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Urbanization as a Land use change driver of Forest Ecosystem: Land-Use Pattern Change Analyzed for the Indore city

Zareena Begum Irfan[a,*], Anu Anna Jo[b] and Mohana Mondal[c]

[a,]Associate Professor, Centre of Excellence in Environmental Economics, Madras School of Economics, Gandhi Mandapam Road, Chennai – 600025, Tamil Nadu, India

[b, c]Research Associate, Centre of Excellence in Environmental Economics, Madras School of Economics, Gandhi Mandapam Road, Chennai – 600025, Tamil Nadu, India

ABSTRACT: *Hotspot analysis involves either the identification or ranking of political and ecological regions on the basis of their biodiversity. A biodiversity hotspot is a region that has an extraordinary amount of diversity. Anthropogenic activities in an ecosystem have caused extinction of certain flora and fauna, or they are entering into an endangered category. Thus identification of such areas is important for the future conservation/restoration program. India, rich in its flora and fauna and with a characteristic of increasing population is an appropriate site for the study. Methods of study include data compilation, defining threat on a per-species basis: the species load, using multiple regressions for hotspot analysis.*

I. INTRODUCTION

Humans are dependent on ecosystem services such as air, water, food and for provision of materials for development and construction. While the importance of ecosystems and their services cannot be underestimated, a wide range of human and natural processes have altered the way they function eroding their capacity to deliver these vital ecosystem services for human well-being. With the development of social economy, human activities (urbanization, deforestation, agriculture reclamation, etc.), as external stress factors, is accelerated the wetland landscape change such as area shrinking, landscape fragmentation and ecological function degradation (Yu et al., 2010). This, in turn, influences the regional hydrological environment, climate change, biodiversity and so on (Xiao et al., 2010). In this way, land use/cover changes in ecosystem region play an important role on ecological environment and global environmental change. Population and challenges in the ecosystem hotspot has been of long-standing interest to ecologists. Over the past years the subject has been researched in various ways, like identification of various areas of biodiversity using different methods, measuring the overlap of human poverty and ecosystem hotspots, spatial patterns and economic contributions of mining and tourism in biodiversity hotspots. With an increase in the population in the Indian hotspot region, population and challenges in the region is unclear, hence this study stands relevant.

Forests are much more than trees, they are a complex, functional system of interacting and often interdependent biological, physical, and chemical components. This complexity produces combinations of climate, soils, trees and plant species. In the contemporary world, human activities may be the most important influence on forests' capacity to maintain their original biodiversity. Such activities as commercial and artisanal logging, large scale land conversion, fuel wood and charcoal production, slash and burn agriculture, harvesting of non-timber forest products, hunting and mining all affect forest biodiversity. Climate change resulting from modification of the atmosphere by anthropogenic emissions of carbon dioxide is also affecting the distribution and status of forest biodiversity.Indore city, largest city of the Indian state of Madhya Pradesh by population is identified as a hotspot under the forest ecosystem classification. Indore belongs to the state of Madhya Pradesh which has the highest land area of forest in India. Indore with forest and rising industrial and commercial activities serve as the hotspot for the analysis.

1.1 Objective of the study

To identify the ecosystem hotspots in India, that are under greater threat due to both natural and anthropogenic activities using geological information. The change in the ecosystem hotspot is correlated with the change in the land use pattern change using dynamic degree model. Identification of ecosystem hotspots based on the intersection of specific ecosystem and anthropogenic activities are to be done. Anthropogenic activities in an ecosystem have caused extinction of certain flora and fauna, or they are entering into an endangered category. Thus identification of such areas is important for the future conservation/restoration program. India rich in its flora and fauna and with a characteristic of increasing population is an appropriate site for the study.

