Chapter 11
Optimising Green Spaces for Sustainable Urban Planning: A Case of Jaipur, Rajasthan

Amrita Bajaj and Ajay Kumar

Abstract World urban population has crossed the mark of 50% in 2009 but in India the urban share of population is just 32% of the total population. In absolute figures, the urban population of Asia and particularly China and India is the highest among all countries. Indian cities are growing very fast and with that the demand of housing and other infrastructure is also increasing. The new built-up comes on either forested area or agriculture land, and in both the cases tree cover is reduced significantly. In India, the total forest cover is already low and such land-use land cover changes threaten the sustainability of environment. The increasing built-up area accentuates the heat island phenomenon making cities hotter and suffocating. The green spaces in urban built-up environment are important to maintain the environmental equilibrium. Having more green spaces in one part of the city is not the solution to the problems; the green spaces should be uniformly distributed. Therefore, the present study aims to identify sectorwise distribution of green spaces and built-up area in order to optimise the future distribution of green spaces for the sustainability of urban environments. The city chosen for the study is Jaipur, Rajasthan as the city has dense green cover in the northern part of the city but very sparse tree cover in the south. The study suggests three-tier solution to optimise the green spaces viz. (i) Conservation in the north part; (ii) Terrace gardens in the central and old part of the city and; (iii) Horizontal expansion of green spaces in the south of the city.

Keywords Green spaces · Optimization · Land-use land cover · NDVI · NDBI

Acronyms

NDVI	Normalised difference vegetation index
NDBI	Normalised difference built-up index

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ESRI Environmental Systems Research Institute
GLOVIS Global visualisation viewer
USGS United States Geological Survey

11.1 Introduction

The growing proportion of human population living in urban areas, and consequent trends of increasing urban expansion and densification fuel a need to understand how urban form and land use affect environmental quality, including the availability of urban green spaces (Davies et al. 2008). The quality of urban environments has increasingly been regarded as an important issue. In particular, the extent, composition and access to green spaces within urban areas have been shown to have significant impacts on the quality of life of urban populations. Their coverage and composition varies in complex ways across urban areas (Duhme and Pauleit 1998; Pauleit and Duhme 2000; Pauleit et al. 2005; Gaston et al. 2005), and is intimately associated with urban form, the patterning of the features of urban areas. To date, emphases on understanding these associations have primarily been concerned with categorising and quantifying the different forms of green space (Brande et al. 1990; Swanwick et al. 2003), comparing their characteristics and influence on environmental performance across relatively small numbers of contrasting study areas (Pauleit et al. 2005; Tratalos et al. 2007), and how temporal change in green space extent affects such performance for the same areas (Pauleit et al. 2005). Such studies have undoubtedly provided many valuable and complementary insights, but the existence and form of broad relationships remains hard to extract. Key issues concern the need to understand the continuum of variation observed across entire urban areas, particularly with respect to the shape of relationships between the extent or quality of green space and different components of the urban built environment. The present study aims to identify that sectorwise distribution of green spaces and built-up are in the Jaipur city and suggests future strategy for optimization of green spaces in Jaipur.

11.2 Need of Green Spaces

11.2.1 Environmental Benefits

Urban green spaces supply to cities with ecosystem services ranging from maintenance of biodiversity to the regulation of urban climate. Urban heat island effect can increase urban temperatures by 5 °C (Bolund and Sven 1999). Therefore, adequate forest plantation, vegetation around urban dweller's house and

management of water bodies by authorities can help to mitigate the situation. Pollution in cities as a form of pollutants includes chemicals, particulate matter and biological materials, which occur in the form of solid particles, liquid droplets or gases. Urban greening can reduce air pollutants directly when dust and smoke particles are trapped by vegetation. Research has shown that in average, 85% of air pollution in a park can be filtered (Bolund and Sven 1999). Urban green spaces in over-crowded cities can largely reduce the levels of noise depending on their quantity, quality and the distance from the source of noise pollution. Green spaces do function as protection centre for reproduction of species and conservation of plants, soil and water quality. Urban green spaces provide the linkage of the urban and rural areas. They provide visual relief, seasonal change and link with natural world (Francis 1997).

