Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 7, Issue 1; July-September, 2020 pp. 26-31

http://www.krishisanskriti.org/Publication.html

An Assessment of Land Use and Land Cover Change in Populous Districts of Bihar using Remote Sensing Database

Shruti Dutta[1], Rakesh K. Ranjan[2], Amit Prakash[3]

[1]*Amity School of Earth & Environmental Sciences, Amity University Haryana, Gurugram, India*
[2]*Department of Geology, Sikkim University, Gangtok, India*
[3]*Department of Environmental Sciences, Tezpur University, Napaam, Sonitpur, Assam, India*
**Corresponding author (ap@tezu.ernet.in; amitprakash.amit@gmail.com)*

Abstract: **The Study of land use pattern has been significant to understand the socio-cultural and economic growth dynamics. The remote sensing techniques are the most relevant method considering their repetitive monitoring and synoptic coverage. The present article attempts to give an insight into the quantitative and qualitative changes in land use for the five most populated districts namely Patna, Poorvi Champaran, Muzaffarpur, Madhubani and Gaya in the state of Bihar, India taking secondary database for satellite based analysis. A statistical analysis was carried out to understand the changing scenario of land cover in Bihar. The results indicate the increase in the built up area towards the rural region more as compared with the urban region at all the locations except Patna where there has been an18.50 percent increase in urbanization. Patna and Muzaffarpur witness exorbitant trend of 186% and 181% increase in mining, respectively.An upsurge is also witnessed in the inland wetlands showing an increase of 616%, 177& and 156% for Patna, Madhubani and Gaya respectively. However, the river and canals have shown a consistent areal shrinkage in all the five districts and it is a matter of concern for water security in the long run.**

1. INTRODUCTION

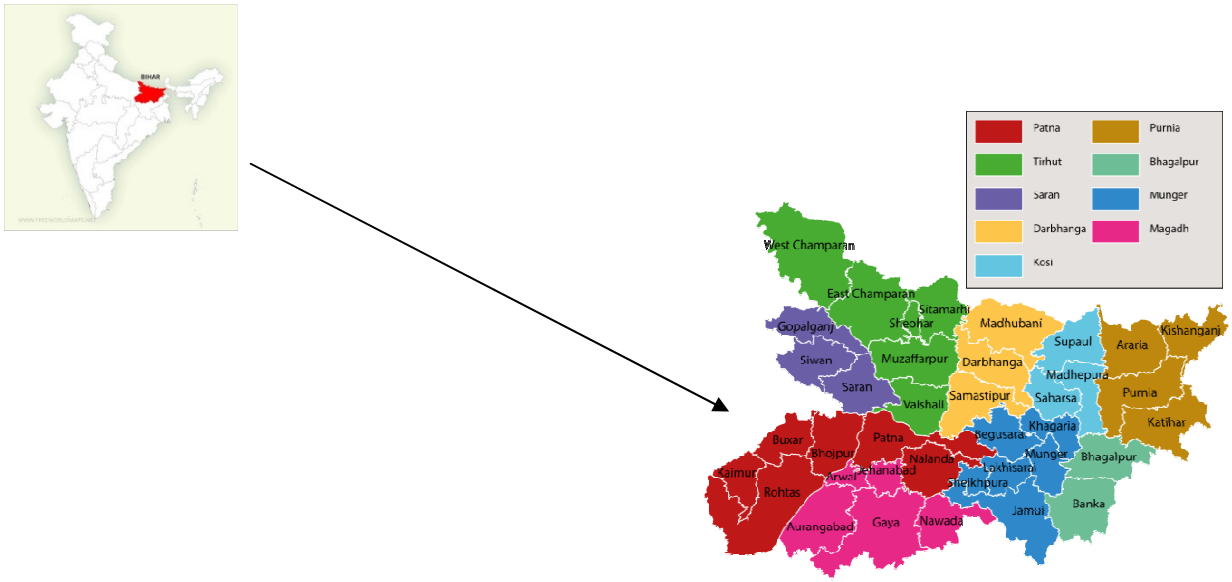
India perceived to be a country of villages and rural dominance has now sprawled exorbitantly into urban panoramic perspective. Land use is a meaningful indicator for the characterization of any ecosystem. Study of land use pattern has played an important role to find out the past use of land and its future trend. It also reflects the socio-cultural and economic development of the people of an area. The progress of an area can be measured to a certain extent by the way in which its land used and maintained. The unmindful exhaustive urbanization because of a rapid population growth has initiated an unplanned growth, causing threat to the natural resources.