II. LITERATURE REVIEW

Due to the linkages between socio-economic systems and ecological systems, issues such as development, poverty eradication, and biodiversity conservation need to be addressed not as individual phenomena but rather as complex dynamic systems. Paper by Fisher and Christopher (2007) presents present five key socioeconomic poverty indicators (access to water, undernourishment, potential population pressure, number living below poverty line and debt service) and integrate them with an ecologically based hotspots analysis in order to illustrate magnitude of the overlap between biological conservation and poverty. Method they used for the research are, 34 hotspots were clipped to a map of the world's countries, these files were combined in order to determine which hotspots overlapped with which country and to select all countries with at least 100,000 ha of overlapping hotspots. This resulted in 125 countries for further analysis. They chose critical socio-economic indicators relating to poverty that show interaction between poverty and conservation threats. They used traditional economic metrics of poverty: national debt service and percentage of people living below the national poverty line. They also included a broader range of poverty indicators (undernourishment, access to clean water and potential population pressure) not based solely on Market-identified poverty. Due to their innate connection with life-supporting ecosystems, they mentioned it as ecological poverty indicators.

The main result of the analysis shows which of the globally important ecoregions for biodiversity are faced with deep and multifaceted poverty. It demonstrates the magnitude of this overlap and points to the possibility of a vicious cycle between poverty and biodiversity loss. This analysis does not imply that poverty is the underlying driver of the ecosystem degradation that leads to biodiversity loss. The analysis here suggests that the overlap between severe, multifaceted poverty and key areas of global biodiversity is great and needs to be acknowledged. Understanding the magnitude of overlap and interactions among poverty, conservation and macroeconomic processes is crucial for identifying illusive, yet possible, win–win solutions. Paper by Zhang, Cheng, Dang and Tian (2013), analyzed the implications of conservation/restoration projects, especially in poverty-stricken rural areas in developing countries. The major goal of the study is to answer the following questions:

(1) Have the social–ecological systems in the impoverished rural region achieved sustainable development under conservation projects?
(2) What are the farmers' attitudes and perceptions towards GGP ('Grain-for-Green' Program) and the regional difference cross varying disturbance intensities?

To address these questions, they analyzed the land use/land cover changes before and after the establishment of FNNR (Foping National Nature Reserve) and the implementation of GGP {and NFCP(Natural Forest Conservation Program)} using Landsat MSS/TM/ ETM imagery obtained in 1978, 1994, 2000, and 2007. They also collected information on the giant panda population, socioeconomic circumstances, local farmer's attitudes and perceptions toward conservation projects and environmental changes. The Jinshui watershed with a total area of 731 km^2located in the subtropical humid region of China was selected for the research purpose.

There had been rapid vegetation recovery from 1978 to 2007, especially after 2000 in the study region. The increase in forests along with the rapid decrease in croplands was largely attributed to the implementation of GGP and NFCP. The forest areas in the FNNR had been preserved at a high percentage, and forest cover along the edge of the nature reserve (i.e., in the moderately-disturbed zone) had been gradually expanded as well. Thus, it seems that conservation projects (i.e., FNNR, GGP, and NFCP) have effectively protected the existing forest, increased forested area, and facilitated vegetation recovery in the study region.

The results showed that the conservation projects had effectively protected the existing forests, facilitated vegetation recovery and economic development, and meanwhile the giant panda population in the FNNP had considerably increased. Farmers living in zones with varying human disturbance intensities generally showed similarly positive attitudes towards the GGP. In the slightly- and moderately-disturbed zones, most farmers showed positive perceptions to environmental changes after the GGP, but the perceptions of most farmers in the intensely-disturbed zone were negative. In a paper by Ding and Nunues (2014), it constitutes a first attempt to model the relationship between climate change, biodiversity, and ecosystem services, with a specific emphasis on European forests. This paper attempted to model the relationships between climate change, biodiversity and the value of ecosystem services with a specific emphasis on the climate change included biodiversity effects in European forests. To our knowledge, this represented one of the first attempts in the literature to formally model and empirically test the strength of biodiversity as a nature-based policy option for climate change mitigation. Firstly, they constructed a composite biodiversity indicator that integrates quantitative and qualitative changes of biodiversity projected to 2050 for the EU-17 under future IPCC scenarios. Secondly, this indicator is integrated into two simultaneous equation models to capture the marginal impacts of changes in biodiversity on the value of ecosystem goods and services (EGS) due to climate change.