11.2.2 Economic and Aesthetic Benefits

Using vegetation to reduce the energy costs of cooling buildings has been increasingly recognised as a cost-effective reason for increasing green space and tree planting in temperate climate cities (Heidt and Neef 2008). Plants improve air circulation, provide shade and they evapotranspire. This provides a cooling effect and help to lower air temperatures. A study in Chicago has shown that increasing tree cover in the city by 10% may reduce the total energy for heating and cooling by 5–10% (Sorensen et al. 1997). Areas of the city with enough greenery are aesthetically pleasing and attractive to both residents and investors. The beautification of Singapore and Kuala Lumpur, Malaysia, was one of the factors that attracted significant foreign investments that assisted rapid economic growth (Sorensen et al. 1997).

11.2.3 Social and Psychological Benefits

People satisfy most of their recreational needs within the locality where they live. Urban green spaces serve as a near resource for relaxation; provide emotional warmth (Heidt and Neef 2008). In Mexico City, the centrally located Chapultepec Park draws up to three million visitors a week who enjoy a wide variety of activities (Sorensen et al. 1997). For people who were exposed to natural environment, the level of stress decreased rapidly compared to people who were exposed to urban environment whose stress level remained high (Bolund and Sven 1999). In the same review, patients in an hospital whose rooms were facing a park had a 10% faster recovery and needed 50% less strong pain-relieving medication compared to patients whose rooms were facing a building wall. This is a clear indication that urban green spaces can increase the physical and psychological wellbeing of urban citizens. In another research conducted in Swedish cities showed that the more time

people spend outdoors in urban green spaces, the less they are affected by stress (Grahn and Stigsdotter 2003). Certainly, improvements in air quality due to vegetation have a positive impact on physical health with such obvious benefits as decrease in respiratory illnesses.

11.3 Study Area

Jaipur is probably the first planned city of Modern India. The foundation of the city of Jaipur was established by Sawai Jai Singh II (1700–1743) in 1727. The city was designed by Sawai Jai Singh II himself and further developed and monitored by his renowned counsellor Vidyadhar. The city planned in the gridiron pattern was built with extraordinary foresight and futuristic planning and is probably the only eighteenth century walled city in India that can still cater to the present-day pressures of vehicular traffic on roads. The site selected for establishing the capital of Jaipur was a valley located south of Amber and the plains beyond, a terrain that was the bed of a dried lake. There used to be dense forest cover to the north and the east of the city. The Jaipur city is situated 254 km south-west of Delhi and is surrounded by Aravalli ranges from two sides. Jaipur city witnessed fast growth both physical and demographic, i.e. with 2001 population at 2.32 million, and in 2011 census the population was 3.07 million, the city is likely to attain a population 6.49 million by the year 2025 with 5.3% annual growth rate. Jaipur has a semiarid climate, receiving over 650 millimetres (26 in.) of rainfall annually but most rains occur in the monsoon months between June and September. Temperatures remain relatively high throughout the year, with the summer months of April to early July having average daily temperatures of around 30 °C. During the monsoon, there are frequent, heavy rains and thunderstorms. The winter months of November to February are mild and pleasant, with average temperatures ranging from 15 to 18 °C and with little or no humidity though occasional cold waves lead to temperatures near freezing (Fig. 11.1).

11.4 Methodology

The use of GIS for landscape planning goes as far back as Warren Manning and Ian McHarg, both landscape architects who, in the nineteenth and twentieth centuries, already used map overlays as the framework for ecology-based land-use planning, setting the basic fundaments of GIS (Dangermond 2008). Since then, GIS tools have evolved and diversified, and thanks to their powerful geo-processing and analyse capabilities have greatly contributed to the areas of environmental planning, design and engineering, and have been increasingly used for landscape architecture, particularly digital landscape analyse and visualisation (Buhmann and Ervin 2003).

