising temperatures will necessitate investments. A study by Ritz et al. (2006) calculated the costs to implement cooling measures into existing office buildings for the city of Zurich. They found that costs would lie at around 6 EUR/m^2 per year (Ritz et al., 2007), which would mean additional costs of around 64,6 Mio EUR per year for Vienna's 10,76 Mio m^2 of office space (CBRE Global Research and Consulting, 2014).

Also concerning the increase in temperatures, the study by Gerersdorfer et al. (2009) showed that the increase in heat waves directly influences the mortality rate. This is especially true when heat waves occur in combination with warm nights (Gerersdorfer et al., 2009). It also showed that densely built districts are more vulnerable to heat waves due to imperfect cooling during night hours (Kromp-Kolb, 2006: 20-23).

Transportation will also most likely be affected by Climate Change. For example, high temperatures will influence passenger comfort and may cause damage to public transportation infrastructure, while flooding might cause troubles with operation of subways (London Climate Change Partnership, 2002). Furthermore, high temperatures could lead to city residents leaving the city for recreation in Vienna's surrounding countryside, causing additional pressure on the transport system (Kromp-Kolb et al., 2007: 37).

All these are examples of possible Climate Change impacts on urban systems, which are already supported by scientific evidence. However, this list is by no means complete and only further research will give a more complete picture of Climate Change impacts and necessary adaptation measures.

5.2 *The Current Resilience Status – Application of the CDRI*

5.2.1 CDRI Questionnaire

Table 5.1 Dimensions and Parameters of the CDRI, modified after Joerin and Shaw. (Joerin and Shaw, 2011: 52)

Physical	**Social**	**Economic**	**Institutional**	**Natural**
Electricity	Population	Income	Mainstreaming of Disaster Risk Reduction and Climate Change Adaptation	Intensity/Severity of Natural Hazards
Water	Health	Employment	Effectiveness of City's Crisis Management Framework	Frequency of Natural Hazards
Sanitation and Solid Waste Disposal	Education and Awareness	Household Assets	Effectiveness of City's Institutions to Respond to a Disaster	Vulnerability of Ecosystem Services
Accessibility of Roads	Social Capital	Finance and Savings	Institutional Collaboration with other Organisations and Stakeholders	Land-use in Natural Terms
Housing and Land-use	Social Cohesion and Community Preparedness during a Disaster	Budget and Subsidy	Good Governance	Environmental Policies and Food Security

1 Physical Condition of the City

1.1 Electricity

1.1.1 Percentage of city population with legal access to electricity from electric companies (This indicator does not take into account illegal connections.)

1 (up to 10%)	2 (11-25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating **5**

As, according to recent statistics, 100% of Viennese households own a refrigerator and 95% own a washing machine (STATISTIK AUSTRIA, 2011a), it can be assumed that at leas an equal amount of households have access to electricity, as this is a necessary prerequisite to run those appliances.

1.1.2 Status of interruption (Status of daily availability of electricity)

1 (available up to 4 hours)	2 (available 5-8 hours)	3 (available 9-15 hours)	4 (available 16-23 hours)	5 (no interruption)	Rating
					5

According to E-Control, Austria's regulatory body for electricity supply, availability in 2011 was as high as 99,99%, with a yearly total of only 27,48 minutes of unplanned interruptions (Energie-Control Austria, 2011). Even total interruptions – including planned interruptions (due to maintenance work) – were less than one hour for the whole year.

1.1.3 Electricity supply authority capable to supply the city's demand for electricity

1 (Up to 10% of demand)	2 (11-25% of demand)	3 (26-50% of demand)	4 (51-75% of demand)	5 (76-100% of demand)	Rating
					5

In 2012, Vienna's total electricity demand was 8.387 GWh (22% of total energy demand) (Wien Energie, 2013: 1). The trend for demand is generally increasing – for the period 1993-2011, a total increase of 30% can be observed (Energieplanung (Magistratsabteilung 20), 2013: 33). Total electricity production was 5.038,9 GWh in 2012, with 83,51% coming from calorific plants, 12,43% from hydro plants, 2,03% from wind and photovoltaics, 1,99% from biomass, and 0,04% from waste to energy plants (Wiener Stadtwerke, 2013). While this covered about 57,6% of demand, 42,4% had to be imported (Wiener Stadtwerke, 2013). Generally, it can be said that electricity imports are continuously increasing since 2010 (Energieplanung (Magistratsabteilung 20), 2012; Wiener Stadtwerke, 2013). However, it needs to be noted that also electricity production within Vienna relies to a very large extend on import of gas from abroad (Wiener Stadtwerke, 2013). At the moment, imports and exports are sufficient to cover total demand and allow for continuous supply without interruptions (Energie-Control Austria, 2011).

1.1.4 City's electric supply dependent on external provision (e.g., from other cities/areas) during most frequent disasters

1 (76-100%)	2 (51-75%)	3 (26-50%)	4 (11-25%)	5 (less than 10%)	Rating
					5

According to *Wiener Netze GmbH* (Vienna's grid operator), during the 2013 heat wave, electricity outages have been reported for more than 4.000 households. However, interruptions were in the order of 1-2 hours, which made external provision unnecessary. (ORF, 2013k) Due to the installation of underground cables instead of overhead lines in 83% of Vienna's electricity grid, the risk of interruptions can generally be seen as low (Wiener Netze GmbH, 2014a). This can also be accounted to the installation of the 400kV-

Transmission Line-North in 2006, which, together with the old line in the south, allows for a sustainable electricity supply and a low risk of general blackouts (Wiener Netze GmbH, 2014b).

1.1.5 Extent of capacity of alternative emergency electric supply system (may include on-site backup generation, uninterruptible power supplies, etc.) to keep emergency services functioning (e.g., hospital, evacuation centres, etc.)

1 (no capacity)	2 (1-25% of demand)	3 (26-50% of demand)	4 (51-75% of demand)	5 (76-100% of demand)	Rating
					5

There are building codes, requiring the installation of on-site backup electricity generation for different types of building. Hospitals, for example, need to install equipment which enables the maintenance of hospital operation (ÖVE/ÖNORM E 8007, 2007). Public buildings, including schools, only need to maintain facilities, which are necessary to ensure safety and prevent panic (i.e. illumination of emergency staircases, fire extinguishing systems) (ÖVE/ÖNORM E 8002-1, 2007). However, Vienna's municipal fire brigade is in possession of mobile electricity generators to supply electricity to evacuation centres, if needed (Rathauskorrespondenz (Magistratsabteilung 53), 2014).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

1.1.1	1.1.2	1.1.3	1.1.4	1.1.5
1	**2**	**3**	**4**	**5**

1.2 Water

1.2.1 Percentage of city population with legal access to potable water supply (including tap water delivered by domestic water companies and protected dug wells, but excluding purified water refilling stations, bottled water, etc.)

1 (up to 10%)	2 (11-25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating
					5

Statistics published by the *Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)* show a connection percentage for Vienna of 99,9% for freshwater connection, and 99,5% for sewer connection (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2012).

1.2.2 Status of water supply (Status of daily water availability)

1 (available up to 1 hour)	2 (available 1-2 hours)	3 (available 3-5 hours)	4 (available 6-10 hours)	5 (no interruption)	Rating
					5

According to the *Austrian Association for Gas and Water (OVGW)*, water supply in Vienna is guaranteed 24 hours a day without interruptions (ÖVGW, 2014a). This can also be attributed to the fact that Austria uses only 3% of its annual freshwater capacities, which amount to 2,6 billion m^3 yearly water supply (ÖVWG, 2011).

1.2.3 Water supply authority capable to supply the city's demand for water

1 (Up to 10% of demand)	2 (11-25% of demand)	3 (26-50% of demand)	4 (51-75% of demand)	5 (76-100% of demand)	Rating
					5

Vienna's water supply authority is able to cover 100% of the city's demand, as yearly production is 142,1 m^3, which is even greater than the annual demand of 132,9 million m^3 (STATISTIK AUSTRIA, 2007).

1.2.4 City's water supply dependent on external provision (e.g., from other cities/areas) during most frequent disasters

1 (76-100%)	2 (51-75%)	3 (26-50%)	4 (11-25%)	5 (less than 10%)	Rating
					5

Generally, Vienna's water supply authority is not dependent on water supply by third parties. However, 96% of its annual production (136,7 million m3) is spring water, which comes from alpine regions in Lower Austria and Styria (areas, far outside city boundaries), while only the remaining 4% are groundwater from within the city limits. (STATISTIK AUSTRIA, 2007) While on the one hand, this causes a strong dependence on Vienna's hinterland, on the other hand, disasters within the city boundaries, such as flooding, have no influence on the city's water supply capacity. This is particularly true as annual production from springs is even larger than total yearly demand (132,9 million m^3) (STATISTIK AUSTRIA, 2007).

1.2.5 Extent of capacity of alternative emergency safe water supply system (water purification system, stored water, etc.)

1 (no capacity)	2 (1-25% of demand)	3 (26-50% of demand)	4 (51-75% of demand)	5 (76-100% of demand)	Rating
					5

Vienna's water supply network has 90 water catchments (20 of which are located within the city boundaries), and 31 water storage facilities (29 within city boundaries). The storage facilities hold a total of 1,61 Mio m3 of drinking water (800.000 m3 within city limits and 800.000 m3 outside) (Wiener Wasser (Magistratsabteilung 31), 2014a; ÖVGW, 2014b). This storage capacity is sufficient to sustain the city's total supply for approximately four days at Vienna's average daily demand of 367.917 m^3 (ÖVGW, 2014b). Furthermore, Vienna's water is supplied by the two major water pipelines *Hochquellenleitung I & II* (carrying spring water), the two large groundwater pumping stations *Lobau* and *Moosbrunn*, and several smaller groundwater pumping stations. Production capacities are as follows:

- I. Hochquellenleitung: 220.000 m^3 per day
- II. Hochquellenleitung: 217.000 m^3 per day
- Pumping station Lobau: 80.000 m^3 per day
- Pumping station Moosbrunn: 64.000 m^3 per day
- Other pumping stations: 10.000 m^3 per day
- Total: 591.000 m^3 per day

  (Wiener Wasser (Magistratsabteilung 31), 2014b)

As can be seen, even with one of the major pipelines not working, Vienna's average daily demand could be supplied relying on the other sources.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

1.2.1	1.2.2	1.2.3	1.2.4	1.2.5
1	**2**	**3**	**4**	**5**

1.3 Sanitation and Solid Waste Disposal

1.3.1 Percentage of city population with hygienic access to sanitation (connection to a public sewer, connection to a septic system, solid waste disposal, etc.)

1 (up to 10%)	2 (11-25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating
					5

According to the *Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)* Vienna has a connection percentage 99,5% for sewer connection (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2012).

1.3.2 Percentage of city population with access to toilets (hygienic latrine: pit latrine, water sealed latrine, or sanitary latrine)

1 (up to 10%)	2 (11-25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating
					5

Statistik Austria published a housing statistic, stating that 7,1% of Vienna's apartments (which is amounts to 69.853 apartments) do not have their own toilet (STATISTIK

AUSTRIA, 2013g). However, even those apartments have access to shared toilets, as can be seen in the 995% of sewer connection percentage (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2012).

1.3.3 Collection of solid waste produced per day

1 (up to 10%)	2 (11-25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating
					5

Eurostat data shows that collection of solid waste in Vienna was 100% for the years 2007-2010 (European Commission, 2014a).

1.3.4 Percentage of solid waste treated before dumping

1 (not treated at all)	2 (up to 25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating
					5

In 2009, Vienna produced 1,14 Mio tons of solid waste. Of these, 51% were incinerated (579.830 tons), 22% were recycled (250.060 tons), 26,5% were treated at composting facilities (301.580 tons), and 0,5% were pre-treated and then landfilled (European Commission, 2014b), as required by Austrian regulation (Bundesgesetz über eine nachhaltige Abfallwirtschaft (Abfallwirtschaftsgesetz 2002 - AWG 2002), 2002: §1(2a)3.; Deponieverordnung 2008 (DVO 2008), 2008: §6).

1.3.5 Percentage of solid waste recycled (both formal and informal: municipal solid waste management and the waste recycling activities of scavengers and waste pickers)

1 (up to 10%)	2 (11-25%)	3 (26-50%)	4 (51-75%)	5 (76-100%)	Rating
					2

In 2009, 22% of Vienna's solid waste (250.060 tons) were recycled (European Commission, 2014b). However, this excludes recycling of organic wastes. Total recycling (including organic wastes) was at 48,5% in 2009 (European Environmental Agency, 2013: 11).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

1.3.1	1.3.2	1.3.3	1.3.4	1.3.5
2	**1**	**5**	**4**	**3**

1.4 Accessibility of Roads

1.4.1 Percentage of city's land used as transportation network

1 (0-5%)	2 (6-10%)	3 (11-15%)	4 (15-20%)	5 (more than 20%)	Rating
					3

5.964,7 ha of Vienna's total area are used as transportation network, which accounts for 14,4% (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 15).

1.4.2 Percentage of city accessible by paved road (asphalt or concrete roads)

1 (less than 50%)	2 (51-60%)	3 (61-70%)	4 (71-80%)	5 (81-100%)	Rating
					5

There is no official data available on the percentage of paved roads. However, studies regarding the emissions of dust from roads in Vienna state that the number of unpaved roads in big Austrian cities like Vienna can be regarded as negligible (Koschutnig et al., 2002: 19).

1.4.3 Percentage of roads remained accessible during normal flooding (e.g., after a heavy rain, during high tide, etc.) in affected areas

1 (less than 40%)	2 (41-50%)	3 (51-60%)	4 (61-70%)	5 (more than 70%)	Rating
					5

Accessibility of all roads during heavy rain is usually given. Even during the severe flood in 2013, only a negligible percentage of Vienna's roads were inaccessible (ZAMG, 2014a).

1.4.4 Percentage of roads remain accessible during catastrophic flooding (e.g., once every 50 years)

1 (less than 15%)	2 (16-30%)	3 (31-45%)	4 (46-60%)	5 (more than 60%)	Rating
					5

Even during the severe flood in 2013, only a negligible percentage of Vienna's roads were inaccessible (ZAMG, 2014a). The only areas affected were the Copa-Cagrana and along the Danube riverbank, parts of the harbour in Albern, and an underground passage in the 19th district (ZAMG, 2014a) – together probably not even accounting for 5% of Vienna's total road network.

1.4.5 Percentage of roads has roadside covered drain

1 (less than 15%)	2 (16-30%)	3 (31-45%)	4 (46-60%)	5 (more than 60%)	Rating
					5

According to Austrian law, all roads need to be planned, built, and preserved so as to ensure safe use, also with regards to weather conditions (Bundesstraßengesetz 1971

(BStG 1971), 1971: §7(1)). This implies that road drainage is required and most certainly implemented for most streets in Vienna.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

1.4.1	1.4.2	1.4.3	1.4.4	1.4.5
1	**3**	**5**	**2**	**4**

1.5 Housing and Land-use

1.5.1 Percentage of buildings constructed following building code (for hydro-meteorological disasters like floods)

1 (0%)	2 (less than 15%)	3 (16-30%)	4 (31-50%)	5 (more than 50%)	Rating
					5

In 2011, a total of 164.746 buildings were located within the city boundaries of Vienna (STATISTIK AUSTRIA, 2013h). Of these buildings, 34,9% were built before 1944 (STATISTIK AUSTRIA, 2013h), which means that most of them were built before entry into force of Vienna's first modern building law in 1930 (Wiener Stadtentwicklungs-, Stadtplanungs- und Baugesetzbuch (Bauordnung für Wien – BO für Wien), 2013). (Laws and regulations before that date were mainly directed towards structural safety and fire safety.) Until today, many old building have been renovated and adapted to modern standards. However, there is no actual data on how many buildings comply with the current building code, except for those built after implementation of the code. It can be assumed that most of the building built after 1930 comply with at least some modern safety regulations, which would account for more than 50% of all houses.

1.5.2 Percentage of non-permanent structure (shanties of informal settlers and other similar illegal structures constructed without a building permit, like vendor carts)

1 (100%)	2 (more than 30%)	3 (20-29%)	4 (10-19%)	5 (less than 10%)	Rating
					5

Persuant to Vienna's building code, all building projects require either a notification to, or an authorization from the local authority, depending to the size and type of the project (Wiener Stadtentwicklungs-, Stadtplanungs- und Baugesetzbuch (Bauordnung für Wien – BO für Wien), 2013). In Vienna, the authority responsible for the implementation of the building code is the department number 37 of Vienna's municipal authority (Magistratsabteilung 37 – Baupolizei) (Baupolizei (Magistratsabteilung 37), 2014a; Wiener Stadtentwicklungs-, Stadtplanungs- und Baugesetzbuch (Bauordnung für Wien –

BO für Wien), 2013: §132(1)). The authority is authorized to conduct assessments regarding the compliance with the law, to impose fines for incompliance, or to pass a verdict for demolition of illegal structures (Wiener Stadtentwicklungs-, Stadtplanungs- und Baugesetzbuch (Bauordnung für Wien – BO für Wien), 2013). Therefore, percentage of illegal structures or buildings in Vienna can be regarded as marginal, although there are no official numbers available.

1.5.3 Percentage of houses above normal/flood water logging

1 (0%)	2 (less than 50%)	3 (51-60%)	4 (61-70%)	5 (more than 70%)	Rating **5**

Data provided by the online database *HORA – Natural Hazards and Overview & Risk Assessment Austria* shows that 7.581 addresses lie below flood water logging of the Danube (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014a), which are 4,6% of Vienna's total buildings (STATISTIK AUSTRIA, 2013h).

1.5.4 Percentage of houses with ownership (as opposed to rented)

1 (0%)	2 (31-40%)	3 (41-50%)	4 (51-60%)	5 (more than 60%)	Rating **1**

According to recent statistics, in 2013, 20% of all houses and apartments were owned by the people living there, while 80% were rented (870.900 apartments/houses in total) (STATISTIK AUSTRIA, 2014b).

1.5.5 Total percentage of city's population living in the proximity of pollutive industries, landfills, and garbage dumpsites

1 (more than 50%)	2 (37.5-49%)	3 (25-37.4%)	4 (12.5-24.9%)	5 (0-12.4%)	Rating **5**

Vienna has only one landfill (*Deponie Rautenweg*), which is located in the 22nd district, collecting pre-treated wastes from all waste incineration plants (Abfallwirtschaft, Straßenreinigung und Fuhrpark (Magistratsabteilung 48) , 2012). In its immediate vicinity, there are mainly industrial areas, retention spaces, protection zones, but also some residential areas (Magistrat der Stadt Wien, 2014). There is no data available on how many people are actually living in the proximity of the landfill. However, population of the whole district was 165.265 in 2013, which at this time accounted for 9,5% of Vienna's total population (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

1.5.1	1.5.2	1.5.3	1.5.4	1.5.5
5	**1**	**3**	**2**	**4**

Weight factor "Physical Condition of the City"

At the end of this first part of questions would you please weigh each parameter by ranking them between 1 and 5 (5 = most important, 1 = least important)

Electricity	Water	Sanitation and Solid Waste Disposal	Accessibility of Roads	Housing and Land-use
2	**4**	**5**	**1**	**3**

2 Social Condition of the City

2.1 Population

2.1.1 Percentage of city's population growth per year

1 (more than 6%)	2 (4-5.9%)	3 (2-3.9%)	4 (1-1.9%)	5 (0-0.9%)	Rating
					4

Increase of population was between 0,75% and 0,85% for the years 2010-2012 (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 71).

2.1.2 Percentage of city's population under 14 years old

1 (more than 35%)	2 (29-34%)	3 (23-28%)	4 (17-22%)	5 (less than 17%)	Rating
					5

In 2012, 13,4% of Vienna's population were under the age of 14 (1.132.556 people) (STATISTIK AUSTRIA, 2013f: 1).

2.1.3 Percentage of city's population over 65 years old

1 (more than 35%)	2 (29-34%)	3 (23-28%)	4 (17-22%)	5 (less than 17%)	Rating
					5

In 2012, 16,8% of Vienna's population were above the age of 65 (1.418.337 people) (STATISTIK AUSTRIA, 2013f: 1-2)

2.1.4 Percentage of city's population live in slum area/urban informal settlements/urban poor areas

1 (more than 50%)	2 (37.5-49.9%)	3 (25-37.4%)	4 (12.5-24.9%)	5 (0-12.4%)	Rating
					5

In 2012, more than 6.000 homeless people demanded assisted living, offered by the city of Vienna and private institutions (L&R Sozialforschung, 2012: 19). If overnight accommodation is included, the number even increased to more than 9.000 people (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 163). This accounts for roughly 0,5% of Vienna's population (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 60). While there are no informal settlements or slum areas, there are certain areas where the income is much below Vienna's average. For example, in Vienna's 15th district, the average gross income per year was 23.053 EUR in 2012, which accounts for only 76,8% of Vienna's average annual gross income of 30.007 EUR (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 147; Österreichischer Integrationsfonds (OIF), 2014: 47). People living in this area accounted for 4,2% of Vienna's total population in 2012 (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 60).

2.1.5 Maximum urban population density (day or night) per square kilometre, weighted throughout the city

1 (more than 12,000)	2 (8,000-11,999)	3 (4,000-7,999)	4 (1,000-3,999)	5 (less than 999)	Rating
					3

In 2012, Vienna's total population was 1.717.084 (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 60), while Vienna's total area was 414,871 km2 (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 15). Density therefore was 4.139 persons per km2.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

2.1.1	2.1.2	2.1.3	2.1.4	2.1.5
1	**2**	**5**	**4**	**3**

2.2 Health

2.2.1 Percentage of city dwellers suffer from waterborne or vector-borne diseases every year

1 (more than 48%)	2 (36-47%)	3 (24-35%)	4 (12-23%)	5 (0-11%)	Rating
					5

In 2012, 2.850 people suffered from infectious diseases, which require notification to the authority (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 110), which accounted for 0,2% of Vienna's total population (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 60).

2.2.2 Percentage of city's population having access to primary health care facility

1 (up to 50%)	2 (51-75%)	3 (76-90%)	4 (91-95%)	5 (96-100%)	Rating
					5

Free access to healthcare is possible for all residents having social insurance (Bundesministerium für Gesundheit (BMG), 2013; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010), which are 99,9% of Vienna's residents (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 60, 158). Additionally, public and private institutions offer healthcare for people without medical insurance (Fonds Soziales Wien, 2011; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010). This system is financed through the city budget and the Healthcare Fund Vienna (*Wiener Gesundheitsfond*) (Wiener Gesundheitsfonds-Gesetz 2013, 2013; Wiener Gesundheitsfonds (WGF), 2013; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010; Finanzwesen (Magistratsabteilung 5), 2013)

2.2.3 Functionality of internal primary health services after most frequent disasters (i.e., floods and typhoons)

1 (up to 10% functional)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					5

As no healthcare facilities were affected by the most frequent disasters and the amount of people needing health serviced due to the disaster was generally low (APA/red (derStandard.at), 2013; ZAMG, 2014a), no problems were experienced regarding the functionality of primary health services.

