ID 1583 | TRANSLATING NEW CONCEPTIONS OF CLIMATE CHANGE RISK INTO URBAN CLIMATE CHANGE RISK ASSESSMENTS AND ADAPTATION RESPONSES

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1 INTRODUCTION

Identifying and assessing risk is common across a number of disciplines from health sciences to disaster risk management to critical infrastructure protection. Yet, the climate change adaptation community has preferred a vulnerability-based framework in order to conceptually understand and respond to climate change (Intergovernmental Panel on Climate Change (IPCC), 2012). However, since 2012, the main scientific organisation that leads on climate change, the Intergovernmental Panel on Climate Change (IPCC) has reframed climate change in order to look at risk rather than vulnerability. Such a move intends to harmonise the climate change adaptation community with those working in the allied discipline of disaster risk management (Aven & Renn, 2015). There is a further supposition that the risk-based concept can help to shift the focus from top-down, science-first vulnerability assessments to risk assessments that can better include a range of stakeholders (Meadow et al., 2015). There is, however, scant literature on the means of co-producing risk assessments.

There are also potential difficulties in translating the new risk-based concept into practice, particularly in spatial planning which combines expertise from a range of disciplines. The definition of risk differs across disciplines and sectors (Thywissen, 2006; Wolf, 2011). In addition, existing climate change adaptation projects have used vulnerability-based conceptual frameworks, and there is therefore a question mark over the way that their resultant data can be easily reused.

Our paper explores the move from a vulnerability based framework to a risk based framework. After outlining the underpinning components of vulnerability and risk, we demonstrate the utility of a risk based framework for spatial planning policy and practice. However, the latter half of the paper points to potential issues in the translation of climate change risk to adaptation policy more broadly and spatial planning in particular. We conclude that the concept of risk helps cities to identify adaption options and build resilience to the changing climate by connecting across disaster risk management and climate change adaptation approaches. However, the conceptual mismatches – particularly around the notion of 'exposure' - have to be approached cautiously particularly with regard to spatial data.

1.1 THE RESIN PROJECT

The paper draws upon work undertaken for the EU Horizon 2020 funded Climate Resilient Cities and Infrastructure (RESIN) project. RESIN is an interdisciplinary, practice-based research project investigating climate resilience in European cities. Through co-creation and knowledge sharing between cities and researchers, the project develops practical and applicable tools to support cities in designing and implementing climate adaptation strategies for their local contexts. This includes a city typology, which utilises European spatial data in order to build a picture of the hazards, exposure and vulnerability at NUTS3 level.

Before the practical work could commence, it was essential to choose a persuasive and easy to communicate conceptual framework and, within that, definitions. We chose to follow the IPCC's risk based definition of climate change which represents the state of the art (Carter et al. 2015). RESIN's conceptual framework is a dynamic risk-based one that highlights two distinct – but potentially interconnected – systems: the urban system and the climate change adaptation system (Figure 1). On the left, the urban system has a number of hazards and drivers of change that lead to climate risk. Awareness of such climate risks may provide the route into the adaptation planning system on the right hand side where city managers can begin a process of assessing risk, identifying and prioritizing adaptation options, and developing an implementation plan. This can then feed back into the urban system in order to build climate resilience. Of course, we recognise that the synergies between the two systems may not be seamless; some cities may never go on the journey of the adaptation planning process and build resilience in reactive ways. The conceptual framework also shows that risk, and the hazards and drivers of risk, can never be completely eliminated.

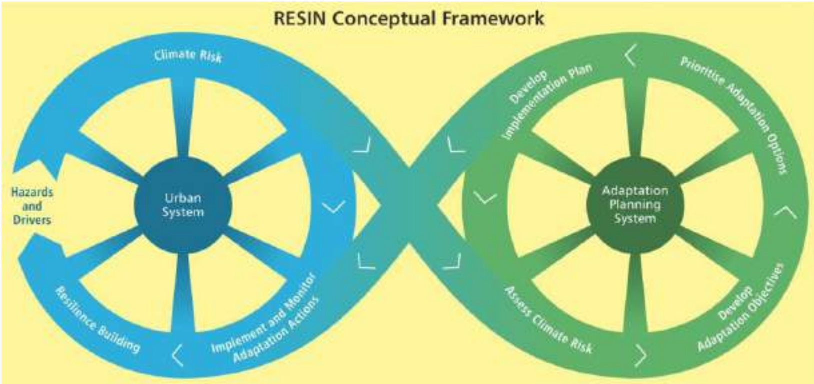

Figure 1 - The RESIN Conceptual Framework. Source: Authors.

