Application of Remote Sensing Satellite Data in the Study of Urban Population-Environment Interactions

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We're living in an age of rapidly growing global population coupled with growing technological capacity and affluence. This has resulted in wide-spread land cover change. At the same time, social organization, attitudes, and values have also undergone profound changes. Issues of sustainable development, pollution prevention, global environmental change and related issues of population-environment interaction are a major concern of the global scientific community as well as common citizens and policy makers. This concern has largely been sparked by climate change and its consequences, which is threatening our very existence.

There are different branches of population-environment research in which remote sensing data can be effectively used. Remotely sensed data both from aerial photographs and satellite images in combination with Geographical Information Systems (GIS) have scientific value not only in the study of land use/land cover change (e.g., decrease in open green areas, increase in impervious areas), but also for the study of depletion of surface, ground water, increasing air pollution and land surface temperature. Using satellite data can increase accuracy (vis-à-vis ground measurements), and also take less time and lower the costs of doing research.

Remote sensing is not a new technology. Aerial photographs have been in use for at least 50 years and publicly available satellite images for almost 30 years. Since the launch of Landsat series of satellite in 1972, remotely sensed data have been observed to have scientific value for the study of human-environment relationships, especially the modification of earth surface features.

Population modeling was one of the early applications of remote sensing (de Sherbinin *et al.* 2002). Although the number of people living in an areas can not be seen directly on the remotely sensed data, it can used as an indirect tool for population estimation by using different methods. The number of dwelling units can be multiplied by the average size of the household in obtaining the estimation of population from remote sensing data (aerial photographs and high resolution satellite data) using three different methods: i) dwelling unit technique, ii) built-up areas technique and iii) housing density technique (Taragi et. al., 1999). Another method, the land use area density method (multiplying urban built up areas by average population densities) was used in estimating the population of Bhimawaram town in India using IRS LISS-I data of 1988 (Raghavaswami, 1994). Remote sensing data also assist in planning censuses by identifying areas of new development and provide regular updates of new housing stock for planners.

High resolution satellite imagery including IKONOS 1 meter/pixel, Quick Bird 0.61 meter/pixel, and IRS-1D 5.8 meter/pixel pan and multispectral data have used to detect, identify, and delineate individual house type. They can be used to separate formal and informal settlement structures, to identify new slum developments, to map the condition of the slum environment (with *in situ* data), to map greenbelts, and to understand urban encroachment (Sur et. al., 2004). Also vacant lands, urban housing, urban utilities and infrastructure, solid waste management, urban transportation and traffic planning, urban hydrology, urban cadastral and real estate, urban ecological hazards, and urban census data all can be mapped, monitored, and analyzed using remote sensing data sets.

Furthermore data obtained from remote sensing satellites offers excellent possibilities for mapping, monitoring, measuring, and managing various earth surface features. The large scale increase in urban population mainly in the developing countries leads to the discharge of large quantities of waste water. In this situation the use of remotely sensed data for surface water quality monitoring is well established and performed routinely in some water resource management studies. Parameters such as water color, depth of water, turbidity, eutrophication, and water surface temperature can be studied using remote sensing data like NASA ASTER and IRS Resourcesat-1 MSS data 15 m and 5.5 m data spatial resolution. What is attractive about remote sensing is the possibility of monitoring water quality changes caused by urbanization, which may help agencies of Government and other public health services to enforce regulatory control measures.

The Water Index (WI) and Normalized Differential Water Index (NDWI) models can be used for change-detection mapping of urban surface water bodies using these satellite data (Rahman, 2005). A groundwater survey using remotely sensed satellite data has been done by NRSA, Hyderabad. In India as part of the National Technology Mission on Drinking Water (NTMDW), mapping of potential groundwater resources has been carried out for the entire country. Although ground water cannot be seen through data from optical instruments, it can be used as an indirect tool to help in identifying the potential ground water zone (e.g., to identify the rock type, lineament, etc.).

