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Delhi's land cover change in post transit era

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ABSTRACT

Growing urbanization and recent Mass Rapid Transit System (MRTS) play an important role in land cover change in Indian cities. However, understanding about direction and magnitude of this change is limited, especially in reference to MRTS introduction, which is required to assess sustainable urban futures. Thus, this study attempts to assess pattern of land cover change, paying special attention to the development of MRTS (both metro lines and stations) in the National Capital Territory of Delhi. Land covers are classified using Landsat images from year 2001 and 2011. In order to measure transformations in developed areas, this study employs maximum likelihood supervised classification and performs buffer analyses along the metro lines and stations. The results reveal that growth of built-up area is higher in peripheral districts, whereas relatively low along the MRTS. This study indicates that ongoing development process needs corrective measures, such as increasing built-up areas across the metro stations and lines, and planned provisioning of physical and social infrastructure in peripheral areas to induce sustainable urban development. To implement these spatial interventions, robust implementation strategies are needed.

1. Introduction

Urbanization provides opportunities for employment, better housing, education, knowledge and technology transfer, and ready markets for the agricultural products, but enormous stress on natural resources, existing social services and infrastructure (Rees, 1992). India, one of the rapidly urbanizing and economically prospering nations of Asia, is full of promises and challenges. Urbanization patterns of developing and developed economies differ in many aspects. Rapid growth and proliferation of informal settlements, in particular, are unique only to developing countries. Urban India accommodated 377 million people (31.2% of total population) as per Census 2011, the second largest urban population in the world (after China), spreads across 7935 urban centers, including 53 Urban Agglomerations (UAs), which are defined as cities with over a million people (Census of India, 2011). The annual urban population growth rate during the last decade (2001–11) was 2.76%, relatively high in comparison to developed economies (UNDESA, 2011). The growth rate of built-up area is higher than the growth rate of population, for instance, global estimate shows that by 2030 built-up area will be tripled, while urban population will be doubled (Angel et al., 2005). This would create excessive pressure on land for development projects, particularly in the developing economies. It was estimated that the overall demand of land for various Government projects/schemes during the XII Five Year Plan (2007–12) would be over 0.3 mHa (Sethi, 2011). This high population growth rate, pressure on land, along with indiscreet urban policy and institutional environment has led to proliferation of unplanned and imbalanced development in urban India.

In 1985, the National Capital Region (NCR) of Delhi came into existence. The motto of the NCR was to diffuse the population in the region and alter the changes in the land use (NCR Board, 2005). In this context, this study maps urban growth patterns of Delhi, the capital city of India, particularly in reference to Mass Rapid Transit System (MRTS) and indicates potential directions for sustainable urban futures. Open areas like agriculture, forests, and scrubs have drawn greater attention among city managers and policy-makers because of their growing role in providing ecosystem services, as well as mitigating greenhouse gas emissions and adaptation to climate change (Avtar, Yunus, Kraines, & Yamamuro, 2015; Emmanuel & Baker, 2012). Strong linkage has been established between built-up density and energy consumption in cities, at least in developed economies. Thus, it may also be construed that densification is by and large a pre-requisite to urban sustainability. For instance, increasing built-up density reduces gasoline consumption (or

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expenditure in public and private vehicles) (Ahmad, Baiocchi, & Creutzig, 2015; Creutzig, Baiocchi, Bierkandt, Pichler, & Seto, 2015; Newman & Kenworthy, 1989). In addition, densification promotes the use of public transport systems, which is predominantly used by disadvantaged communities that leads to inclusive mobility. Depending upon the nature of spatial policy, MRTS follows densification or sprawl, as observed in case of transit oriented development. In this backdrop, this study investigates the influence of MRTS on land cover change in Delhi. Findings reveal that built-up area has increased, whereas agriculture area has decreased significantly. Notably built-up area has largely been added in peripheral areas rather than along transit. Based on these findings we suggest for transit oriented development, and provision of urban services in peripheral areas through robust implementation strategies.

Following introduction, Section 2 presents literature review on understanding the impact of urban rail system on land cover change. Subsequently, Section 3 specifies the methodological framework, and Section 4 presents results from the remote sensing–geographical information system (RS–GIS) based analysis. Finally, Section 5 synthesizes the findings and presents policy implications.

2. Urban rail systems and land cover change

Urban rail systems influence land cover/use change, urban mobility, property values, and greenhouse emissions, among others, which affect urban sustainability in both ways positive as well as negative. For positive outcomes, merely introduction of transits is not sufficient, but require comprehensive interventions. Today one of the major challenges in land use planning is how it deals with urbanization, particularly rapid land cover change, over and above that induced by mass rapid transit systems. For decades, inquiry related to influence of transportation infrastructure investment on urbanization patterns has been front and center of urban and regional planning discourse. Historically, changes in urban forms, regardless of its shape and density follow the evolution of transportation technology, especially the innovation of automobile (Muller, 2004). The contribution of several transportation infrastructures, such as highways, to suburbanization has been analyzed intensively, whereas discussion concerning urban rail system is limited (Baum-Snow, 2007). The evolution of sprawl in American cities, in particular, can be traced back to how car-oriented infrastructure created urban sprawl as development reinforced the way people travel (Handy, 2005). Over the last decade, research concluded that automobile-oriented urbanization has become the main engine for metropolitan growth pattern, including directing its population movement (Baum-Snow, 2007; Handy, 2005).