2 FROM VULNERABILITY TO RISK

2.1 THE IPCC'S EVOLVING FRAMEWORK

Until recently, the vulnerability assessment of socio-ecological systems (SES) was the main focus of the climate change adaptation literature. Vulnerability, as adopted by the IPCC up to the Fourth Assessment Report (AR4), was defined as: 'The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC, 2001, p. 995). This could be expressed as a function: Vulnerability = f (Exposure, Sensitivity, Adaptive Capacity) and is visually outlined in Figure X.

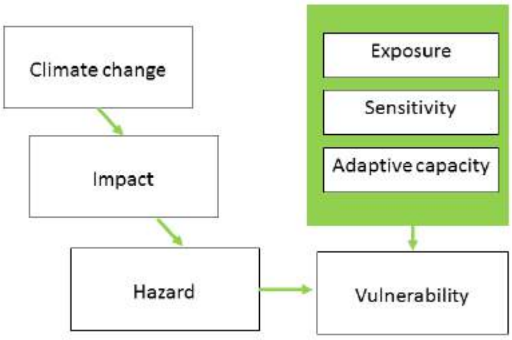

Figure 1: Pre-IPCC AR4 Conceptual Framing of Climate Change Vulnerability

Where:

- Sensitivity: is 'the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change' (IPCC, 2014b);
- Exposure: is 'the nature and degree to which a system is exposed to significant climatic variations' where the exposure unit is 'an activity, group, region, or resource that is subjected to climatic stimuli' (IPCC, 2001);
- Adaptive Capacity: is the 'ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC, 2001).

Here, climate change impacts upon a system. The degree to which that system is exposed in terms of the character and magnitude of climate change and the degree to which a given unit of analysis is affected combine to make an impact. Once the adaptive capacity of a system is subtracted, the residual figure would indicate the extent of the system's vulnerability.

Vulnerability-based frameworks developed quickly. Within the climate change literature, the emphasis of early work (so-called 'first-generation') was on biophysical vulnerability which tends to focus on observed and projected changes in climate that may exacerbate exposure and sensitivity (Füssel & Klein, 2006). However, this could be criticized for privileging a 'science first' perspective to the detriment of implementing action. Thus, scholars began to draw attention to the ways in which existing socio-economic circumstances interact with climate change, and led to a distinction between outcome vulnerability and contextual vulnerability (O'BRIEN, ERIKSEN, NYGAARD, & SCHJOLDEN, 2007).

Critics pointed to a number of reasons why the framing climate change in terms of vulnerability could be problematic. Vulnerability can be interpreted negatively and, thus, by labeling people and places as 'vulnerable', a passive attitude may be adopted to climate change. Similarly, the negative framing overlooks the importance of local culture and underlying resilience, particularly in non-western nations (Bankoff, 2001; Giupponi & Biscaro, 2015).

The vulnerability framework also did not fit with other models available in the more present-day oriented disaster risk management literature whereby the concept of risk predominates (e.g. UNISDR 2009). Given that climate change adaptation and disaster risk management have many overlaps, bringing the two disciplines together is desirable from a practical point of view (EEA 2012). Thus, the IPCC has modified their definition of vulnerability in AR5 by moving to a risk-based conceptual framework (IPCC, 2012; 2014a).

Yet, risk is also a term that is difficult to define (e.g. Thywissen 2006; Wolf 2011) even though there is an international standard on risk management. ISO 31000 defines risk as the 'effect of uncertainty on objectives' (ISO/IEC 31000: 2009). An 'effect' is a positive and/or negative deviation from what is expected, whilst 'objectives' may be different aspects or goals. Furthermore, risk is characterised with reference to potential events and consequences, and can be expressed in terms of a combination of the consequences of an event and the associated likelihood of occurrence. Likelihood is the 'chance of something happening' and can be measured qualitatively or quantitatively (ISO/IEC 31000: 2009). In general terms, likelihood can be used interchangeably with probability. That said, probability more precisely refers to a quantifiable measurement where 'measure of the chance of occurrence [can be] expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty' (ISO/IEC 31000: 2009).