Land use/land cover study requires a lot of field survey, time and labour, if done by manual field survey techniques. Moreover, the conventional methods do not provide a large coverage of area. With the gradual advancements in remote sensing, the issue with logistics almost diminishes as remote sensing data has the capability of synoptic view, repetitive coverage and accurate and unbiased data. The image classification done through the interpretation of spectral signature and subsequently validated by ground observations is the most accepted method of assessment of land use and change estimation. The use of remote sensing and geographical information system thus, plays a vital role in observing the changes in the land use/ land cover for suitable arrangement and utilization of the resources and their administration.

The state of Bihar has seen unprecedentedpopulation growth of about 35.4 percent in the last two decades in the last two decades from 8.30 Cr in 2001 to 12.86 Cr at present (projected). However, the rate of urbanization remains extremely low in the last two decades, from 10% to 11.29%. Still with the highest growth rate in population, a consideration towards the monitoring and examination of the growth pattern and changes, if any, should be monitored and considered. Numerous studies have been conducted in context of land use at the global level. However, in the present article, we aim to analyze the qualitative and quantitative change and pattern of land use in the five most populous districts of Bihar. Few studies exist in literature (Sinha et al, 2017, Das and Sinha 2020, Richards et al, 2012, Ahmed & Munim, 2020). These studies explain different spatial extents and parameters for estimation of land use variation in different regions of Bihar. Therefore, the aim of this article is to present a comparative account of quantitative and qualitative changes in land use in five most populous districts of Bihar, viz. Patna, Poorvi Champaran, Muzaffarpur, Madhubani and Gaya for the study period 2011-12 and 2015-16. The growth patterns are significant as few of these districts are the majorcentres for economic growth.

2. AREA OF STUDY

Bihar is the third largest state of India, expanded over an area of 94163 km^2. In this study, five districts Patna, Poorvi Champaran, Muzaffarpur, Madhubani and Gaya (Fig 1) have been selected based on the highest populated districts as per the census 2011. Patna and Muzaffarpur are the prospective smart cities to be developed under the Smart Cities Mission. The districts of Madhubani, Poorvi Champaran and Muzaffarpur are situated towards the northern side of the state whereas Gaya forms the Southern part of the state. Patna is the state capital and massive change in the landscape has been noticed in the last few decades because of developmental activities.



3. DATASET AND METHODOLOGY

The dataset for the year 2011-12 and 2015-16 were selected and downloaded from the freely available database of NRSC, ISRO, Department of Space under Natural Resources Census (NRC) Project of National Natural Resources Repository (NRR) Programme, prepared for the Land Use map under the project "National Land Use/ Land Cover Mapping (Second Cycle) on 1:50,000 scale(https://bhuvan.nrsc.gov.in/). The satellite imageries were categorized into various classesthrough visual interpretation and variation in spectral signature, thus making them categorized into various classes. The satellite Resourcesat-2 derived inventory for various parameters has been carefully analysed for the period of study. A preliminary validation through the high resolution Google Earth image was also done. The above generated various LULC parameters and attribute information (Natural Resource Census- Land Use Land Cover (LULC) Database Type of Document Technical Report – Ver.1) were subjected to statistical analysis and subsequent change was computed for spatial and temporal changes. The trend and extent of change detection was examined for the five selected district of Bihar.

4. RESULTS AND DISCUSSION

The parameters for land use and land cover pattern for five most populous districts of Bihar (Patna, Poorvi Champaran, Muzzaffarpur, Madhubani and Gaya) were systematically analyzed and the attributes for various classes were compared with each other for two periods, 2011-12 and 2015-16 (Table 1-3) . The land use has been primarily divided into five categories viz. (i) Agriculture, (ii) Barren/unculturable/ Wastelands, (iii) Built Up area, (iv)Forest and (vi) Wet lands / Water bodies.All the districts have shown similar trend of change in few land use class, but also have differing patterns from each other. A graphical representation of change in various categories of land use has been depicted in Fig 2 a-2e.