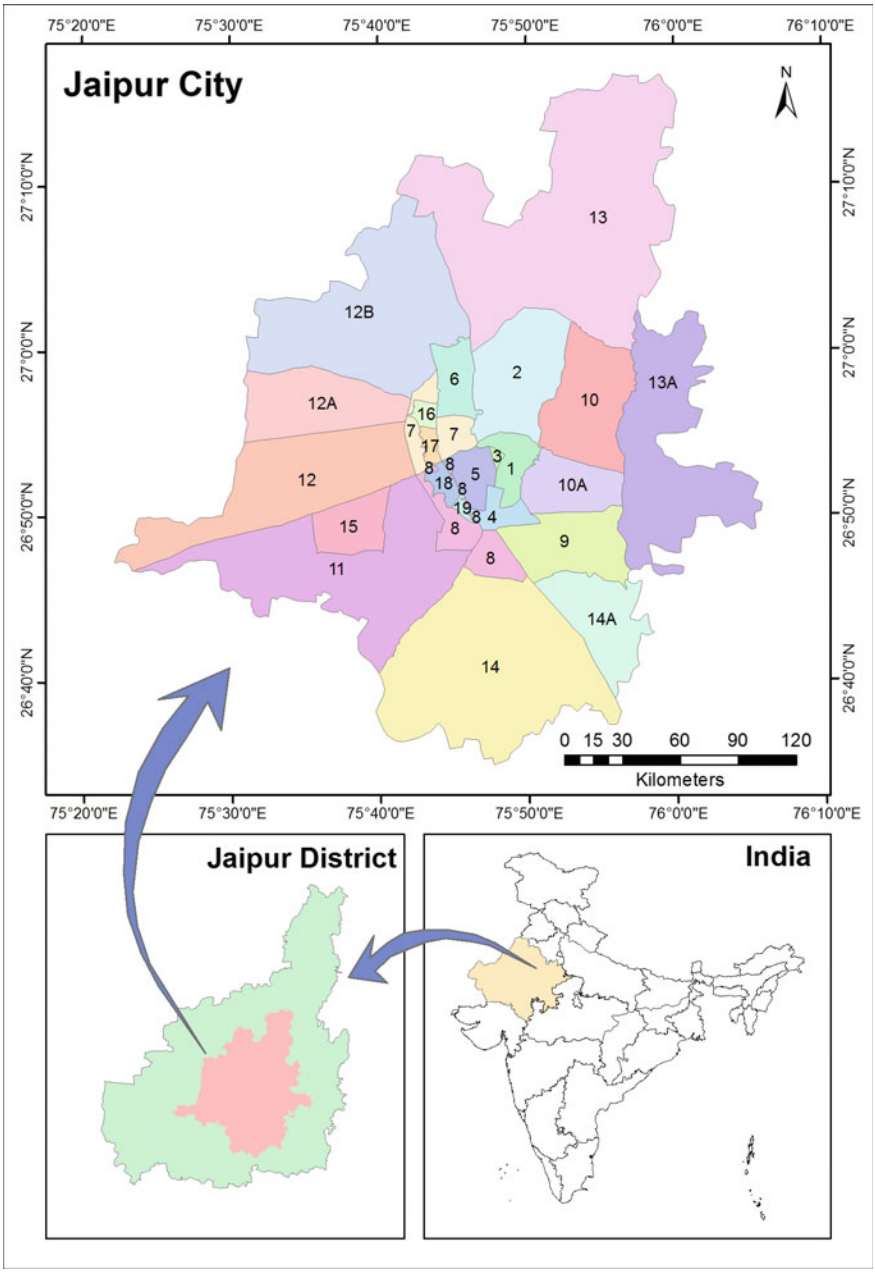

Fig. 11.1 Location of the study area

The GIS technology has become particularly useful to create and implement models for problems of spatial nature (Buhmann et al. 2002; Maguire et al. 2005). GIS tools help not only to process, analyse and combine spatial data, but also to organise and integrate spatial processes into larger systems that model the real world (ESRI 2000). As abstractions and simplifications of complex systems and processes, these spatial models can be powerful tools for prediction, forecasting and planning, used to assess scenarios and reduce uncertainties about the future (Goodchild 2005).

In the present study, ArcGIS has been used for deriving the results. Landsat 8 Satellite data for year 2013 has been obtained from GLOVIS (USGS) website. The Jaipur Development Authority administrative boundary has been used for the analysis. Satellite data has been pre-processed followed by calculation of Normalised Differentiated Vegetation Index (NDVI), Land-use land cover and Normalised Differentiated Builtup Index (NDBI). Finally zonal statistics tool has been used in ArcGIS and sectorwise green areas and built-up areas has been extracted (Fig. 11.2).

