European Journal of Geography Volume 9, Number 3:23-44, September 2018

POPULATION CHANGE AND LAND USE DYNAMICS: A CASE STUDY OF PASCHIM MEDINIPUR DISTRICT, WEST BENGAL, INDIA

Jadab Chandra HALDER
Gangarampur College, Department of Geography, West Bengal, India
hcjadab@yahoo.com

Abstract

Land is one of the most remarkable natural resources and land use is the conversion of the biophysical traits of land by several human activities. In developing nations like India, due to incessantly growing pressure of population on the restricted available land resources, land uses have been sculpted and changed over time and space. In Paschim Medinipur, human population has increased by 86.42% that coupled with economic growth has resulted in significant land use changes during 1971-2011. In this study, researcher has incorporated Survey of India (SOI) topographical maps, remote sensing dataset (IRS P6 LISS-III image) and existing inventory datasets to generate land use datasets during 1971–2011. Results have shown that a significant losses of forests and arable land (-2.71% and -16.51%) have occurred during the study period. In contrast to forests and arable land, other uncultivated land excluding fallow land and area not available for cultivation have increased (16.24% and 24.68%). The spatio-temporal analysis of land use dynamics by Remote sensing and GIS and statistical evidences by significant correlations between population change and land use change derived from this study would help to enhance our understanding of the impact of population change on land use dynamics.

Keywords: *Land use, Land use dynamics, Conversion, Population pressure, Remote Sensing and GIS*

1. INTRODUCTION

The properties of the biophysical attributes of land and its use are the pivotal parameters in global change (Herold M et al. 2006; Vishwakarma et al. 2016) and concerns of land use changes have unfolded in research agenda over the last few decades (Lambin et al. 2003). Land use change, increase or decrease in the areal extent of a given type of land use (Briassoulis 1999) is one of the main driving forces of global environmental change (Goldewijk and Ramankutty 2004; Jansen 2006) and it is the central to sustainable development (Meyer and Turner 1992). It is, therefore, the apprehension about land use change has become progressively important in order to scrutinize environmental processes and problems (Jansen 2006). Land use change embraces three processes (Jansen et al. 2007) viz. land use conversion, land use modification and no change. Among theses processes, land use conversion, as the complete replacement of a certain land use type by another (Lambin et al. 2003) is the key parameter to quantify the land use change and can be performed by a simple overlapping of consecutive land use maps.

Human activities, the proximate sources of change (Meyer and Turner 1992) are the major factors contributing to global environmental change (Ojima et al. 1994; Ramankutty and Foley 1999; Tian et al. 2014). In single comprehensive approach (Commoner 1972; Ehrlich and Ehrlich 1990; Meyer and Turner 1992), the candidate driving forces (Turner et al. 1994) have been expressed by IPAT (impact is the repurcussion of population, affluence and technology), the well-known Ehrlich-Holdren formula (Kummer and Turner 1994). In this study, the author has emphasized on population, an important macro-scale variable as an important parameter of human activities. It determines the biological demands and resource scarcity causing pressure of production on resources, one of the important fundamental high level causes of land use change.

