American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-5, Issue-7, pp-176-184
www.ajer.org
Research Paper Open Access

Ecosystem Hotspot Identification And Examination of The Land Use Change in Agricultural Ecosystem Using Geological Information: Evidence From India

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ABSTRACT*: This paper focuses on the ecosystem based hotspot identification and the pattern of land use change in Agricultural Ecosystem using the land use dynamic degree model. Geological Information on the agricultural ecosystem is obtained by the remote sensing images for the identification of land change. With this hotspot identification it brings a clear picture of how to look into a new definition of hotspots, which identifies a region or specific area and how each area could be identified as a hotspot. Geographic Information System (GIS) images were used to analyze the changes in land over specific time period.*

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. Agricultural ecosystem is a subset of conventional ecosystem. Agro ecosystem is not restricted to the immediate site of agricultural activity but it includes the region that is impacted by this activity, usually by changes to the complexity of species assemblages and energy flows, as well as to the net nutrient balance. Agricultural activities necessarily involve a reduction and simplification of the immense biological diversity of nature, at both the species and genetic level. However, since the first farmers selected their preferred plants and cultivated their land with the few simple tools and mostly organic inputs available at a local (small) scale, their activities were, in general, of low impact or at least of a limited geographical scale. The growth in population and the increasing urbanization led to the need to produce larger quantities of food being transported over longer distances. Larger areas of land were dedicated to agricultural activities, using animal traction, irrigation canals and other intensification techniques. The change in land use through clearing forested or grassland for cultivation, changes in agricultural practices such as crop rotation and mixes, grazing practices, residue management, irrigation and drainage all affect the soil environment and change the range of habitats and foods for soil organisms. Treatments to land such as liming, fertilizers, manure and other organic materials, tillage practices, the use of pesticides and so forth, all change the physical and chemical environment. With the urbanization of the population, proportionally fewer numbers of people were involved in food production. This led to changes in agricultural practices such as the development of modernized agricultural techniques with the use the moldboard plow, motorized tractors, hybrid cultivars, inorganic fertilizers and pesticides. This created new pressures on the land, dramatically increasing the influence of agricultural practices on biodiversity.

1.1 Objective of the study

To identify the ecosystem hotspots in India, which 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

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 my study stands relevant.

A landmark paper that deals with biodiversity by Myers (2000), entitled "Biodiversity hotspots for conservation priorities" developed a strategy for prioritizing areas of biodiversity by providing a ranking of hotspots in order to assist planners in the face of insufficient funding. The authors focused their analysis on and defined 'hotspots' as areas having "exceptional concentrations of endemic species and experiencing exceptional loss of habitat". They defined 25 original hotspots, but this list was recently expanded to 34 hotspots and has become the major focus of Conservation International's (CI) work. By focusing on these hotspots, the authors estimate it may be possible to protect 44% of all vascular plant species and 35% of 4 major vertebrate groups in only 1.4% of the earth's surface. This was, and continues to be, an important and timely effort due to the growing evidence of human driven ecosystem degradation and species loss (Vitousek, 1997). While an excellent endeavour to help prioritize funding for conservation, their paper does not address the fact that the success of conservation initiatives is largely dependent on the socio-economic conditions of the areas where these hotspots occur. Paper by Cincotta (2000)., entitled " Human population in the biodiversity hotspots" estimated of key demographic variables for each hotspot, and for three extensive tropical forest areas that are less immediately threatened. They estimated that in 1995 more than 1.1 billion people, nearly 20% of world population, were living within the hotspots, an area covering about 12% of Earth's terrestrial surface. They estimated that the population growth rate in the hotspots (1995-2000) is 1.8% yr(-1), substantially higher than the population growth rate of the world as a whole (1.3% yr(-1)) and above that of the developing countries (1.6% yr(-1)). These results suggest that substantial human-induced environmental changes are likely to continue in the hotspots and that demographic change remains an important factor in global biodiversity conservation. The results also underline the potential conservation significance of the continuing worldwide declines in human fertility and of policies and programs that influence human migration.

