Chapter 8: Summary
8.1. Summary

Land use–land cover change (LULCC) is a crucial driver of global change. It is easy to understand, detect and forecast the direct effects of LULCC. Still, many subsidiary and cumulative effects of landscape change are unforeseen and difficult to predict. The decisions of planning and policy making must deal with these inadvertent and secondary consequences of land-use decisions, which are becoming more predominant with globalization (Liu & Yang, 2015; Mayer et al., 2016). Land use policies can draw from all the information provided by LULC about a land parcel.

Land use and land cover conversion can have extensive landscape-level impacts which may be positive or negative. However, most of them harm ecosystem services of biodiversity, habitats, and water and nutrient cycles. They form a nexus with climate change by giving a positive feedback through connections between the air, water and biota. Some of the land conversions like agriculture or pasture lands to forests have positive effects on ecological services. While other conversions like logging, tree felling or monoculture plantations for growing commercially viable plants, can have long-term bequest effects on ecological dynamics, including disturbance, invasion and succession (Erb et al., 2016; Houghton & Goodale, 2004; Mayer et al., 2016). Most crucial drivers of land-use conversion are globally are deforestation, agricultural and urban expansion (Ramankutty et al., 2007; Schwilch et al., 2015; Searchinger et al., 2008).

Studies depicting the effects of land-use on ecological factors have been documented across the globe. Global effects have been documented by (De Baan, Alkemade, & Koellner, 2013; Guo & Gifford, 2002; N. M. . Mahowald et al., 2017; Newbold et al., 2015; Poeplau & Don, 2015). Many scientists have also conducted and reported studies on land-use change and their impacts in India (Bhuyan et al., 2003; Mangalassery, Dayal, Meena, & Ram, 2014; Mehta et al., 2013; Paul & Nagendra, 2015; Roy et al., 2015; Sha et al., 2013). However, there is still huge scope to perform a comparative analysis of ecosystem services in different land-use systems. Very few studies have explored this facet of land-change science in India (Ghosh et al., 2006; Konig, 2012; Mangalassery et al., 2014; Srivastava et al., 2016) though many studies have been conducted across the
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world (Bryan et al., 2015; Croft et al., 2012; Edmondson et al., 2014; Kessler et al., 2005; Lambin & Meyfroidt, 2011; Maitima et al., 2009; Manlay et al., 2007). There have been a couple of studies on land-use mapping, biodiversity, carbon stocks and soil characteristics around Ahmedabad and Gandhinagar including some governmental and non-governmental projects (Arya et al., 2017; Gadani, 2011; GEER Foundation & Report, 2014; Goswami & Khire, 2016; Jaiswal et al., 2014; Karlikar & Solanki, 2014; Maitreya, 2015; Patel, Patel, & Pandya, 2014; Revenue Department, 2012). These studies have only targeted at the land-use mapping or other ecosystem services. This gave us the knowledge gap and an opportunity to look at the land-use change pattern and the three key associated ecological parameters in correlation with one another.

The current study tried to assess land use patterns and assess the Gandhinagar district for its ecological parameters. The main objectives of this work were i) to map the changes in land-use and land-cover of the region in two decades from 1995-2016 ii) predict a future land-use change in the subsequent decade iii) assess plant diversity across land-use systems in the study area iv) estimate carbon stocks in different land-use types and v) evaluate soil characteristics across land-use patterns in Gandhinagar district.

By utilizing the patterns and trends in land-use/land cover change in four different periods, we modeled land-use scenario of 2025 with the help of a modeling software. A mapping of land use/land cover change and prediction of future land-use scenario was performed. On the basis of the changes happened in two decades a multiple linear regression model was applied and extrapolated in future to obtain a land-use land-cover scenario of 2025. The Markov chain analysis was applied to these LULC maps for prediction supported by a GIS-based model inbuilt in IDRISI Terrset.