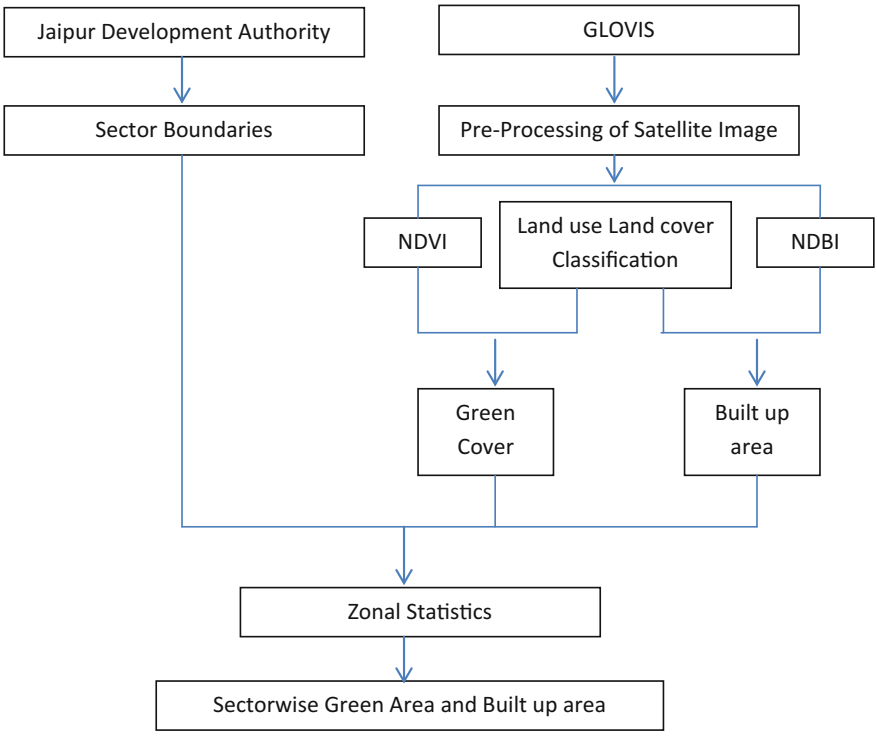

Fig. 11.2 Research methodology

11.5 Results and Discussion

The NDVI analysis of satellite image shows that the ridges on the north and east side of Jaipur are the most green areas of the city. The northern and eastern sectors of the city have about 20% of area under green cover, whereas the southern plain region is having below 8% green cover. The central part of the city has green cover ranging between 11 and 17% (Fig. 11.3). On analysing the built-up area, it is concluded that the central part of the city is the most densely built area of the city. The northern and southern peripheral sectors of the city have below 10% built-up area compared to more than 50% built-up area in the old city and central part of the city (Fig. 11.4).

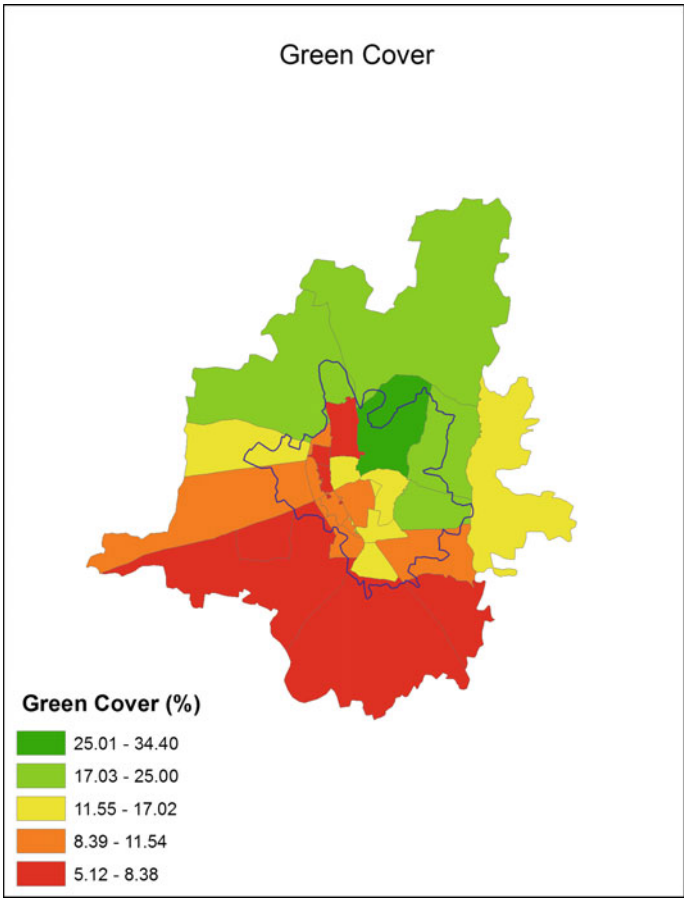

Fig. 11.3 Jaipur development authority sectorwise green cover in Jaipur city. *Source* Author

