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Social vulnerability assessment of the Cologne urban area (Germany) to heat waves: links to ecosystem services

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ABSTRACT

More than three-quarters of the European population live in urban areas and this proportion is increasing, leading, in some cases, to increased vulnerability of cities to environmental hazards. The health impacts of heat waves are aggravated in cities due to the high density of buildings, the fragmentation of green areas and the higher concentrations of air pollutants. Ecosystems can provide important benefits that mitigate the impacts of heat waves but at the same time can themselves be affected by the hazard, thus limiting their services. The objective of this study was to assess the vulnerability of the Cologne urban population to heat waves, taking into consideration a range of social and ecological variables. Based on the MOVE framework, indicators were developed and GIS applications were used to spatially assess the relative vulnerability of the 85 districts of Cologne to heat waves. The insights gained were integrated and corroborated with the outcomes of stakeholders' interviews. As environmental factors play a major role in this assessment, it is suggested that ecosystem management in Cologne and its surroundings be improved. In addition, though vulnerability is higher in central districts, attention needs to be paid to the periphery where the most susceptible groups reside.

1. Introduction

In Europe, 75% of the population live in urban areas and the proportion is increasing [1]. However, absolute population growth is not the major contributor to the increase of the disaster potential in cities [2]. Rather, the shift in the location of industries and homes, driven by economic factors and lifestyles plays a significant role in the conversion of rural lands near European cities [3] which in turn alters ecosystems, affecting their services through e.g. the compaction of soil and the impairment of its functions. These changes increase the loss of water permeability (soil sealing), compromise the availability of water supply in terms of groundwater recharge and fragment green cover which is accompanied by an increase in resources and energy consumption [1]. In addition, under scenarios of climate change, geographical areas that were less affected by heat spells are likely to become at higher risk of extreme hydro-meteorological events [4]. The vulnerability of urban populations to hazards is in this way further exacerbated.

The impacts of heat waves on the ageing segment of the population that lives in the highly modified ecosystem of urban areas are of increasing concern for European cities. In fact, urbanization affects climate locally, as cities tend to be warmer than their surroundings, producing the

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so-called Urban Heat Island (UHI) effect. This manifests itself especially at night and principally as a consequence of the properties and density of built infrastructures, low albedo, low green cover and low moisture availability in cities. Air quality is also degraded in cities, mainly due to the higher concentration of road traffic and industrial activities which require fuel combustion leading to the emission of air pollutants dangerous for human health. As a result, during heat waves, the rates of heat-related morbidity and mortality are often higher in cities than in their surroundings [5]. This is especially true for densely populated areas, where heat-retaining buildings, few and fragmented green areas with a lower cooling capacity, and higher levels of air pollution due to higher road traffic, amplify the impacts of the hazard [6–11]. It is therefore suggested that excess deaths occurring in urban areas during periods of extreme heat can be significantly reduced through appropriate urban land cover planning [12]. Land use patterns are in fact related to the capacity of urban ecosystems to provide regulating services which can be assessed through landscape functions (i.e. the capacities of a landscape to provide goods and services to the society) [13,14]. It should however be emphasized that social and institutional considerations (e.g. early warning systems, the adoption of appropriate behaviours, facilitating tighter social networks) remain paramount while dealing with this type of vulnerability.

The objective of this study is to assess the social vulnerability of the 85 districts of the Cologne urban area as part of the Methods for the improvement of Vulnerability Assessment in Europe (MOVE) project funded by the European Commission. In the following introductory sections, vulnerability assessment, social vulnerability to heat waves, the role of ecosystem services in mitigating the impacts of heat waves, as well as the assessment of ecosystem services as landscape functions are briefly reviewed and defined. Section 2 presents the methodology developed, Section 3 presents the results, which are then discussed in Section 4.

1.1. Vulnerability assessment

An extensive review of the vulnerability terminology was carried out by Thywissen [15] and includes a comprehensive list of definitions that primarily differ according to the school of thought in which these are developed and in use. According to these different schools, which can mainly be clustered into “political economy”, “social-ecology”, “holistic vulnerability and disaster reduction assessment” and “climate change science” [16], various approaches and frameworks have been developed to assess vulnerability. The MOVE project was intended to overcome these differences by producing a generic Framework (Fig. 1) that would bring together and be applicable both in the domain of disaster risk reduction and climate change adaptation. The MOVE framework is intended to be a guiding tool more than a close representation of reality. By assembling the main elements of the vulnerable social–ecological system (i.e. a coupled system of biophysical and social components that interact and evolve according to complex dynamics) at multiple scales, and representing the risk factors, the framework closes the loop through the adaptation section. Adaptation is actually considered as a central element in shaping vulnerability in the long term

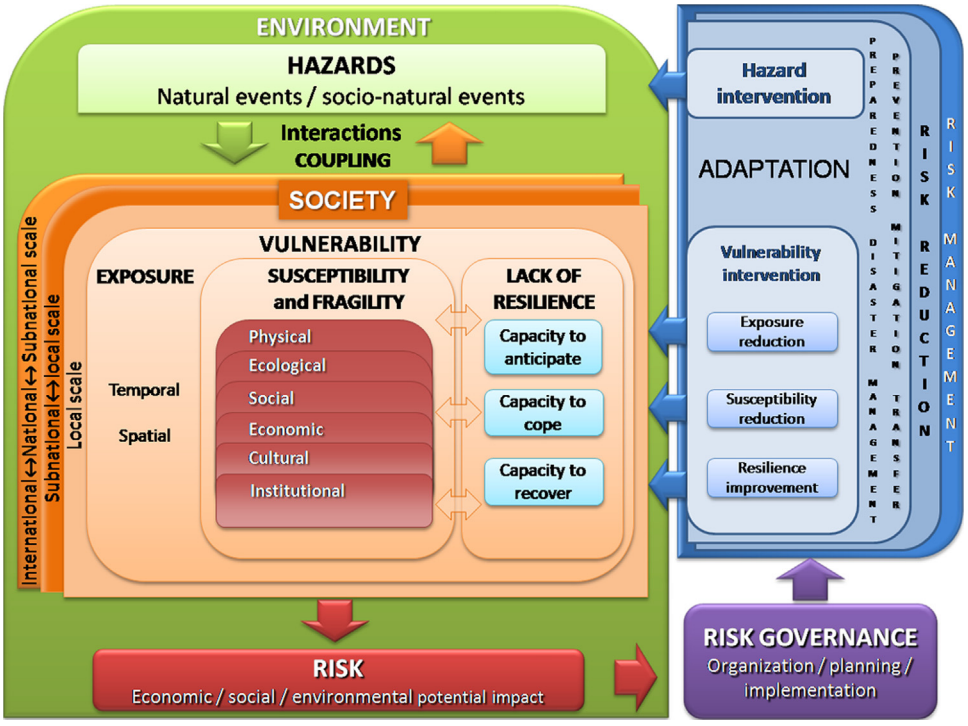

Fig. 1. The MOVE Generic Framework.