To assess the ecological parameters, stratified random sampling was performed. The study design consists of mapping LULCC in Gandhinagar district. About four or five sites were selected in each land-use class with at least one site in each of the four cardinal directions viz., north, east, west and south. At each site 2-3 quadrates of dimensions 31m * 31m were laid with a distance of at least 100 m between the quadrates. Out of 9
different land-use classes classified in LULC map, 5 classes were analyzed for the study of plant diversity viz., vegetation, scrub, rural, urban and others.

The prediction result provided an improved understanding about the amount and location of probable changes spatially and quantitatively. According to prediction results for 2025, an increase of 129.37 km² in built up area whereas slight increase of 13.46 km² in agricultural land was estimated between 2016 and 2025. Furthermore, the prediction results for 2050 showed that built up area increased by 184.84 km², while agricultural land decreased by 32.26 km² between 2016 and 2050. The vegetation-covered area was also found to be decreased by 118.73 and 157.05 km² during 2016–2025 and 2016–2050, respectively.

Further, objectives were to assess the ecological characteristics of different land-use systems obtained from the land-use map. Vegetation diversity and carbon stocks along with soil parameters were evaluated for all the land-use categories.

Biodiversity is one of the critical indicators of anthropogenic impacts on ecosystem health. In this work, we tried to assess the changes in plant diversity covering both woody and non-woody species. The degree of invasion and the number of invasive species as well as weeds were also assessed in the land-use classes analyzed for plant diversity. Vegetation class showed maximum diversity ($H’= 2.72$) and density of plants (665 stems per ha.). The urban class (412.2 stem per ha.) performed better than the classes, scrub (266 per ha.) and others (305 per ha.) in terms of stem density. $H’$ values declined in the order vegetation > rural > scrub> others > urban. Families Fabaceae (Mimosaceae, Malvaceae, and Asteraceae) showed maximum number of species. Plantation was observed to be carried out in all land-use classes but were mostly mono-culture. All the landscapes seem to be taking a similar structure due to plantations everywhere. Natural landscapes seem to have vanished except in remnant patches of natural forest.

It was found that natural vegetation consisting of forests sequestered more carbon than other land-use systems. *Azadirachta indica, Prosopis juliflora and Acacia nilotica* were the top three species leading in total carbon stocks. The results obtained showed more variations in scrub class. This was due to plantations carried out in some scrublands while
the others were left as wastelands. Mean values of carbon stocks were highest in vegetation class (80 Mg C/ha) was followed by urban and rural nearly equal (50 Mg C/ha) and lowest in others (about 20 Mg C/ha). These results are not truly proportionate to the results of vegetation diversity but indicate the need of more diverse plants species to be included in plantation of urban and industrial areas and maintenance of plantations.

Land-use change drastically alter soil characteristics and increased soil carbon emissions. This study depicted the variation in six soil properties among land use classes and tried to study their causes. Areas of reserve and protected forests were reported to have highest carbon amounts (about 3 % of SOC) while ‘others’ class had (0.98%) very low and barren areas had (0.5%) lowest SOC. Nitrogen values did not show much difference among the land-use classes with peak values of .15 in agriculture and lowest values of 0.08 in barren areas. Phosphorous was highest in agricultural areas (182 Mg/ha), due to fertilizer inputs, followed by vegetation (97.3 Mg/ha) and lowest in barren areas with second lowest in urban (63 Mg/ha). Potassium content was also very high in agricultural fields (12 Mg/ha) ensued by forests (6 Mg/ha) and lowest in urban areas (4.3 Mg/ha). It was found that vegetation contained most fertile soil. Apart from the industrial effects of deposition, soil nutrients were found to be depleted in urban, scrub and barren areas as compared to vegetation and rural areas. The chief factor driving this can be attributed to the lesser amount of vegetation in anthropogenic land use systems.

The paucity of data on the comparative analysis of ecological parameters in different land-use systems in Gandhinagar region was the key motivation to conduct this research work. The information derived from this study will help to develop a better understanding of the impacts of land-use change activities carried out as a part of development projects in the region. The predicted land-use scenario emphasizes the need of a critical review of the developmental projects by the governmental and non-governmental organizations to give more weightage to ecosystem services as a part of sustainable development framework.