2.2.4 Capacity of city's health facility to face emergency/hazardous situation

1 (up to 10% have capac.)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					5

As required by law, all public healthcare facilities need to establish the capacity to adequately face emergency situations (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §4; kav - Wiener Krankenanstaltenverbund, 2014).

2.2.5 Ability of city's health care system prepared for the event of a disaster

1 (up to 10% are prepared)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					5

All health care facilities have developed emergency operation schedules as required by §4 of Vienna's Disaster Management Law (*Wiener Katastrophenhilfe- und Krisenmanagementgesetz*). Those schedules are tested for practicability once a year in the form of an emergency exercise. (AK Wien, 2014)

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

2.2.1	2.2.2	2.2.3	2.2.4	2.2.5
1	**5**	**2**	**3**	**4**

2.3 Education and Awareness

2.3.1 Literacy rate of city's population

1 (less than 50%)	2 (50.1-62.5%)	3 (62.6-75%)	4 (75.1-87.5%)	5 (87.6-100%)	Rating
					5

The Austrian law requires compulsory education for all children ages 6 to 15 (Schulpflichtgesetz 1985 (BGBl. Nr. 76/1985), 2014). This means that consequently, all children learn how to read and write. However, a recent OECD study revealed that there is a quite large amount of people in all OECD countries, suffering from "functional literacy" (OECD, 2013). Functional literacy means that those people are in principle able to read and write, however, their skill level it too small to get along in their job and everyday life (Bundesministerium für Bildung und Frauen (BMBF), 2013). According to the OECD study (2013), 15,3% of Austria's adults (age 16-65) have a proficiency level of 1 or below (OECD, 2013: 257). As Vienna's education level is, on average, higher than those of other Austrian states (Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010:

23-28), it can be expected that also the literacy rate is slightly higher than the Austrian average.

2.3.2 Awareness or knowledge of city's population about threat and impact of disasters

1 (up to 10% are aware)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					4

Risk for natural disasters is generally perceived as low in Vienna (DieHelferWiens, 2014e). To raise awareness, Vienna established *Die Helfer Wiens*, its official organisation dealing with disaster prevention. Their mandate is to raise awareness about potential disasters by (1) providing personal information and free disaster trainings, and (2) organising and public information events. (Die Helfer Wiens, 2014b) To this end, 11 permanent information and competence centres were installed in the city, providing weekly/monthly trainings for different security subjects (Die Helfer Wiens, 2014c). Material on many issues of disaster prevention can be downloaded for free on their website (http://www.diehelferwiens.at). So while in principle, enough information material and education trainings are available, some politicians point out that more large campaigns need to be done to raise general awareness about potential threats and to inform the general public about the measures to be taken to prevent and deal with possible emergencies (ÖVP Wien, 2000). Information about imminent risks are distributed to the population via media, relying on information provided by Austria's *Central Institute for Meteorology and Geodynamics* (*Zentralanstalt für Meteorologie und Geodynamik - ZAMG*) (ZAMG, 2014b).

2.3.3 How often does the city authority organize public awareness program/disaster drills

1 (never so far)	2 (once every 5 years or less)	3 (once every 2 years)	4 (once every year)	5 (more than once a year)	Rating
					4

Vienna's siren warning system consists of 176 sirens, which are tested once a year in October (Bundeskanzleramt Österreich, 2014). This test is usually accompanied by TV information programmes regarding disaster prevention and behaviour in time of disaster. Additionally, the city of Vienna organises a yearly disaster prevention event, called the *Wiener Sicherheitsfest*, which should raise public awareness towards disaster prevention and management (Die Helfer Wiens, 2014d).

2.3.4 City's average population has access to Internet at home

1 (up to 10% have access)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					4

According to statistics, in 2010 71% of Vienna's households had access to Internet at home (STATISTIK AUSTRIA, 2011a). With an average of 1,9 people per household (STATISTIK AUSTRIA, 2011a), this means that more than 71% of the population had access to Internet.

2.3.5 Functionality of schools after most frequent disaster

1 (up to 10% functional)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					5

As no schools were affected by the most frequent disasters and the amount of damage due to the disaster was generally low (APA/red (derStandard.at), 2013; ZAMG, 2014a), no problems were experienced regarding the functionality of schools.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

2.3.1	2.3.2	2.3.3	2.3.4	2.3.5
2	**5**	**4**	**3**	**1**

2.4 Social Capital

2.4.1 Extent of city's population participate in community activities

1 (less than 10%)	2 (11-20%)	3 (21-30%)	4 (31-40%)	5 (more than 40%)	Rating
					3

There is no data available on the number and type of informal activity groups, which are not registered as clubs. However, a recent study shows that 27,1% of the Austrian population – and 26,4% of Vienna's residents – participate in some kind of informal community activity (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 65).

2.4.2 Extent of city's population participate in a club or social activity group

1 (less than 10%)	2 (11-20%)	3 (21-30%)	4 (31-40%)	5 (more than 40%)	Rating
					2

There are more than 1.000 sports clubs in Vienna (ASKÖ Landesverband Wien, 2014; ASVÖ-Wien, 2014; Sportunion Wien, 2014), and probably an even larger amount of other kinds of clubs and social activity groups. A recent study shows that 27,9% of the Austrian population participates in clubs or other voluntary activities. The five most popular areas of engagement are Arts and Culture (7,5%), Sports (6,9%), Religion (6,2%), Disaster Help and Rescue Services (6,0%), and Politics (3,5%) – followed by Social Work (3,3%), Environment (2,6%), Education (2,5%), and Community Services (2,1%). (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 52) However, engagement decreases with increasing population density. Consequently, Vienna has a much lower participation rate of only 14,3% (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 61).

2.4.3 Ability of city's communities to build consensus and deliver shared interest

1 (not able)	2 (poor)	3 (limited)	4 (moderate)	5 (fully able)	Rating
					5

All districts of Vienna are represented by elected representatives, as defined in Vienna's City Constitution (*Wiener Stadtverfassung*) (Verfassung der Bundeshauptstadt Wien (Wiener Stadtverfassung – WStV), 2013). Representatives are entitled to take part in or be heard in most decision-making processes of the city (Stadt Wien - Bereichsleitung Dezentralisierung, 2014). Furthermore, directly affected residents are often involved in the process through formal or informal participation procedures (Arbter et al., 2005).

2.4.4 Level of democracy: city's communities have the opportunity to participate in the city's decision-making process

1 (no opportunity)	2 (poor)	3 (limited)	4 (moderate)	5 (full participation)	Rating
					5

In Austria, and consequently also in Vienna, there are different possibilities to participate in the decision-making process, depending on the issue for which a decision has to be made (Arbter et al., 2005). On the one hand, there are formal proceedings, such as environmental impact assessments or land-use plans, where public opinion needs to be taken into account, as regulated by law. Results of these proceedings are legally binding. On the other hand, there is a variety of informal participation procedures, such as round tables, local Agenda 21 proceedings, or mediation, which are not legally required, but are often used to collect feedback from directly affected people and to find consensus. Results of these procedures are not legally binding per se, but are mostly used to guide decision-making. They can, however, get legally binding status by resolution of the municipal council. (Arbter et al., 2005: 10) Access to the proceedings depends on the type of procedure and can either be open to all people, or only to those directly affected by/with immediate interest in the decision. (Arbter et al., 2005).

2.4.5 Extent that social classes mix and interlink with each other (opposite: social segregation)

1 (not mixed)	2 (poor)	3 (limited)	4 (moderate)	5 (fully mixed)	Rating
					4

A report of the Austrian Integration Fund (*Österreichischer Integrationsfond – OIF*) shows that not only do 34,6% of Vienna's residents have migration background (Österreichischer Integrationsfonds (OIF), 2014: 44), but that those people are at a higher risk for being unemployed and are generally earning less money than Austrian citizens (Österreichischer Integrationsfonds (OIF), 2014: 47). For example, Vienna's 15th district has the highest percentage of people with foreign citizenship (48,4%) (Österreichischer Integrationsfonds (OIF), 2014: 44), while at the same time is has the lowest per capita income (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 147). Therefore, mixing of social classes is highly interdependent with the integration of people with foreign citizenship. The study on voluntary community activities mentioned above shows that the number of people with migration background participating in community activities and clubs is comparable to those of Austrian citizens. It can be seen, however, that this section of the population tend to engage in informal activities rather than formal activities, such as clubs. (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 142-147) The study also mentions that participation in clubs and other community activities can be essential for the process of successful integration (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 139). This would mean that social integration is fairly established in Austria. However, the sometimes large differences in participation numbers between formal and informal activities still show that there are still social barriers to many formal activities – mostly in the area of large and well-established organisations, such as rescue services or citizen initiatives (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 139). Data for Austrian citizens show a similar trend. While an almost equal number of all social classes (and education levels) participate in informal community activities (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 68-69), formal clubs and activities are more dominated by people with higher education and/or social classes (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 59-60).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

2.4.1	2.4.2	2.4.3	2.4.4	2.4.5
4	**2**	**1**	**3**	**5**

2.5 Social Cohesion and Preparedness during a Disaster

2.5.1 Extent to which households are prepared for a disaster in terms of logistics, materials, and management

1 (up to 10%)	2 (poor: 11-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (good: 76-100%)	Rating
					3

A recent study by the *Austrian Board for Transport Safety* (*Österreichisches Kuratorium für Verkehrssicherheit - KFV*) shows that 63% of the Austrian population estimates the risk for a natural disaster at their hometown to be extremely low or non-existent, while even 93% do not feel personally at risk at all. Areas, which are at actual risk show similar numbers. (Versicherungsverband Österreich (VVO), 2013) While preparedness in terms of food, medication, first aid equipment, and sanitary products is still generally quite good – 66-80% of households have inventories for more than a week – only 45-60% have battery-operated radios or enough drinking water. There is also a big deficit regarding information in terms of logistics and management. More than 80% of the population declare not to know about the responsible contact person at their city authority, nor do they have enough knowledge about emergency plans and the warning system. (Versicherungsverband Österreich (VVO), 2013)

2.5.2 Extent of city's population participate in relief works after a disaster (volunteering)

1 (up to 10%)	2 (poor: 11-15%)	3 (limited: 16-20%)	4 (moderate: 21-25%)	5 (good: over 25%)	Rating
					1

The study concerning voluntary work showed that 14,3% of Vienna's residents (236.300 people in 2006 (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a)) participate in club activities (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 61), while 6% of these people engage in clubs and activities related to Disaster Help and Rescue Services (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 52). These 6% accounted for 14.178 people in 2006, which were only 0,9% of Vienna's total population at that time (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a).

2.5.3 Extent of city's population provide shelter or emergency support for affected people after a disaster

1 (up to 10%)	2 (poor: 11-15%)	3 (limited: 16-20%)	4 (moderate: 21-25%)	5 (good: over 25%)	Rating
					1

Emergency shelters are provided by the city government (DieHelferWiens, 2014e). They are city-owned but are usually run by private organisations, such as the Red Cross (Österreichisches Rotes Kreuz - Landesverband Wien, 2014a). While there are examples where private people offered shelter in times of emergency (Vienna Online, 2012), this is rather an exception.

2.5.4 Extent of support to residents from NGOs/CBOs or religious organisations after a disaster

1 (no support)	2 (poor)	3 (limited)	4 (moderate)	5 (full support)	Rating
					5

Austria has a large network of NGOs, which engage in disaster relief (Österreichisches Rotes Kreuz - Landesverband Wien, 2014b). For example, during the 2013 flooding, many NGOs, such as the *Red Cross*, *Caritas*, *Volkshilfe*, and *Hilfswerk*, but also religious organisations, such as the *Diakonie*, provided help and support to affected people, and also collected donations of 4,2 Mio EUR to provide interim aid until state money could be distributed (ORF-Pressestelle (Humanitarian Broadcasting), 2013; Diakonie Katastrophenhilfe, 2013: 7).

2.5.5 Extent of affected people evacuate voluntarily after a disaster

1 (no voluntary ev.)	2 (poor: 1-25%)	3 (limited: 26-50%)	4 (moderate: 51-75%)	5 (76-100%)	Rating
					5

Evacuation of affected people is usually requested by the authority rather than by the people. However, there is no legal compulsion to make people leave their home. (Jachs, 2014) Examples from other parts of Austria show that people are generally willing to leave their homes in times of hazards. Exceptions mostly involve responsibilities towards pets and livestock. (Jachs, 2014)

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

2.5.1	2.5.2	2.5.3	2.5.4	2.5.5
5	**3**	**2**	**4**	**1**

Weight factor "Social Condition of the City"

At the end of this second part of questions would you please weigh each parameter by ranking them between 1 and 5 (5 = most important, 1 = least important)

Population	Health	Education and Awareness	Social Capital	Social Cohesion and Preparedness during a Disaster
1	**3**	**4**	**2**	**5**

3 Economic Condition of the City

3.1 Income

3.1.1 Percentage of city's population living below the poverty line

1 (more than 35%)	2 (25-34%)	3 (15-24%)	4 (5-15%)	5 (less than 5%)	Rating
					2

In 2012, 25% of Vienna's population lived below the poverty line, even after having received social transfer payments (STATISTIK AUSTRIA, 2013a).

3.1.2 Average number of sources of income per household

1 (no source/income)	2 (1 source)	3 (2 sources)	4 (3 sources)	5 (more than 3 sources)	Rating
					3

Vienna has 870.900 households, 401.600 of which are single households (46,1%). The average household is size is 1,99 persons, which means that there are at the most 2 sources of income per household. (STATISTIK AUSTRIA, 2014a) However, there is no actual data available concerning the sources of income per household.

3.1.3 Percentage of households depending on only one income source

1 (100%)	2 (75-99%)	3 (50-74%)	4 (25-49%)	5 (less than 24%)	Rating
					4

As there are 46,1% single-households in Vienna, these households certainly depend on only one income source (STATISTIK AUSTRIA, 2014a). However, also households with more people might depend on only one income source, which would make the percentage even higher. As stated above, data on this issue is not available.

3.1.4 Extent of income disparity between the lowest 10% and the highest 10% of income (Example: lowest 10% = 2%; highest 10% = 30% → Factor = 30/2 = 15)

1 (factor 30 or more)	2 (23-29)	3 (16-22)	4 (9-15)	5 (less than 8)	Rating
					5

A study conducted by the University of Vienna in 2003 showed that the richest 10% of the population earn around 23% of Vienna's total gross income, while the poorest 10% earn around 3% (Universität Wien - Arbeitsgemeinschaft für Interdisziplinäre Angewandte Sozialforschung (AIAS), 2006: 16). The factor therefore lies at 23/3 = 7,7.

3.1.5 Percentage of households depending on income from activities derived in the informal sector

1 (100%)	2 (more than 26%)	3 (16-25%)	4 (6-15%)	5 (less than 6%)	Rating
					4

In 2011, 620.000 Austrian citizens worked in the informal sector (11% of the total labour force of 5,6 Mio people) (Schneider, 2013; STATISTIK AUSTRIA, 2014b). 39% of the informal work is done in the construction industry, 32% in other industries (such as manufacturing and tourism), and 29% in other service industries (Schneider, 2013). In Vienna, only 8,2% of total labour force are employed in construction industry, 8,9% in tourism, and 10,7% in manufacturing industries (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2010). As the majority of people (more than 70%) work in industries, which are not prone to illegal employment, it can be expected that the informal sector in Vienna is smaller than the Austrian average and the percentage of households depending on income derived in this sector is probably not higher than this number. However, data on the issue is hard to collect and therefore not readily available.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

3.1.1	3.1.2	3.1.3	3.1.4	3.1.5
5	**2**	**1**	**4**	**3**

3.2 Employment

3.2.1 Percentage of labour unemployed in formal sector

1 (more than 25%)	2 (19-24%)	3 (13-18%)	4 (7-12%)	5 (less than 7%)	Rating
					4

Vienna's unemployment rate in 2012 was between 7,9% (EU definition) and 9,5% (Austrian definition), depending on the definition (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2012a)

3.2.2 Percentage of youth unemployed in formal sector (UN definition "youth": those persons between the ages of 15 and 24 years)

1 (more than 25%)	2 (19-24%)	3 (13-18%)	4 (7-12%)	5 (less than 7%)	Rating
					5

In 2011, 11.181 people between the age of 15 and 25 were unemployed (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2012b), which accounts for 5,4% (STATISTIK AUSTRIA, 2013d).

3.2.3 Percentage of all women employed in formal sector

1 (less than 20%)	2 (21-35%)	3 (36-50%)	4 (51-65%)	5 (more than 65%)	Rating
					3

In 2012, 470.314 women were employed in the formal sector, which are 48,8% of all people employed (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 64, 134).

3.2.4 % of employees in formal sector come from outside the city (night/day population)

1 (more than 80%)	2 (60-79%)	3 (40-59%)	4 (20-39%)	5 (less than 20%)	Rating
					4

In 2011, 262.761 people, which are 28,4% of all employees, came from outside the city (STATISTIK AUSTRIA, 2013e).

3.2.5 Percentage of labour employed in informal sector

1 (more than 25%)	2 (19-24%)	3 (13-18%)	4 (7-12%)	5 (less than 6%)	Rating
					4

As explained in question 3.1.5, due to Vienna's distribution of industries, the percentage of people working in the informal sector can be expected to be slightly smaller than the Austrian average of 11% (Schneider, 2013; Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2010).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

3.2.1	3.2.2	3.2.3	3.2.4	3.2.5
3	**5**	**4**	**2**	**1**

3.3 Household Assets

3.3.1 Percentage of city's households which has television or radio

1 (less than 61%)	2 (61-70%)	3 (71-80%)	4 (81-90%)	5 (91-100%)	Rating
					5

In 2011, 93% of Vienna's households owned a TV (STATISTIK AUSTRIA, 2011a).

3.3.2 Percentage of city's population which has mobile phone/telecommunication

1 (less than 61%)	2 (61-70%)	3 (71-80%)	4 (81-90%)	5 (91-100%)	Rating
					5

In 2011, 95% of Vienna's households owned a mobile phone (STATISTIK AUSTRIA, 2011a).

3.3.3 Percentage of city's households which has motorized vehicle

1 (less than 16%)	2 (16-30%)	3 (31-45%)	4 (46-60%)	5 (more than 60%)	Rating
					4

In 2011, 59% of Vienna's households owned a car, while 6% owned a motorcycle (STATISTIK AUSTRIA, 2011a).

3.3.4 Percentage of city's households which has non-motorized vehicle (e.g., bicycle)

1 (less than 30%)	2 (31-45%)	3 (46-60%)	4 (61-75%)	5 (more than 75%)	Rating
					4

In 2011, 61% of Vienna's households owned a bicycle (STATISTIK AUSTRIA, 2011a).

3.3.5 Percentage of city's households which has basic furniture (beds, kitchen, etc.)

1 (less than 70%)	2 (71-80%)	3 (81-90%)	4 (91-95%)	5 (96-100%)	Rating
					5

There is no data available on basic furniture's in Vienna's households. However, in 2011, 100% of Vienna's households owned a refrigerator and a stove (STATISTIK AUSTRIA, 2011a), which implies existence of a kitchen.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

3.3.1	3.3.2	3.3.3	3.3.4	3.3.5
5	**4**	**2**	**3**	**1**

3.4 Finance and Savings

3.4.1 Access and availability of credit facility in the city's financial institutions to prevent disasters

1 (no access/ availability)	2 (poor)	3 (limited)	4 (moderate)	5 (full access/ availability)	Rating
					5

According to information provided by a big Austrian financial institution, a large amount of subsidies is invested on state-level to allow availability of cheap loans (Kunert, 2014). Also, it can be said that barriers to take out a loan ware generally low (Kunert, 2014).

3.4.2 Effectiveness of credit facility after a disaster for urban poor or low-income groups

1 (not effective)	2 (poor)	3 (limited)	4 (moderate)	5 (fully effective)	Rating
					4

According to information provided by a big Austrian financial institution, barriers to take out loans are generally low and also people with low income mostly have access to loans (Kunert, 2014).

3.4.3 Habit/practice of saving of city dwellers (household)

1 (1-20% have savings)	2 (21-40%)	3 (41-60%)	4 (61-80%)	5 (81-100%)	Rating
					5

According to an enquiry, conducted for a big Austrian financial institution in 2012, 72% of the population regard saving as "very important" or "extremely important" (Kunert, 2014; IMAS International, 2013: 2). Furthermore, a study conducted by the Austrian National Bank shows that in Austria, 23 Mio savings accounts exist, which amounts to 3-4 per Austrian citizen (Höller, 2013).

3.4.4 Percentage of city's household properties under any sort of insurance scheme

1 (1-20% are insured)	2 (21-40%)	3 (41-60%)	4 (61-80%)	5 (81-100%)	Rating
					5

According to STATISTIK AUSTRIA, in 2009, 11% of the Austrian population did not possess any household insurance (Angel et al., 2009: 1113). However, data availability on the issue is limited, as there is no data synchronisation between the different insurance providers (Kunert, 2014). Estimates assume that between 80-85% of Vienna's households are under some sort of insurance scheme (Kunert, 2014).

3.4.5 Existence of or access to a catastrophe risk financing framework/instrument

1 (not existing/ no access)	2 (poor)	3 (limited)	4 (moderate)	5 (full access)	Rating
					5

The Austrian Emergency Fund was established by law in 1966. The law was subsequently revised afterwards, and is still in force in its 1996 version (Bundesministerium für Finanzen (BMF), 2012a). This fund annually allocates money to the Austrian states, necessary to repair and/or prevent further damage from flooding, landslides, avalanches, earthquakes, extreme snowfall, storms, and hail (Bundesgesetz über Maßnahmen zur Vorbeugung und Beseitigung von Katastrophenschäden (Katastrophenfondsgesetz 1996 - KatFG 1996), 2014). This money is used for damage on public infrastructure, as well as to compensate damage to private individuals (Bundesministerium für Finanzen (BMF), 2012a). Additionally, Vienna allocates around 1,4% of its yearly expenses to disaster risk management (Finanzwesen (Magistratsabteilung 5), 2013).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

3.4.1	3.4.2	3.4.3	3.4.4	3.4.5
1	**2**	**5**	**4**	**3**

3.5 Budget and Subsidy

3.5.1 Percentage of city's annual budget targeting disaster risk management

1 (0%)	2 (less than 2.5%)	3 (2.6-5%)	4 (5.1-7.5%)	5 (more than 7.5%)	Rating
					2

In Vienna's preliminary budget for 2014, 167,6 Mio EUR are allocated to disaster risk management, which accounts for 1,4% of the total expenses of 12,3 Bio EUR. Additionally, 7.801.000 EUR will be available from the Austrian emergency fund (*Katastrophenfond*) (Finanzwesen (Magistratsabteilung 5), 2013: IX, 54-55, 167).

