SP-2006-09

LAND, URBAN FORM AND ECOLOGICAL FOOTPRINT OF TRANSPORT: APPLICATION OF GEO-INFORMATION TO MEASURE TRANSPORT RELATED URBAN SUSTAINABILITY IN DEVELOPING COUNTRIES WITH A CASE OF AHMEDABAD CITY, INDIA.

DR. MARK ZUIDGEEST, MR. MARK BRUSSEL, FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION (ITC), UNIVERSITY OF TWENTE, ENSCHEDE, THE NETHERLANDS

PROF. TALAT MUNSHI, FACULTY OF PLANNING AND PUBLIC POLICY, CEPT UNIVERSITY, AHMEDABAD, INDIA

IN COLLABORATION WITH:

PROF. DR. GEETAM TIWARI AND DR. ANVITA ARORA, VREF COE, IIT DELHI – TRIPP, DELHI, INDIA

ABSTRACT

INTRODUCTION

With the current pace of social and economic development of cities in rapidly developing countries such as India and the resulting growth of the urban population, sustainable urban transport has become a major concern. This growing concern for sustainable transport highlights the need for consistent information to support informed policy and decision making in this sector. Most issues of sustainable transport are related to a better understanding of people's travel patterns, which are highly influenced by urban form elements and socio-economic attributes. The research undertaken in the VREF Smaller Project defines urban form indicators and addresses how important indicators can be derived and quantified using spatial analysis techniques and remotely sensed imagery. The research culminates in the quantification of a Transport Ecological Footprint (TEF), an easy-to-understand measure to communicate the impacts of the transport system on the environment.

Urban form and urban land use information are intrinsically linked to travel patterns (Stead & Marshall 2001; Snellen 2001; Badoe and Miller 2000, Song and Knaap 2004) and consequently to the transport ecological footprint. The relationship between transport, land use and urban form is complicated by the fact that a change in any one of these aspects will also result in changes in the other two (Cao et al. 1998). Therefore a better understanding of the three-way dynamics between the level of land supply, urban form and travel demand would be helpful to decision-makers. Important urban form elements in this research are distance of residence from the urban centre, settlement size, mixing of land uses, compactness, provision of local facilities, density of development, proximity to transport networks, availability of residential parking, road network type, neighbourhood type and population distribution (based on income). These can all be considered as important proxies for travel pattern characteristics like the number of trips people make, average trip length, mode choice etc. A number of these indicators have been developed using remote sensing (RS) and geographical information systems (GIS) for the city of Ahmedabad in India. The extraction of urban form and land use information in developing indicators to support urban transport analysis using RS and GIS has received considerable attention recently (Zhang & Guindon 2006; Guindon & Zhang 2006; Song & Knaap 2004; Torrens & Alberti 2000). Remotely sensed imagery provides a global information resource that, when compared to traditional methods of data collection, has the ability to provide data of an entire area, including areas that are difficult to access, at a greater data acquisition frequency, reusable for different projects and in a cost efficient way (Jensen, 2000). With the arrival of high resolution satellite imagery, new imaging technology and image analysis techniques, new opportunities for more detailed mapping and analysis of the urban area have come up. At the same time, the transport planning community is increasingly showing interest in topics related to urban remote sensing research.

RESEARCH

To address these issues, a framework has been developed in this research to link urban remote sensing technology through the development of relevant indicators to TEF analysis using GIS methods and techniques. Image classification techniques are used to classify relevant urban land use characteristics, from which urban form and transport indicators, including TEF indicators, can be derived spatial modeling and analysis in GIS.

Based on the classified images several spatial indicators have been computed and mapped such as in Figure 1. These indicators are used to compute and relate urban form, travel patterns, and the TEF.