European-aggregated model specification results confirmed that rising temperature negatively affected biodiversity conditions at an accelerating rate across geo-climatic regions in Europe by 2050. They also found a strong relationship between temperature and the value of EGS (Ecosystem Goods and Services), but the direction of this relationship depended on the type of EGS under consideration. For example, this relationship was estimated to be positive for provisioning and regulating services, but negatively related to cultural services. The regional model specification results suggested that the negative impacts of climate change on biodiversity (i.e. CCIBE) could go against the positive direct climate change impact on forest growth and generate a net negative impact on total value of EGS, such as for the provisioning services in the Mediterranean Europe . Our estimation results confirm the role of biodiversity as a nature-based policy solution for climate change mitigation, shedding light on the policy actions that generate co-benefits by enhancing ecosystems' capacity to mitigate climate change impacts, while conserving biodiversity and sustaining the flows of EGS for human livelihoods. Especially, nature-based mitigation policies are more cost-effective and better at coping with the ethic and inequality issues associated with distributional impacts of the policy actions, compared to the pure technical solutions to improving energy efficiency and reducing emissions. However, the strength of biodiversity as a nature-based policy option for climate change mitigation depends on both the nature of the EGS and the geographical area under consideration.

III. METHODOLOGY

The geographical information of forest ecosystem across India for a particular time series is analyzed. Simultaneously, the degradation of this ecosystem is examined by the anthropogenic activities, which has gradually or steeply increased in these zones at the same time period. Based on this intersection of data, the hot spot is selected and investigated. Satellite remote sensing (RS) and geographic information system (GIS) have been widely applied in identifying and analyzing land use/cover change.GIS provides a flexible environment for displaying, storing and analyzing digital data necessary for change detection. Using GIS (Geographical Information System) tool, the land use data of agriculture and forest ecosystem in the years 2000, 2005, 2010 and 2015 were extracted as the basic data of land use/cover change analysis [Figures 1-4].

Figure 1: GIS image Indore district (2000)

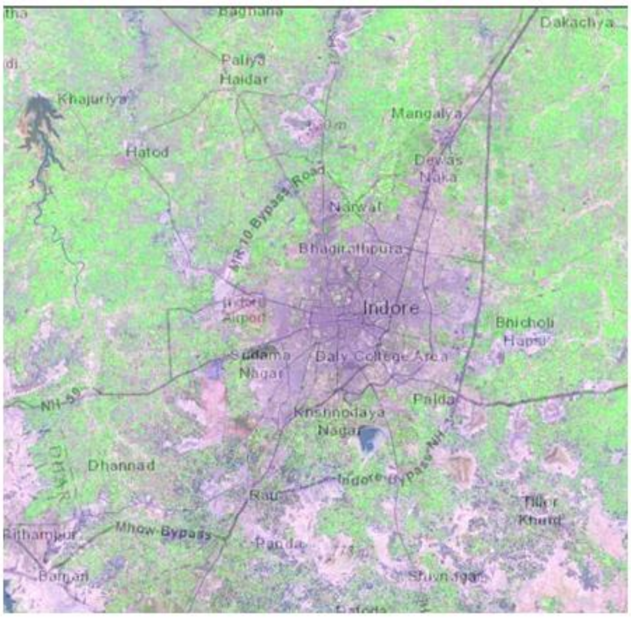


Figure 2: GIS image Indore district (2005)