The agricultural coverage has experienced that the fallow land has drastically decreased in area except Gaya whereas the plantation and cropland has increased reasonably in five years in the most populated districts of Bihar. The decrease of fallow land might be taken in coherence with the subsequent growth of built up area and settlement. The built up area has expanded towards the rural region more as compared with the urban region except Patna where there has been an increase of 18.50 percent of urbanization. It is evident since Patna is the capital city and hub of commercial activities. The extent of mining has significantly shown an accelerated pace over time, But Patna and Muzaffarpur have witnessed an exorbitant trend of 186 and 181 percent respectively.

Another striking observation is the increase in the areal extent of wetland and water bodies in the state. It is evident from the tabular data that there has been an upsurge in the inland wetlands showing an increase of 616%, 177& and 156% for Patna, Madhubani and Gaya respectively, the maximum witnessed by Patna for an interval of five years, However, the river and canals have shown a consistent areal shrinkage in all the five districts and it is a matter of concern.

5. CONCLUSIONS

Bihar is the emerging centre for economic activities and the rural set up is also migrating towards urban areas, in the search of employments and better services. In the unmindful aspiration for supposedly better standard of living, we have been negligent towards the environment and its well being. The densely populated districts of Bihar have seen a declining trend of environmental assets like rivers and water bodies. However, with the reduction in crop land, the plantations have increased.The satellite based remote sensing is the most efficient technique, which can monitor the growth on a synoptic coverage and identify the drivers associated with the change. The technology with an integration with the policy can be a substantial path to decipher the causal factors in the prominent regions of Bihar, especially when they are the projected as the future smart cities of the state.

TABLE 1: Attributes for various LULC for 2011-12 and 2015-16 for Gaya, Bihar

Land Cover data in Gaya				
L 1	**L 2**	**2011-12 (in Km^2)**	**2015-16(in Km^2)**	**Change (%)**
Agriculture	Crop land	3256.48	3117.78	-4.26
	Fallow	370.07	490.63	32.58
	Plantation	5.96	7.31	22.65
Barren/unculturable/Wastelands	Barren Rocky	26.62	24.32	-8.64
	Gullied / Ravinous Land	NA	5.5	NA
	Sandy Area		0.14	
	Scrub Land	170.22	135.36	-20.48
Builtup	Mining	2.24	5.75	156.70
	Rural	136.93	140.78	2.81
	Urban	41.01	44.74	9.10
Forest	Deciduous	597.16	598.14	0.16
	Scrub Forest	220.82	259.05	17.31
Wet lands / Water bodies	Inland Wetland	0.14	0.63	350.00
	River/Stream/Canals	144.49	142.26	-1.54
	Water bodies	3.87	3.59	-7.24

TABLE 2: Attributes for various LULC for 2011-12 and 2015-16 for Madhubani and Muzaffarpur, Bihar

Land Cover data in Madhubani					**Land Cover data in Muzaffarpur**		
L 2	L 2	2011-12 (in Km^2)	2015-16(in Km^2)	Change (%)	2011-12 (in Km^2)	2015-16(in Km^2)	Change (%)
Agriculture	Crop land	2531.66	2581.08	1.95	1953.12	2015.54	3.20
	Fallow	269.17	46.32	-82.79	363.41	123.37	-66.05
	Plantation	268.5	345.88	28.82	269.35	346.49	28.64
Barren/unculturable/ Wastelands	Sandy Area	1.42	0.64	-54.93	NA	1.65	NA
	Scrub Land	20.49	18.06	-11.86	76.89	60.92	-20.77
Builtup	Mining	NA	16.5	NA	4.66	13.1	181.12
	Rural	245.41	308.82	25.84	191.23	285.46	49.28
	Urban	15.35	13.56	-11.66	60.25	70.8	17.51
Forest	Deciduous	NA	0.03	NA	NA	1.19	NA
Wet lands / Water bodies	Inland Wetland	26.59	73.85	177.74	166.08	174.04	4.79
	River/Stream/Canals	112.99	83.95	-25.70	82.41	75.29	-8.64
	Water bodies	9.44	12.32	30.51	4.6	4.14	-10.00

TABLE 3: Attributes for various LULC for 2011-12 and 2015-16 for Patna and Poorvi Champaran, Bihar