3.5.2 Budget for climate change related disaster risk reduction measures sufficient

1 (no funds)	2 (extremely insufficient)	3 (insufficient)	4 (moderate)	5 (sufficient)	Rating
					4

Vienna's budget for disaster risk management has been increasing continuously from 111,6 Mio EUR in 2006 (1,1% of total expenses) to 167,6 Mio EUR in 2014 (1,4%) (Finanzwesen (Magistratsabteilung 5), 2008; Finanzwesen (Magistratsabteilung 5), 2010; Finanzwesen (Magistratsabteilung 5), 2012; Finanzwesen (Magistratsabteilung 5), 2013). Furthermore, the Austrian emergency fund has not only been adapted in years of higher damage (Bundesministerium für Finanzen (BMF), 2014a: 6), but has been continuously increasing since 2006 (Bundesministerium für Finanzen (BMF), 2012b: 131), which shows an enhanced commitment to disaster risk management. However, a continuous increase also shows that adaptation is still necessary/ongoing and current financial resources might not be totally sufficient.

3.5.3 Availability of subsidies/incentives for residents/institutions to rebuild houses after a disaster

1 (not available)	2 (poor)	3 (limited)	4 (moderate)	5 (sufficiently available)	Rating
					4

The Austrian emergency fund allocates a yearly budget to all Austrian states, which they can use to repair and/or prevent further damage from flooding, landslides, avalanches, earthquakes, extreme snowfall, storms, and hail (Bundesgesetz über Maßnahmen zur Vorbeugung und Beseitigung von Katastrophenschäden (Katastrophenfondsgesetz 1996 - KatFG 1996), 2014: §3). This money is used for damage on public infrastructure, as well as to compensate damage to private individuals. In general, private households are entitled to get reimbursements for 20-30% of their damages, in severe cases up to 80% (Bundesministerium für Finanzen (BMF), 2012a). Additionally, organisations, such as the "*HILFE IM EIGENEN LAND. Katastrophenhilfe Österreich*" (Help Within your Country – Emergency Help Austria), collect donations to help private households after disasters. In 2012, *HILFE IM EIGENEN LAND* allocated 29.549,87 EUR to Vienna, to provide money for 64 emergencies (HILFE IM EIGENEN LAND, 2013). Remaining costs will either be covered by private insurance companies (if available), or through private assets. However, many household insurances do not cover damage due to flooding and earthquakes – as there is generally a low risk for that in Vienna (AK Wien, 2014; Hausverwaltung4you GmbH, 2014) – and those who do, only cover a very limited amount (in average, between 3.650 EUR and 8.000 EUR) (AK Wien, 2014). Therefore, it is possible by law to offset costs, which are connected to disaster damage, against tax (Lohnsteuerrichtlinien 2002 (LStR 2002), 2011: § 34 Abs. 6 EStG 1988, Rz 838 - 838g; Bundesministerium für Finanzen (BMF), 2014b).

3.5.4 Availability of subsidies/incentives for residents/institutions to receive/provide alternative emergency livelihood during disaster

1 (not available)	2 (poor)	3 (limited)	4 (moderate)	5 (sufficiently available)	Rating
					5

Depending on the magnitude of the disaster, different options for emergency shelters are available. For very small-scale emergencies, people are usually accommodated by relatives and friends, or emergency shelters provided by the city government. If a larger amount of people is affected, emergency shelters are provided in school gyms and other public buildings. (DieHelferWiens, 2014e) The city-owned emergency shelters are usually run by private organisations, such as the Red Cross (Österreichisches Rotes Kreuz - Landesverband Wien, 2014a).

3.5.5 Availability of subsidies/incentives for residents/institutions to receive/provide emergency health care

1 (not available)	2 (poor)	3 (limited)	4 (moderate)	5 (sufficiently available)	Rating
					5

Emergency healthcare is provided by all public healthcare institutions. Free access to healthcare is possible for all residents having social insurance (99,9% of Austrian citizens) (Bundesministerium für Gesundheit (BMG), 2013; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010). Additionally, public and private institutions offer healthcare for people without medical insurance (Fonds Soziales Wien, 2011; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010). This system is financed through the city budget and the Healthcare Fund Vienna (*Wiener Gesundheitsfond*) (Wiener Gesundheitsfonds-Gesetz 2013, 2013; Wiener Gesundheitsfonds (WGF), 2013; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010; Finanzwesen (Magistratsabteilung 5), 2013)

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

3.5.1	3.5.2	3.5.3	3.5.4	3.5.5
2	**5**	**4**	**3**	**1**

Weight factor "Economic Condition of the City"

At the end of this third part of questions would you please weigh each parameter by ranking them between 1 and 5 (5 = most important, 1 = least important)

Income	Employment	Household Assets	Finance and Savings	Budget and Subsidy
3	**1**	**2**	**4**	**5**

4 Institutional Condition of the City

4.1 Mainstreaming of Disaster Risk Reduction and Climate Change Adaptation

4.1.1 Incorporation of disaster risk reduction and climate change adaptation measures in city's land use plans

1 (not incorporated)	2 (poor)	3 (limited)	4 (moderate)	5 (fully incorporated)	Rating
					5

The *Austrian Strategy for Adaptation to Climate Change* (*Österreichische Strategie zu Anpassung an den Klimawandel*) was initiated in 2007 and, after 6 workshops between 2007 and 2011, was adopted by the ministerial conference in October 2012. The strategy defines 14 spheres of activity, including disaster risk reduction and management, ecosystems and biodiversity, (spatial) planning, housing, mobility, and urban greenspace. These spheres should be subject to future adaptations measures, including (1) *grey* measures – technical measures (i.e. flood protection buildings); (2) *green* measures – measures to stabilise and/or improve natural ecosystems and their natural capacity to adapt; and (3) *soft* or *smart* measures – measures targeting the increase of awareness and knowledge, the creation of economic incentives, and the facilitation of institutional implementation. (BMLFUW, 2012a; BMLFUW, 2012b) In Vienna, climate change adaptation has a slightly longer history. In 1999, Vienna adopted its First Climate Protection Programme (*Klimaschutzprogramm der Stadt Wien – KliP I*) covering the years 1999-2009. In December 2009, the second programme – Klip II – was adopted for the years 2010-2020. (Magistrat der Stadt Wien (MDKLI), 2009) The programme addresses greenhouse gas mitigation measures, as well as measures for adaptation to global climatic change in the spheres of energy generation and consumption, mobility and city planning, resource management, agriculture, protection of ecosystems and biodiversity, and public awareness (Magistrat der Stadt Wien (MDKLI), 2009). Yearly evaluations to display the programme's performance have shown that KliP I outperformed its targets (Magistrat der Stadt Wien (MDKLI), 2009) and the most recent evaluation shows that also *KliP II* is well under way (Österreichische Energieagentur – Austrian Energy Agency, 2012).

With regards to special planning and land-use, the *Austrian Spatial Development Concept* (*Österreichisches Raumentwicklungskonzept ÖREK 2011*) includes four areas of action, one of them being Climate Change, Adaptation and Resource Efficiency (Österreichische Raumordnungskonferenz (ÖROK), 2011). The ÖROK and the KliP are both implemented in Vienna's Urban Development Plan (*Stadtentwicklungsplan Wien – STEP 05*)

(Stadtentwicklung Wien, 2014a; Stadtentwicklung Wien, 2014b; Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005).

4.1.2 Incorporation of disaster risk reduction and climate change adaptation measures in city's housing plans and policies

1 (not incorporated)	2 (poor)	3 (limited)	4 (moderate)	5 (fully incorporated)	Rating
					5

Housing plans and policies are part of the city's urban development plan, which implements the city's climate protection programme, as described in question 4.1.1 (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005; Magistrat der Stadt Wien (MDKLI), 2009).

4.1.3 Incorporation of disaster risk reduction and climate change adaptation in city's school education curriculum

1 (not incorporated)	2 (poor)	3 (limited)	4 (moderate)	5 (fully incorporated)	Rating
					3

The *Austrian Strategy for Adaptation to Climate Change* mentions incorporation of climate change adaptation issues into school and university curricular as a priority for short- and medium-term action (BMLFUW, 2012b: 167, 221, 297). At the moment, there is material available on how teachers and schools should react in case of a natural disaster (Bundesministerium für Bildung und Frauen (BMBF), 2006), however, implementation into the curriculum is still limited. This is might be due to the facts that the risk for natural disasters is generally perceived as low in Vienna (DieHelferWiens, 2014e). Vienna's disaster prevention and public awareness institution *Die Helfer Wiens* organise workshops for schools dealing with disaster prevention (Die Helfer Wiens, 2014a). However they currently do not have the capacity to achieve full coverage of all schools (DieHelferWiens, 2014e). Yet, schools are obliged to teach Vienna's siren warning system (Bundesministerium für Bildung und Frauen (BMBF), 2012).

4.1.4 Incorporation of disaster risk reduction and climate change adaptation in city's transport plans and policies

1 (not incorporated)	2 (poor)	3 (limited)	4 (moderate)	5 (fully incorporated)	Rating
					5

Transportation plans and policies are part of the city's urban development plan, which implements the city's climate protection programme, as described in question 4.1.1 (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005; Magistrat der Stadt Wien (MDKLI), 2009).

4.1.5 Incorporation of disaster risk reduction and climate change adaptation in city's environmental plans and policies (e.g., flood risk, biodiversity, urban green space, air quality, etc.)

1 (not incorporated)	2 (poor)	3 (limited)	4 (moderate)	5 (fully incorporated)	Rating
					5

As described in question 4.1.1, Vienna's climate protection programme addresses greenhouse gas mitigation measures, as well as measures for adaptation to global climatic change in the spheres of energy generation and consumption, mobility and city planning, resource management, agriculture, protection of ecosystems and biodiversity, and public awareness (Magistrat der Stadt Wien (MDKLI), 2009). The KliP is implemented in the STEP05, Vienna's urban development plan (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

4.1.1	4.1.2	4.1.3	4.1.4	4.1.5
3	**2**	**4**	**1**	**5**

4.2 Effectiveness of City's Crisis Management Framework

4.2.1 Existence and effectiveness of city's disaster management plan

1 (no plan existing)	2 (poor)	3 (limited)	4 (moderate)	5 (fully effective)	Rating
					5

Vienna's disaster management plan is implemented according to *Vienna's Disaster Management Law* (*Wiener Katastrophenhilfe- und Krisenmanagementgesetz - W-KKG*) (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003) and fully effective, covering multiple levels (Sabitzer, 2003; Wiener Rettung (Magistratsabteilung 70), 2014).

4.2.2 Incorporation of uncertainties of climate change in disaster management plan

1 (not incorporated)	2 (poor)	3 (limited)	4 (moderate)	5 (fully incorporated)	Rating
					1

According to information by the Department of Fire Control and Disaster Management (*Feuerwehr und Katastrophenschutz – Magistratsabteilung 68*), conventional risk assessment is an integral part of Vienna's disaster management plans (Steiner, 2014). However, climate change scenarios are not incorporated at the moment (Steiner, 2014).

4.2.3 Existence and effectiveness of emergency team DURING a disaster (leadership/competence)

1 (not existent)	2 (poor)	3 (slightly effective)	4 (moderate)	5 (fully effective)	Rating
					5

Coordination of different emergency services and the development of operation schedules is done by the city authority's department for disaster management (Krisenmanagement und Sicherheit (Magistratsdirektion), 2014c). According to law, responsibility for disaster management in terms of on-site logistics and operation lies with the officer-in-charge of the municipal fire brigade, while medical emergencies related to the disaster are within the responsibility of the executive emergency doctor of the municipal ambulance (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §14; Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014d). Since the employees of Vienna's municipal fire brigade, as well as the municipal ambulance are professionals rather than volunteers, and since education and training is highly professional (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014b; Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a; Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014a; Sabitzer, 2003), the emergency team is fully competent (trained and knowledgeable) to handle a disaster situation.

4.2.4 Existence and effectiveness of emergency team AFTER a disaster

1 (no response)	2 (poor)	3 (slightly effective)	4 (moderate)	5 (fully effective)	Rating
					5

Emergency healthcare is provided by all public healthcare institutions. As required by law, all public healthcare facilities need to establish the capacity to adequately face emergency situations (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §4; kav - Wiener Krankenanstaltenverbund, 2014). They have developed emergency operation schedules as required by §4 of Vienna's Emergency Management Law (*Wiener Katastrophenhilfe- und Krisenmanagementgesetz*). Those schedules are tested for practicability once a year in the form of an emergency exercise (AK Wien, 2014). Psychological support is equally important after a disaster. To this end, the city authority will establish a *Centre for Recording/Admission, Information and Help* (*Zentrum für Aufnahme, Information und Hilfe - RISC*), where the affected population will receive information and psychological support (Krisenmanagement und Sicherheit (Magistratsdirektion), 2014b). At the moment, more than 60 professional psychologists are part of Vienna's emergency response team (Krisenmanagement und Sicherheit (Magistratsdirektion), 2014d). Depending on the magnitude of the disaster, different options for emergency shelters are available. For very small-scale emergencies, people are usually accommodated by relatives and friends, or emergency shelters provided by the city government. If a larger amount of people is affected, emergency shelters are provided in school gyms and other public buildings. (DieHelferWiens, 2014e) The city-owned emergency shelters are usually run by private organisations, such as the Red Cross (Österreichisches Rotes Kreuz - Landesverband Wien, 2014a). Furthermore, the city is required to provide the necessary means to execute disaster help operations (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §3(2)). For example, this can be in the form of mobile electricity generators to supply electricity to evacuation centres, if needed (Rathauskorrespondenz (Magistratsabteilung 53), 2014). Also, the Red Cross Austria is able to provide tents, blankets, camp beds, and medication for up t0 9.000 people, as well as drinking water purification systems for up to 80.000 litres/hour (Adam, 2006).

4.2.5 Existence and readiness of alternates/back-up decision making personnel during a disaster (e.g., the head decision-maker is out of country)

1 (not existent)	2 (poor)	3 (limited)	4 (moderate)	5 (fully ready)	Rating
					5

As specified in Vienna's Disaster Management Law, head-decision maker in times of crisis and disaster is the major of the city (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §12(2)). In times of absence, he will be represented by his first or second vice major, as regulated by Vienna's city constitution (Verfassung der Bundeshauptstadt Wien (Wiener Stadtverfassung – WStV), 2013: 94) On-site leadership in terms of on-site logistics and operation lies with the officer-in-charge of the municipal fire brigade, while medical emergencies related to the disaster are within the responsibility of the executive emergency doctor of the municipal ambulance (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §14; Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014d).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

4.2.1	4.2.2	4.2.3	4.2.4	4.2.5
5	**2**	**4**	**3**	**1**

4.3 Effectiveness of City's Institutions to Respond to a Disaster

4.3.1 Effectiveness of a city's formal organizations/institutions during and after a disaster

1 (very ineffective)	2 (ineffective)	3 (slightly effective)	4 (moderately effective)	5 (fully effective)	Rating
					5

In 2013, Vienna's municipal fire brigade had more than 1.700 professional emergency workers at its disposal (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a). The professional emergency workers are obliged to participate in mandatory periodical trainings (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014b; Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a). The new education centre in the north of Vienna is equipped to host a large variety of trainings for different emergency scenarios (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014a). This contributes to enhancing the effectiveness of disaster reduction operations (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014a). Vienna's municipal ambulance service has a similar education and training centre available (Sabitzer, 2003). In 2013, Vienna's ambulance had a staff or more than 800 people, conducting more than 152.000 operations (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013c). Furthermore, there are research/training programmes, which target the increase of effectiveness in specific emergency situations, such as the *GASRESPONSE* programme, funded by the *Austrian Federal Ministry of Transport, Innovation and Technology* (*Bundesministerium für Verkehr, Innovation und Technologie - BMVIT*) and the *Austrian Research Promotion Agency* (*Österreichische Forschungsförderungsgesellschaft - FFG*) (FFG - Österreichische Forschungsförderungsgesellschaft mbH, 2014). Due to extensive education and training, and the large amount of available emergency workers, the municipal disaster management institutions in Austria are can be rated as very effective (Österreichischer Bundesfeuerwehrverband (ÖBFV), 2013).

4.3.2 Effectiveness of a city's informal organizations/institutions (NGOs, etc.) during and after a disaster

1 (very ineffective)	2 (ineffective)	3 (slightly effective)	4 (moderately effective)	5 (fully effective)	Rating
					5

Austria's disaster management is founded on intensive cooperation between municipal services and NGOs (Adam, 2006; Jachs, 2011). Vienna therefore has a strong interest in increasing the effectiveness not only for municipal emergency workers, but also for emergency personnel employed in private organisations. To this end, comprehensive emergency trainings are provided for emergency workers from municipal and private organisations, which shall ensure effectiveness and cooperation in times of disaster

(Arbeiter-Samariter-Bund Österreichs (ASBÖ), 2014; Österreichischer Arbeiter-Samariterbund - Landesverband Wien, 2011; Bundesministerium für Landesverteidigung und Sport (BMLV), 2014; Wien Energie Stromnetz GmbH, 2011; Österreichisches Rotes Kreuz - Landesverband Niederösterreich, 2012; Sabitzer, 2006).

4.3.3 Availability and efficiency of trained emergency workers during and after a disaster

1 (not available)	2 (poor)	3 (limited)	4 (moderate)	5 (fully efficient)	Rating
					5

As stated above, the *K-Kreis* provides for the availability of more than 16.000 people of different professions (Die Helfer Wiens, 2013/2014). The municipal fire brigade itself has more than 1.700 professional emergency workers at its disposal (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a), while the municipal ambulance service employed more than 800 people (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013c). Also, ensuring the availability of enough emergency personnel is required by law (Wiener Feuerwehr-Verordnung, 1957: §3(2)).

4.3.4 Availability and frequency of regular disaster training programs for emergency workers

1 (not available)	2 (less than 1 every 2 years)	3 (1 every 2 years)	4 (1 or 2 per year)	5 (more than 2 per year)	Rating
					5

Vienna's professional emergency workers – the municipal fire brigade – are obliged to participate in mandatory periodical trainings (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014b; Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a). The intention to further improve education and training for emergency workers can be seen through the construction of a new education centre in the north of Vienna, which, according to the authorities, should contribute to enhancing the efficiency and quality of the education (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014a). To this end, the centre is equipped to host a large variety of trainings for different emergency scenarios (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014a). Vienna's municipal ambulance service has a similar education and training centre available, which was built in 2001 (Sabitzer, 2003).

4.3.5 Effectiveness to learn from previous disasters

1 (not effective)	2 (poor)	3 (limited)	4 (moderate)	5 (fully effective)	Rating
					5

There is no statistical data available regarding the effectiveness to learn from previous disasters. However, during the 2002 floods in Austria, problems were encountered in many municipalities of Lower Austria, regarding the transfer of information to the affected people during, and immediately after a disaster (Adam, 2006). Vienna's disaster management reacted by acquiring and installing media information vehicles (*Presseinformationsfahrzeuge*) directly at the disaster location, dealing with the dissemination of up-to-date, on-site information to the media (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a). One other example is the 2003 flood, where many spontaneous volunteers wanted to help but only caused more chaos (TECNUN Universidad de Navarra, 2013a: 33-34). So in 2007, the *Austrian Red Cross* in cooperation with *Hitradio Ö3* (the biggest Austrian radio station) launched a campaign called *Team Österreich*. People, willing to volunteer in times of disaster, can get registered and receive a three hour training course dealing with disaster management. They will be called upon in times of need and receive full insurance protection during the operation. (TECNUN Universidad de Navarra, 2013a: 33-34; Österreichisches Rotes Kreuz und ORF Hitradio Ö3, 2010) „This best practice conveys how the Austrian Red Cross has managed to structure the volunteers and unleash the potential of this workforce (TECNUN Universidad de Navarra, 2013a: 34)." At the moment, more than 35.000 people are registered all over Austria (ORF Hitradio Ö3, 2013). Furthermore, it can be pointed out that the *Austrian Federal Ministry of Defense and Sports*, as well as the *Austrian Red Cross* and the *Austrian Federal Fire Brigade Association* are part of the ELITE programme (*ELITE - Elicit to Learn Crucial Post-Crisis Lessons*), a project funded by the EU to share knowledge and best practise insights in disaster management, as well as promote future research on this topic (TECNUN Universidad de Navarra, 2013b; TECNUN Universidad de Navarra, 2013c).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

4.3.1	4.3.2	4.3.3	4.3.4	4.3.5
5	**4**	**3**	**2**	**1**

4.4 Institutional Collaboration with other Organizations and Stakeholders

4.4.1 Extent of dependency to external institutions/support during and after a disaster

1 (fully dependent)	2 (heavily dependent)	3 (dependent)	4 (slightly dependent)	5 (independent)	Rating
					3

According to the principle of subsidiary, Austria's (and also Vienna's) disaster management is founded on intensive cooperation between municipal services and NGOs (Adam, 2006; Jachs, 2011). Municipal services will therefore not be able to manage larger disasters on their own, as Vienna's disaster management plan is designed to include support from Vienna's *K-Kreis*, a unique network of municipal and private organisations, employing professionals and volunteers and providing a comprehensive set of disaster reduction services (Die Helfer Wiens, 2013/2014). For example, will the municipal fire brigade be able to lead on-site operations during a disaster, however, for relief work after a disaster, they depend on equipment provided by the Red Cross Vienna (Adam, 2006; Österreichisches Rotes Kreuz - Landesverband Wien, 2014a; Österreichisches Rotes Kreuz - Landesverband Wien, 2014c).

4.4.2 Interconnectivity (network)/collaboration with neighbouring cities for emergency management during and after a disaster

1 (no network)	2 (poor network)	3 (limited network)	4 (moderately strong netw.)	5 (strong network)	Rating
					5

In Austria, disaster management lies within the responsibility of the federal states (Jachs, 2011; Adam, 2006; Österreichischer Bundesfeuerwehrverband (ÖBFV), 2011). For optimal cooperation in times of larger disasters, the *Austrian Federal Fire Brigade Association* has established the *Katastrophenhilfsdienst (KHD)*, a network of all Austrian fire brigades (Österreichischer Bundesfeuerwehrverband (ÖBFV), 2011). This network shall ensure fast support with personnel and equipment (Österreichischer Bundesfeuerwehrverband (ÖBFV), 2011). Vienna's municipal fire brigade is part of this network and additionally has the competence to directly request support from the Austrian military (Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014e; Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014d). Other organisations involved in disaster reduction, such as the *Austrian Red Cross*, are organised in regional associations (*Landesverbände*) connected via a state secretariat, which makes coordination across municipal borders easier (Österreichisches Rotes Kreuz, 2014a; Österreichisches Rotes Kreuz, 2014b). Furthermore, there are networks with several cities outside Austria (Geschäftsbereich Europa und Internationales (Magistratsdirektion), 2014). For example, the *CARESS@Danube* Programme (*Connecting all Rescue- and Support Services on the Danube*), funded by the European Union, was established to ensure future cooperation between Vienna and Bratislava at all levels of disaster management, such as the coordination and transportation of equipment and personnel, the training of emergency teams, etc. (Europäische Angelegenheiten (Magistratsabteilung 27), 2014b).