This definition, albeit broad, results in a classic risk calculation whereby risk is a multiplication of the probability of an event with the consequences of an event (1):

Risk = Probability X Consequences (1)

However, in the case of natural hazards, the variables are not independent of one another insofar as likelihood of occurrence is affected by the size of the impact (European Commission 2010: 16). That is, it is not the presence of a hazard that indicates the risk, rather, a hazard only becomes a risk when a system is exposed and vulnerable; thus, 'risk is also a function of the underlying environmental and socioeconomic context in which …. climate change occurs' (Preston & Jones, 2008, p. 278). For these reasons, the notions of vulnerability and exposure can be introduced to capture these nuances – since the probability of an impact occurring may be affected by enacting vulnerability and exposure reduction measures. Therefore, as reflected in the IPCC AR5 approach, there is a functional relationship between the elements of risk, which are broken down to reflect the hazard, exposure, and vulnerability (Figure 2). Exposure and vulnerability combine as the consequences ('the impacts, if these events/trends occur') whilst probability relates to the hazard; or the 'probability of the occurrence of hazardous events/trends' (Birkmann et al., 2014, p. 23)). Ultimately, these concepts lend themselves well to the spatial identification of risk.

Risk (R) = f (Probability of a Hazard (p),* Exposure (E), * Vulnerability (V)) (2)

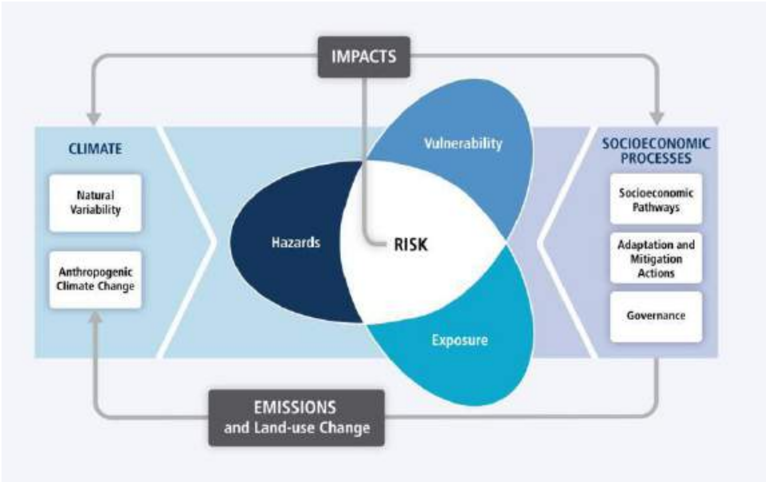

Figure 2 - The IPCC AR5 conceptual framework with risk at the centre. Source: IPCC, 2014

2.2 COMPARING DEFINITIONS

Table 1 compares and contrasts the key concepts between each knowledge area to explore the commonalities and differences. When those working within the pre-IPCC AR5 concepts refer to vulnerability, IPCC AR5 and disaster risk management understands this as risk. Similarly, vulnerability in IPCC AR5 equates to sensitivity and adaptive capacity within climate change studies (pre-IPCC AR5), or, for disaster risk management, simply ‘sensitivity’ (Kaźmierczak and Handley, 2011).

	IPCCAR4	IPCCAR5
Adaptive Capacity	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 2007)	The ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term (IPCC 2014b).
Exposure	The nature and degree to which a system is exposed to significant climatic variations (IPCC 2001).	The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected (IPCC 2014b)
Hazard	No glossary definition	The potential occurrence of a natural or human-induced physical event or trend, or physical impact, that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC 2014).
Risk	No glossary definition	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.
Sensitivity	The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change.	The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change.
Vulnerability	Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2007)	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Table 1 – Comparison of vulnerability related terminology

The most important shift has occurred in the formulation of exposure, a concept has not been well-defined in climate change adaptation studies (Räsänen et al 2016; Jurgelivich et al. 2017). The pre-IPCC AR5 considered the degree of exposure (that is, the degree to which railway tracks or electricity substations come into contact with a hazard as a consequence of the magnitude of climatic variation). IPCC AR5 modifies this to focus more on what is exposed (an electricity substation or railway tracks) (Table 1) It is argued that this makes sense, particularly when thinking about critical infrastructure, because an electricity transmission line, for example, is only exposed to windstorms if it is above ground (McCord et al., 2015, p. 48).

Vulnerability, on the other hand, is now only composed of two components: sensitivity and adaptive capacity which, largely, retain the same definition. Risk, on the other hand, is a newly introduced definition which tries to capture both the language of probability/consequence in addition to the spatial formulation of hazard, exposure and vulnerability. Both definitions are suitably open enough for divergent interpretations.