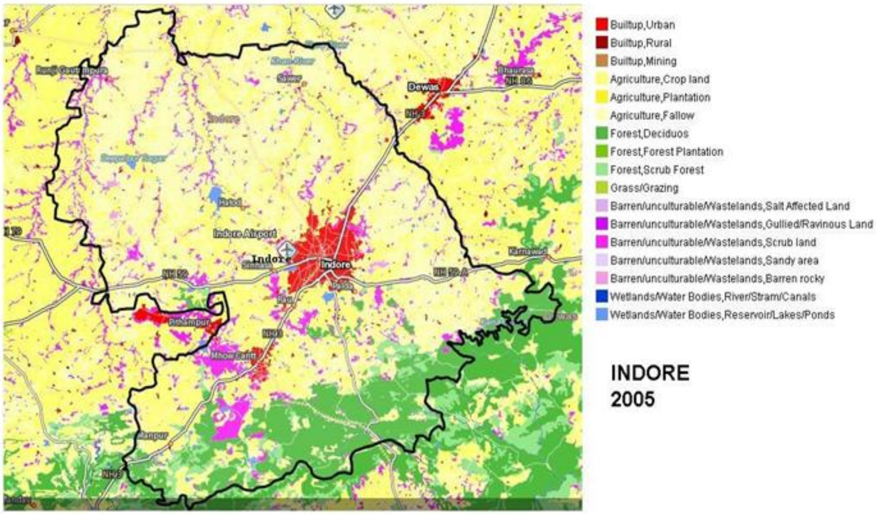


Figure 3: GIS image Indore district (2010)

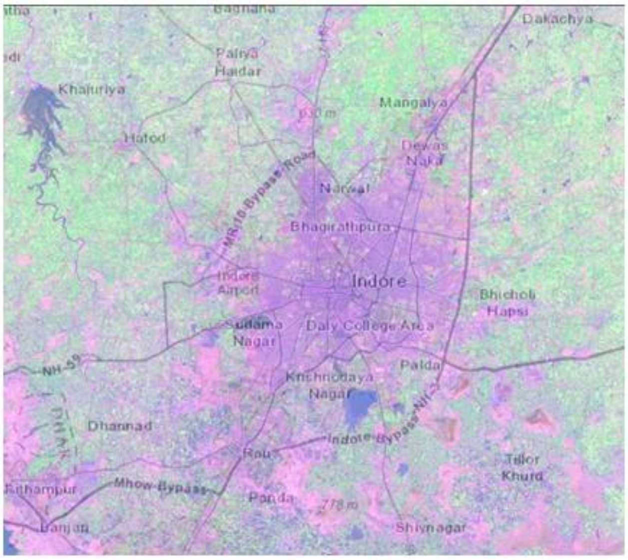
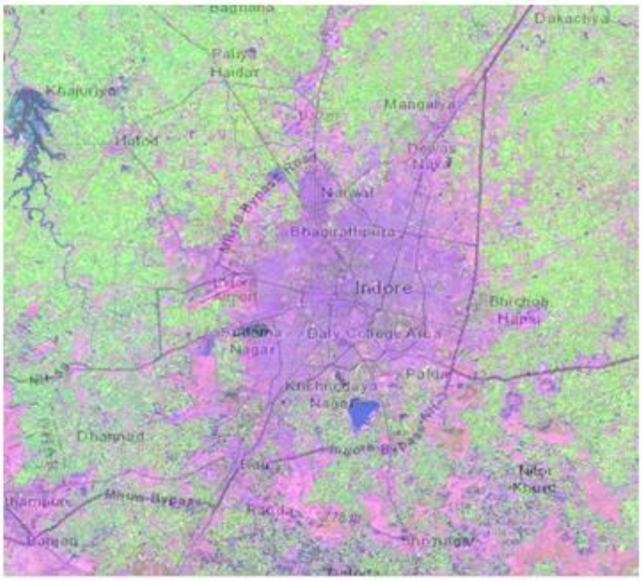


Figure 4: GIS image Indore district (2015)



Land use/cover change is a major factor for global change because of its interactions with climate, ecosystem processes, biogeochemical cycles; biodiversity, and, even more important, human activities (Vogelmann and Howard, 1998; Xiao et al., 2006), research on land use/cover change has become an important aspect of global change. Geographic information system (GIS) has been widely applied in identifying and analyzing land use/cover change. GIS can provide multi-temporal data that can be used to quantify the type, amount and location of land use change. GIS also provides a flexible environment for displaying, storing and analyzing digital data necessary for change detection (Wu et al., 2006).