4.4.3 City's institutional collaboration with national government during and after a disaster

1 (no collaboration)	2 (poor)	3 (limited)	4 (moderate)	5 (strong collaboration)	Rating
					3

In Austria, disaster management generally lies within the responsibility of the federal states (Jachs, 2011; Adam, 2006; Österreichischer Bundesfeuerwehrverband (ÖBFV), 2011). However, in case of transnational disasters, or disasters affecting multiple Austrian states (i.e. epidemics, nuclear accidents), the Austrian Crisis and Disaster Management plan (*Staatliches Krisen- und Katastrophenschutzmanagement – SKKM*) provides for coordination of disaster management efforts by the Austrian Federal Ministry of the Interior (Jachs, 2011). However, cooperation of the states is voluntary and decision lies with the person in charge of disaster management – in Vienna, the city major (Jachs, 2011). If coordinative action is initiated, the Federal Ministry will install a coordination committee, lead by the director general for public safety and consisting of representatives from the *Federal Chancellery (BKA)*, the *Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA)*, the *Federal Ministry of Finance (BMF)*, the *Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)*, the *Federal Ministry of Defence and Sports (BMLVS)*, the *Federal Ministry of Health (BMG)*, and, if needed, other ministries and news services (*ORF, APA*) (Jachs, 2011). If no national coordination is required, the support from the national government is mainly in the form of financial support. To this end, the Austrian Emergency Fund (*Österreichischer Katstrophenfond*) was established by law in 1966. The law was subsequently revised afterwards, and is still in force in its 1996 version (Bundesministerium für Finanzen (BMF), 2012a). This fund annually allocates money to the Austrian states, necessary to repair and/or prevent further damage from flooding, landslides, avalanches, earthquakes, extreme snowfall, storms, and hail (Bundesgesetz über Maßnahmen zur Vorbeugung und Beseitigung von Katastrophenschäden (Katastrophenfondsgesetz 1996 - KatFG 1996), 2014). This money is used for damage on public infrastructure, as well as to compensate damage to private individuals (Bundesministerium für Finanzen (BMF), 2012a).

4.4.4 City's institutional collaboration with NGOs during and after a disaster

1 (no collaboration)	2 (poor)	3 (limited)	4 (moderate)	5 (strong collaboration)	Rating
					5

Austria's disaster management is founded on intensive cooperation between municipal services and private organisations (Adam, 2006; Jachs, 2011). To this end, in 1977 Vienna established the *Wiener Rettungsgemeinschaft*, a network consisting of Vienna's municipal ambulance and ambulance services provided by the *Red Cross*, the *Arbeiter Sameriterbund*, and the *Johanniter Unfallhilfe*, ensuring medical assistance 24 hours a day (Sprengseis and Lang, 2006: 94-96; Wiener Rettung (Magistratsabteilung 70), 2014). Furthermore, to ensure effective disaster management and cooperation in times of disaster, the city of Vienna established the so-called *K-Kreis*, a unique network of municipal and private organisations, employing professionals and volunteers and providing a comprehensive set of disaster reduction services. Members of the K-Kreis are, among others, the municipal fire brigade, Vienna's police corps, the *Wiener Rettungsgemeinschaft*, Vienna's hospitals, the city's department for drinking water infrastructure, the city's department for energy supply, the city's news service (*Presse- und Informationsdienst – Magistratsabteilung 53*), Austria's state-owned TV station *ORF*, and many more. Altogether, the network consists of 37 organisations and institutions, employing more than 16.000 people, being available 356 days a year. (Die Helfer Wiens, 2013/2014)

4.4.5 City's institutional collaboration with private organizations

1 (no collaboration)	2 (poor)	3 (limited)	4 (moderate)	5 (strong collaboration)	Rating
					3

As mentioned above, Vienna's disaster management is founded on intensive cooperation between municipal services and private organisations (Adam, 2006; Jachs, 2011). However, private organisations involved are mostly non-profit organisations, such as the *Wiener Rettungsgemeinschaft*, the Austrian Mountain Rescue, or the Austrian Water Rescue (Adam, 2006), rather than private companies. Private religious organisations, such as the *Diakonie*, collect donations to provide help and support to affected people after a disaster (Diakonie Katastrophenhilfe, 2013). Donation of private companies and private individuals play an important role in providing interim aid to affected people until state money can be distributed (ORF-Pressestelle (Humanitarian Broadcasting), 2013; Diakonie Katastrophenhilfe, 2013: 7). To create incentives to donate money, the Austrian government passed a regulation, making it possible to offset donations to specific organisations, such as for example disaster help organisations, against tax (Bundesministerium für Finanzen (BMF), 2014c). Furthermore, the Austrian Crisis and Disaster Management Strategy 2020 (*Staatliches Krisen- und Katastrophenschutzmanagement – SKKM*) mentions the need to better include private companies and to establish public-private-partnerships, especially in the field of protection of critical infrastructure (Bundesministerium für Inneres (BM.I), 2009).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

4.4.1	4.4.2	4.4.3	4.4.4	4.4.5
1	**3**	**4**	**5**	**2**

4.5 Good Governance

4.5.1 Integration and implementation of disaster risk management plans/policies

1 (no implementation)	2 (poor: 1-25% implemented)	3 (limited: 26-50% imp.)	4 (moderate: 51-75% imp.)	5 (good: 75-100% imp.)	Rating
					5

The establishment and implementation of disaster management plans is regulated by law (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003; Berufsfeuerwehr der Stadt Wien (Magistratsabteilung 68), 2014c).

4.5.2 Accountability/transparency (e.g., dissemination of information) of city government during and after a disaster

1 (no transparency)	2 (poor: 1-25% info dis.)	3 (limited: 26-50% info)	4 (moderate: 51-75% info)	5 (good: 75-100% info	Rating
					5

Transfer of information about a disaster is conducted via media (Krisenmanagement und Sicherheit (Magistratsdirektion), 2014a). To this end, a new unit of Vienna's municipal fire brigade – Vienna's responsible authority for disaster management – was established in 2013, dealing solely with the dissemination of up-to-date, on-site information to the media. This is possible by installing media information vehicles (*Presseinformationsfahrzeuge*) directly at the disaster location. (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014a) For the directly affected population, the city authority will establish a *Centre for Recording/Admission, Information and Help* (*Zentrum für Aufnahme, Information und Hilfe - RISC*), where they will receive information and psychological support (Krisenmanagement und Sicherheit (Magistratsdirektion), 2014b).

4.5.3 Availability and implementation of building codes led by city government

1 (not available)	2 (poor: 1-25% implemented)	3 (limited: 26-50% imp.)	4 (moderate: 51-75% imp.)	5 (good: 75-100% imp.)	Rating
					5

The establishment and implementation of building codes is regulated by law (Wiener Stadtentwicklungs-, Stadtplanungs- und Baugesetzbuch (Bauordnung für Wien – BO für Wien), 2013).

4.5.4 Existence and effective operation of early warning systems led by city government

1 (not existent)	2 (poor: 1-25% oper.)	3 (limited: 26-50% oper.)	4 (moderate: 51-75% oper.)	5 (good: 75-100% oper.)	Rating
					5

Vienna's siren warning system consists of 176 sirens, which are tested once a year in October (Bundeskanzleramt Österreich, 2014). Information about possible meteorological risks is distributed to the population via media, relying on information provided by Austria's *Central Institute for Meteorology and Geodynamics* (*Zentralanstalt für Meteorologie und Geodynamik - ZAMG*) (ZAMG, 2014b).

4.5.5 Existence and frequency to run drills for disaster scenarios led by city government

1 (not existent)	2 (less than 1 every 2 years)	3 (1 every 2 years)	4 (1 every year)	5 (more than 1 per year)	Rating
					4

Vienna's siren warning system consists of 176 sirens, which are tested once a year in October (Bundeskanzleramt Österreich, 2014). This test is usually accompanied by TV information programmes regarding disaster prevention and behaviour during a time of disaster. Schools are obliged to teach how Vienna's siren warning system functions (Bundesministerium für Bildung und Frauen (BMBF), 2012), to inform their students about possible emergencies, and to run disaster drills twice per term.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

4.5.1	4.5.2	4.5.3	4.5.4	4.5.5
5	**2**	**1**	**4**	**3**

Weight factor "Institutional Condition of the City"

At the end of this fourth part of questions would you please weigh each parameter by ranking them between 1 and 5 (5 = most important, 1 = least important)

Mainstreaming of Disaster Risk Reduction and Climate Change Adaptation	Effectiveness of City's Crisis Management Framework	Effectiveness of City's Institutions to Respond to a Disaster	Institutional Collaboration with other Organizations and Stakeholders	Good Governance
1	**4**	**5**	**3**	**2**

5 Natural Condition of the City

5.1 Intensity/severity of natural hazards in the past 12 months

5.1.1 Floods

1 (very severe)	2 (severe)	3 (moderate)	4 (normal)	5 (no floods)	Rating
					3

According to the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW), the 2013 flood was more severe than the historical flood of 1899 (the most severe flood since the beginning of modern measurements) (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2013). However, due to Vienna's advanced flood control system (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2009: 35), damage to the city was limited and affected areas were less than 5% of the city (ZAMG, 2014a; ORF, 2013a; ORF, 2013b; ORF, 2013c).

5.1.2 Typhoons (*Storms/Intense Winds*)

1 (very severe)	2 (severe)	3 (moderate)	4 (normal)	5 (no typhoons)	Rating
					2

Since typhoons are defined as tropical cyclones, this category is not applicable to Vienna. However, as storms do play a role in Vienna's regional weather, this thesis will treat the category "typhoon" as synonymous with "storm/intense wind". On 17th March 2014, squalls of more than 100 km/h have been reported in Vienna, leading to the death of one person, damage to property, and requiring more than 850 operations of the municipal fire brigade (ORF, 2014a; ORF, 2014b).

5.1.3 Rainfall-induced landslides

1 (very severe)	2 (severe)	3 (moderate)	4 (normal)	5 (no landslides)	Rating
					5

No rainfall-induced landslides were reported in Vienna within the last 12 months. One landslide was reported during the winter months of 2013. However, no one was injured and damage to property was insignificant. (Kramsl, 2013)

5.1.4 Heat waves

1 (very severe)	2 (severe)	3 (moderate)	4 (normal)	5 (no heat waves)	Rating
					1

In July/August 2013, Vienna experienced a heat wave, which broke the historical temperature record of 38,9 °C. Temperatures of up to 39,5 °C were reported, causing problems for most hospitals and private households, since most buildings in Vienna do not have air conditioning. It was also assumed that there were several deaths caused by the heat, although this is difficult to prove. Furthermore, the high temperatures were the reason for various electricity outages around the city and local farmers reported damage to their harvest in the range of 20-35%. (ORF, 2013d; ORF, 2013e; ORF, 2013f; ORF, 2013g; ORF, 2013h; ORF, 2013i; ORF, 2013j; Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2013). Temperatures were more than 10 °C above the regional average climatological values for July/August of between 25 °C and 27°C (ZAMG, 2014c).

5.1.5 Droughts (water scarcity)

1 (very severe)	2 (severe)	3 (moderate)	4 (normal)	5 (no droughts)	Rating
					5

In 2013, the absence of rain starting in June and the July/August heat wave have lead to severe drought (ORF, 2013g), high fire risk (ORF, 2013d; ZAMG, 2014a), and damage to crops in the range of 20-35% (ORF, 2013g; ZAMG, 2014a). However, drinking water supply was not threatened at any time. This is also due to Vienna's sustainable drinking water supply system (see question 1.2.5).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

5.1.1	5.1.2	5.1.3	5.1.4	5.1.5
5	**3**	**1**	**4**	**2**

5.2 Frequency of Natural Hazards

5.2.1 Floods

1 (more than once per year)	2 (once per year)	3 (once every 5 years)	4 (less than every 5 years)	5 (no floods)	Rating
					4

Statistics show that severe floods are not very common in Vienna, occurring only every 15-20 years (Wiener Gewässer (Magistratsabteilung 45), 2013a). Nevertheless, the city of Vienna has established a great flood control system over the past decades, making damage from flooding very unlikely, even with very severe floods (Wiener Gewässer (Magistratsabteilung 45), 2013b; Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2009).

5.2.2 Typhoons (*Storms/Intense Winds*)

1 (more than once per year)	2 (once per year)	3 (once every 5 years)	4 (less than every 5 years)	5 (no typhoons)	Rating
					2

Vienna generally is a rather windy city, as can be seen when looking at wind statistics (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014b). Between 2012 and 2014 there were on average 4 days of storm per month, meaning wind speeds of more than 60 km/h (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014b). There were two events within that period, where wind speeds were reported to be higher than 90 km/h (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014b), meaning that the average frequency is around one severe storm per year. Since 1951, there has been only one year, where no wind event with wind speeds above 90 km/h has been reported (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014c).

5.2.3 Rainfall-induced landslides

1 (more than once per year)	2 (once per year)	3 (once every 5 years)	4 (less than every 5 years)	5 (no landslides)	Rating
					4

There is no data available on the frequency of rainfall-induced landslides in Vienna. "Within the local government of Vienna, the Department of Bridge and Civil Engineering (MA 29, Magistratsabteilung für Brücken- und Grundbau) has neither landslide inventory nor susceptibility, hazard and risk maps (Schweigl and Hervás, 2009)." However, reported events are rather an exception.

5.2.4 Heat waves

1 (more than once per year)	2 (once per year)	3 (once every 5 years)	4 (less than every 5 years)	5 (no heat waves)	Rating
					1

For the period 2012-2014, an average of 8,5-9 hot days (*Hitzetage*) for each summer month (Juni-August) has been reported. (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014d). In 2013, three heat waves were reported to Vienna's health authority (Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2013). Data for the previous years show three heat waves for 2012 (Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2012), two for 2011 (Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2011), and three for 2010 (Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2010). The period 2006-2009 shows comparable numbers of 1-3 heat waves per year (Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2009; Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2008; Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2007; Gesundheitsdienst der Stadt Wien (Magistratsabteilung 15), 2006).

5.2.5 Droughts (water scarcity)

1 (more than once per year)	2 (once per year)	3 (once every 5 years)	4 (less than every 5 years)	5 (no droughts)	Rating
					4

Periods of 10 to 14 consecutive days without rainfall have gradually increased over the past 50 years – from around 3 per year for the period of 1954-1963, to almost 7 per year for the period 1994-2003 (Auer et al., 2005: 24). Severe droughts of 35-39 days only occurred once every 20 years since 1951, while droughts of 40-44 days only occurred once since 1951, and droughts longer than 45 days did not occur at all (Auer et al., 2005: 24).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

5.2.1	5.2.2	5.2.3	5.2.4	5.2.5
3	**4**	**1**	**5**	**2**

5.3 Vulnerability of Ecosystem Services

5.3.1 Quality of urban biodiversity (e.g., rich variety of flora and fauna, low number of endangered species → good/desirable)

1 (very poor)	2 (poor)	3 (moderate)	4 (good)	5 (very good)	Rating
					5

Vienna has a rich biodiversity (Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2012: 37; Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2013). However, an increase in population and related extension of city boundaries put pressure on the ecosystem. To protect its biodiversity, 35, 4% of Vienna's total area are nature protection zones (14.699 ha) (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 16). Additionally, different regulations require the protection of endangered species (Wiener Naturschutzverordnung (Wr. NschVO), 2000). Protection programmes, such as the *Vertragsnaturschutzprogramm* or the programme *Netzwerk Natur* help to implement nature protection laws and therefore vastly contribute to reaching Vienna's goals in terms of protection of biodiversity (Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2014a; Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2012: 37; Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2013: 26-34).

5.3.2 Urban soil quality – degraded land, derelict land (industrial contamination)

1 (very poor)	2 (poor)	3 (moderate)	4 (good)	5 (very good)	Rating
					4

A study published in cooperation with the European Union Regional Development Fund shows that in 2007, 66,7% of Vienna's soil have high quality, while 25,8% have medium, and only 7,5% have low quality (Siebielec et al., 2010: 25). However, a negative trend can be observed as new surface sealing took place mostly on the high quality soils between 1991 and 2007 (Siebielec et al., 2010: 23-25). However, there are also efforts to increase the soil quality in the long run (Europäische Angelegenheiten (Magistratsabteilung 27), 2014a).

5.3.3 Urban air quality during the day – problems of urban heat (island effect)

1 (very poor)	2 (poor)	3 (moderate)	4 (good)	5 (very good)	Rating
					4

In 2012, most air quality standards were fulfilled according to measurements at Vienna's measurements stations (Augustyn et al., 2013). For SO_2, CO, and $PM_{2,5}$, no exceedances of limit or target values were reported at any measurement station PM_{10} showed no exceedances of annual limit values, but some exceedances of daily limit values. For NO_2, there were no exceedances of the 30-min limit value, but some exceedances of the annual limit and target values. Ozone warning levels were not exceeded, and critical values were only exceeded on one day. (Augustyn et al., 2013: 2-4) Summarising, it can be said that air quality in Vienna can be rated as good (Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2012: 7-11).

5.3.4 Urban water quality in lakes, rivers, etc. (e.g., contaminated water)

1 (very poor)	2 (poor)	3 (moderate)	4 (good)	5 (very good)	Rating
					5

The EU directive 2000/60/EG establishes a framework for Community action in the field of water policy and thereby regulates the status of European water bodies by defining quality standards for different water types of water bodies and by requiring monitoring and reporting for all water bodies (RICHTLINIE 2000/60/EG DES EUROPÄISCHEN PARLAMENTS UND DES RATES vom 23. Oktober 2000 zur Schaffung eines Ordnungsrahmens fü r Maßnahmen der Gemeinschaft im Bereich der Wasserpolitik (ABl. L 327 vom 22.12.2000, S. 1), 2000). Additionally to setting limits for specific pollutants, the directive prohibits the deterioration of water quality for all water bodies, and provides for public participation for implementation of the directive (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014c). The directive was implemented into Austrian law in 2003 (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014c). Data provided by the online database *WISA* (*Water Information System Austria*) of the *Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)* shows that more than 80% of Vienna's water bodies have "very good" quality, while the rest has "good" quality (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014b; Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2012)

5.3.5 Level of urban salinity (e.g. high water table → high risk)

1 (very poor)	2 (poor)	3 (moderate)	4 (good)	5 (very good)	Rating
					4

Fertilisation and winter salting are among the main influences of increased soil salinity in urban areas (Unterköfler et al., 2009). Introduction of salts through precipitation in Vienna shows a more or less constant trend for the years 1990-2003 (Lederer and Puxbaum, 2003). Furthermore, a study published in cooperation with the European Union Regional Development Fund shows that in 2007, 66,7% of Vienna's soil have high quality, while 25,8% have medium, and only 7,5% have low quality (Siebielec et al., 2010: 25).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

5.3.1	5.3.2	5.3.3	5.3.4	5.3.5
3	**2**	**5**	**4**	**1**

5.4 Land-use in Natural Terms

5.4.1 Extent of city area vulnerable to climate-related hazards

1 (100-76%)	2 (75-51%)	3 (50-26%)	4 (25-1%)	5 (0%)	Rating
					4

Data provided by the online database *HORA – Natural Hazards and Overview & Risk Assessment Austria* shows that 7.581 addresses lie below flood water logging of the Danube (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014a), which are 4,6% of Vienna's total buildings (STATISTIK AUSTRIA, 2013h). The total area vulnerable towards flooding is probably higher, as the size of the buildings and the area taken by roads need to be included. However, the database shows data for a worst-case scenario, meaning that existent flood control is not taken into account (or that it won't be sufficient in times of flooding). In reality, it can be seen that Vienna's flood control is very effective (Bundesministerium für Land- und Forstwirtschaft, Umwelt und

Wasserwirtschaft (BMLFUW), 2009: 35), as the severe 2013 flood did not cause significant damage (ZAMG, 2014a; APA/red (derStandard.at), 2013). As far as heatwaves are concerned, it can be said that around 20% of Vienna's total area have a high building density and are therefore more likely to act as heat islands (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005: 181). However, at the same time, densely built-up areas are less vulnerable towards storms since each individual building is less exposed.

5.4.2 Intensity of land-use – urban morphology (level of urbanization; extent of urbanized areas)

1 (very high)	2 (high)	3 (moderate)	4 (limited)	5 (low)	Rating
					4

Vienna's total area is 41.487,1 ha, 49,8% of which are built (buildings and roads) (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 15). The rests consists of green space (45,6%) and water bodies (4,6%) (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 15).

5.4.3 Settlements located on hazardous ground (e.g. steep slope, flood prone areas) – vulnerable exposure

1 (majority)	2 (numerous)	3 (few)	4 (negligible)	5 (none)	Rating
					4

Data provided by the online database *HORA – Natural Hazards and Overview & Risk Assessment Austria* shows that 7.581 addresses lie below flood water logging of the Danube (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014a), which are 4,6% of Vienna's total buildings (STATISTIK AUSTRIA, 2013h). However, the database shows data for a worst-case scenario, meaning that existent flood control is not taken into account (or that it won't be sufficient in times of flooding). In reality, it can be seen that Vienna's flood control is very effective (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2009: 35), as the severe 2013 flood did not cause significant damage (ZAMG, 2014a; APA/red (derStandard.at), 2013). As far as heatwaves are concerned, it can be said that around 20% of Vienna's total area have a high building density and are therefore more likely to act as heat islands (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005: 181). However, at the same time, densely built-up areas are less vulnerable towards storms since each individual building is less exposed.

5.4.4 Percentage of total area that is urban green space (parks, trees, forests, etc.)

1 (less than 1%)	2 (2-5%)	3 (6-10%)	4 (11-15%)	5 (more than 16%)	Rating
					5

45,6% of Vienna's total area are urban green space and nature protection zones (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 15-16).

5.4.5 Loss of urban green space (parks, trees, forests) due to development of infrastructure, housing, etc. over the last 50 years

1 (very severe)	2 (severe)	3 (moderate)	4 (negligible)	5 (no loss)	Rating
					5

Vienna's green spaces (including water bodies) show no significant changes over the last 25 years and have stayed in the dimension of around 50% of Vienna's total area. Although population density is still increasing, this positive trend can be attributed to efforts in terms of increased cultivation, and the purchase of new green spaces, which were integrated into the city (Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2008; Pillmann and Wieshofer, 2007).