The knowledge of surface temperature is important for urban climatology and human health. With rapid industrialization and growth in the peri-urban areas, there is a general warming and change in weather conditions. Thermal infrared remotely sensed data in the bandwidth of 10.4-12.5 µm, available from Landsat-7 Thematic Mapper and Enhanced Thematic Mapper (TM and ETM+), which has 60 m resolution in thermal region can be used to identify urban heat islands (Rahman, 2007). Thermal infrared data acquired over urban areas during the day and at night can be used to monitor the heat island effect associated with urban areas, as well as atmospheric pollution (Cornelis et al. 1998). To ascertain the influence of land-use and land-cover categories and vegetation density on surface temperature Landsat 7 ETM+ and ASTER Advanced Space-borne Thermal Emission and Reflection Radiometer (band 10-14) which has 90 m resolution datasets can be used.

There is a new generation of satellite data from GeoEye-1 which operates in 4 spectral bands (0.45-0.92 µm) and offers unprecedented spatial resolution by simultaneously acquiring 0.41 meter panchromatic and 1.65 meter multi-spectral imagery. At this resolution, one would be able to count the manholes on a city street or discern home plate on a baseball diamond. Geospatial data users in the urban planning, utility and cartographic disciplines, all of which traditionally map small features, are expected to expand their use of satellite imagery as a result (Corbley, 2009).

Another satellite is the WorldView-2 (WV-2), which is the first commercial satellite to offer data in 8 spectral bands. The WV-2 sensor provides a high resolution data panchromatic band (0.46 m resolution) and eight 8 multi-spectral bands (1.8 meters resolution) i.e. 4 traditional standard colors (red, green, blue, and near-infrared) and 4 new bands (an additional blue band (400-450 nm), yellow, red edge, and near-infrared). These 8 bands of the WV-2 satellite are well suited for variety of urban planning applications including urban planning, mapping of impervious surface maps (ISM), urban tree canopy (UTC), land use/land cover (LULC), coastal and geological mapping, agriculture and forestry mapping and others (Navulur, 2009). The satellite data with a resolution of less than 2 m from WV-2 is quite useful for the identification of housing type, assessing slums and squatter settlements, delineation of open drains (an important factors for assessing the quality of life of the people living in the low class residential areas). This data is also useful for the mapping the various urban utility and service facilities.

References

Corbley, K (2009). The Spring launch of 2007 GeoEye-1 will mark the Beginning of New Era in Commercial Earth Imagine. Earth Imagine Journal (EIJ). http://www.eijournal.com/Next_Generation.asp

Cornelis B., Binard M. and Nadasdi I. (1998). Potentials ubains et ilots de chaleur. Publications de l'Association Internationale de Climatologie, Vol. 10, pp. 223-229. Paris

de Sherbinin, A., D. Balk, K. Yager, M. Jaiteh, F. Pozzi, C. Giri, and A. Wannebo. 2002. "Social Science Applications of Remote Sensing," *A CIESIN Thematic Guide*, Palisades, NY: Center for International Earth Science Information Network of Columbia University. Available on-line at http://sedac.ciesin.columbia.edu/tg/guide_main.jsp

Navulur, K (2009). Enhance your Analysis with WorldView-2's Eight Spectral Bands. Map Asia. http://www.gisdevelopment.net/technology/rs/ma09_210.htm

Raghavaswamy, V., (1994). Remote Sensing for urban planning and management, Space Technology and Geography, Hyderabad, NRSA, pp. 295-323

Rahman A. (2007). 'Application of remote sensing and GIS technique for urban environmental management and sustainable development of Delhi, India', In Applied Remote Sensing for Urban Planning, Governance and Sustainability, (eds.) Netzband M. & Stefnow W. L., Redman, C L., Springer-Verlag Publishes, Berlin, Germany. pp.165-197.

Rahman A., 2005. Urban sprawl and its environmental impact assessment (EIA) of twin city Hyderabad-Secundrabad using remote sensing and GIS techniques. Pilot project report submitted to Centre for Space Science and Technology (CSSTEAP-UN), affiliated to United Nations, IIRS Campus, Dehradun.

Sur. U., Jain S., Sokhi. B. S., (2004). Identification/Mapping of Slum Environment using IKONOS Satellite Data: A Case Study of Dehradun, India. Proceedings, Map India Conference 2004, New Delhi

Taragi, R C S., Sokhi, B S., Sharma N D., Bisht, K S. (1999). Aerial Remote Sensing in Census Operation and Population Estimation. In Remote sensing of urban environment, (eds.) B. S., and Rashid, S.M. Manak Publications Ltd., Delhi.