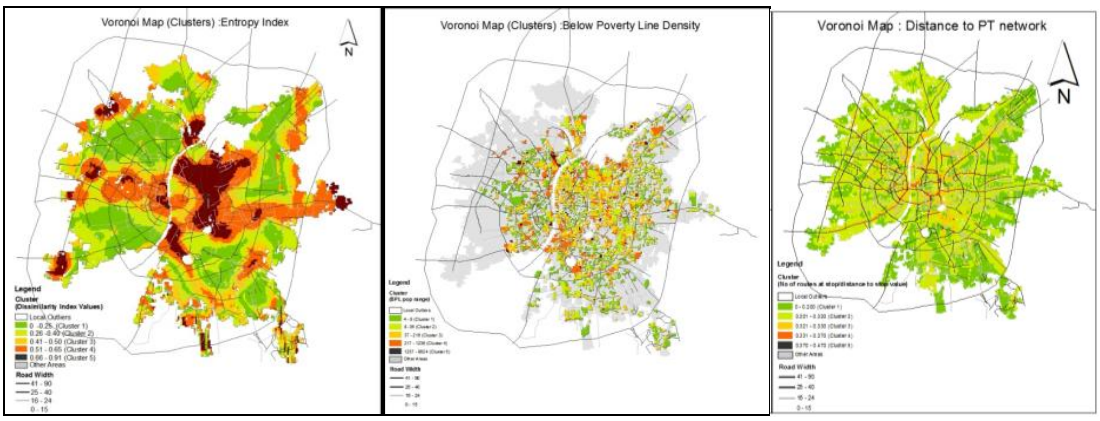
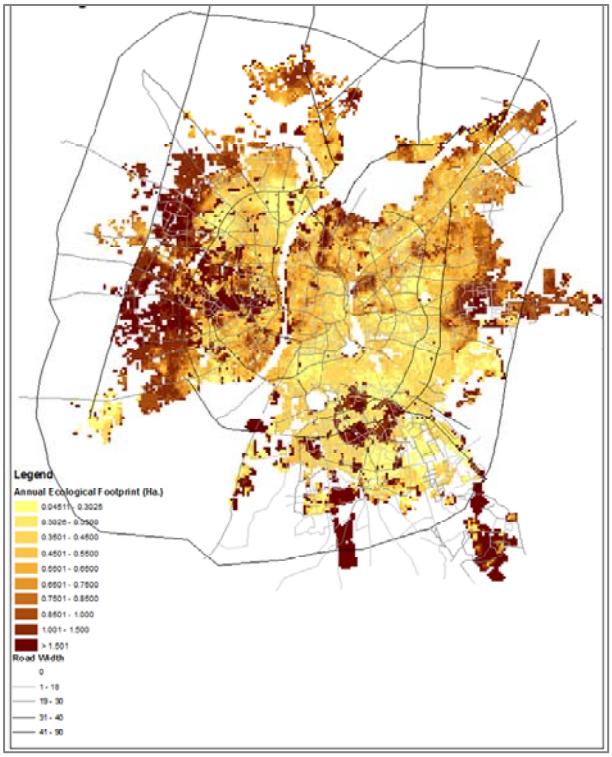


Fig. 1: urban form indicators (related to dissimilarity, poverty and accessibility)

Land use diversity and dynamics and corresponding transport infrastructure relates to travel patterns that influence vehicle fuel consumption and emissions, not to mention land conversion for transport infrastructure expansion (Barrett et al. 2001, Kenworthy and Newman 1989, Barrett 1995, Stead and Marshall 2001). These components (expressed by the urban form indicators) as well as some ancillary data play an important role in the calculation and mapping of the TEF; see Figure 2. Ancillary data such as socio-economic data, transport data, etc. also served an important role in the operationalization of the spatial indicators, to establish the relation with transport and finally in the calculation of the TEF. Several studies (e.g., Harris and Ventura 1995, Mesev 1997, Vogelmann et al. 1998, and Chen 2001) confirm that classification of satellite imagery alone does not produce adequate enough results for specific urban applications, such as transport. Urban classifications are often improved by integrating satellite-derived classifications with ancillary data in a GIS environment, and as such lead to a better understanding of urban impacts and urban drivers of environmental and social changes.