Dynamics and interactions between mining and tourism were discussed by Huang, Zhou, Ali(2011). This paper examined how mining and tourism industry interact in terms of their economic contributions and spatial patterns in a biodiversity hotspot, Yunnan, China. Studies showed nearly one third of active mines and exploration sites are within areas of intact ecosystems or high conservation value (e.g. Miranda,2003). The negative impacts associated with mining include land degradation, ecosystem disruption, and negative impacts on the local community (i.e. sexually-transmitted diseases) (The World Bank, 2004). The negative impacts of tourism include land degradation, water pollution, waste and noise brought by tourists, and overwhelming pristine cultures by the modern lifestyle (Butter, 1980). Both mining and tourism have been recognized for their positive roles in alleviating poverty by providing jobs and income to local communities. In this paper two questions were put forward, first, do mining and tourism industries reinforce or impede each other in terms of their economic contributions? Second, what is the spatial pattern of the locations of mining and tourism sites? Do they tend to cluster or avoid each other? Answers to these questions provided important insights on how mining and tourism together may impact the economy and environment in biodiversity hotspots.

In their study they selected Yunnan region in China one of the 34 global biodiversity hotspots. Yunnan hosts the "mountains of southwest China" biodiversity hotspot. Mining and tourism in Yunnan have been growing at a rate of 20-30 percent since 1998. In this paper they used correlation analyses to measure the relationships between mining activities, tourism visits and local gross domestic productions. They also employed a distance based technique to investigate the nature of any dependency between mining and tourism sites.

Results showed that mining activities tend to be in relatively fluent areas while tourism tends to occur in less developed areas when measured by economic indicators. The physical locations of mines and tourism sites are clustered. Conflicts between tourism and mining exist when they occur in the same area as tourism income is impacted by mines nearby.

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. Perhaps the first hotspot analysis was that conducted by Myers (1988, 1990) when he described the immense endemic plant diversity found in several regions of the world. Since then, hotspot analysis has become more quantitative and comprehensive. “Incorporating socioeconomic factors into the analysis of biodiversity hotspots” paper by J.A. Veech introduces a new method of hotspot analysis that ranks hotspots on the basis of biodiversity and anthropogenic threats to biodiversity.

Methods of study include data compilation, defining threat on a per-species basis: the species load, using multiple regressions for hotspot analysis. Data on the total number and number of endemic non-fish vertebrate species and vascular plant species in each mega diversity country were obtained from Mittermeier, Myers, and Thomsen. (1997). Socioeconomic data for each country were obtained from their ‘Data Profiles’ on the World Bank website, specifically population size, population growth rate, rural population density, and debt. Prior to conducting the hotspot analysis, the four socioeconomic variables were standardized to the number of species within a hotspot; these standardized variables are referred to as ‘species loads’. Using data from all 17 mega diversity countries, a multiple regression was performed of species richness against the inverse of the area of each country and the species load for population size (Lpop), population growth rate (Lpgr), rural population density (Lrpd), and debt (Ldeb).

The primary goal of the study was to test whether threats to biodiversity can be usefully incorporated into a comprehensive hotspot analysis. More specifically, it tested whether the ranking of hotspots was significantly improved by including socioeconomic variables presumed to represent processes (e.g. habitat destruction) that result in the loss of biodiversity. Using the standardized residuals obtained from multiple regression models, the mega diversity countries were ranked on the basis of the threat per species (i.e. species load variables) and the number of species per unit land area; this was the full regression model. This ranking was then compared with a ranking based only on the number of species per unit land area. The ranking obtained from the full regression model differed substantially from that obtained from the area-only model, as evidenced by the low Spearman rank correlation coefficients comparing the two models. It is reassuring that the ranking of hotspots based on either endemic vertebrate or endemic plants species richness are similar to one another and similar to rankings based on total vertebrate and plant species richness. However, perfect agreement (100%) on the very top ranks should not be expected and was not obtained.

Paper by Venevsky and Venevskaia (2005) suggests quantitative measures which enable two criteria of the global biodiversity hotspots to be applied on a national level for 74 large countries, and show how these measures can be applied to map national biodiversity hotspots. The basic concept in identifying biodiversity hotspot is to elaborate and further develop the national protected area system, to satisfy both national and international conservation goals. They showed how national biodiversity hotspots can be mapped from the species–energy relationship for vascular plants using climate, topographical and land use data when spatial pattern of species richness is not known. This methodology to map national biodiversity hotspots from abiotic factors is applied to Russia as a case study. Three Russian biodiversity hotspots, North Caucasus, South Siberia and Far East were identified. The resulting hotspot maps cover national-scale environmental gradients across Russia and although they are also identified by Russian experts their actual geographical locations were hitherto unspecified. The large-scale national hotspots, identified for Russia, can be used for further fine scale and more detailed conservation planning.