Land Cover data in Patna					Land Cover data in Poorvi Champaran		
L 2	**L 2**	**2011-12 (in Km^2)**	**2015-16(in Km^2)**	**Change (%)**	**2011-12 (in Km^2)**	**2015-16(in Km^2)**	**Change (%)**
Agriculture	Crop land	2420.84	2466.34	1.88	2844.44	2989.41	5.10
	Fallow	148.54	47.5	-68.02	300.85	79.74	-73.50
	Plantation	17.59	18.88	7.33	177.68	229.45	29.14
Barren/unculturable/ Wastelands	Sandy Area	NA	0.82	NA	NA	2.77	NA
	Scrub Land	42.78	55.39	29.48	93.69	86.87	-7.28
Builtup	Mining	6.26	17.91	186.10	8.89	12.47	40.27
	Rural	123.16	136.74	11.03	256.75	282.05	9.85
	Urban	136.85	162.17	18.50	24.25	26.45	9.07
Forest	Deciduous	NA	0.13	NA	NA	0.59	NA
Wet lands / Water bodies	Inland Wetland	7.12	50.98	616.01	117.44	131.16	11.68
	River/Stream/Canals	292.24	238.82	-18.28	134.83	118.58	-12.05
	Water bodies	0.25	0.43	72.00	9.49	8.46	-10.85

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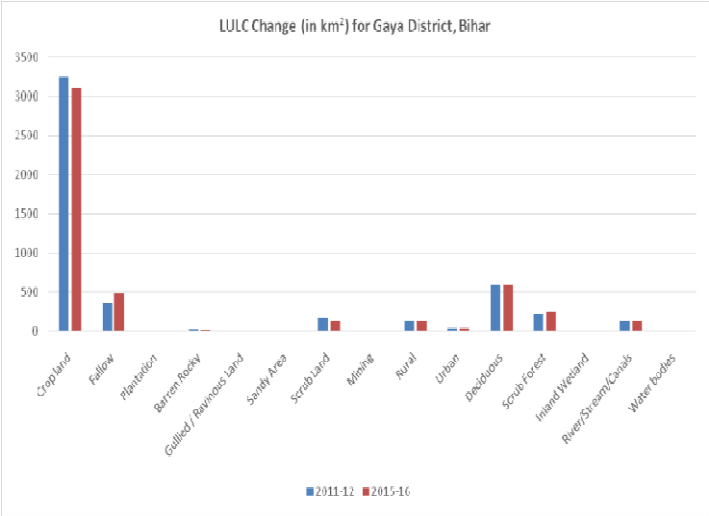


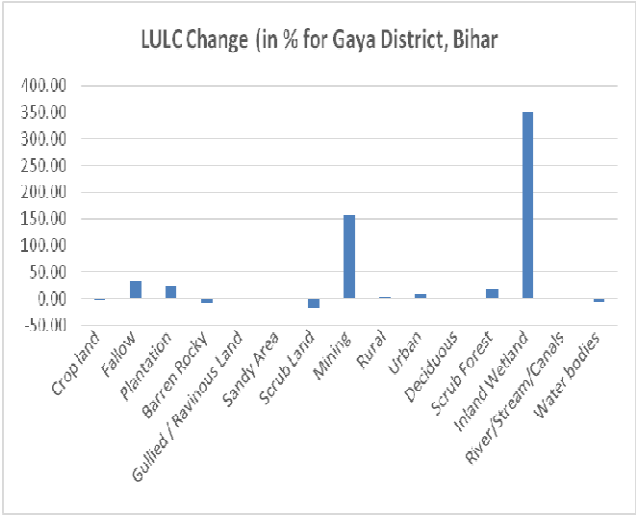
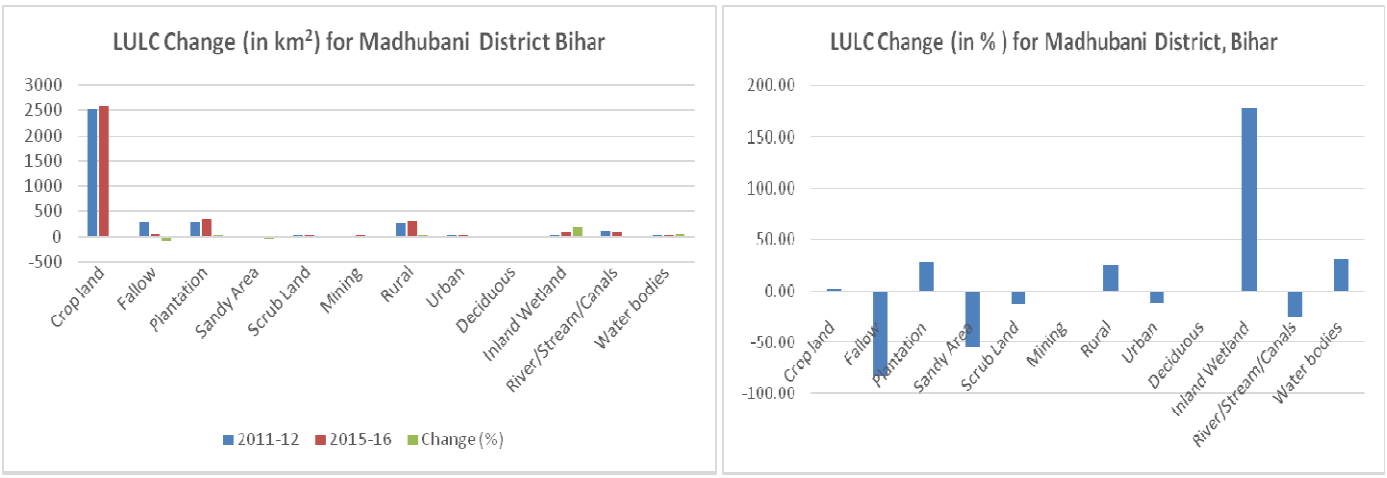