3 ISSUES IN TRANSLATING CLIMATE CHANGE RISK FOR SPATIAL PLANNERS

Now, why do any of these conceptual changes matter? Quibbling over conceptual differences may seem pedantic in the face of the hard work of trying to increase the resilience of people and places to extreme weather events and climate change. However, the framing of climate change, whether that be through the lens of 'vulnerability', 'risk' or 'resilience', is important because 'frames allow certain questions to be asked while others get silenced' (Fünfgeld & McEvoy, 2011, p. 15). Therefore, the remainder of this paper focuses on why the movement towards risk appears to be a useful concept for spatial planners, but also point to some of the difficulties that the RESIN project has encountered as a result of the changing IPCC terminology.

3.1 WHY IS RISK USEFUL?

3.1.1 DECISION MAKING

There are a number of reasons why the concept of risk, and the undertaking of risk assessments, has advantages over vulnerability driven terminology and related assessments. Conceptually, separating out exposure can be beneficial to spatial planners as it emphasises the worth of exposure reduction measures (e.g. not building in flood risk areas). Conversley, a focus only on probability and consequences tends to privilege the construction of more robust flood defences (Klijn, Kreibich, de Moel, & Penning-Rowsell, 2015). The separation of exposure from vulnerability helps decision makers prioritise actions that can either reduce exposure to a hazard, or else reduce vulnerability through measures that address sensitivity and adaptive capacity. It also moves the climate change adaptation community closer to models that have been used in disaster risk management and, in turn, the insurance industry (Lindley, Handley, Theuray, Peet, & Mcevoy, 2006).

An example may illustrate this. In order to understand the risk of flooding to a building, it is necessary to understand whether the building is exposed (spatially) to the flood in the first place. Further accentuating the risk may be particular factors that make a building sensitive to flooding (such as the presence of basement floors). The risk may be less if adaptive capacity is high; the existence of early warning systems is an example here. Given the understanding of the different elements of risk, a decision maker can then prioritise actions based on:

- Reduce greenhouse gas emissions to lessen the frequency and severity of future hazards
- Undertaking adaptation measures that reduce exposure (by relocating the building outside of the potentially flooded area)
- Undertaking adaptation measures that reduce sensitivity (by making sure that vulnerable groups or activities are not housed in that building)
- Undertaking adaptation measures that increasing adaptive capacity (by installing flood mitigation measures for the building; presence of early warning systems).

The resultant data on the IPCC's risk elements (hazard, exposure, vulnerability) can be useful separately; for example, in communicating hazard probabilities and informing measures to reduce vulnerability to hazards. The ability to deconstruct different risk elements offers additional insights to decision makers when planning adaptation responses, by identifying which issues are driving risk in a particular situation. But, it is when these elements are brought together within a risk assessment they become more powerful. This is particularly the case where supporting spatial data is available, as the elements of weather and climate risk vary according to location (Tapia et al. 2015).

Impact and vulnerability assessments remain useful as elements of the risk assessment process in order to advance climate change adaptation and resilience goals. The differences between impact, vulnerability and risk assessments, and the functions that they perform in adaptation and resilience planning, are outlined in Table 2.

It can be seen that impact, vulnerability and risk assessments all have a role to play in adapting and building resilience to climate change. However, neither impact nor vulnerability assements consider the probability of occurence of hazards, potential exposure, or the severity of related impacts and vulnerability assessments do not provide the outputs to enable such decisions to be taken as effectively, and could therefore be usefully seen as processes that can contribute to a risk assessment. Risk assessments go beyond impact and vulnerability assessments, and bring together different elements of the adaptation agenda (including impacts and vulnerability) to provide a basis for analysing which weather and climate risks are most pressing.

Risk assessment is, therefore , a process that is focused on supporting decision-making. Brown and Wilby (2012) describe analysing climate risk as a matter of 'due diligence', which can be interpreted as taking a reasonable level of care before taking a decision. This, as Dickson et al. (2012: 23) suggest, ties risk assessment closely to decision making; '… [risk] assessments aim to simplify complicated experiences of risk in order to assist in decision making.'