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

5.4.1	5.4.2	5.4.3	5.4.4	5.4.5
5	**1**	**4**	**2**	**3**

5.5 Environmental Policies and Food Security

5.5.1 Compliance rate to environmental policies

1 (no compl./ no policies)	2 (poor: 1-25% compl.)	3 (limited: 26-50% compl.)	4 (moderate: 51-75% com.)	5 (good: 75-100% compl.)	Rating
					5

According to recent enquiries, Vienna's compliance with laws concerning the separation of wastes (Wiener Abfallwirtschaftsgesetz (Wr. AWG), 2013: §11) is generally high – over 85% of the population separate paper, glass, and hazardous wastes, while 76% additionally separate plastics, and 67% also separate metals (STATISTIK AUSTRIA, 2009: 87-92; STATISTIK AUSTRIA, 2013i). With regards to emission limits, the compliance rate is probably even higher. This is, for example, because cars, not complying with emission standards, will not be licensed in the first place (Kraftfahrgesetz 1967 (KFG. 1967), 1967; Kraftfahrgesetz-Durchführungsverordnung 1967 (KDV. 1967), 1967), and heating systems are subject to periodical controls by the authority (Technische Gewerbeangelegenheiten (Magistratsabteilung 36), 2014).

5.5.2 Existence and sufficiency of environmental preservation policies

1 (no existing policies)	2 (poor)	3 (limited)	4 (moderate)	5 (fully sufficient)	Rating
					5

To protect Vienna's rich cultural heritage, 120 protection zones for buildings, ensembles, and built objects (i.e. fountains, etc.) were established, covering around 13.500 buildings (9% of Vienna's total built environment) (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005: 61-63). Furthermore, Vienna's inner city and the castle *Schönbrunn* (as well as a few other, smaller sites) are protected as UNESCO World Heritage Sites (Stadtentwicklung und Stadtplanung (Magistratsabteilung 18), 2005: 178-179). Additionally, 35,4% of Vienna's total area (14.699,0 ha) are nature protection zones (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 15-16), while 438 trees or tree ensembles are under protection as natural monuments (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013b: 17).

5.5.3 Existence and efficiency of waste management system (Reduce, Reuse, Recycle)

1 (no existing system)	2 (poor)	3 (limited)	4 (moderate)	5 (fully efficient)	Rating
					5

According to Austrian law, waste management needs to be sustainable and fulfil three main goals: (1) Protection of men and the environment, (2) Resource conservation, (3) After-care-free waste management (Bundesgesetz über eine nachhaltige Abfallwirtschaft (Abfallwirtschaftsgesetz 2002 - AWG 2002), 2002: §1(1)). Furthermore, a management hierarchy is defined as follows: (1) prevention, (2) reuse, (3) recycling, (4) energy recovery, (5) disposal (Bundesgesetz über eine nachhaltige Abfallwirtschaft (Abfallwirtschaftsgesetz 2002 - AWG 2002), 2002: §1(2)). The Austrian law is fully implemented in Vienna's waste management law (Wiener Abfallwirtschaftsgesetz (Wr. AWG), 2013). Furthermore, there are regulations regarding the requirement of pre-treatment of waste before dumping (Deponieverordnung 2008 (DVO 2008), 2008). Eurostat data shows that collection of solid waste in Vienna was 100% for the years 2007-2010 (European Commission, 2014a). Of these, 51% were incinerated (579.830 tons), 22% were recycled (250.060 tons), 26,5% were treated at composting facilities (301.580 tons), and 0,5% were pre-treated and then landfilled (European Commission, 2014b), as required by Austrian regulation (Bundesgesetz über eine nachhaltige Abfallwirtschaft (Abfallwirtschaftsgesetz 2002 - AWG 2002), 2002: §1(2a)3.; Deponieverordnung 2008 (DVO 2008), 2008: §6).

5.5.4 Existence and sufficiency of mitigation policies to reduce air pollution (e.g., CO2), for example from traffic or household emissions

1 (no existing policies)	2 (poor)	3 (limited)	4 (moderate)	5 (fully sufficient)	Rating
					5

In 1999, Vienna adopted its First Climate Protection Programme (*Klimaschutzprogramm der Stadt Wien – KliP I*) covering the years 1999-2009. In December 2009, the second programme – Klip II – was adopted for the years 2010-2020. (Magistrat der Stadt Wien (MDKLI), 2009) The programme addresses greenhouse gas mitigation measures, as well as measures for adaptation to global climatic change (Magistrat der Stadt Wien (MDKLI), 2009). In 2011, the Austrian Climate Protection Law (*Klimaschutzgesetz*) was passed by the government, regulating the maximum amount of greenhouse gas emissions per sector (heating, energy generation, transport, industry, waste management, and agriculture) for the period 2013-2020 (Klimaschutzgesetz - KSG (BGBl. I Nr. 106/2011), 2011). Additionally, another Austrian law regulates threshold values and critical values for immissions of different air pollutants (i.e. Ozone, SO2, NO2, PM10, PM2.5) (Immissionsschutzgesetz (Luft, IG-L), 2010). To ensure air quality standards, emission sources (plants, vehicles, heating devices, etc.) are required to comply with emission limits, established by the respective laws (IG-L Maßnahmenkatalog 2005, 2005; Abgas- und Emissionsgrenzwertverordnung 2004, 2004; Wiener IPPC-Anlagengesetz 2013 (WIAG 2013), 2013).

5.5.5 City is supplied with food after a disaster (food availability is secured; city has sufficient supply)

1 (no food security)	2 (poor)	3 (limited)	4 (moderate)	5 (good)	Rating
					1

During the early Cold War, Vienna maintained food stocks to supply its population for up to 84 days (Schmidl, 2000). Today, Vienna's disaster management system is founded on three pillars: (1) Authorities (legislation and implementation), (2) Organisations for emergency response (on-site operations), and (3) Population (prevention measures and preparedness) (Hummer, 2013). While the city is required to provide the necessary means to execute disaster help operations (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §3(2)), it is the responsibility of private households to have enough supply of essentials to be prepared for a disaster. To this end, the city is required to distribute adequate information and training to its residents (Wiener Katastrophenhilfe- und Krisenmanagementgesetz (W-KKG), 2003: §8(1)). While the city is not required to maintain food stocks, shops are probably able to provide food to the population for a certain amount of time.

Weight factor

Please rank the variables between 1 and 5 (5 = most important, 1 = least important)

5.5.1	5.5.2	5.5.3	5.5.4	5.5.5
5	**3**	**4**	**1**	**2**

Weight factor "Natural Condition of the City"

At the end of this fifth part of questions would you please weigh each parameter by ranking them between 1 and 5 (5 = most important, 1 = least important)

Intensity/severity of Natural Hazards	Frequency of Natural Hazards	Vulnerability of Ecosystem Services	Land-use in Natural Terms	Environmental Policies and Food Security
3	**2**	**5**	**4**	**1**

5.2.2 CDRI Scores

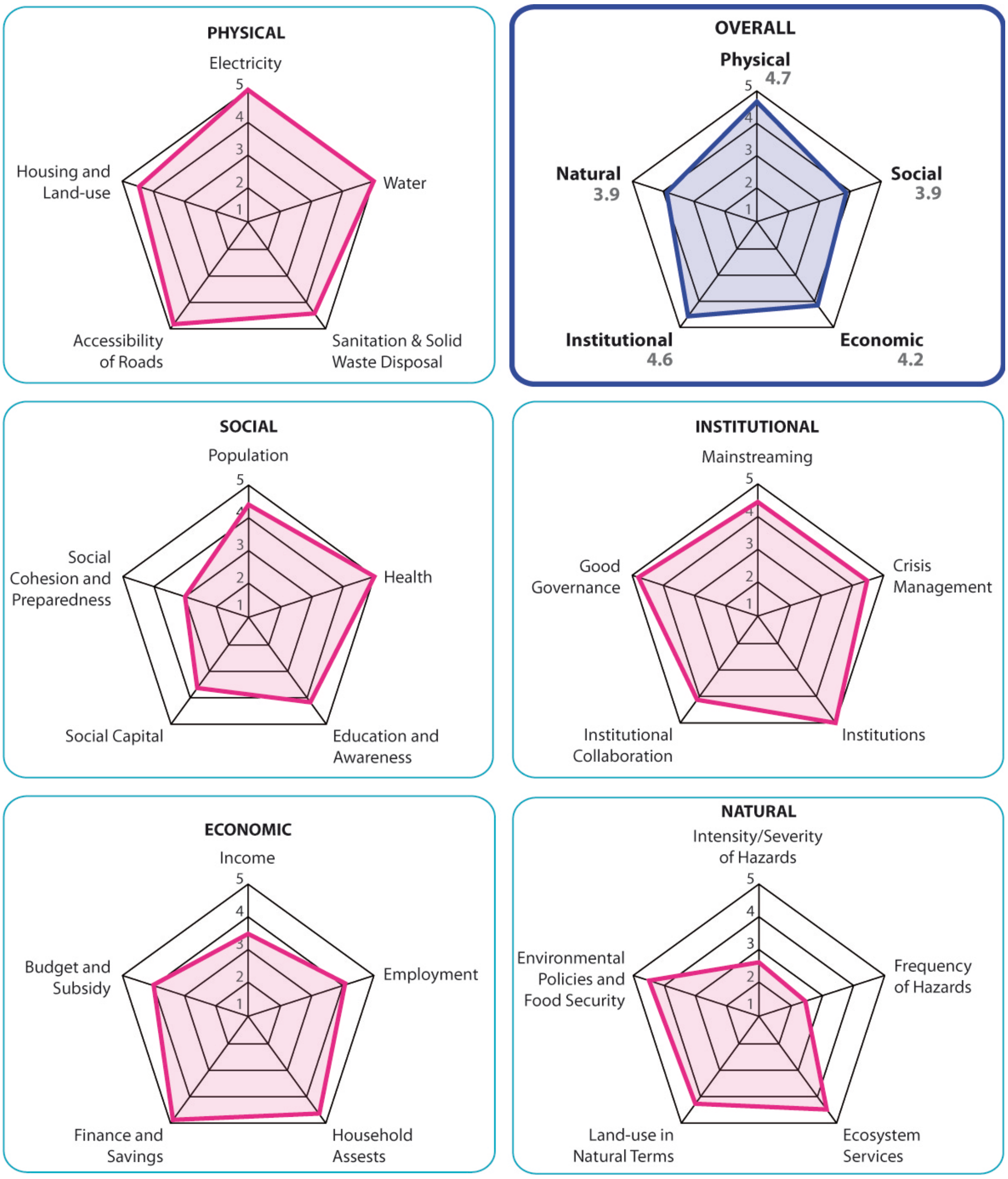

Fig. 5.9 Physical, Social, Economic, Institutional, and Natural Condition of the City & Overall CDRI Score (*Source*: author)

6 Summary and Conclusions

6.1 *Interpretation of the Findings*

It can be said that Vienna is generally well prepared for handling natural disasters. No score ranked below a value of 3, and only very few rank below 4. So while the level of resilience can be evaluated as high, the purpose of the CDRI is to reveal strengths and weaknesses. This is why I will focus on all scores ranked below 4,5, the scores that are lowest within their respective parameter, as well as areas where overall high scores could be achieved.

6.1.1 Physical Condition of the City (Utilities and Infrastructure)

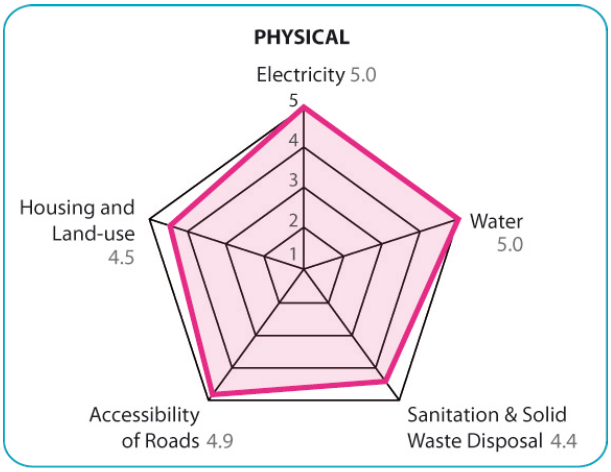

Fig. 6.1 CDRI Score Physical Condition (*Source*: author)

The physical infrastructure represents Vienna's strongest asset. It can clearly be seen that Vienna is well prepared, especially in the areas of electricity and water supply. This is, because drinking-water supply represents Vienna's oldest and most prestigious infrastructure and Vienna's residents and the local government are very proud of the city's high drinking water quality. The importance Vienna's residents place on their drinking water quality, as well as the water quality's contribution to Vienna's high ratings in international living standard indices, are two reasons why investments into this infrastructure has always been high in the past (Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2012).

The high scores in the electricity sector are less obvious. However, Austria's geographical position within the EU places the country in an important position regarding electricity transmission within Europe. This is why many projects have been developed and implemented within the recent decades to strengthen Austria's electricity grid.

Furthermore, Vienna's Climate Protection Programmes (KliP I&II) stress the importance of renewable energy sources (RES) in the city's energy mix and lead to the development of many projects in this area, some of them with participation of the population (Energieplanung (Magistratsabteilung 20), 2012; Energieplanung (Magistratsabteilung 20), 2013; Österreichische Energieagentur – Austrian Energy Agency, 2012). RES are generally suitable to reduce dependencies on energy imports and strengthen a city's independent energy supply. However, with regards to Vienna, most of the electricity produced by RES are exported to neighbouring states, while the majority of the city's energy supply is secured by imported gas, mostly from Eastern Europe (Energieplanung (Magistratsabteilung 20), 2012; Energieplanung (Magistratsabteilung 20), 2013). It should be in the interest of future energy security to intensify development of RES, while reducing the dependency on fossil energy sources, which need to be imported from abroad. Also, experts warn that European cities are not aware of the threat of major blackouts and are generally not well prepared for such events (Systemic Foresight Institute, 2014). They state that upgrading of the old European transmission grids cannot keep pace with increasing demand for electricity. Therefore, risks for blackouts is increasing, while awareness of governments and the population is lacking behind. This could lead to a lack of preparedness for future events of this kind (Systemic Foresight Institute, 2014).

While Vienna is a role model regarding waste collection, separation, and treatment, it's recycling rate lacks behind the Austrian average (European Environmental Agency, 2013). According to a report by the European Environmental Agency, this is due to Vienna's highly advanced waste incineration plants, which are not included in the recycling statistic (European Environmental Agency, 2013). However, within the recent years, the city has initiated and implemented many project targeting the increase of public awareness towards recycling (Wiener Umweltschutzabteilung (Magistratsabteilung 22), 2012).

Summarising, it can be said that Vienna's general infrastructure is well managed and that the city is constantly trying to improve its condition. Future challenges will mainly be focussed on energy (and grid) security and the development of strategies to establish a more independent energy supply by the use of RES.

6.1.2 Social Condition of the City

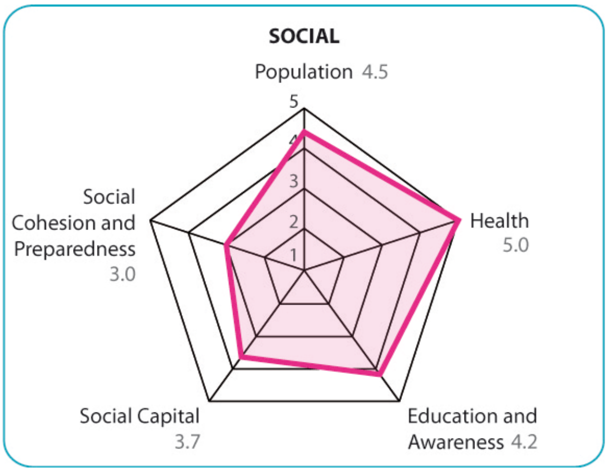

Fig. 6.2 CDRI Score Social Condition (*Source*: author)

Vienna has an excellent health system, providing free access to healthcare for all residents having social insurance (Bundesministerium für Gesundheit (BMG), 2013; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010), which are 99,9% of Vienna's residents (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 60, 158). Additionally, public and private institutions offer healthcare for people without medical insurance (Fonds Soziales Wien, 2011; Gesundheits- und Sozialplanung (Magistratsabteilung 24), 2010).

While the city shows one of its lowest scores when it comes to social cohesion and preparedness, this is mostly due to the fact that shelter after a disaster is provided by the city. The has not been any disaster in the recent past, which was so severe as that emergency shelters could not be provided by the authority and private households would have been needed to provide shelter to affected people. Therefore, it is hard to evaluate if Vienna's residents would generally not be willing to provide support. The same is true for the city's population participating in relief work after a disaster. As municipal institutions have so far been able to deal with disasters without the help of the population, it is hard to estimate their general willingness. However, participant numbers for *Team Österreich* show that Vienna's residents are not lacking behind in their efforts to engage in voluntary disaster help. Were they do have room for improvement is their preparedness towards disasters. While most households do have enough food, medication, and sanitary supply for up to a week (Versicherungsverband Österreich (VVO), 2013), this is mostly not connected to their intention to prepare for a disaster. It can rather be explained by the Austrians' general stockpiling attitude.

This lack of preparedness can be attributed to a general lack in awareness for the risks posed to the city. Most Austrian people do not feel at risk at all, not even those living in highly threatened areas (Versicherungsverband Österreich (VVO), 2013). This shows through the rather low score of the parameter Education and Awareness. Measures aimed at increasing the awareness of people towards natural hazards are apparently not effective and new strategies should be developed to increase the population's preparedness. This is also extremely important as Austria's disaster management concept is build on three pillars, one of them being the self-protection (*Selbstschutz*) or preparedness of the population (Hummer, 2013). Based on this concept, effective disaster management will not be possible if people are not aware of the risks. However, it should be avoided to spread fear among the population. Strategies could be in the form of including disaster preparation and information into school curricula, or by offering more information on the topic via the public media. Offering voluntary courses, trainings, and free material in disaster information centres, as it is currently done, is definitely a good thing, but will probably not lead to an increase in general awareness, as people will not make demand of these opportunities if they do not feel at risk. It will be necessary to actively transmit information to the population rather than passively providing information.

While a recent study shows that 27,9% of the Austrian population participate in clubs or other voluntary activities, it also states that engagement decreases with increasing population density. Consequently, Vienna has a much lower participation rate of only 14,3% (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009). This is quite important as participation in clubs and other social activity groups can be essential for the process of successful integration into the community (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009). The mixing of social classes and successful integration can play a large role in disaster management. This is because social cohesion proves important when it comes to the willingness to provide help. Segregated communities are therefore more prone to disasters than mixed communities with strong solidarity. Integration of residents with migration background will play a large role in this respect, as this group of the population is most economically vulnerable and threatened by segregation (Österreichischer Integrationsfonds (OIF), 2014). Successful integration programmes therefore also vastly contribute to a city's disaster resilience.

Summarizing it can be said that future challenges in this dimension will lie in the areas of awareness-building and increasing the preparedness of the population so as to strengthen the city's disaster management plan. Additionally, integration policy will also play a large role in the social and economic development of the city, and the solidarity in times of disaster.

6.1.3 Economic Condition of the City

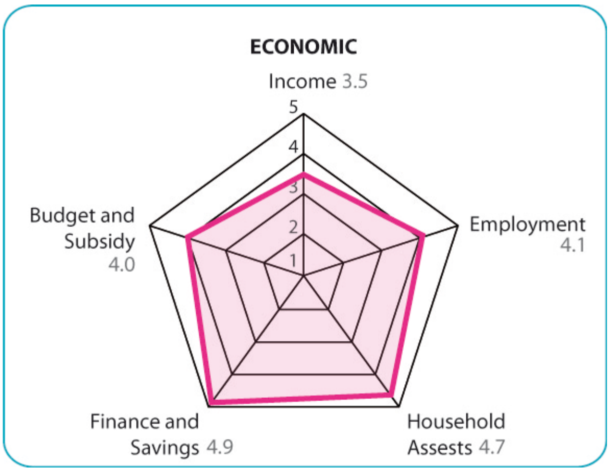

Fig. 6.3 CDRI Score Economic Condition (*Source*: author)

Vienna's score for the parameter Income is particularly low for two reasons. First, because the number of households depending on only one source of income is quite high. This is because the number of single-households in Vienna is very high compared to other Austrian cities and the average number of people per household is generally below two (STATISTIK AUSTRIA, 2014a). If incomes were high enough and security of employment was given, this would not generally be a problem. However, if jobs are not secure, those households depending on only one income source are particularly threatened as they cannot balance a loss of income. Second, 25% of Vienna's population lives below the poverty-line (STATISTIK AUSTRIA, 2013a). This means that even after receiving social benefits, those people are not able to maintain a certain standard of living and can therefore not actively participate in the community. While missing household assets, such as TV and internet, can be a risk during a disaster, as information cannot be transmitted to these households, a lack in savings will lead to further deprivation after a disaster if private property was damaged. Additionally, poverty can lead to social segregation, which also may become a problem in the aftermath of a disaster, as described in the previous section. While the income disparity between the lowest and highest 10% of income achieves a good score, there is a noticeable negative trend.

Strategies targeting the income problem will also need to include measures targeting youth unemployment. Austria shows the lowest unemployment rate within the EU (statista, 2013a). However, this is not true for youth unemployment. While Austria still ranks very low in terms of youth unemployment (statista, 2013b), there is a general trend towards increasing unemployment since the 2007 financial crisis, and Vienna is no exception (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2014d). Vienna, however, implemented first programmes to decrease youth unemployment, such as the *Wiener Ausbildungsgarantie*, which not only ensure education but also aim at decreasing youth unemployment, and could already present positive results in 2013 (SPÖ, 2013). Another problem in the sphere of employment is the surprisingly low percentage of women employed in the formal sector (48,8%) (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 64, 134). This again plays a role for the number of income sources per household and therefore represents a possible risk factor threatening a city's resilience. Reasons for this are, on the one hand, family policies, and on the other hand, integration policies, as women with migration background show a much lower employment rate than Austrian citizens (STATISTIK AUSTRIA, 2012).

With regards to budget and subsidy, it is not quite clear why the percentage of the city's annual budget targeting disaster risk management is actually important. Much more important should be the question whether the allocated budget is sufficient. However, it is difficult to find data on this issue, as probably all city resorts would gladly accept more money, if they had the choice. Also, while the money available at the moment might be sufficient for the current risk potential, an increase in the likelihood for natural disasters might increase the need for additional budget in the future. However, if the development of the city's budgets over the last 10 years is taken into account, a general willingness to allocate more money to disaster reduction can be seen (Finanzwesen (Magistratsabteilung 5), 2008; Finanzwesen (Magistratsabteilung 5), 2010; Finanzwesen (Magistratsabteilung 5), 2012; Finanzwesen (Magistratsabteilung 5), 2013).

Summarising it can be said that fighting the increasing poverty will be a big challenge in the future of the city, so as to prevent segregation and ensure social cohesion in times of disaster. For reasons stated above, the two areas that will need special focus are youth unemployment and the employment rate of women.