Despite several studies investigating the relations between urban rail system and urbanization, yet many aspects remain unexplored, particularly related to emerging economies. The existing literature primarily focuses on challenges and prospects of urban rail development to residential and commercial property, including causal effect between rail stations and property values (Anas & Armstrong, 1993; Bowes & Ihlanfeldt, 2001; Cervero, 2004; Cervero & Duncan, 2002; Dewees, 1976), and rail transit and economic development (Bollinger & Ihlanfeldt, 1997; Cervero, 1984, 2004). Studies also explore how urban rail systems curb sporadic urbanization and direct metropolitan growth (Guiliano & Agarwal, 2010).

Dulal, Brodnig, and Onoriose (2011) look at the role of urban design forms – settlement density – housing and employment activities and the effects they could have in reducing travel demands, motor vehicle dependency and GHG emissions. They infer that urban planning can be very effective in shifting private vehicle dependency to public and other alternative environmentally friendly modes of transports (such as walking and cycling), in the long term. A mixture of high residential development and employment density could influence shorter commuting trips and a reduction in private vehicle use, if supported by an efficient public transport system and appropriate fiscal and regulatory instruments. Santos, Behrendt, and Teytelboym (2010) rightly suggest that a sustainable model for transport policy requires integration with land-use policies. These may be somewhat limited within the bounds of existing cities, but as cities grow and new cities are built, urban planners must emphasize on land use for sustainable transport in order to reduce congestion and CO_2 emissions.

In this context, Suzuki, Cervero, and Iuchi (2013) for a World Bank study explore the complex process of transit and land-use integration in rapidly growing cities in developing countries. They report that well-integrated transit and land development create urban forms and spaces that reduce the need to travel by private motorized vehicles. Areas with good access to public transit and well-designed urban spaces, that are walkable and bikeable, become highly attractive places for people to live, work, learn, play and interact. The study draws lessons from global best case examples of transit-oriented metropolises that have direct relevance to cities in developing countries. It differentiates articulated densities (that are strategically introduced across parts of the metropolitan area) and average density, and seeks for highly concentrated development rather than dispersed ones for transit and land-use integration. It further mandates that in order to integrate transit and land-use, there is a need for strategic vision and enabling institutional and regulatory framework.

From a methodology perspective, a limited number of researchers have relied on remote sensing data to assess direct and indirect effects of urban rail system and urbanization (Seto, Güneralp, & Hutyra, 2012). They developed spatially explicit probabilistic forecasts of global urban land-cover change and direct impacts on biodiversity hotspots and carbon biomass. However, some researches utilize transportation models to examining the relationship between the availability of transportation infrastructure and services and the pattern of house prices in an urban area (Martínez & Viegas, 2009). Moreover, empirical investigation from developing countries that may account for the effect of urban rail system on land cover change is limited.

An urban rail system, in theory, is seen as a tool to reduce the use of automobile, improve the environment while increasing urban density and curb urban sprawl (American Planning Association, 2002). It is normatively expected that urban rail investment will induce land cover change yet research predicts ambiguous results according to the status of existing transit system, as it may or may not change the relative accessibility significant enough for residents and business to change their property location in the proximity of rail system (Giuliano, 1995). Thus, this paper aims to build empirical evidence to fill the research gaps in explaining whether and how urban rail system and its subsequent complementary policies produce land cover change. Using the newly built metro in the Delhi Metropolitan Area as the case, this paper analyzes whether and to what extent the urban rail transit initiates a change of land cover along the metro lines/stations and the peripheral areas.

3. Methodology

To appreciate the relationship between urbanization and Land Use and Land Cover (LULC), a quantitative and evidence based methodology is adopted, at multiple scales—the city, the sub-city (district) and the local station level. Decadal urban population data for the city is available since 1931, enumerated by the Census of India. It includes significant demographic indicators such as migration and natural increase, which help in comprehensively understanding the pattern of urbanization. LULC for Delhi have regularly been documented since the first Master Plan of Delhi, 1962 (MPD), prepared by the Delhi Development Authority (DDA). Thereafter, temporal data is available for successive plans i.e. 1981, 2001 and 2021. Since one of the key interests of this research is to analyze local changes in land cover in the recent past, evidence available from remote sensing data is used. Satellite imageries acquired from Landsat satellite for the year 2001 and 2011 are used.

Remotely sensed data have been extensively used to monitor and model urban change (Banerjee & Srivastava, 2013; Dewan &