	Impact Assessment	Vulnerability Assessment	Risk Assessment
Inputs	Impact assessments require details of weather and climate hazards and the natural and human systems with the potential to be affected.	Sensitivity and adaptive capacity data are needed to undertake a vulnerability assessment, based on the IPCC's approach.	The IPCC's risk approach focuses on the interaction between hazard, exposure and vulnerability. Data is required on these themes to complete an assessment.
Outputs	Potential weather and climate impacts to natural and human systems. Cascading impacts, within and between systems, are significant yet can be difficult to establish due limited data and modelling capacity.	Details of the vulnerability of 'receptors' to weather and climate hazards. Data permitting, vulnerability can be mapped spatially.	Identification of weather and climate risks according to their probability and impact . Data permitting, risk assessment outputs can be mapped spatially.
Issues	Impact assessments generally provide no indication of the probability that impacts may occur. Impact severity, which relates factors including hazard intensity and the vulnerability of the system to the event, is not commonly considered.	Adaptation responses can be developed to reduce vulnerability. However, without details of the probability of, and potential spatial exposure to, hazards, responses to reduce vulnerability cannot be as effectively targeted.	Risk assessments provide a picture of priority risks, in terms of their probability and consequence, enabling available response capacity and resources to be targeted more effectively.

Table 2 Differences between impact, vulnerability, and risk assessments. Source: Authors

The benefits of undertaking a risk assessment can also be observed in the outcomes of decisions informed by a risk-based approach, particularly where spatial risk data is available. Here, developing responses to minimise losses and negative impacts associated with climate change is key. Cities and urban areas face risks from a range of sources, one of which is extreme weather that might occur more often as a result of climate change. Other risks, generated by socio-economic and bio-physical drivers of change, may have a greater or lesser influence on decisions than climate change. This judgement can be made if climate and non-climate risk information is available to be evaluated (Willows and Connell 2003).

King et al (2015: 8) highlight the importance of such an evaluation, noting that; 'The most important decision that any government has to make about climate change is one of priority: how much effort to expend on countering it, relative to the effort that must be spent on other issues.'

3.1.2 ADDRESSING UNCERTAINTY

Risk assessments are particularly good for reducing uncertainty because they focus attention on (i.e. the highest risks), the locations where risks are most prominent, and the relative significance of climate and non-climate related risks. Here, the risk assessment is narrowing or helping to prioritise the range of possible risks to consider, and clarifying the objectives of the adaptation planning process. This can, in turn, help to direct attention to the allocation of available capacity and resources for climate change adaptation and resilience building. Risk assessments also help to fill knowledge gaps by increasing understanding of the probability and consequence of different risks. King et al. (2015: 23) build on this noting that, 'one of the key purposes of risk assessment is to allow decision-makers to weigh choices for action under uncertainty.' Risk assessment can help to illuminate the implications of different decision options when responding to climate risk, which may include a decision not to act and therefore to accept the identified risk(s).

However, risk assessment processes (and therefore outcomes) are affected by uncertainty. For example, uncertainty in climate projections must be recognised within any analysis of the probability of occurrence of hazard events. Here, it is important to be clear as to which dimensions of uncertainty risk assessment can respond to. Addressing this point, Willows and Connell (2003: 48) note that, 'risk assessment deals explicitly with uncertainty in decision-making rather than giving an over-confident view of what is known.' Climate change risk assessments do not reduce uncertainty associated with climate change, but the process can support decision makers in analysing the consequences of an (uncertain) changing climate in order to focus and target strategies and actions in response.

3.2 POTENTIAL PROBLEMS

Having established the utility of a risk assessment, we now turn to some of the problems that may be encountered by the movement from vulnerability to risk in climate change adaptation studies. Many studies undertaken to understand climate change within Europe work within the IPCC's pre-AR5 framework. The EEA's Urban Vulnerability Map (2015) used indicators relating to sensitivity, exposure and response capacity. The ESPON climate vulnerability assessment also utilized the IPCC's AR4 definition where vulnerability is a function of sensitivity, exposure and adaptive capacity (ESPON Climate 2011). The Vulnerability Sourcebook (BMZ 2014), which outlines a detailed process of undertaking vulnerability assessment, also holds to the IPCC's AR4 definition. There is thus a challenge for those who wish to draw on assessments and approaches that have been formulated under the earlier IPCC definition.