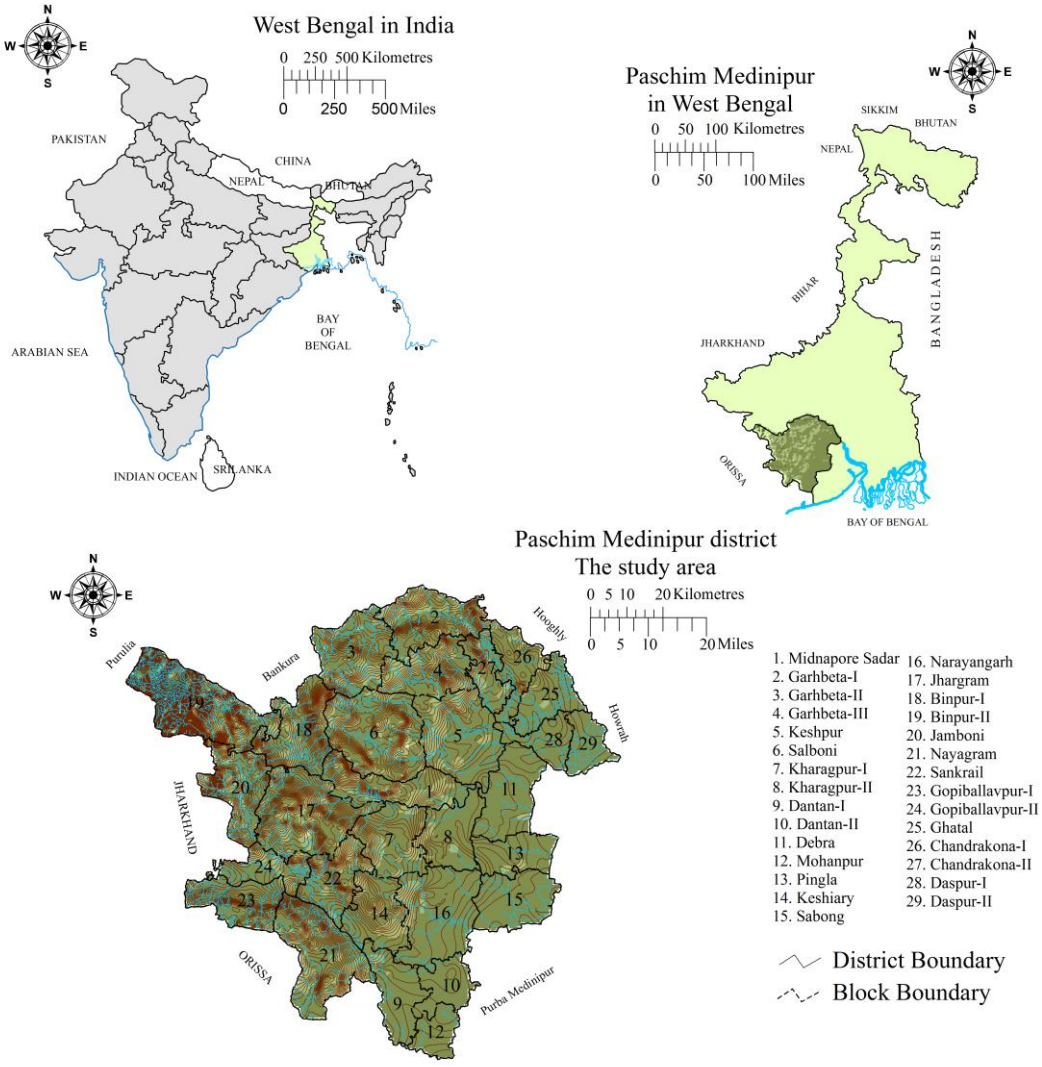
At present there is no standard classification system in India and a very few organizations like National Atlas and Thematic Mapping Organization (NA&TMO), Directorate of Economics and Statistics etc. have evolved their own classification strtegies for land use mapping. Initially, the land area in India was classified into five broad categories, five-fold land utilization classification system (Bhattacharya 1995) including forests, area not available for cultivation, other uncultivated land excluding the current fallow, fallow land and net area sown. This five-fold system was not found adequate enough to meet the needs of agricultural planning in the country. Thus the country requires a broader classification system for better cognizance. Keeping this view in mind, Ministry of Food and Agriculture entrenched the Technical Committee on Co-ordination of Agricultural Statistics (TCCAS) in 1948. This committee endorsed a nine-fold classification scheme replacing the former five-fold classification system, which is adopted by the states all over India (Ramanaiah and Reddy 1990). The revised categories include forests, land put to non agricultural uses, barren and uncultivable land, permanent pastures and other grazing lands, miscellaneous tree crops and groves, cultivable waste land, fallow land other than current fallows, current fallows and net area sown. In this study area, there have changes in the categories of land use during the two study years. The land use categories have been expanded in the second study year. For instance, in 1970-71, there was no sub classification of arable land, but in 2010-11, arable land has been classified as fallow land and net sown area. Therefore, it is difficult to compare the land use pattern of 1970-71 with that of 2010-11.