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 agriculture 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 steeplyincreased 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 [Figure 1-4]. 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).
Figure: 1 GIS map of Cuddalore district (2000)

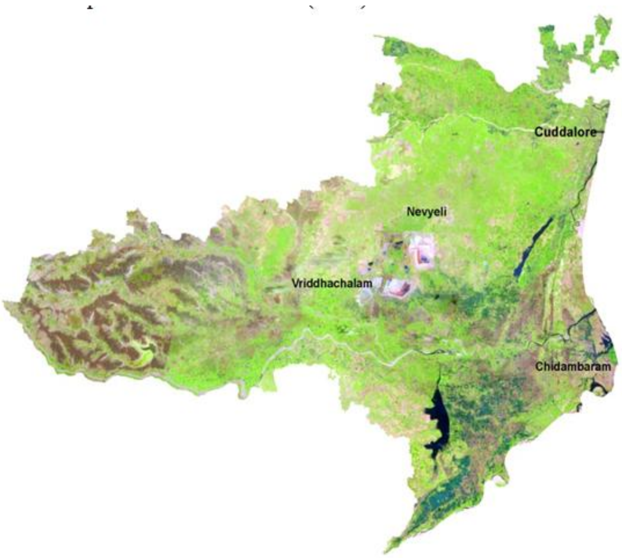


Figure 2 GIS map of Cuddalore district (2005)

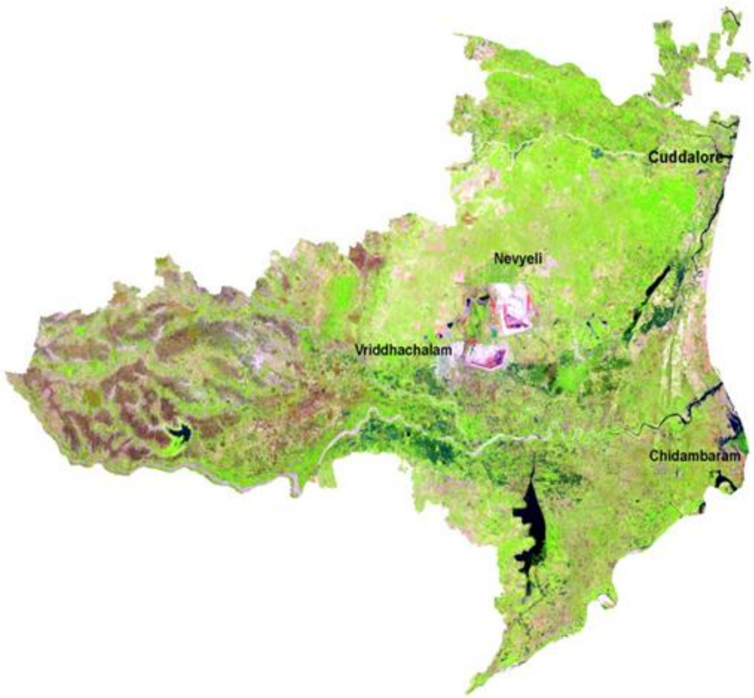


Figure 3 GIS map of Cuddalore district (2010)

