Remote Sensing for the Mapping of Urban Poverty and Slum Areas

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Urban focused social science investigates the present-day challenges (threats) to the welfare of urban populations. Social science research mostly relies on interactions with individuals, e.g., through surveys or ethnographic research. Social science studies are attracted to remote sensing (RS) data for observing changes in physical characteristics on a local (e.g. urban studies), regional (forest cover change), or even a global scale. Those are the ones that can be coupled with social science data streams, e.g. within surveys or observation of behavior (e.g., migration, market activities). But there is no natural correspondence to grids or even small-scale administrative units. On the other hand technological requirements seriously reduce the usability of RS data in social science (SS) applications.

Urban RS has proven to be a useful tool for urban planning and urban ecological topics on different scales. But remote sensing in urban areas is by nature defined as the measurement of surface radiance and properties connected to the land cover and land use in cities. Beyond the physical measurement the question remains whether there is (or potentially could be) value for social scientists working on urban topics too. Is it more than just a pretty picture and can it fill spatial gaps in social science data?

Studies concentrating on the challenge of world urbanization still claim an unmet need for linked spatial and socio-demographic information. Rindfuss and Stern (1998) discuss the gap between social science and remote sensing research as well as the potential benefits in bridging that gap. As a justification for expensive publicly funded satellite programs, remote sensing scientists argue that remote sensing data are valuable for society. Some social scientists view remote sensing as a tool for gathering information on the context that influences social phenomena or the environmental consequences of various social, economic, and demographic processes. Social science itself can contribute to remote sensing research by validating and interpreting the data as well as investigating the implications of using remote sensing data for confidentiality.

Identifying Spatial Patterns of Urban Poverty

Attempts to address the question of whether the worldwide urbanization process is dealing with poverty have, thus far, been based on limited information. There is little scientific and operational knowledge about this process. Urban growth and land consumption patterns are only beginning to be recognized and regulation is still limited. Thus, the available information is very often inadequate for policy and planning. Due to the microstructure and irregularity of fast growing urban agglomerations as well as their direct adaptation to local conditions and terrain, a generically applicable and operational mapping of these settlements has proven difficult.

Sophisticated data and methods of image analysis are thus necessary. High resolution remotely sensed data sets (e.g. IKONOS, Quick Bird, Cartosat, World View) help to document the growth of urban areas, both quantitatively and, in combination with ancillary data sets, qualitatively. In order to analyze and evaluate intra-urban patterns as well as trends in slums across cities, such data must be taken throughout the various levels of planning processes and must incorporate all existing and documented socio-economic information and environmental issues.

Recent research activities have focused on the identification of the poor in the context of slums, informal settlements, marginal areas and low income neighborhoods, as well as their spatial embeddedness in a number of fast growing cities and megacities across the globe (Netzband et al., 2009). The spatial profile that traces poverty in complex, cluttered, uncontrolled, and fast growing urbanized regions is elaborated by means of very high resolution (VHR) remote sensing data and the associated geospatial techniques.

There are several issues in addressing the question of how remote sensing can help access the spatial configuration of urban informal settlements and living conditions. These include:

- Examining whether a spatial correlation exists between the results of the different thematic land-use/ land-cover analyses;
- Identifying land-use patterns combined with a vegetation index analysis (NDVI) and Urban Structure Types (UST); and
- Estimating spatial indicators for quality of life and vulnerability to natural hazards such as flooding.

The concept of classifying UST by remote sensing and GIS has been proved increasingly important as a baseline for urban spatial research (Banzhaf and Höfer 2008; Puissant and Weber 2002; Niebergall et al . 2007; Taubenböck et al . 2006). The UST are characterized as follows. First, they can identify different classes such as types of buildings (different types of housing, industrial and commercial sites, infrastructure), other classes of impervious surfaces (road and rail infrastructure, parking lots, etc.), and classes of open spaces (woodland, allotments, parks). Second, they can typify structures as per their individual compositions, as it takes the composition of two to three of the aforementioned classes to form an urban structure type. Therefore, the amount, connectivity, and distribution of impervious surfaces, green spaces, and other open spaces on an aggregated neighborhood scale are the goal of the quantitative spatial characterization.

In terms of the urban vegetation pattern analyzed with the NDVI, existing vegetation and other open areas are considered as positive urban structure elements because of their ecological functions (biodiversity conservation, production of oxygen, cleansing air of pollutants) as well as their social functions for individual recreational purposes and as social meeting points. Water bodies as potential carriers of disease and the road system as a potential air polluter are considered as negative urban structures in the sense that their proximity can cause respiratory and infectious diseases. Due to the rapid population growth of megacities lacking appropriate infrastructure measures, multiple health complaints result for their inhabitants.

After the classification of such single objects, the structural composition in terms of the amount and connectivity of the single objects is aggregated on a neighborhood scale to generate a UST (Banzhaf & Höfer 2008). The resulting UST layer forms the basis for socio-environmental studies on topics such as socio-spatial differentiation or for socio-ecological investigations on neighborhoods exposed to natural hazards (e.g., flooding and landslides) and also supports socio-economical research on inclusion and exclusion.

Ebert et al. (2009) have developed a new method based on the contextual analysis of VHR images and GIS data. An approach based on proxy variables derived from high-resolution optical and laser scanning data is applied, in combination with elevation information and existing hazard data. With respect to social vulnerability indicators, an object- oriented image analysis is applied to define and estimate variables such as buildings, road access (paved/unpaved) and green spaces with associated physical characteristics.

Sliuzas and Kuffer (2008) analyze the spatial heterogeneity of poverty using selected high resolution remote sensing based spatial indicators such as roof coverage densities and a lack of proper road network characterized by the irregular layout of settlements. Based on these indicators, the heterogeneity of several deprived neighborhoods was identified and different types of poverty areas were delineated. Other approaches, such as that taken by Gamba et al. (2007), analyze VHR images of disaster events to develop efficient methods for building detection.

These methods also estimate damages on the basis of pre and post event images in order to map the presence, location and status of buildings in order to provide a statistical basis for planning instruments. Such approaches exemplify the possibilities of VHR images for poverty mapping and demonstrate the scale of VHR needed to gain detailed information. In other words, data aggregation may hide the spatial variation of the urban structure, and thus, of poverty.

Studies concentrating on the challenge of world urbanization and its links to global environmental change oftern refer to a need for combined spatial, physical and socio- demographic information. Geospatial technology and RS can help to fill some of these gaps. For example, RS can help identify vulnerable groups and their spatial urban environment, which if acted upon, could support the search for equity in megacities. Methods are improving, but cross-disciplinary skills need still better integration and forethought. One major actor within the growing international network, the “100 Cities Project”, has sought to understand how urban remote sensing can best be utilized by researchers and practitioners in developing urban models, planning, and policy formulation for the sustainable development of urban areas.

This contribution attempted to show some potential benefits of bridging the gap between spatial analysis and remote sensing in social science by characterizing the deprivation of quality of life for the urban poor, who are strongly influenced by their physical environment.

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