Fig 1 (a)



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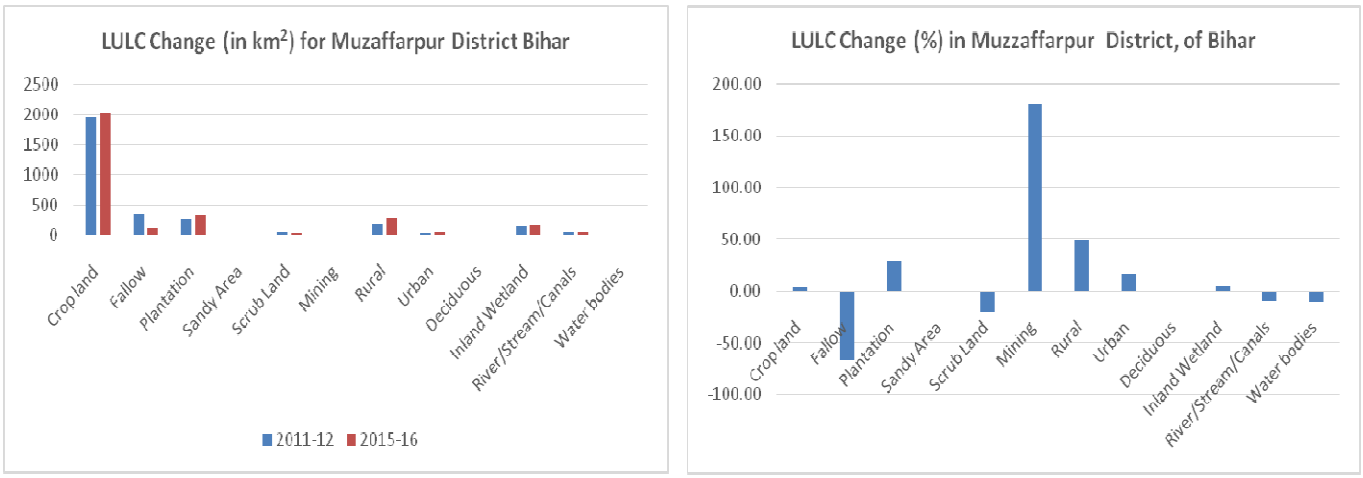