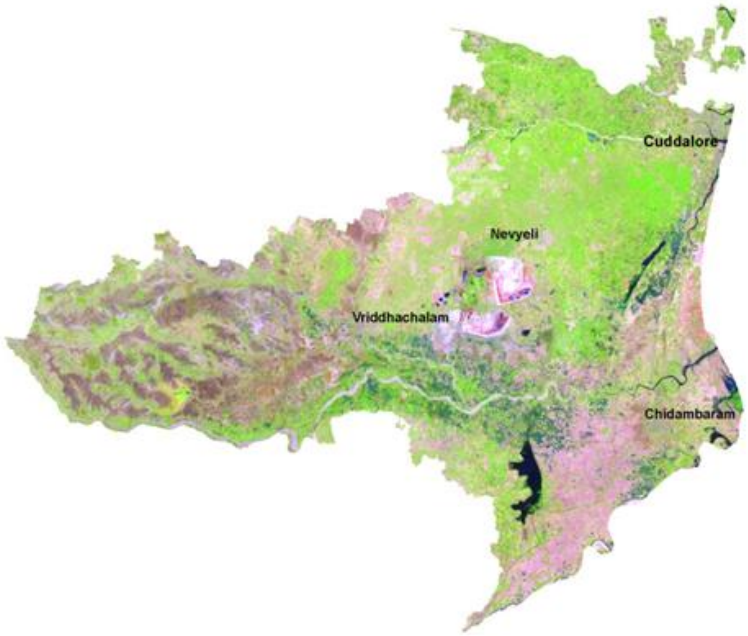
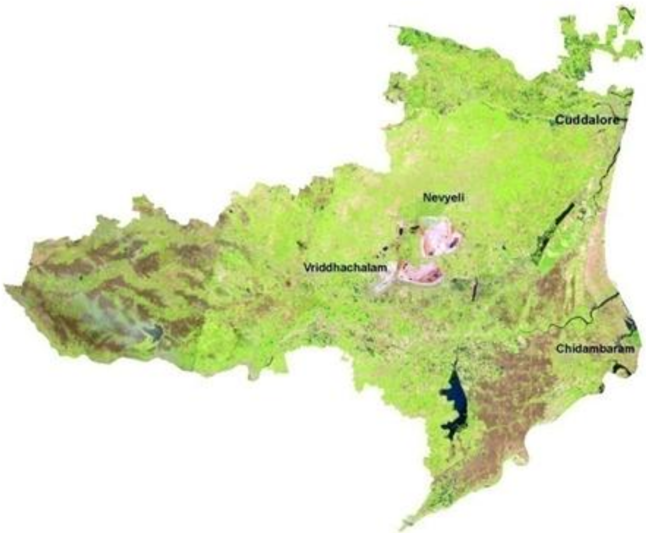


Figure 4 GIS map of Cuddalore district (2015)



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):

$$S_i = (A_i\text{-}UA_i)/A_i/(T_2\text{-}T_1)\times100\% \quad (1)$$

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):

$$S = [\sum(\Delta A_{i\text{-}j}/ A_i)]\times(1/t) \times100\% \quad (2)$$

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 $\Delta A_{i\text{-}j}$ 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

For the analysis in the agricultural ecosystem we have identified Cuddalore district in Tamil Nadu as a hotspot. Cuddalore region is famous for its upcoming export quality rice cultivation. Rice is the major crop of the district. System of Rice Intensification (SRI) is the latest technology which is widely popularized both by Agriculture department and Krishi Vigyan Kendra and the farmers are having a lot of interest in adopting this technology. Cuddalore also hosts the heavy chemical, pharmacological and energy industries in SIPCOT, an industrial estate set up by the state government. With the intersection of agricultural activity and industries in the region, Cuddalore was identified as a hotspot.

The land use change for the three sub-periods is shown in Table 1. An increase of irrigation land during the second period and third period than the first period, suggests that the disappearance rate of irrigation land has increased. The areas for building zone and industrial zone decreased during the sub- periods. During the sub-periods decreased (2005-2010) and then increased (2010-2015). The areas of forest decreased (2005-2010) and then increased (2010-2015).

Table 1: Cuddalore profile from GIS mapping (hectares)

Type of ecosystem	2000	2005	2010	2015
Water Body	24615	23894	21749	21684
Building Zone	28146	45084	47684	58793
Irrigation land	298416	249257	217331	206548
Scrub / Fallow land	8630	36127	64981	64303
Industrial zone	6453	11943	14622	15055
Forest	1521	1476	1414	1398
Total	367781	367781	367781	367781

4.1 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, irrigation land annual conversion rate was the highest during the three periods. Losses of irrigation land were mainly observed due to conversion into building zone, scrub/fallow land and industrial zone (Table 2, 3 and 4).