3.1 Land use dynamic degree model

The land use change was determined using the land use dynamic degree model that included the single land use dynamic degree model and the synthesis land use dynamic degree model. Region differences in the rate of land use change were determined with the single land use dynamic degree that could be mathematically expressed by the following relationship (Li and He, 2002):

$S_i = (A_i\text{-}UA_i)/A_i/(T_2\text{-}T_1)\times 100\%$ (1)

Where S_i is the rate of the ith type land use change during the monitoring period T_1 to T_2; A_i is the area of the ith type land use at the beginning, and UA_i is the area of the ith type land use that remains unchanged during this monitoring. Thus, this model represented the time rate of change for one type of land use that was converted into another type of land use relative to the land use situation at the beginning of the monitoring period. Regional difference in land use characteristics was determined using the synthesis land use dynamic degree model as follows (Liu and Buhe, 2000):

$S = [\square\ (\square\ A_{i\text{-}j}/\ A_i)]\times(1/t)\ \times 100\%$(2)

S is the land use change rate over time t, A_i is the ith type land use area at the beginning of the monitoring period, and $\square\ A_{i\text{-}j}$ is the total area of the ith type land use that is converted into the other types of land use. This model was thus defined as the time rate change of land use that converted into the other types of land use and that at the beginning of monitoring period was part of the land use subject to change. This dynamic degree represented, in a comprehensive manner, the change of land use in a given region.

IV. DISCUSSION AND RESULTS

Forests are much more than trees, they are a complex, functional system of interacting and often interdependent biological, physical, and chemical components. This complexity produces combinations of climate, soils, trees and plant species. In the contemporary world, human activities may be the most important influence on forests' capacity to maintain their original biodiversity. Such activities as commercial and artisanal logging, large scale land conversion, fuel wood and charcoal production, slash and burn agriculture, harvesting of non-timber forest products, hunting and mining all affect forest biodiversity. Climate change resulting from modification of the atmosphere by anthropogenic emissions of carbon dioxide is also affecting the distribution and status of forest biodiversity.Indore city, largest city of the Indian state of Madhya Pradesh by population is identified as a hotspot under the forest ecosystem classification. Indore belongs to the state of Madhya Pradesh which has the highest land area of forest in India. Indore with forest and rising industrial and commercial activities serve as the hotspot for the analysis.

4.1 Quantity analysis of land use change: Indore district

The land use change for the three sub-periods is shown in Table 1 with an increase of irrigation land during the third period (2010-2015) than the second period (2005-2010) and the first period (2000-2005) which suggested that the disappearance rate of irrigation land has increased.

Table 1: Indore profile from GIS mapping (hectares)

Type of ecosystem	2000	2005	2010	2015
Water Body	121659	90435	75049	58732
Building Zone	205438	296839	329032	358597
Irrigation land	78210	56912	35772	23375
Scrub / Fallow land	78075	23988	30436	41122
Industrial zone	5583	31756	34205	35778
Forest	86480	75515	70951	57841
Total	575445	575445	575445	575445

The areas for building zone and industrial zone decreased during the three sub-periods. During the sub-periods water body, scrub / fallow land changes increased. The areas of forest increased during the second period compared to first period and then decreased in the third period (Table 2).