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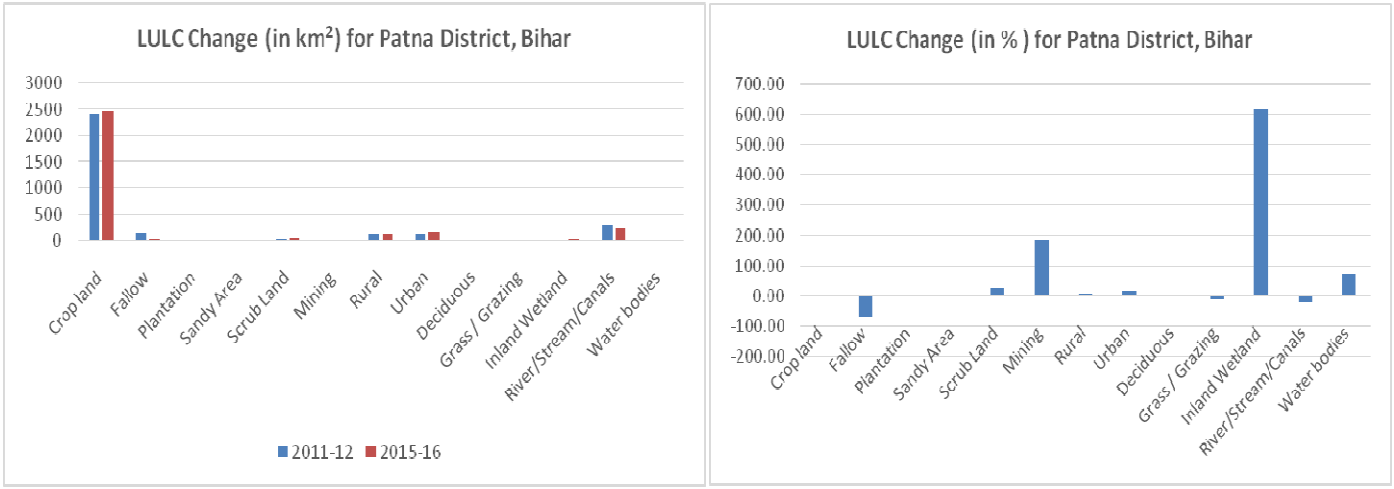

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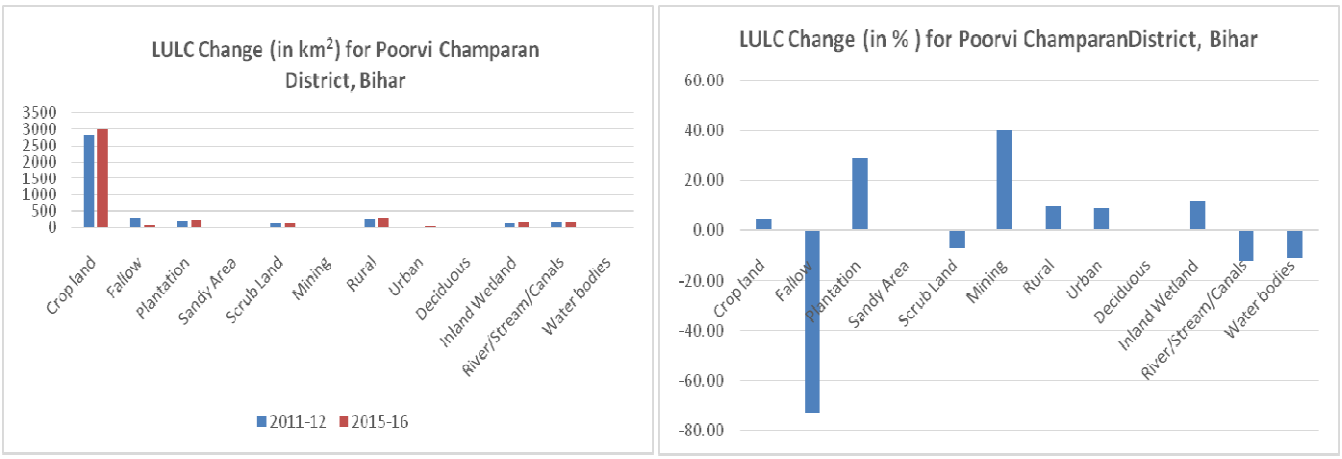

Fig 1 (e)

Fig. 1. A graphical representation of change in various categories of land use; 1(a) Gaya; 1(b)Madhubani; 1(c) Muzaffarpur; 1(d) Patna and 1(e)Poorvi Champaran