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

Type of ecosystem	2000-2005	2005-2010	2010-2015
Water Body	-144.2	-429	-13
Building Zone	3387.6	520	2221.8
Irrigation land	-9831.8	-6385.2	-2156.6
Scrub / Fallow land	5499.4	5770.8	-135.6
Industrial zone	1098	535.8	86.6
Forest	-9	-12.4	-3.2

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

Type of ecosystem	Water Body	Building Zone	Irrigation Land	Scrub/Fallow land	Industrial zone	Forest	Total
Water Body	23894	721	0	0	0	0	**24615**
Building Zone	0	28146	0	0	0	0	**28146**
Irrigation land	0	16217	249257	27499	5443	0	**298416**
Scrub / Fallow land	0	0	0	8630	0	0	**8630**
Industrial zone	0	0	0	0	6453	0	**6453**
Forest	0	0	0	2	47	1476	**1525**
Total	**23894**	**45084**	**249257**	**36131**	**11943**	**1476**	

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

Type of ecosystem	Water Body	Building Zone	Irrigation Land	Scrub/Fallow land	Industrial zone	Forest	Total
Water Body	21749	2145	0	0	0	0	**23894**
Building Zone	0	45084	0	0	0	0	**45084**

Irrigation land	0	455	217331	28788	2683	0	**249257**
Scrub / Fallow land	0	0	0	36131	0	0	**36131**
Industrial zone	0	0	0	0	11943	0	**11943**
Forest	0	0	0	62	0	1414	**1476**
Total	**21749**	**47684**	**217331**	**64981**	**14626**	**1414**	

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 Cuddalore agricultural ecosystem hotspot (Table 4.5).
Table 5: Land Conversion Matrix: Cuddalore district 2010-2015

Table4.6: Land use dynamic degree of each land use types for the three periods (in %): Cuddalore district

Type of ecosystem	Water Body	Building Zone	Irrigation Land	Scrub/Fallow land	Industrial zone	Forest	Total
Water Body	21684	65	0	0	0	0	**21749**
Building Zone	0	47684	0	0	0	0	**47684**
Irrigation land	0	10783	206548	0	0	0	**217331**
Scrub / Fallow land	0	261	0	64303	417	0	**64981**
Industrial zone	0	0	0	0	14626	0	**14626**
Forest	0	0	0	0	12	1398	**1410**
Total	**21684**	**58793**	**206548**	**64303**	**15055**	**1398**	

4.3.Driving factors of land use change:

Most of the irrigation land got converted into building zone. The synthesis land use dynamic degree of Cuddalore agricultural ecosystem hotspot for the period 2000 to 2005 was -39.76%, for 2005-2010 was -16.4% and for 2010-2015 was -3.86% (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 (in %): Cuddalore district

	Type of ecosystem	**2000-2005**	**2005-2010**	**2010-2015**
Single Land Use Dynamic Degree Model	Water Body	0.5858	1.7954	0.0597
	Building Zone	-12.0358	-1.1534	-4.6594
	Irrigation land	3.2765	2.5616	0.9923
	Scrub / Fallow land	-63.7242	-15.9736	0.2086
	Industrial zone	-17.0153	-4.4863	-0.5922
	Forest	0.5917	0.8401	0.2263
Synthesis land use dynamic degree model		**-39.76**	**-16.4**	**-3.86**

V. POLICY IMPLICATIONS

Land-cover change has been identified as one of the most important drivers of change in agricultural 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 industrialization initiated at the Cuddalore district during the 2000 -2005 period. Almost 40% of change in the land use pattern of the agricultural ecosystem surely makes the identified district to be the agricultural ecosystem hotspot which needs to restoration measures. The impact of industrialization of the first study period was gradually creating an impact in the further study periods of 2005-2010 and 2010-2015 also. Since the Cuddalore district also bears the property of a coastal-agricultural ecotone, the high level of cumulative pollutant release from the special economic zones and other small scale industries established in the fertile ecosystem of Cuddalore district draws a parallel relation with the change in the land use pattern of fifteen year duration from the present study analysis.

VI. CONCLUSION

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 agricultural land shrunk, bringing the conversion from agricultural land to building zone, fallow land and industrial zone. The annual conversion rates indicated the rapid land use changes in Cuddalore agricultural 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 Cuddalore agricultural ecosystem hotspot must focus on agricultural land use changes in future, so as to achieve effective conservation of the agricultural land. The study results could provide foundations for target protection in Cuddalore agricultural ecosystem hotspot.

ACKNOWLEDGEMENT

The authors are grateful to the host institute, Madras School of Economics.

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