6.1.4 Institutional Condition of the City

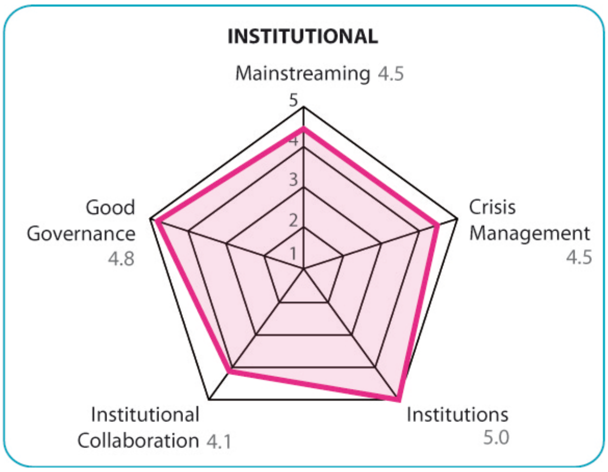

Fig. 6.4 CDRI Score Institutional Condition (*Source*: author)

The dimension of Institutional Condition shows the second highest overall score. This is probably due to the fact that Austria has a long history of bureaucracy. While bureaucratic controls sometimes inhibit economic growth, they can be very effective in the areas of environmental protection or disaster risk reduction, whose effectiveness depend on the compliance with laws and their exact execution following a hierarchic structure. The lower score for the parameter Institutional Collaboration with other Organisations and Stakeholders can again be explained through the disaster management system in Austria. According to the principle of subsidiary, the three pillars: (1) Authorities (legislation and implementation), (2) Organisations for emergency response (on-site operations), and (3) Population (prevention measures and preparedness) (Hummer, 2013), necessitate an intensive cooperation between municipal institutions and NGOs in times of disaster. Therefore, city's do not aim at becoming independent from the help of private organisations, which is why the score in this area is low. Also, according to Austrian law, the federal states are responsible for disaster management within their boundaries, which is why collaboration with the national government is limited to transregional or transnational disasters. This does not mean, however, that this system has less potential to be resilient as long as collaboration is not generally excluded. Furthermore, national coordination is mostly not needed as Vienna has strong direct collaboration with is surrounding municipalities (and even with cities abroad, such as Bratislava) in the area of disaster management. The concept of involving NGOs also makes regional cooperation easier, as NGOs are mostly organised in associations (*Landesverbände*) connected via a state secretariat, which makes coordination across municipal borders easier.

The incorporation of climate change adaptation into city policies is generally well under way. However, as climate scenarios on a local level still have high uncertainties, this will mainly be an area of future development. These uncertainties are the main reason why climate change scenarios are not yet incorporated into the city's disaster management plan. This should not, however, be a reason not to include climate change adaptation into the school education curriculum. While at the moment, school material on the issue is still limited, this problem has already been identified by the *Austrian Strategy for Adaptation to Climate Change* and has been made a priority for short- and medium-term action (BMLFUW, 2012b: 167, 221, 297).

Summarising it can be said that Vienna's institutional basis is already well-developed and further capacity building needs only be given low priority. Also, the Austrian system of DRR works differently than in other places in the world, which is why the questions of the CDRI might not be applicable in some places or the scores might not have high significance.

6.1.5 Natural Condition of the City

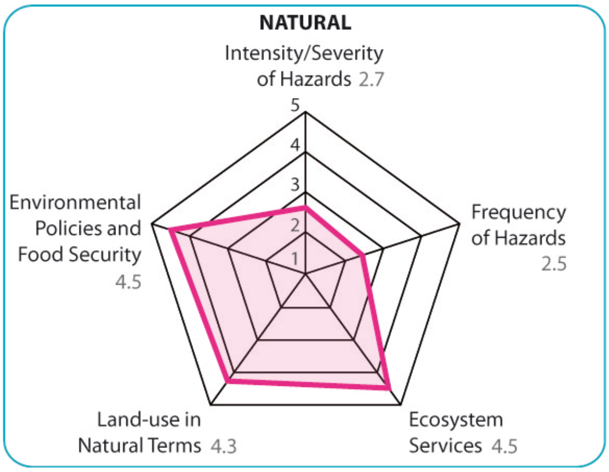

Fig. 6.5 CDRI Score Natural Condition (*Source*: author)

As can clearly be seen by the low score, the year 2013 was quite unique as to the occurrence and intensity of natural hazards. While in June, Vienna experienced a flood of higher magnitude than any historical record, in July and August it had to face a heat wave and accompanying drought that threatened the health of its more vulnerable inhabitants and caused great damage to agriculture. Thanks to the city's very effective flood control system, however, damage to the city was negligible. This flood control system also makes lower scores in the area of land-use less significant. Because even while a certain percentage of houses are built on potentially flood-prone areas, in reality all flood control systems would need to fail for those houses to be actually flooded.

However, as can be seen by the extremely low score for the frequency of natural hazards, the 2013 events might not be an exception in the future. The score would probably be even lower if the category "rainfall induced landslides" (which seldom occur in Vienna) was replaced by the category "earthquakes", as Vienna is situated in a geographical area with quite significant risk for smaller earthquakes (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014a). This low score only proved that proper DRR policies need to be implemented and strategies for future improvements need to be developed. Especially in the area of food security it is not clear how Vienna would manage a large-scale disaster, affecting also its surrounding regions or neighbouring countries.

With regards to environmental protection, Vienna seems to be going into the right direction, as many laws and programmes are already in force. Especially Vienna's large amount of protected green space should be highlighted in this regard. Intensively urbanised cities are very vulnerable towards heat waves, as the large mass of concrete will act as a so-called "heat island". Green spaces have a significant cooling effect, which is why the protection of green space should have high priority for all cities. However, protection of large areas within the city boundaries also has the effect that built areas are becoming increasingly densely populated, which again has a negative impact on the heat-island effect. On the other hand, densely built areas are less prone to damage from storms than openly exposed structures. However, even with protection of green space, heat waves will be a major challenge for future city planning. This is because the majority of buildings in Vienna (including all hospitals) do not have installed air condition. As heat waves lasting for not more than 3 weeks per year do not constitute a significant argument for installation of permanent air condition into all new buildings, retrofitting old buildings with mobile air condition systems will significantly increase the energy demand of the city. It will therefore be necessary to develop passive cooling systems, such as green roofs and facades, so as to allow for cooling while not significantly increasing construction costs. Ideally, these new concepts will be applicable also for already existing buildings.

Summarising it can be said that while Vienna has experienced two severe floods within the last ten years, the city's flood control is well equipped to withstand floods with even historical magnitude without suffering major damage. A larger future risk will be severe and frequent heat waves, as the city's buildings and infrastructure is not (yet) prepared to face them without difficulty.

6.1.6 CDRI at Microlevel

It needs to be pointed out that all CDRI scores mentioned in this thesis represent results for the city as a whole. However, as Gulsan et al. rightly emphasise that "[a] city, especially a large one, covers a substantial and often physiographically heterogeneous area with different exposures and susceptibility to hazards. Furthermore, a city's population and the conditions under which it lives are diverse (Gulsan et al., 2011: 103)." Therefore, DRR will be most effective if a resilience assessment is also done at a city's microlevel, showing specific hot spots within the overall city area. This will also contribute to understand the actual complexity of an urban system. While research on microlevel assessment is still at its very beginning (Gulsan et al., 2011), a study by Gulsan et al. – applying the CDRI at microlevel for three different cities in Asia – has shown that it proves very useful to "[…] recognize the priority sectors and needs of a specific area (Gulsan et al., 2011: 125)".

The structure of the CDRI provides for it to be used not only on national or city level, but also for microlevel assessment (Gulsan et al., 2011; Joerin and Shaw, 2011). This is, because institutional conditions are a separate dimension and the according questions can easily be adapted to better represent the political framework on district level. The authors of the index state that "[…] the CDRI questionnaires at microlevel are more tailored to the specific administrative conditions where the policy framework is already given (Joerin and Shaw, 2011: 58)." Also, as the CDRI questions are meant to be answered by experts and officials at the respective level of observance, microlevel assessment will probably lead to more accurate "best answers" for qualitative questions, as experts and officials operating on microlevel are more directly involved in the urban development process and have closer contact to local communities. However, Gulsan et al. point out that "[n]onavailability of data at the microlevel often posed a serious problem in all the cities (Gulsan et al., 2011: 125)." Even at city level, data availability often is a limiting factor, as will be explained in the next section. However, at microlevel, this problem becomes increasingly profound, as many data is not collected on district level.

Looking at the CDRI scores for Vienna, it can be assumed that the physical dimension would most likely show similar results, even when assessed on microlevel. This is, because infrastructure is evenly distributed over the total area of the city. For the institutional dimension, it can be said that disaster management is regulated on city level, which would also lead to the assumption of a similar score. However, as mentioned above, institutional questions would be different for microlevel assessment. Therefore, as the questionnaire for microlevel assessement was not available to the author, no well-founded statement can be given about possible results for this dimension.

While the economic dimension will probably show similar results for the parameters household assets, financing, and subsidies, results for income and employment would most likely show vast differenced between the different districts. For example, as already mentioned in the questionnaire and the previous sections, in Vienna's 15th district, the average gross income per year was 23.053 EUR in 2012, which accounted for only 76,8% of Vienna's average annual gross income of 30.007 EUR, while residents of the 1st district earned 53.601 EUR, or 166,7% of Vienna's average (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 147; Österreichischer Integrationsfonds (OIF), 2014: 47). Also, as the 15th district shows a very high number of resident with migration background (Österreichischer Integrationsfonds (OIF), 2014), employment of women will show a lower percentage than Vienna's average, as women with migration background show a much lower employment rate than Austrian citizens (STATISTIK AUSTRIA, 2012). This then again plays a role for the score in the number of income sources per household. Furthermore, a report of the Austrian Integration Fund shows that people with migration background are at a higher risk for being unemployed (Österreichischer Integrationsfonds (OIF), 2014: 47).

The social dimension will likely show similar results for the parameters health, education and awareness, and social cohesion and awareness. However, population will probably show different results on microlevel, as population growth varies between the districts (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 72). Especially districts with a higher percentage of people with migration background, as well as the districts on the north side of the Danube, show a higher annual population growth (Wirtschaft, Arbeit und Statistik (Magistratsabteilung 23), 2013a: 72). Also, the microlevel score for the parameter social capital will probably differ from the city level score. For example, as already explained in previous sections, this is because people from a lower social class tend to engage in informal activities rather than formal activities, such as clubs. (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 142-147) While an almost equal number of all social classes (and education levels) participate in informal community activities (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 68-69), formal clubs and activities are more dominated by people with higher education and/or social classes (Institut für interdisziplinäre Nonprofit Forschung an der

Wirtschaftsuniversität Wien (NPO-Institut), 2009: 59-60). This means that districts with lower income or higher unemployment levels would probably show different scores than those with higher levels.

For several reasons, the natural dimension will most likely show very different results when assessed on microlevel. First, all districts show a different vulnerability for natural hazards. While areas along the Danube and in the low-lying 11th district are more prone to flooding (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2014a), areas in the densely built inner districts show higher vulnerability for heat waves (Kromp-Kolb, 2006: 20-23). While ecosystem services seem to be quite stable throughout the city, land-use characteristics (density, green space, etc.) vary greatly between the districts and will therefore also show very different results.

Summarising, it can be said that assessments at the microlevel will further increase the resolution of the results and will give a deeper insight into the complex problems of a city. This will therefore help to implement DRR policies more effectively. However, as applying the CDRI on microlevel would need an assessment of 125 variables for all 23 of Vienna's districts, giving detailed statements on this level is out of the scope of this thesis.

6.1.7 Comparison of CDRI Scores

While comparability of CDRI scores between cities is not the main goal of the index (Joerin and Shaw, 2011), comparison might still help to reveal areas of common problems and initiate cooperation between cities to target those problems. Table 6.1 shows the results of a CDRI study, conducted in 36 cities from eight countries in Asia. Interestingly, it can be seen that 89% of the cities score their highest results in either the physical or institutional dimension. This is also the case for Vienna. Consequently, it can be assumed that establishing basic infrastructure is the least problematic goal to achieve in the sphere of disaster risk reduction. Also, it seems as if the institutional basis is established in most cities, showing that capacity building programmes have proven effectively. Looking at the dimensions receiving the lowest results, it can be seen that the majority of cities (64%) score lowest for their economic conditions. The natural condition seems to be the second most problematic area, with 31% of the cities having their lowest score in this dimension. While Vienna shows a similar low result for the natural dimension, its second lowest score is in the social dimension. Within all 36 cities in Asia, only one city – Bhubaneshwar in India – has its lowest score in the social dimension. Also interestingly, 39% of the Asian cities have a social score, which is higher than that of Vienna, while 14%

show a similar score, and only 47% show a lower score. However, it must be noted that those cities showing a lower social score than Vienna have a much lower overall score. While their social score is often above their overall CDRI result, Vienna's social score of 3,9 is below its overall score of 4,26.

Table 6.1 CDRI scores for 36 cities in Asia. (Shaw and Sharma, 2011b: 285)

Ranking	City Name	Country	Overall CDRI	Physical	Social	Economic	Institutional	Natural
1	Mandaluyong	Philippines	4.27	4.81	4.54	3.45	4.99	3.56
2	Navotas	Philippines	4.01	4.22	4.39	2.31	4.88	4.26
3	Suwon	South Korea	4.01	4.88	3.87	3.50	4.06	3.75
4	Makati	Philippines	3.99	4.48	4.25	3.59	4.62	3.00
5	Pasig	Philippines	3.96	4.71	4.31	3.76	4.10	2.94
6	Muntinlupa	Philippines	3.92	4.36	4.03	3.00	4.77	3.44
7	Manila	Philippines	3.90	4.60	4.81	3.65	3.34	3.08
8	Parañaque	Philippines	3.87	4.24	4.03	3.45	4.44	3.20
9	Hue	Vietnam	3.87	4.35	4.18	3.04	4.31	3.45
10	Port Blair	India	3.86	3.64	4.16	3.08	4.64	3.80
11	Valenzuela	Philippines	3.83	4.25	3.76	3.68	4.63	2.83
12	Nagpur	India	3.79	4.32	4.22	2.76	3.88	3.76
13	Las Piñas	Philippines	3.78	4.42	4.02	3.07	3.88	3.50
14	Taguig	Philippines	3.77	4.12	4.24	2.91	4.76	2.82
15	Caloocan	Philippines	3.75	4.76	3.65	2.57	4.80	2.98
16	Quezon City	Philippines	3.71	4.64	3.92	3.46	3.54	2.99
17	Marikina	Philippines	3.65	4.54	3.85	3.09	3.58	3.17
18	Pasay	Philippines	3.61	4.10	3.88	2.91	4.28	2.90
19	Kuala Lumpur	Malaysia	3.57	4.38	3.60	3.16	3.26	3.44
20	Pateros	Philippines	3.54	4.30	3.94	2.77	3.68	3.02
21	San Juan	Philippines	3.51	4.00	3.64	3.21	3.76	2.96
22	Kolkata	India	3.43	4.16	3.68	2.42	3.48	3.40
23	Guwahati	India	3.35	3.68	3.52	2.44	3.04	4.07
24	Chennai	India	3.29	2.92	4.08	3.06	3.56	2.83
25	Kanpur	India	3.15	3.36	3.16	2.52	3.60	3.12
26	Delhi	India	3.14	3.84	3.08	2.44	2.84	3.52
27	Colombo	Sri Lanka	3.14	3.91	3.23	2.77	2.57	3.20
28	Jaipur	India	3.13	4.04	3.32	2.44	2.76	3.08
29	Malabon	Philippines	3.02	3.43	2.96	2.56	3.35	2.82
30	Bhubaneshwar	India	2.92	3.24	2.60	2.60	2.93	3.24
31	Aizawl	India	2.91	3.16	4.24	2.24	2.36	2.56
32	Varanasi	India	2.86	2.99	3.14	2.52	2.58	3.08
33	Sukabumi	Indonesia	2.79	2.51	2.96	2.05	3.46	2.96
34	Shimla	India	2.76	3.44	3.44	2.52	2.20	2.19
35	Amritsar	India	2.71	3.36	2.60	2.40	2.08	3.12
36	Dhaka	Bangladesh	2.35	2.90	2.56	1.64	2.15	2.51

Interpretation of this comparison is difficult. However, it seems as if highly developed Western cities, such as Vienna, face problems when it comes to integrating disaster management into their communities. Vienna's residents are used to public authorities handling disaster help and are mostly not aware of the fact that Austria's disaster management systems heavily relies on the integration of the population and the concept of self protection. The issue is further complicated by the fact that most residents are not aware of the risks posed to the city as the city's disaster management system prevented most damage from recent disasters. Social cohesion plays an important role in times of disaster and it is not clear at the moment, whether Vienna's residents would be willing and prepared to help.

6.2 General Problems Encountered in the Case Study

6.2.1 Data Availability

As Tanguay (2010) has already pointed out, data availability is a generally well-known problem when working with indices. He mentions that the constraints of availability and accessibility of data often "(…) dictate[ ] the use of less than maximally efficient indicators to capture sustainable development on the municipal scale (Tanguay et al., 2010: 413)." However, the CDRI aims at being a comprehensive index covering as many of a city's functions and features as possible, and therefore requires 125 variables to be rated. To this end, the authors suggest that the questionnaire should be completed by different departments of the local government "(…) either through secondary data for quantitative questions or through a well-thought perception (best answer) to provide response for qualitative questions and also for those quantitative questions for which no data is available (Joerin and Shaw, 2011: 54-55)." As the author of this thesis is neither a member of the local government, nor an expert in all of the areas covered by the index, "best answers" had to be based on intense literature research and data comparison, rather than experience and expertise. This might has lead to a different result than had the questionnaire been completed by the respective experts in the local authority.

Generally, it can be said that quantitative questions are generally easier to answer, given that the respective data is collected and available to the public. Data availability is generally higher for economic and population indicators, such as employment, income, household assets, age of the population, and literacy rates, which are collected by the national central statistical office. Environmental primary measurement data is also available, however, mostly in the areas of air and water quality/pollution. Environmental data in the areas of biodiversity and soil quality is mostly limited to secondary data in studies and reports.

For obvious reasons, answering qualitative questions is much harder to accomplish. Without the necessary experience and expertise, intensive literature research and data comparison is necessary to provide an appropriate answer. Moreover, the available literature often is restricted to press releases, newspaper articles, and published expert interviews. Secondary literature, such as studies on the issue, was available only in rare cases, such as, for example, the study on volunteering (Institut für interdisziplinäre Nonprofit Forschung an der Wirtschaftsuniversität Wien (NPO-Institut), 2009: 65) and the study on poverty in Vienna (Universität Wien - Arbeitsgemeinschaft für Interdisziplinäre Angewandte Sozialforschung (AIAS), 2006). This is especially a problem since the qualitative questions often seemed to have greater significance for the overall rating than the quantitative questions. For example, the quantitative question on the percentage of the city's annual budget targeting disaster risk management (question 3.5.1) seems less important than the related qualitative question on whether this budget is sufficient (question 3.5.2). However, this second question is clearly more difficult to answer for a non-expert than the first question.

Furthermore, in some cases availability of data was restricted by the fact that data was simply not collected. This often was the case for data on basic infrastructural, such as the percentage of people with legal access to electricity, drinking water, or sanitation. While these are issues, which might be still problematic in the developing world, a western country like Austria has long since established nationwide access to basic infrastructure and is therefore not longer collecting statistical data on the issue. In such cases, assumptions had to made using other data. For example, the amount of electronic devices in households indirectly also points to whether these households have access to electricity. This indirect data collection was further complicated by the fact that it often was not clear from the beginning, which indirect data is actually available and could be used in the particular case.

Summarising it can be said that while most of the data collected by public institutions is available to everybody, data collected for private or internal governmental studies is not generally available but depends on publication of the respective study or report. Also, while quantitative questions are in general easier to answer, qualitative questions often are more significant for the final result, which is why research on the issue should be done thoroughly.

6.2.2 CDRI Features

Apart from the general problem of data availability, also some problems related to the design of the index were encountered in the process of completing the questionnaire. These problems are mostly related to the formulation of the questions and the concept of weighting that needs to be applied after answering the questions.

6.2.2.1 Questions

While the 125 questions give a comprehensive overview of all important features and functions of a city, a general problem regarding the margins of the quantitative questions arises. It is not clear whether the numerical intervals allocated to the "best" or "worst" rating should represent a general standard for all regions in the world, or whether they represent standards for the Asian region, where the index was developed. It seems as if a different allocation of the intervals, according to the region, would give a more significant result with a higher resolution. For example, electricity outages in Europe are not in the range of many hours per day, but rather some hours per year. Therefore, all European countries would achieve the same score for this question, even if in reality there are local differences electricity availability. If CDRI results aimed at global comparability, this localisation would of course not make sense. However, according to the authors of the index, the CDRI aims at revealing strengths and weaknesses within a localised context (Joerin and Shaw, 2011), which is why regional customisation of the questions would increase the significance of the assessment.

A second problem regards varying definitions technical terms. For example, with regards to the recycling rate, there are different definitions available on EU level and country level – some of them including the recycling of organic waste and some not. This obviously leads to different results depending on the definition used by the person filling in the questionnaire. While this gives cities, which do not collect the respective data in great detail, the opportunity to still answer the question, a more precise definition of technical terms would allow for better comparability between cities.

6.2.2.2 Numerical vs. Qualitative Rating

The combination of numerical and qualitative questions seems to be a very effective way of getting a comprehensive picture of a city's overall resilience status. This is, because rating systems relying solely on quantitative questions often tend to oversimplify complex issues. Qualitative answers are often more suitable to identify connections between issues and highlight local characteristics. However, qualitative answers always add a subjective element to the result, as they depend on the person answering the question rather than simple statistical data. Numerical ratings, on the other hand, are very useful in "(…) summarizing and communicating assessment results to stakeholders (U.S. Indian Ocean Tsunami Warning System Program, 2007: 4-8)" and decision-makers, and facilitate comparison between cities. The CDRI therefore also translates qualitative questions into numerical results. This, of course, causes problems similar to the problems mentioned in the previous section. To ensure that qualitative answers are similarly translated into ratings by all cities, a guidance sheet is available (see Appendix V), which defines benchmarks and margins. Again, it can be argued whether these margins are suitable on a global level or whether they should be customised for regional conditions.