Table 2: Indore Annual average change (hectares/year)

Type of ecosystem	2000-2005	2005-2010	2010-2015
Water Body	-6244.8	-3077.2	-3263.4
Building Zone	18280.2	6438.6	5913
Irrigation land	-4259.6	-4228	-2479.4
Scrub / Fallow land	-10817.4	1289.6	2137.2
Industrial zone	5234.6	489.8	314.6
Forest	-2193	-912.8	-2622

4.2 Land use dynamic degree analysis

The single land use dynamic degree for each land use types that is the annual conversion rates of land use types were calculated for the three periods. Among the various land use types, building zone annual conversion rate was the highest during the three periods. Losses of forest land were mainly converted to building zone, scrub/fallow land and industrial zone (Table 3, 4 and 5).

Table 3: Land Conversion Matrix: Indore district 2000-2005

Type of ecosystem	Water Body	Building Zone	Irrigation Land	Scrub/Fallow land	Industrial zone	Forest	Total
Water Body	90435	5051	0	0	26173	0	**121659**
Building Zone	0	205438	0	0	0	0	**205438**
Irrigation land	0	21298	56912	0	0	0	**78210**
Scrub / Fallow land	0	54087	0	23988	0	0	**78075**
Industrial zone	0	0	0	0	5583	0	**5583**
Forest	0	10965	0	0	0	75515	**86480**
Total	**90435**	**296839**	**56912**	**23988**	**31756**	**75515**	

Table 4: Land Conversion Matrix: Indore district 2005-2010

Type of ecosystem	Water Body	Building Zone	Irrigation Land	Scrub/Fallow land	Industrial zone	Forest	Total
Water Body	75049	15386	0	0	0	0	90435
Building Zone	0	296839	0	0	0	0	296839
Irrigation land	0	16807	35772	4333	0	0	56912
Scrub / Fallow land	0	0	0	23988	0	0	23988
Industrial zone	0	0	0	0	31756	0	31756
Forest	0	0	0	2115	2449	70951	75515
Total	**75049**	**329032**	**35772**	**30436**	**34205**	**70951**	

Table 5: Land Conversion Matrix: Indore district 2010-2015

Type of ecosystem	Water Body	Building Zone	Irrigation Land	Scrub/Fallow land	Industrial zone	Forest	Total
Water Body	58732	16317	0	0	0	0	**75049**
Building Zone	0	329032	0	0	0	0	**329032**
Irrigation land	0	12397	23375	0	0	0	**35772**
Scrub / Fallow land	0	0	0	30436	0	0	**30436**

Though the areas of other land use types (building zone, scrub/fallow land and industrial zone) increased during the study periods, their annual conversion rates indicated the rapid land use changes in

.

Indore forest ecosystem hotspot (Table 6).The synthesis land use dynamic degree of Indore forest ecosystem hotspot for the period 2000 to 2005 was -75.68%, for 2005-2010 was 2.94% and for 2010-2015 was 5.24% (Table 6). Comparing with the overall land use change during the earlier stage, the land use change for the later stage had increased.

Table 6: Land use dynamic degree of each land use types for the three periods: Indore district (in %)

	Type of ecosystem	**2000-2005**	**2005-2010**	**2010-2015**
Single	Water Body	5.1330	3.4026	4.3438
Land	Building Zone	-8.8981	-2.1690	-1.7970
Use	Irrigation land	5.4463	7.4290	6.9311
Dynamic	Scrub / Fallow land	13.8551	-5.3760	-7.0219
Degree	Industrial zone	-93.7596	-1.5423	-0.9197
Model	Forest	2.5358	1.2087	3.6955
Synthesis		**-75.68**	**2.94**	**5.24**
land use				
dynamic				
degree				

Firstly, temporal changes of land use characteristics were quantitatively analyzed through land use dynamic degree. And then the driving forces of land use changes were analyzed based on natural and artificial factors. From 2000 to 2015, as the result of natural factors and human disturbances, the area of forest land shrunk, bringing the conversion from forest land to building zone and industrial zone. The annual conversion rates indicated the rapid land use changes in Indore forest ecosystem hotspot. Through the synthesis land use dynamic degree for the three sub-periods, the land use changes during the period 2010-2015. 2005-2010 increased comparing with that during the period 2000 to 2005. Hence, the management of Indore forest ecosystem hotspot must focus on forest land use changes in future, so as to achieve effective conservation of the forest land. The study results could provide foundations for target protection in Indore forest ecosystem hotspot.