Retrofitting extant data may be problematic. For example, the ESPON project produced supporting data on the Territorial Effects of Climate Change on European Cities (ESPON Climate 2011). Underpinning the report was spatial data that resulted in the broad identification of five 'climatic types'. The data is at NUTS 3 level and includes data for climatic conditions and the pre-AR5 components of vulnerability: exposure, sensitivity and adaptive capacity. The data is available for reuse. However, examination of this data entails detailed considerations of how the concepts were developed to ensure that it remains of use today. ESPON's exposure indicators measure change in a hazard (e.g. Changes in annual mean temperature), which corresponds to AR5's 'hazard'. Similarly, ESPON's sensitivity data indicates susceptibility to harm insofar as a receptor is located (AR5's 'exposure') in the presence of an exposure element (AR5's hazard). ESPON Climate (2011) then combine sensitivity and exposure to create an impact which, with the addition of adaptive capacity, gives overall vulnerability scores. The sensitivity indicators are comprised of physical sensitivity, cultural sensitivity, social sensitivity, environmental sensitivity and economic sensitivity. All but the economic sensitivity data are spatial. It is not that the data cannot be reused, but a process of working through the definitions and looking at the indicators is required in order to reframe and repackage them in order to be useful to the AR5 concepts: it is surely a waste of resources to compile new datasets where significant effort has been made to commission and promote the original ones. Exposure indicators may be used as 'Hazard' whilst some, but not all, of the sensitivity indicators can be used to represent 'Exposure'.

4 CONCLUSION

From the perspective of adaptation and resilience, climate change risk assessments can offer decision support in a number of ways, including:

- The provision of valuable insights into context-specific risks associated with the changing climate, which may otherwise not be accessible.
- Risk assessments focus attention on the highest risks, with the highest probability of occurrence and the most severe negative consequences (or impacts). Therefore, a risk assessment can help decision makers to prioritise risks to respond to when aiming to adapt to the changing climate.
- Identifying high risks associated with the changing climate can clarify objectives, help to prioritise adaptation options, and to support the allocation of resources that are available for adaptation and resilience work.

However, in order to make previous climate change adaptation assessments usable for state-of-the-art thinking on climate change, there needs to be a careful translation of the concepts and their allied data: this is particularly acute around the concept of exposure. Vulnerability and risk are commonly employed in everyday usage, thus they are useful to advancing climate change adaptation; however, the focus should be to 'concentrate on assessments instead of detailed theoretical definitions' (Wolf, 2011, p. 1108).

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ID 1602 | THE SPATIAL DISTRIBUTION OF URBAN HEAT VULNERABILITY AND COPING STRATEGIES IN BEIJING

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1 INTRODUCTION

Under the influence of global climate change and local urbanization, the heat wave is thought to be more intensified and frequent. So far, the definition of heat wave has not been reached a general agreement all over the world, but severe consequences caused by heat waves on health effects have been demonstrated in many cities. With the constant process of Asia's urbanization, heat wave events will be the uppermost one of extreme weather conditions that Asian cities have to confront in the future (IPCC,2014). Thus, it is emerging objectives for urban planning that how to efficiently reduce the urban vulnerability and prevent public health from the current or potential risk of heat wave events.

Similar to other extreme weather conditions, impact areas of heat wave event are distributed unevenly. Thus, before reducing urban heat vulnerability (UHV) by means of urban planning, to identify the place and people vulnerable to heat waves is the fundamental basis for variant planning strategies. In terms of spatial pattern caused by the heat wave, the intra-urban variation of magnitude and duration during heat waves is significant. Some studies find urban heat island (UHI), a atmospheric phenomena that city area warmer than its countryside, aggravates the intensity of heat wave events within the urban area (Yang and Chen et al., 2015). In turn, higher temperature during heat wave events make UHI effect more significant. With the interaction between heat waves and UHI, urban residents have to be suffered from a higher risk of consistent heat stress. In addition to the variation of geographical range, the difference of heat-related health is another aspect need to be identified. Under the same weather condition, some people may be affected more than others. The research from public health recognizes general characteristics of people that are vulnerable to heat waves by the case study of heat-related mortality and morbidity, which includes age, economic characteristics, pre-existing health condition and thermal environment (Harlan and Brazel et al., 2006). Therefore, mapping UHV, which emphasize not only vulnerable areas, but also susceptible people, is urgently needed.

Through the lens of international experiences, UHV mapping is the key instrument to support technologically the implementation of heat waves prevention and mitigation (Wilhelmi and Purvis et al., 2004). In the cooling actions of eighteen American cities, UHV assessment is widely adopted as a necessary part (GCCA, 2014). For the Birmingham's climate change adaptation action, UHV is utilized in identifying priority areas to improve the resilient capacity (Birmingham city council, 2012). Similarly, based on the map of UHV in Australian capital cities (NCCARF, 2013), Moreland UHI effect action plan identifies five types of priority areas (Moreland city council, 2016). Thus, the first section of this article summarizes the recently progress in UHV assessment, in order to select the comprehensive framework presented for Beijing central city.