6.2.2.3 Weighting

While customisation of the questions is not (yet) available, the index provides another opportunity to make the results more significant in the localised context – weighting. By applying a certain weight to each variable, the local importance of each indicator can be highlighted. However, as mentioned in a previous chapter, this approach has encountered a lot of criticism, as it is usually a rather "(…) arbitrary process and no weighting structure can rationally justify the attribution of a given weight (e.g. greater weight) to a given indicator (Tanguay et al., 2010: 408)." Apart from the problem of subjectivity, it is not clear why the parameters also have to be weighted between each other. While the weighting of variables makes sense as some questions might not be significant for or not applicable to some cities, it is not clear why some parameter, or functions of a city, should be less important than others, even in a localised context. It rather seems that electricity, water, and waste disposal are equally important functions of a city, which should therefore be given equal weight. Also, the "comparing apples with oranges" problem will be encountered in the weighting process, as it is difficult to directly compare the parameters "health" and "water". Therefore, it might be a better idea to apply weighting only on the level of variables, while the final dimension score should be calculated by a standard mean value, giving every parameter the same weight.

Tanguay (2010) also points out that there is a clear "(…) tradeoff between consideration of specific factors for each city or municipality and the need to homogenize the indicators such that they allow a fairer comparison between municipal jurisdictions of the same stature (Tanguay et al., 2010: 411)." However, the CDRI was not developed primarily to compare status of different cities, but to reveal weaknesses and strengths in a particular local context and to support implementation of suitable local DRR measures.

6.3 Policy Implications of the Results in Relation to the HFA – Recommendations for future action planning

The aim of this thesis was to show whether urban resilience could be properly assessed. However, the eventual aim of a resilience assessment is to deliver important information on the current status of a city and to reveal hot spots, where future action is needed. By concentrating on the most vulnerably areas, DRR measures will become more effective and will contribute to increase a city's resilience towards disasters. While a comprehensive action plan would be out of the scope of this thesis, certain areas of possible action should be highlighted to give guidance for future research, planning, and policy-making. Following, tasks and/or tools will be given, to contribute towards the implementation of the five HFA priorities of action. To this end, the HFA-CDRI implementation matrix, as well as the tables for tasks and tools to implement the HFA at local level will be used (see Appendix IV). However, the tasks mentioned will in no way constitute a comprehensive action plan and further research on the topic will be necessary.

HFA-1 (Governance):

There is a need to evaluate, whether current DRR funding is sufficient to face the future increase in risks caused by Climate Change (Task 4). This is particularly necessary because Climate Change uncertainties are not yet incorporated into the city's disaster management plans (Steiner, 2014), and current funding therefore might not be adequate in the future. Incorporation of uncertainties should also gain higher priority to develop a strong institutional basis for DRR (Task 3). At the moment, no scientific research or experts are consulted in the development of the disaster management plans, which may lead to ill-founded decisions. A multistakeholder dialogue would contribute towards more effective disaster management plans and would facilitate the incorporation of Climate Change uncertainties. Furthermore, the Austrian Crisis and Disaster Management Strategy 2020 mentions the need to better include private companies and to establish public-private-partnerships, especially in the field of protection of critical infrastructure (Bundesministerium für Inneres (BM.I), 2009). As most critical infrastructures in the sphere of electricity are owned or operated by private, or semi-private companies, letting these stakeholders participate in the disaster management planning would certainly strengthen the physical dimension and contribute to the overall resilience of a city.

HFA-2 (Risk Assessment and Early Warning System):

An adequate early warning system exists. Dissemination of information during and after an event has experienced improvement over the last years. However, there are still difficulties, as can be seen with large countrywide disasters (Adam, 2006). Action planning should therefore aim at establishing a guidance and/or policy framework on how information should be distributed to the affected population during and after a disaster (Task 8). Furthermore, it is not clear how comprehensively risk-related data is collected at the moment. Development of a comprehensive disaster risk database should have high priority (Task 6). Also, availability of this data to the general public would widely contribute to the awareness of the population and to the development of land-use plans. The online database *HORA – Natural Hazards and Overview & Risk Assessment Austria* is a first step in this direction. However, the database should be extended to cover a greater variety of natural hazards. This data should then constitute the knowledge base for future spatial planning and disaster management planning.

HFA-3 (Knowledge Management):

As mentioned in earlier sections, risk awareness is one of the major problems of Vienna's disaster management system. This is, because people are mostly not well-prepared for disasters as their perception of risks is very low (Versicherungsverband Österreich (VVO), 2013). Measures aimed at increasing the awareness of people towards natural hazards are apparently not effective and new strategies should be developed to increase the population's preparedness. This is also extremely important as Austria's disaster management concept is built on three pillars, one of them being the self-protection (*Selbstschutz*) or preparedness of the population (Hummer, 2013). Based on this concept, effective disaster management will not be possible if people are not aware of the risks. Strategies could be in the form of incorporating disaster risk reduction into school curricula, or by offering more information on the topic via the public media (Task 9). Offering voluntary courses, trainings, and free material in disaster information centres, as it is currently done, is definitely eligible, but will probably not lead to an increase in general awareness, as people will not make demand of these opportunities if they do not feel at risk. It will be necessary to actively transmit information to the population rather than passively providing information.

HFA-4 (Vulnerability Reduction):

As social differences seem to be a critical issue in Vienna's overall resilience result, it will be of high priority to develop measures to decrease the vulnerability of low-income groups (Task 13). On the one hand, measures should aim at reducing social and economic differences, for example by guaranteeing education and create job opportunities. On the other hand, accompanying measures should aim at reducing the severity of disaster impacts for the highly vulnerable groups. This could be accomplished in the form of subsidies for adequate household insurances, especially for people living in hazardous areas. Ensuring disaster insurance will reduce the need for funding after a disaster and increasing preparedness will contribute towards the adaptive capacity and reducing the recovery time.

When looking at the incorporation of DRR into land-use plans (Task 14), focus should again lie on developing a comprehensive knowledge base of possible hazards. Especially temperature changes and heat waves should be integrated into urban planning policies, as current trends go in the direction of increased building density to avoid the loss of green space. While protection of urban green space should remain a priority to prevent a further increase in the heat island effect, the densely built areas are more vulnerable to heat waves (Kromp-Kolb, 2006: 20-23). Past building codes did not provide for cooling systems, which are adequate to face future temperatures and adapting buildings to rising temperatures would necessitate large investments (Ritz et al., 2007). Also, electric/artificial cooling systems require a high amount of energy and are generally too expensive to implement in all buildings, given that they will only be needed over a short time period each year. It should therefore be of high priority to develop guidance and standards on how to effectively incorporate natural cooling systems for buildings (such as, for example, green roofs, green facades, passive air circulation, concrete core cooling, etc.). After sufficient testing, these standards may be incorporated into building codes. Simultaneously, within flood prone areas, an assessment of all buildings built before 1930 (when Vienna's first modern building code went into force) should be conducted to see whether they adequately fulfil modern safety standards towards natural hazards (Task 15). A similar assessment should also be done for all critical infrastructures.

HFA-5 (Disaster Preparedness):

A disaster management plan exists (not including the uncertainties of Climate Change) and the city's emergency team is fully capable of handling disaster situations (leadership, readiness, alternative decision-making). Also the city is well interlinked with NGOs and private organisations during and after a disaster, as this is an integral part of Austria's disaster management system. Improvements could still be made regarding the cooperation with neighbouring cities in disaster management planning (Task 20), which is still only in the pilot phase. Also, cooperation in disaster trainings for emergency workers from the municipal institutions and private organisations should be given higher priority to strengthen disaster preparedness capacity (Task 19 & 20). Furthermore, concrete Climate Change disaster scenarios should be developed to make trainings more efficient.

6.4 Conclusion

In the face of a changing global climate and increased probability for natural disasters, it was the aim of this thesis to evaluate, whether resilience is a suitable concept for urban systems, why this concept is needed, and whether the resilience status of a city can be properly assessed. There is still no general consensus on how to transfer the meaning of resilience to the sphere of urban systems (Folke, 2006; Turner et al., 2003; Gallopin, 2006). Also, varying definitions and uses of the term in the academic literature make it difficult to compare the research done in this field. However, the increasing amount of research dealing with urban resilience points towards consensus regarding the question whether the concept per se is valuable to deal with the future development of cities. This is, because this concept is the first to acknowledge that cities are dynamic, socio-ecological systems rather than static systems staying around a certain equilibrium.

Since the late 1970s, the neoliberal agenda has shaped the structure and functioning of urban systems. Deregulation and the increasing pressure of globalisation have destroyed the system's self-regulating capacities and have led to high economic and social vulnerability. This can easily be seen in many financial and economic crises within the last years and their domino effect among cities around the world. (Eraydin, 2013) These vulnerabilities have called for a new model in urban planning, which aims at reducing these vulnerabilities by enhancing the adaptive capacity, self-organisation, and transformability of the urban system. Adaptive capacity, being the core of the new model, intends to make urban systems more capable in dealing with change, and sustain important ecosystem services in the face of internal and external disturbances.

While it is agreed upon that resilience is a suitable concept for future city-planning, there is no consensus yet on how to assess the resilience of a system. Many different approaches have been developed until today (U.S. Indian Ocean Tsunami Warning System Program, 2007; Asian Cities Climate Change Resilience Network (ACCCRN), 2009; Prasad et al., 2009; Normandin et al., 2009; Tanguay et al., 2010). However, most of them focus only on particular issues of the problem, such as the vulnerability of the system, or the procedural aspects on how to assess resilience. While all of these approaches give valuable insights into how resilience mapping could be accomplished, they are not able to give a comprehensive picture of the overall resilience status of a city. Under the initiative of the United Nations, the *International Strategy for Disaster Reduction (ISDR)* was established as the first platform to address disaster risk reduction on a global level. The *Hyogo Framework for Action*, a first policy guidance for DRR, subsequently increased the need for a comprehensive assessment tool for urban resilience and inspired the development of the *Climate Disaster Resilience Index (CDRI)*. The CDRI is the first approach which provides "(…) a comprehensive baseline assessment that addresses [the] linkages between various actors, aspects of the physical, economic, institutional, and natural components of a city or and urban area (Joerin and Shaw, 2011: 51)", and acts as "(…) a planning tool that has the objective to disclose sectors that are least resilient or not capable of responding adequately in the event of a climate-related disaster (Joerin and Shaw, 2011: 51)."

Application of the index in the case study revealed many aspects of urban systems, contributing towards resilience. Even if certain problems were encountered in the course of the assessment, most of them were general problems regarding the development of indices, rather than shortcomings of the CDRI itself. Results showed that while Vienna is generally well-equipped to handle disturbances, there are certain areas which need improvement. It can also be seen that many areas are connected and that problems need to be tackled comprehensively. The index therefore proves to be a valuable tool to reveal strengths and weaknesses of an urban systems and although it is still in its pilot phase, it may prove to be an extremely useful tool in implementing the HFA at the local level and in providing valuable guidance for future policy making.

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Appendix I

Resilience Benchmarks developed by USAID

(U.S. Indian Ocean Tsunami Warning System Program, 2007: 3-5, 3-6)

	Benchmarks			
Resilience Element	Policy and Planning Capacity	Physical and Natural Capacity	Social and Cultural Capacity	Technical and Financial Capacity
Governance	A1. Community development policies, plans, and programs are implemented and monitored in a participatory and transparent manner.	A2. Basic services (i.e. water, transportation, security, etc.) are accessible to all sectors of society.	A3. Participatory collaboration mechanisms among different sectors and various levels of government are established and used to manage for resilience.	A4. Technical and financial support mechanisms are transparent, accountable, and available to support planned community actions.
Society and Economy	B1. Development policies and plans build social capital and skills for economic diversity and self reliance.	B2. Local economies are characterized by diverse and environmentally sustainable livelihoods.	B3. Social and cultural networks promote self-reliant communities and have the capacity to provide support to disaster-stricken areas.	B4. Technical and financial resources are available to promote stable and robust economies, reduce vulnerability to hazards, and aid in disaster recovery.
Coastal Resource Management	C1. Policies and plans are implemented and monitored to effectively manage natural coastal resources.	C2. Sensitive coastal habitats, ecosystems, and natural features are protected and maintained to reduce risk from coastal hazards.	C3. Communities are actively engaged in planning and implementing coastal resource management activities.	C4. Communities and local governments value and invest in management and conservation to sustain their natural resources.
Land Use and Structural Design	D1. Land use policies and building standards that incorporate measures to reduce risks from hazards and protect sensitive habitats are established, monitored and enforced.	D2. Critical infrastructure are located outside high-risk areas and constructed to address risks from priority hazards.	D3. Developers and communities incorporate risk reduction into the location and design of structures.	D4. Education, outreach, and training programs are established to improve compliance with land use policies and building standards.
Risk Knowledge	E1. Coastal hazard risk assessments are completed at a scale appropriate to the community and routinely updated.	E2. Coastal hazard risk assessments are comprehensive and incorporate risks to all elements of resilience (e.g. livelihoods, coastal resources, land use, etc.).	E3. Community participates in the hazard risk assessment process.	E4. Information from risk assessment is accessible and utilized by the community and government.
Warning and Evacuation	F1. Community warning and evacuation systems, policies, plans, and procedures are in place and capable of alerting vulnerable populations in a timely manner.	F2. Community warning and evacuation infrastructure is in place and maintained.	F3. Community is prepared to respond to hazard warnings with appropriate actions.	F4. Technical and financial resources are available to maintain and improve warning and evacuation systems.
Emergency Response	G1. Predefined roles and responsibilities are established for immediate action at all levels.	G2. Basic emergency and relief services are available.	G3. Preparedness activities (drills and simulations) are ongoing to train and educate responders.	G4. Organizations and volunteers are in place with technical and financial resources to support emergency response activities.
Disaster Recovery	H1. Disaster recovery plan is pre-established that addresses economic, environmental, and social concerns of the community.	H2. Disaster recovery process is monitored, evaluated, and improved at periodic intervals.	H3. Coordination mechanisms at international, national, and local levels are pre-established for disaster recovery.	H4. Technical and financial resources are available to support the recovery process.

Appendix II

City Typology and Risk Characterization Matrix (Prasad et al., 2009: 44-49)

A. City description	
1. City location	
a. In a coastal area? (Y or N)	
b. On or near mountain area? (Y or N)	
c. On inland plain? (Y or N)	
d. On inland plateau? (Y or N)	
e. Near or on a river(s)? (Y or N)	
f. Near earthquake fault lines? (Y or N)	
B. Size characteristics of city	
1. Resident population (VH, H, M, or L)	
VH = Greater than 10 million	
H = 2 million to 10 million	
M = 0.5 million to 2 million	
L = up to 0.5 million	
2. Population growth during last 10 years (H, M, or L)	
H = Greater than 10%	
M = Between 2% to 10%	
L = Less than 2%	
3. Floating population (VH, H, M, or L)	
VH = Greater than 30% of resident population	
H = Between 20%–30% of resident population	
M = Between 10%–20% of resident population	
L = Less than 10% of resident population	
4. Area in square kilometers (km^2)	
5. Maximum population density (day or night) (H, M, or L)	
H = Greater than 2,000 persons per km^2	
M = Between 1,000 to 2000 persons per km^2	
L = Less than 1,000 persons per km^2	

C. Governance structure as related to disaster risk management	
1. Appointed head of government? (Y or N)	
a. Term of assignment? (Years)	
2. Elected head of government? (Y or N)	
a. Term of elected officials? (Years)	
3. Local government office structure: Does it have…	
a. Disaster risk management department? (Y or N)	
b. Environment, sustainability or climate change department? (Y or N)	
c. Are (a) and (b) in the same department? (Y or N)	
4. Other government office structure (state, national): Does it have…	
a. Disaster risk management department? (Y or N)	
b. Environment, sustainability, or climate change department? (Y or N)	
c. Are (a) and (b) in the same department? (Y or N)	
D. City management on climate change and disaster risk management	
1. Responsibilities clearly specified? (Y or N)	
2. Responsibility for climate change management established? (Y or N)	
3. Responsibility for disaster risk management established? (Y or N)	
4. Authority to contract for services? (Y or N)	

E. Financial resources	
1. Total budget	
2. From local taxes and levies (% of total)	
3. From state and national government grants & devolutions (%)	
4. From domestic market—bonds & loans (%)	
5. From international market (%)	
6. From external or multilateral lending agencies (%)	

F. Built environment	
1. Does the city have urban growth Master Plans? (Y or N)	
2. Does the city have urban development plans and land-use plans? (Y or N)	
a. Population in authorized development? (% of total)	
b. Population in informal colonies? (% of total)	
c. Population density of informal colonies? (H, M, or L)	
H = Population of informal colonies >20% of total	
M = Population of informal colonies <20% but >10% of total	
L = Population of informal colonies <10% of total	
d. Population in old tenements and historical development? (% of total or H, M, or L using ratings in 2c)	
3. Does the city have building codes? (Y or N)	
a. Level of compliance? (% compliant buildings)	
4. Observed vulnerability of buildings in past natural disasters (extent of disruption of building functionality)	
a. Informal buildings (H, M, or L)	
H = Greater than 15% of informal buildings highly vulnerable	
M = Between 5% and 15% of informal buildings highly vulnerable	
L = Less than 5% of informal buildings highly vulnerable	
b. Historic buildings (H, M, or L)	
c. New & formal developments (H, M, or L)	
H = Greater than 5% of new & formally developed buildings highly vulnerable	
M = Between 1% and 5% of new & formally developed buildings highly vulnerable	
L = Less than 1% of new & formally developed buildings highly vulnerable	

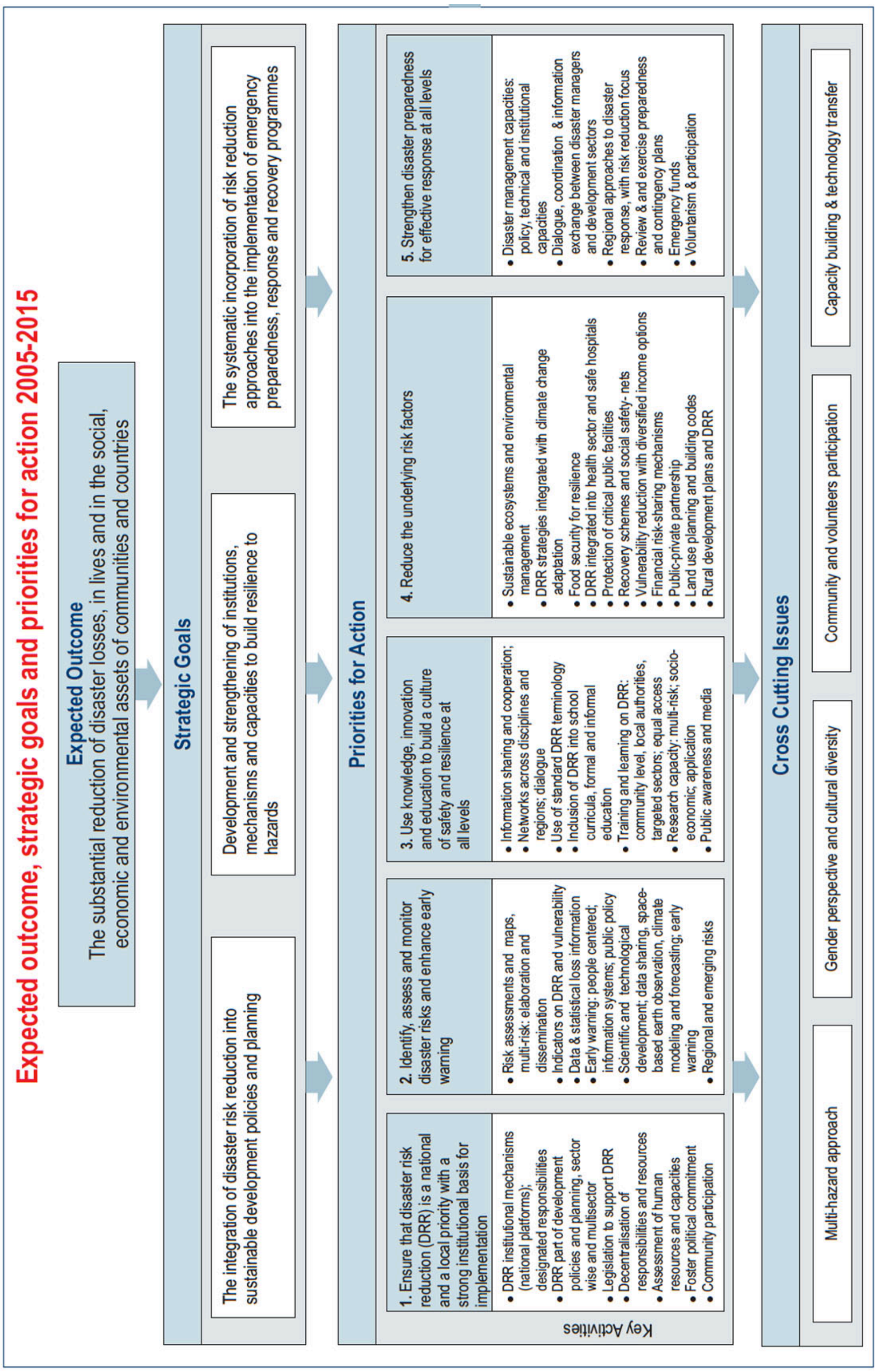
G. Political impact of disasters	
1. Is the city a national/provincial capital or where a large number of decision-makers live? (Y or N)	
2. Is impact of disaster in the city likely to influence political activity in areas far away from affected regions? (Y or N)	
H. Economic impact of disasters	
1. Is the city a major center of economic activity in regional or national context? (Y or N)	
2. Do the following sectors have major activity in the city?	
a. Industrial sector? (Y or N)	
b. Services sector? (Y or N)	
c. Financial sector? (Y or N)	
d. Tourism and hospitality sectors? (Y or N)	

I. Threat of natural hazards	
1. Earthquake? (Y or N)	
2. Wind storm? (Y or N)	
3. River flood? (Y or N)	
4. Flash rainwater flood or extreme precipitation? (Y or N)	
5. Tsunami? (Y or N)	
6. Drought? (Y or N)	
7. Volcano? (Y or N)	
8. Landslide? (Y or N)	
9. Storm surge? (Y or N)	
10. Extreme temperature? (Y or N)	
J. Disaster response system	
1. Does a disaster response system exist in the city? (Y or N)	
2. Is the response system comprehensive and equipped for all natural hazards specified? (Y or N)	
3. Is the disaster response system regularly practiced? (Y or N)	
4. Is the disaster response system regularly updated? (Y or N)	

K. Climate change impact	
1. Is the impact of climate change on the city known? (Y or N)	
2. Are the following sectors vulnerable to the consequences of climate change?	
a. Built environment? (Y or N)	
b. Cultural and religious heritage? (Y or N)	
c. Local business, industry, and economy? (Y or N)	
d. Energy generation and distribution system? (Y or N)	
e. Health-care facilities? (Y or N)	
f. Land use? (Y or N)	
g. Transportation system ? (Y or N)	
h. Parks and recreation areas? (Y or N)	
k. Tourism? (Y or N)	
3. Is climate change assessment based on local studies instead of regional/global models? (Y or N)	
4. Does the city have a climate change strategy (maybe as a component of national policy)? (Y or N)	
5. Does the city have climate change programs in place? (Y or N)	
6. If Yes, do the climate change programs consider:	
a. Mitigation? (Y or N)	
b. Adaptation? (Y or N)	
c. Resilience? (Y or N)	

Appendix III

Hyogo Framework for Action: strategic goals and priorities for action 2005-2015
(UNISDR, 2005: 1)



Appendix IV

20 Tasks Drawn from Five HFA Priorities to Be Implemented by Local Stakeholders
(Matsuoka and Shaw, 2011: 138)

Local/city governance (HFA Priority 1 related)

Task 1. Engage in multistakeholder dialogue to establish foundations for disaster risk reduction.

