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A conceptual framework for integrated analysis of environmental quality and quality of life

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ABSTRACT

Environmental quality has a strong influence on the quality of life for human beings. There are direct linkages between primary elements of the environment, such as air, water, and land surface and the quality of life. Our main research refers to the question how residents and their environment interact by assessing the measured and perceived environmental quality and quality of life. Although, this integrated research requires a wide range of data, there is a lack of studies which have attempted to combine qualitative and quantitative data on quality of the environment and subsequently, quality of life. Based on Lawrence's (2011) notion of environmental quality as a complex concept that is neither static nor absolute, we focus on two interrelated sets of components: bio-geophysical, measurable components and subjective susceptibility of the environmental burdens. We do this by a combined qualitative and quantitative analysis to draw out dimensions of environmental quality and subsequently, quality of life.

1. Introduction

Environmental quality has a strong influence on the quality of life for human beings. There are direct linkages between primary elements of the environment, such as air, water, and land surface and the quality of life (Brown, 2003; Pacione, 2003). However, in order to gain an understanding of how elements interact, a multitude of data is needed. Although, the integration of a wide range of data is required, there is a lack of studies which have attempted to combine qualitative and quantitative data on quality of the environment and subsequently, quality of life (Liang and Weng, 2011). Based on Lawrence's (2011) notion of environmental quality as a complex concept that is neither static nor absolute, we focus on two interrelated sets of components in urban regions: bio-geophysical, measurable components and subjectively perceived meanings, values and assessments of them. We do this by integrating qualitative and quantitative data to draw out dimensions of environmental quality and subsequently, specific bio-geophysical aspects of quality of life (Lawrence, 2011, p. 521).

It is our understanding of integrated scientific work in urban regions that research should be designed in such a way as to integrate the work of both, social and natural scientists. We also believe that the study design is very important. The study was developed in collaboration with different disciplines in order to effectively realize the project's objectives. As it was a pilot study it can be stated that the interdisciplinary framework needs to be developed at an early stage but kept adjustable throughout the course of the research project. In this field of study, drawing on qualitative and quantitative data to show quality of life and environmental quality is a novel technique (e.g., The Baltimore Ecosystem Study (www.beslter.org)), in particular for the Latin American Region, where research and knowledge on these topics is limited (Pauchard and Barbosa, 2013). Regarding our investigations on environmental quality as part of quality of life with reference to Santiago de Chile, it must be understood that quality is an ambiguous concept because scientists and professionals working in different disciplines interpret it differently (Lawrence, 2011, p. 521). Therefore an overall analysis of environmental quality and quality of life is hardly feasible to be carried out. Studies from the Millenium

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Ecosystem Assessment (2005) and by the UN Habitat Agenda Goals and Principles (2003) clarify that a selection of indicators allows approaching to this all-embracing topic.

Our main research refers to the question how residents and their environment interact by assessing the measured and perceived environmental quality and quality of life. Therefore population (differentiated by age, occupation and socio-economic status), land use (urban structure types and green infrastructure) and selected environmental burdens (heat stress, air pollution) are quantitatively analyzed at different spatial and temporal scales in the Metropolitan Area of Santiago de Chile (MAS). This approach is completed by qualitative evaluations on the subjective susceptibility of the above-mentioned environmental burdens. Therefore, problem-oriented analysis of environmental quality is essential in order to gain an understanding of the set of indicators demanded to tackle the research question. We want to identify potential conflicts caused by low environmental quality that might affect different social groups in different ways. To deal with the ambiguity of the concept of quality, the limitations of the study need to be accounted for in terms of manpower, available and updated data and their respective scales.

2. Urban regions as key landscapes

Today, urban regions are home to more than half of the global population. It is in the urban landscape where the environment and human beings experience the most intensive ongoing and complex interaction with each other. Therefore, it is important to observe and measure environmental conditions of urban regions and their impact on the quality of life. Because the urban environment is a composition of built, natural and social elements, the interaction takes place on all levels (e.g., private gardens and green spaces, or disperse and densely built structures and their relations to different socio-economic groups) and at different scales (e.g., amount and distribution of green spaces in entire municipalities and of trees throughout neighborhoods and their relations to different socio-economic groups) (Heinrichs et al., 2012).