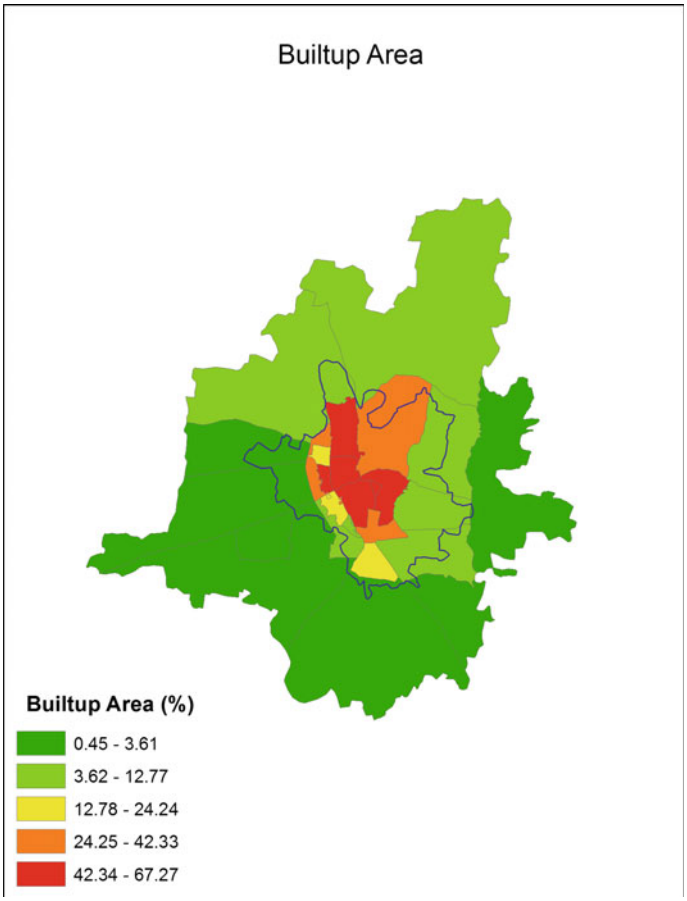

Fig. 11.4 Jaipur development authority sectorwise built-up area in Jaipur city. *Source* Author

11.6 Optimising Green Spaces for Sustainability

The different part of the city needs different treatment to increase the green areas

(i) ***Conservation of Greenery in North***
The north and east part of the city has good amount of green cover, but expansion of the city and stone mining are big threats to such green spaces. The area in Amer ward is restricted for construction but still construction activities are continuing to ruin the natural environment. Therefore, there is a need to protect the existing green cover in the north and east part of the city.

(ii) ***Terrace Gardens in Central Part***
It is not possible to bring down the existing construction in the old and central part of the city. The green spaces in these areas are very low. In order

to increase the green spaces, the government should promote terrace gardens in these parts of the city. It should be made mandatory that the new buildings should have low-height parkings in front part of the plot and the roof of such parking should be occupied by the gardens. Such initiative will solve the problem of green space as well as parking.

(iii) **Expansion of Green Spaces in South**
The city is expanding fast in the south and west part of the city. The south-west part of the city is plain region. There is ample opportunity for government to pre-plan the green areas in this region and promote sustainability

11.7 Conclusion

This study shows that major gradients of urban densification and topography are important drivers of the availability and quality of urban green spaces. The extent of the buildings' footprint in an area is not correlated in the city, as in south of the city both green areas and built-up areas are low. Though, the buildings' footprint has the more potent negative influence on the quality of green space as measured by levels of tree cover and especially overall vegetation cover. Elevation and slope of terrain reveal a positive relationship with green space metrics, where elevation and slope are more positive predictor of extent of green space, the positive influence of slope increases between the prediction of extent and quality of green space, and is the best-fit predictor of levels of tree cover.

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