Task 2. Create or strengthen mechanisms for systematic coordination for DRR.

Task 3. Assess and develop the institutional basis for DRR.

Task 4. Prioritize disaster risk reduction and allocate appropriate resources.

Risk assessment and early warning (HFA Priory 2 related)

Task 5. Establish an initiative for community risk assessment to combine with country assessments.

Task 6. Review the availability of risk-related information and the capacities for data collection and use.

Task 7. Assess capacities and strengthen early warning systems

Task 8. Develop communication and dissemination mechanisms for disaster risk information and early warning.

Knowledge management (HFA Priority 3 related)

Task 9. Raise awareness of DRR and develop education program on DRR in schools and local communities.

Task 10. Develop or utilize DRR training for key sectors based on identified priorities.

Task 11. Enhance the compilation, dissemination, and use of DRR information.

Vulnerability reduction (HFA Priority 4 related)

Task 12. Environment: incorporate DRR in environmental management.

Task 13. Social needs: establish mechanisms for increasing resilience of the poor and the most vulnerable.

Task 14. Physical planning: establish measures to incorporate DRR in urban and land-use planning.

Task 15. Structure: strengthen mechanisms for improved building safety and protection of critical facilities.

Task 16. Economic development: stimulate DRR activities in production and service sectors.

Task 17. Financial/economic instruments: create opportunities for private sector involvement in DRR.

Task 18. Emergency and public safety; disaster recovery: develop a recovery planning process that incorporates DRR.

Disaster preparedness (HFA Priority 5 related)

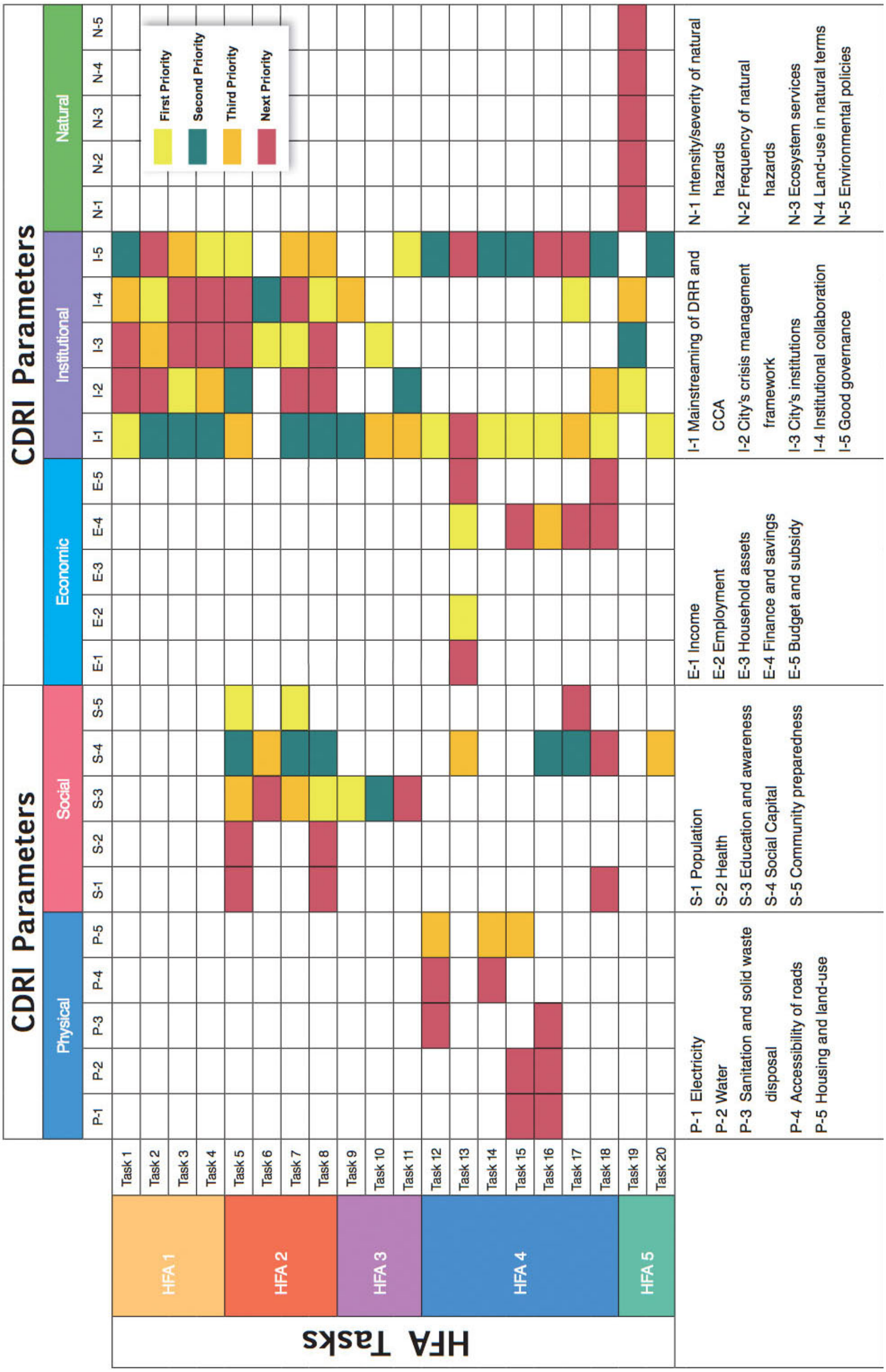
Task 19. Review disaster preparedness capacities and mechanisms, and develop a common understanding.

Task 20. Strengthen planning and programming for disaster preparedness.

Tools for Implementing HFA by Local Stakeholders (Matsuoka and Shaw, 2011: 139)

HFA Priority 1 – related tools
Focal point for disaster risk reduction
Multistakeholder dialogue
Disaster risk reduction framework and action plan
Stakeholder engagement/coordination mechanisms
HFA Priority 2 – related tools
Risk communication and dissemination mechanisms for disaster risk information
Early warning systems
Community risk assessment
Gap analysis (including risk-related information)
HFA Priority 3 – related tools
Disaster information system
Public disaster awareness raising program/strategy
Training programs and networks in support of DRR
HFA Priority 4 – related tools
Disaster recovery plan
Environmental impact assessment
Financial/economic instruments
Poverty reduction program/strategy
Promoting building safety and protection of critical facilities
Risk-sensitive urban and land-use planning
Sectoral subwork groups to stimulate DRR activities in production and service sectors
HFA Priority 5 – related tools
Disaster preparedness planning and programming
Capacity assessment of disaster preparedness and mechanisms

Example for a HFA-CDRI Linkage Matrix
(Climate and Disaster Resilience Initiative, 2010: 16-17)



Appendix V

Explanatory and Supplementary Notes for the CDRI Questionnaire

Physical Dimension

1.1.4 'most frequent disasters' → typhoons and floods in the case of Metro Manila

1.2.4 'most frequent disasters' → typhoons and floods in the case of Metro Manila

1.4.3 'normal flooding' → after intense rainfall, for instance, during monsoon period frequently occurring heavy rainfall (many times a month)

1.5.4 'ownership' → percentage of houses which belong to private person

Social Dimension

2.2.3 'most frequent disasters' → typhoons and floods in the case of Metro Manila

2.3.4 percentage of city's population have access to internet at home.

2.3.5 'most frequent disasters' → typhoons and floods in the case of Metro Manila

2.4.1 'community activities' → all activities (volunteering group, political group, religious activities, etc.) which are initiated by people from a particular community.

2.4.2 'club or social activity group' → sports club, music club/group/orchestra, etc.

2.4.3 Ability of residents to defend and support common interests

2.4.4 Availability or level of democracy in the city

2.5.3 'disaster' → typhoons, flooding, rainfall-induced landslides, etc.

2.5.4 'support' → to residents; 'disaster' → typhoons, flooding, rainfall-induced landslides, etc.

Economic Dimension

3.1.1 'poverty line' → as defined by the National Statistics Office

3.3.3 'motorized vehicle' → scooter, motorcycle, car, jeep, van, etc.

3.3.4 'non-motorized vehicle' → Bicycle, etc.

3.4.1 Availability and affordability of credits, loans, etc. for the purpose of disaster prevention for residents.

3.4.2 Availability and affordability of credits, loans, etc. for recovery and rehabilitation activities after a disaster* for urban poor or low-income groups.

3.4.3 Spending behavior of residents.

3.4.5 'catastrophe risk financing framework/instrument' → tool which covers (financial) the damages on all properties which are affected in city after a natural hazard has struck.

3.5.1 'disaster risk management' → includes all sectors/definitions related to this term: disaster management, disaster risk reduction, etc.

3.5.3 'Availability of subsidies/incentives for residents/institutions' → availability through the city government/national government.

3.5.4 'Availability of subsidies/incentives for residents/institutions' → availability through the city government/national government.

3.5.5 'Availability of subsidies/incentives for residents/institutions' → availability through the city government/national government.

Institutional Dimension

4.1.1 'Fully incorporated' → incorporated in more than 75% of all land use plans; 'Moderate' → incorporated in 51-75% of all land use plans; 'Limited' → incorporated in 26-50% of all land use plans; 'Poor' → incorporated in up to 25% of all land use plans; 'Not incorporated' → incorporated in 0% of all land use plans.

4.1.2 'Fully incorporated' → incorporated in more than 75% of all city's housing plans and policies; 'Improved' → incorporated in 51-75% of all city's housing plans and policies; 'Reduced' → incorporated in 26-50% of all city's housing plans and policies; 'Poor' → incorporated in up to 25% of all city's housing plans and policies; 'Not incorporated' → incorporated in 0% of all city's housing plans and policies.

4.1.3 'Fully incorporated' → school materials (textbooks, cds, videos, etc.) on DRR and CCA fully available, curriculum includes DRR and CCA lessons, and teachers are well informed and updated on the topic; 'Moderate' → some school materials (textbooks, cds, videos, etc.) on DRR and CCA available, curriculum partly includes DRR and CCA lessons, and teachers are aware and occasionally updated on the topic; 'Limited' → few school materials (textbooks, CDs, videos, etc.) on DRR and CCA available, curriculum touches DRR and CCA in occasional lessons, few teachers are aware and updated on the topic; 'Poor' → very few school materials (textbooks, cds, videos, etc.) on DRR and CCA available, curriculum slightly touches DRR and CCA rarely in lessons, very few teachers are aware and updated on the topic; 'Not incorporated' → DRR and CCA is not incorporated and mentioned in the city's school education curriculum.

4.1.4 'Fully incorporated' → incorporated in more than 75% of all city's transport plans and policies; 'Moderate' → incorporated in 51-75% of all city's transport plans and policies; 'Limited' → incorporated in 26-50% of all city's transport plans and policies; 'Poor' → incorporated in up to 25% of all city's transport plans and policies; 'Not incorporated' → incorporated in 0% of all city's transport plans and policies. 'transport plans and policies' → are all plans and laws with relevance to transport: road network plans and policies, public transport plans and policies, etc.

4.1.5 'Fully incorporated' → incorporated in 76-80% of all city's environmental plans and policies; 'Moderate' → incorporated in 51-75% of all city's environmental plans and policies; 'Limited' → incorporated in 26-50% of all city's environmental plans and policies; 'Poor' → incorporated in up to 25% of all city's environmental plans and policies; 'Not incorporated' → incorporated in 0% of all city's environmental plans and policies.

4.2.1 'Existence and effectiveness of disaster management plan' → Existing and implemented disaster management plan for the city. 'Fully effective' → implementation of disaster management plan is fully effective in all relevant areas/sectors; 'Moderate' → implementation of disaster management plan is mostly effective in all relevant areas/sectors; 'Limited' → implementation of disaster management plan is partly effective in relevant areas/sectors; 'Poor' → implementation of disaster management plan is hardly effective in relevant areas/sectors; 'No plan existing' → disaster management plan is not existing.

4.2.2 If disaster management plan is available, uncertainties (fragility of climate change scenarios/predictions and impacts) of climate change incorporated? 'Fully incorporated' → implementation of uncertainties of climate change are fully incorporated in disaster management plan; 'Moderate' → implementation of uncertainties of climate change are mostly incorporated in disaster management plan; 'Limited' → implementation of uncertainties of climate change are partly incorporated in disaster management plan; 'Poor' → implementation of uncertainties of climate change are hardly incorporated in disaster management plan; 'Not incorporated' → uncertainties of climate change are not incorporated in disaster management plan.

4.2.3 'Fully effective' → emergency team is fully capable to deal with the situation, leaders are appointed and team is fully competent (trained and knowledgeable) to handle a disaster; 'Moderate' → emergency team is mostly capable to deal with the situation, some leaders are appointed and team is mostly competent (trained and knowledgeable) to handle a disaster; 'Slightly effective' → emergency team is slightly capable to deal with the situation, few leaders are appointed and team is slightly competent (trained and knowledgeable) to handle a disaster; 'Poor' → emergency team is poorly capable to deal with the situation, very few leaders are appointed and team is poorly competent (trained and knowledgeable) to handle a disaster; 'Not existent' → emergency team is not existent/available in case a disaster occurs.

4.2.4 'Fully effective' → emergency team is fully capable to respond (providing decision-making, logistics, care team, shelter, etc.) after a disaster; 'Moderate' → emergency team is mostly capable to respond (providing decision-making, logistics, care team, shelter, etc.) after a disaster; 'Slightly effective' → emergency team is slightly capable to respond (providing decision-making, logistics, care team, shelter, etc.) after a disaster; 'Poor' → emergency team is poorly capable to respond (providing decision-making, logistics, care team, shelter, etc.) after a disaster; 'No response' → emergency team is not existent or there is no emergency response in case a disaster occurs.

4.2.5 'Fully ready' → alternate decision-making personnel is fully available and ready to replace (appointed leadership) or support current leadership during a disaster; 'Moderate' → alternate decision-making personnel is mostly available and ready to replace (appointed leadership) or support current leadership during a disaster; 'Limited' → alternate decision-making personnel is limited available and ready to replace (appointed leadership) or support current leadership during a disaster; 'Poor' → alternate decision-making personnel is poorly available and ready to replace (appointed leadership) or support current leadership during a disaster; 'Not existent' → alternate decision-making personnel is not existent/available.

4.3.5 'Effectiveness to learn from previous disasters' → to include lessons learned from previous disasters in the decision-making process and strategies to confront a disaster to prevent same damages to occur again.

4.4.1 'Independent' → municipality is fully independent and can manage the situation 100% alone; 'Slightly dependent' → municipality can manage most operations itself but minor support is received from other institutions (NGOs, etc.); 'Dependent' → municipality can manage some operations itself but requires support from other institutions (NGOs, etc.); 'Heavily dependent' → municipality can poorly manage any operations itself and requires heavy support from other institutions (NGOs, etc.); 'Fully dependent' → municipality cannot manage any operations itself and is fully dependent from other institutions (NGOs, etc.).

4.4.3 The extent to which the city receives support from national government in form of financial support, technical help (logistics, food, assistance, material for shelter, etc.), and information/knowledge on how to recover from disaster.

4.4.4 The extent to which the city receives support from NGOs in form of financial support, technical help (logistics, food, assistance, material for shelter, etc.), and information/knowledge on how to recover from disaster.

4.4.5 The extent to which the city receives support from private organizations (trusts, religious organizations, firms, business groups, corporations, local and international donor organizations, etc.) in form of financial support, technical help (logistics, food, assistance, material for shelter, etc.), and information/knowledge on how to recover from disaster.

4.5.1 City has implemented a disaster risk management plan and ensures that it is enforced.

4.5.2 City ensures that all relevant information is transferred from city government to residents to provide them with information about dangerous or affected sites, expected scenarios (weather, disaster situation), and how to recover from a disaster, etc.

4.5.3 City implemented and enforces building codes related to climate-related hazards.

Natural Dimension

5.1.1 'No floods' → no floods occurring; 'Normal' → floods vanish after 24 hours, or floods cover 5% of city; 'Moderate' → floods vanish after two days or floods cover 10% of city area; 'Severe' → floods persist for up to one week, or cover 10-20% of city area; 'Very severe' → floods persist for more than one week, or cover more than 20% of city area.

5.1.2 'No typhoons' → no typhoons occurring; 'Normal' → occurrence of tropical cyclones (30-60 km/h; corresponding to PAGASA's Public Storm Warning Signal #1); 'Moderate' → occurrence of tropical cyclones (60-100 km/h; PSWS #2); 'Severe' → occurrence of severe tropical cyclones (100-185 km/h; PSWS #3); 'Very severe' → occurrence of very severe tropical cyclones/super typhoons (more than 185 km/h; PSWS #4).

5.1.3 'No landslides' → no landslides occurring; 'Normal' → occurrence of landslides which are characterized by slow velocity of rockfall, debris flow, and mass slide; 'Moderate' → occurrence of landslides which are characterized by medium velocity of rockfall, debris flow, and mass slide; 'Severe' → occurrence of landslides which are characterized by high velocity of rockfall, debris flow, or mass slide; 'Very severe' → occurrence of landslides which are characterised by very high velocity of rockfall, debris flow, and mass slide. Categorization derived from Glade et al. (2005) *Landslide Hazard and Risk,* Wiley, Chichester, England.

5.1.4 'No heat waves' → no heat waves occurring; 'Normal' → occurrence of heat waves which are either up to 1 degree Celsius above average regional climatological values for up to three days during summer period or exceeding daily maximum temperatures of 40 degrees Celsius for up to two days; 'Moderate' → occurrence of heat waves which are either up to 2 degrees above average regional climatological values during summer period or exceeding daily maximum temperatures of 40 degrees Celsius for 2-5 days; 'Severe' → occurrence of heat waves which are either 2-5 degrees Celsius above average regional climatological values during summer period or exceeding daily maximum temperatures of 40 degrees Celsius for 5-10 days; 'Very severe' → occurrence of heat waves which are more than 5 degrees Celsius above average regional climatological values during summer period or exceeding daily maximum temperatures of 40 degrees Celsius for more than 10 days.

5.1.5 'No droughts' → no occurrence of droughts; 'Normal' → abnormally dry: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered. 'Moderate' → abnormally drought: some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested 'Severe' → severe drought: crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed 'Very severe' → extreme drought: Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions. And exceptional drought: exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies Categorisation derived from National Drought Management Mitigation Center, Lincoln, USA.

5.3.1 Biodiversity: low or zero number of species endangered and rich variety of fauna and flora → Desirable.

5.3.2 'Very Good' → no land degraded or derelict due to contamination (industrial, household, etc.); 'Good' → 0.1% of city area degraded or derelict due to contamination (industrial, household, etc.); 'Moderate' → 0.1-0.5% of city area degraded or derelict due to contamination (industrial, household, etc.); 'Poor' → 0.5-2% of city area degraded or derelict due to contamination (industrial, household, etc.); 'Very poor' → more than 2% of city area degraded or derelict due to contamination (industrial, household, etc.).

5.3.3 'Average urban air quality during the day'

5.3.4 'Very Good' → less than 5% of urban water bodies (lakes, rivers, etc.) are polluted (contaminated); 'Good' → 5-10% of urban water bodies (lakes, rivers, etc.) are polluted (contaminated); 'Moderate' → 10-20% of urban water bodies (lakes, rivers, etc.) are polluted (contaminated); 'Poor' → 20-40% of urban water bodies (lakes, rivers, etc.) are polluted (contaminated); 'Very poor' → more than 40% of urban water bodies (lakes, rivers, etc.) are polluted (contaminated);

5.4.2 'Low' → less than 30% of city area built (housing, industries, infrastructure, etc.); 'Limited' → 30-50% of city area built (housing, industries, infrastructure, etc.); 'Moderate' → 50-70% of city area built (housing, industries, infrastructure, etc.); 'High' → 70-90% of city area built (housing, industries, infrastructure, etc.) 'Very high' → more than 90% of city area built (housing, industries, infrastructure, etc.).

5.4.3 'None' → no settlements on hazardous areas; 'Negligible' → less than 10% of settlements on hazardous ground; 'Few' → 10-25% of settlements on hazardous ground; 'Numerous' → 25-50% of settlements on hazardous ground; 'Majority' → more than 50% of settlements on hazardous ground.

5.4.5 'No loss' → no loss of urban green space in last 50 years in city area; 'Negligible' → less than 10% loss of urban green space in last 50 years in city area; 'Moderate' → 10-20% loss of urban green space in last 50 years in city area; 'Severe' → 20-40% lossof urban green space in last 50 years in city area; 'Very severe' → more than 40% loss of urban green space in last 50 years in city area.

5.5.1 'Compliance rate to environmental policies' → the extent to which residents, companies, etc. follow environmental policies, for example, recycling of waste, exhaustion of greenhouse gases, etc.

5.5.2 'Fully sufficient' → 76-100% of all relevant sites, areas, etc. of high environmental and heritage value are protected by policies; 'Moderate' → 51-75% of all relevant sites, areas, etc. of high environmental

5.5.3 'Fully efficient system' → efficient waste management is in place, 76-100% of waste segregated and 75-100% of all residents follow instructions; 'Moderate' → 51-75% of waste segregated and 51-75% of all residents follow instructions; 'Limited' → 26-50% of waste segregated and 26-50% of all residents follow instructions; 'Poor' → 1-25% of waste segregated and 1-25% of all residents follow instructions; 'No existing system' → waste management system (reduce, reuse, recycle) is not existing.

5.5.4 'Fully sufficient' → 76-100% of all vehicles, households, companies are required to reduce greenhouse gas emissions; 'Moderate' → 51-75% of all vehicles, households, companies are required to reduce greenhouse gas emissions; 'Limited' → 26-50% of all vehicles, households, companies are required to reduce greenhouse gas emissions; 'Poor' → 1-25% of all vehicles, households, companies are required to reduce greenhouse gas emissions; 'No existing policies' → no existence of mitigation policies to reduce greenhouse gas emissions.

5.5.5 'Good' → city provides enough food stock for more than a week after a disaster; 'Moderate' → city provides enough food stock for 3-7 days after a disaster; 'Limited' → city provides enough food stock for 1-3 days after a disaster; 'Poor' → city provides enough food stock for only 1 day after a disaster; 'No food security' → city provides no food stocks.