The case study location for this research is the city of Ahmedabad in India. The city is the seventh most populated city of India with around five million people. It is characterized by massive urban sprawl. This city is a typical example of rapidly urbanizing cities in developing countries faced with tremendous pressure upon its existing transport system, which raises concerns of sustainability. As many cities in developing countries suffer the same concern as Ahmedabad, the results from this research may encourage the use of remote sensing and GIS in deriving sustainability indicators such as on transport ecological footprints in addressing city's overall development towards sustainability.

Fig. 2: per capita TEF in ahmedabad

REFERENCES

- Badoe, D.A., Miller, E.J. (2000). Transportation–land-use interaction: empirical findings in North America, and their implications for modeling. *Transportation Research Part D*, 5, 235–263.
- Barrett, G. M. J. (1995). Transport emissions and travel behavior: A critical review of recent European Union and UK policy initiatives. *Transportation*, 22(3), 295-323.
- Barrett, G.M.J., Scott, A., Vallack, H. (2001). *The Ecological Footprint of Passenger Transport in Merseyside*. Stockholm Environment Institute, University of York, U.K.
- Cao, C. Strauss, T., Souleyrett, R.R., Shinn, R.D., 1998, Transportation and Urban Form: A Case Study of the Des Moines Metropolitan Area. *Crossroads 2000 proceedings*, 232-237.
- Chen, K. (2001). An Approach to Linking Remotely Sensed Data and Areal Census Data. *International Journal of Remote Sensing*, 23(1), 37-48.
- Guindon, B., Zhang, Y. (2006). Using satellite remote sensing to survey transport-related urban sustainability. Part II. Results of a Canadian urban assessment. *International Journal of Applied Earth Observation and Geoinformation*, 9(3), 276 – 293.
- Harris, P.M. and Ventura, S.J. (1995). The Integration of Geographic Data with Remotely Sensed Imagery to Improve Classification in an Urban Area. *Photogrammetric Engineering & Remote Sensing*, 61(8), 993-998.
- Jensen, J.R. (2000). *Remote Sensing of the Environment, An Earth Resource Perspective*. Pentice Hall, NJ.
- Kenworthy, J., Newman, P. (1989). *Cities and Automobile Dependence*. Gower, Aldershot.
- Mesev, V. (1997). Remote Sensing of Urban Systems: Hierarchical Integration with GIS. *Computers, Environment and Urban Systems*, 21(3/4), 175-187.
- Snellen, D. (2001). Urban Form and Activity-Travel Patterns: An Activity-Based Approach to Travel in a Spatial Context. *PhD Dissertation*, Eindhoven University of Technology.
- Song, Y. and Knaap, G. J. (2004). Measuring Urban Form: Is Portland Winning the War on Sprawl. *Journal of the American Planning Association*, 70(2), 210-225.
- Stead, D. and Marshall, S. (2001). The Relationships between Urban Form and Travel Patterns. An International Review and Evaluation. *European Journal of Transport and Infrastructure Research*, 1(2), 113-141.
- Torrens, P. M., and Alberti, M. (2000). Measuring Sprawl. *Centre for Advanced Spatial Analysis (CASA) Working Paper Series*, 27, CASA, University College London.
- Vogelmann, J.E, T. Sohl and S.M. Howard. (1998). Regional Characterization of Land Cover Using Multiple Sources of Data. *Photogrammetric Engineering & Remote Sensing*, 64(1), 45-57.
- Zhang, Y. and Guindon, B. (2006), Using Satellite Remote Sensing to Survey Transport related Urban Sustainability Part 1: Methodologies for Indicator Quantification, *International Journal of Applied Earth Observation and Geoinformation*, 8, 149 -64.