4.3 Service Declines, Degradation, and Increasing Vulnerability

Our work highlights the substantial impact of land-cover change on ecosystem services, resulting in declines in ecosystem service levels. These declines mirror biodiversity losses in the region. The decline in the water-flow regulating service and the decline in areas responsible for erosion control is of particular concern to the region’s future sustainability. The significance of these declines relates to the overarching role regulating services play in soil conservation and nutrient cycling, and in turn, the services of primary production and water. It is the latter services that underpin the agricultural economy. These results also point to the substantial impacts of the extensive areas of degraded land. Degraded areas, overlap with the hotspots of the carbon, forage, erosion, and tourism services. Overgrazing of these areas, together with clearing of other areas to grow livestock feed to supplement the forage production service, have been major drivers of change in ecosystem services.The declines in what are mostly regulating and supporting services, together with the documented biodiversity losses, raise concerns about long-term decreases in the region’s productivity and resilience, and thus increases in its vulnerability to shocks such as floods, drought, or market shifts. The examined regions are facing decreased ecosystem service levels, threatened biodiversity, high unemployment levels, and narrowing future options. The situation mirrors semiarid regions around the world, which house the most vulnerable people, ecosystems, and ecosystem services. Understanding the drivers of changes in land cover and subsequently in ecosystem services is essential in the design of interventions.

V. POLICY IMPLICATIONS

Land-cover change has been identified as one of the most important drivers of change in ecosystems and their services. However, information on the consequences of land cover change for ecosystem services and human well-being at local scales is largely absent. Where information does exist, the traditional methods used to collate and communicate this information represent a significant obstacle to sustainable ecosystem management. Embedding science in a social process and solving problems together with stakeholders are necessary elements in ensuring that new knowledge results in desired actions, behavior changes, and decisions. We have attempted to address this identified information gap, as well as the way information is gathered, by quantifying the local-scale consequences of land-cover change for ecosystem services of the highly degraded ecosystems of Indian subcontinent of major ecosystems. The land use dynamic degree model results correlate to the high level of resettlement of private and public sector initiated at the Indore district of Madhya Pradesh during the 2000 - 2005 period. Almost 75% of the change in the land use pattern of the forest ecosystem can be attributed to the bifurcation of Madhya Pradesh to form Chattisgarh. It was Indore, rather than Bhopal, the capital city of Madhya Pradesh, that received the major influx of investment. This contributed to the expansion of the building zone.

VI. CONCLUSION

The political, social, economic, and technological changes associated with the ecosystems were key drivers of change in the examined ecosystems. The history of land-use decisions and their impacts point to the need to manage systems in ways that recognize their natural constraints and vulnerabilities, as well as the need to create future economies and livelihoods that foster sustainable use of services along with the promotion of human well-being. Sustainable land-use practices rely on the consideration of, and protection of, ecosystems and their services. Such practices focus on maintaining the resilience of ecosystems, and on building agility into production strategies, enabling responses to market trends and fluctuations. Based on our research, we outline below some recommendations aimed at building sustainable landscapes. Creating a sustainable ecosystem will require improvements in the current condition of its ecosystems and their services. This, in turn, will require large-scale conservation and restoration activities targeted at areas of importance to water-flow regulation and erosion control. This realization is not new and, the government formulated policies to deal with drought and erosion. However, the lack of policy coordination and alignment and the slow pace of ecosystem recovery, leave the analysed ecosystem hotspots as some of the most degraded areas of India. The management of Indore forest ecosystem hotspot must focus on forest land use changes in future, so as to achieve effective conservation of the forest land. The study results could provide foundations for target protection in Indore forest ecosystem hotspot.

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