In these multifunctional urban landscapes the analysis and assessment of environmental conditions is challenging because we are confronted with a wide range of overlaying processes that affect the quality of life. Urban areas can be characterized by a large diversity of environmental conditions such as a highly heterogeneous structure of densities (e.g., built-up areas, green infrastructure, and persisting dynamic land cover patterns), and health related exposures (e.g., urban heat stress, and air pollution) (Rauch et al., 2013). These diverse conditions interact with different socio-economic and socio-demographic patterns determining various kinds of urban environmental qualities and urban qualities of life (Blanco et al., 2009). Although urban sociological and ecological researchers have realized in recent years that joint research is essential in urbanized areas in order to achieve the urban sustainability, the goals of individual research are still diverging and the methods are not yet well-adjusted.

3. The pilot project as a platform for future integrated studies

From 2011 to 2013 the bi-national pilot project "Evaluating Environmental Quality and Quality of Life to analyze Urban Vulnerability in Santiago de Chile" (Germany: BMBF-IB FKZ 01DN12033; Chile: CONICYT/BMBF 2010-005) has been run as a platform for different scientific disciplines and international research exchanges. The aim of the project design was to undertake integrated research with both, social and natural scientists.

To meet the needs of integrated research on environmental quality and the quality of life in urban areas, we carried out an explorative study with a conceptual and methodological design building on extensive literature review and on the experience of former research initiatives (Risk Habitat Megacity – Heinrichs et al., 2012; Climate Adaptation Santiago – Krellenberg and Hansjürgens, 2014). In the project *Risk Habitat Megacity* (2007–2011) the science community elaborated indicators and exchanged knowledge in scientific workshops. The project *Climate Adaptation Santiago* (2009–2012) reflected scientific state-of-the-art with stakeholders at roundtable discussions and incorporated stakeholder knowledge for added value. Starting from these findings the appropriate indicators are selected for the presented pilot project. Bio-geophysical and socio-demographic indicators were defined (according to their applicability, availability and relevance), monitored (by means of medium, high and very high resolution satellite imageries and census data) and analyzed (using image processing, statistical analysis, and Geographic Information System (GIS)). Based on former studies they are exemplified in three selected municipalities of the Metropolitan Area of Santiago (MAS) that are representative for low, middle and high income groups (Banzhaf et al., 2013). These pieces of information are supplemented by qualitative interviews with experts and residents. The bio-geophysical indicators are the quantitative measurements each of which possesses a different unit. These indicators are completed by integrating their results with the socio-demographic data from the census on block level to evaluate the environmental condition for different social strata and age groups. This outcome is then validated by means of human–environmental perception, a subjective and individual-based dimension derived from the interviews (see Fig. 1).

4. Environmental indicators as a central toolbox

The set of indicators was tailored for problem-oriented research. Such a set of indicators must be adjusted to the cultural background, geographical setting and other components that characterize the specifics of an urban region. The suggested urban environmental indicators consist of objective and quantitative as well as subjective and qualitative indicators.

Bio-geophysical indicators comprise air quality and air temperature, built-up structure and vegetation. Air pollution and thermal exposure are serious environmental problems in metropolitan areas that affect human health and well-being (Escobedo and Nowak, 2009; Chen et al., 2012). The quantitative data acquisition starts with long-term monitoring networks on air pollution and climate data. This baseline information is enhanced through the use of a new mobile and easy to handle equipment and stationary measurement towers gathered records of PM10, CO and CO_2, and air temperature. These measurements are completed by data taken routinely in urban monitoring networks, including hydrocarbons, particulate matter (PM10, PM 2.5) nitrogen oxides, tropospheric ozone, and sulfur dioxide. Furthermore, built-up structure and vegetation are the basic indicators in the built and natural urban environment (Weiland et al., 2011). Satellite images are processed and classified for the years 1993, 2002, 2006 and 2009 (ASTER and QuickBird satellite sensors), to receive information on land use and land cover (LULC), and calculation on vegetation index, is derived from MODIS satellite for the years 2000–2012 (each 16 days). These pieces of information allow us to gain an understanding of local gradients. Collocated statistical analysis of data (spatial distribution of classified high spatial resolution imagery and linear regression of seasonal vegetation index, i.e., NDVI, based on high temporal resolution imagery) explores the green infrastructure on block level, and the behaviour of chlorophyll fraction, which is a well-known indicator for vegetation cover, for long timescales.