Therefore for comparative purposes, in this research work, land use categories have been reclassified into four broad categories including arable land, forest land, other uncultivated land excluding fallow land and area not available for cultivation.

In last four decades, Paschim Medinipur has experienced by 86.42% increase in population that has resulted in large scale changes in land use. Despite these, there have no systematic attempts to quantify these changes at different administrative levels in a spatially explicit fashion. The researcher has therefore made the first attempt to generate more reliable and convenient spatially explicit land use datasets for the period of 1971-2011 in the district by integrating the generated datasets from topographical maps and IRS LISS-III image with existing inventory datasets at block level. The researcher believes that his newly developed land use dataset would provide more detailed and accurate information on the spatial and temporal pattern of land use changes in the district. In addition, the researcher has also established the statistical evidence by significant correlations between population change and land use change. Therefore, this research work would be greatly supportive to augment our understanding on the impacts of population change on land use change.

2. STUDY AREA

This district is situated between 20º23' to 22º56' N latitudes and 86º34' to 87º54' E longitudes, covering a geographical area of approximately 9254.64 Km^2 (Figure 1).



Source: District Census Handbook, Midnapore, 2001 and NA & TMO, 2006

Figure 1. Location of the study area

The district is characterized by the abundance of red and lateritic soils, having low organic matter as well as plant nutrients, acidic in reaction, variable soil depth and ground water table, and most significantly the variable slope of the topography. The western part consists of the rolling lateritic soils with dots of hills and the mounds in the extreme north western part, subjected with high surface and subsurface runoff, resulting in severe soil erosion (Basu

1986). This tract of land is also designated as drought prone area of the district. The eastern part, on the contrary is the legatee of the flowing down water and enriched soil transported from the west and has thus shown all signs of productive and progressive land. The eastern most part of the district is often subjected to floods due to stagnation of excessive rain water coming from the western upland.

The entire geographical area of the district experiences Tropical Monsoon Climate is prevalent over here with an average annual rainfall varying between 1425 and 1455 mm. The summer temperature rises to a maximum of 44 ºC in the month of May and the minimum temperature falls to 6 ºC in January. The general climatic condition has influenced the characteristics of soil as well as potentiality of crop production. The land surface of the district is characterized by hard rock upland, lateritic covered area, and almost flat plain; with a slope direction from north-west to south-east (Halder and Das 2010). The district is drained by Kangsabati, Silabati, Dulung, Subarnarekha, Kubai, Kaliaghai and their tributaries and these are flood prone rivers.

3. DATA AND METHODS

3.1 Data sources

The data used can be subdivided into remote sensing data and ancillary data. Satellite data have been used for remote sensing application. Among ancillary data, the SOI topographical maps at a scale of 1:50,000 for the study area are mainly used. Apart from these, some thematic maps and some relevant spatial attribute data have been utilized.

The satellite (IRS-P6) imagery of the sensor Linear Imaging Self-Scanner-III (LISS-III) has been used for the preparation of land use map of 2010-11. The SOI topographical maps (1:50,000) have been wielded for geometric correction of satellite imagery and preparing thematic layers of different land use categories for the year 1970-71. These are also the basis of administrative boundary of the district. In this study, several spatially explicit datasets of land use for two study periods, published by different governmental offices have been used. These data sets are used for reconstructing a spatially emphatic land use datasets by calibrating against the derived data from satellite imagery and topographical maps. Besides, population data have been collected from District Census Handbook (DCH) and primary census abstract (PCA) of Paschim Medinipur district. The ground based data, collected through Global Positioning System (GPS) survey have been used for accuracy assessment purpose.

3.2. Methods

The present research is an outcome of Remote Sensing (RS) and Geographical Information System (GIS) based approach to meet the expected results in order to fulfill the research objectives. Towards this viewpoint, informations are extracted from topographical maps and satellite imagery. For this purpose, onscreen polygon digitizations, using visual interpretation of topographical maps and digital image processing of satellite image have been performed. Object oriented method of topographical map digitization and digital image processing of satellite image along with required preprocessing and post classification analysis for change detection assessment have been adopted for the whole study (Figure 2).

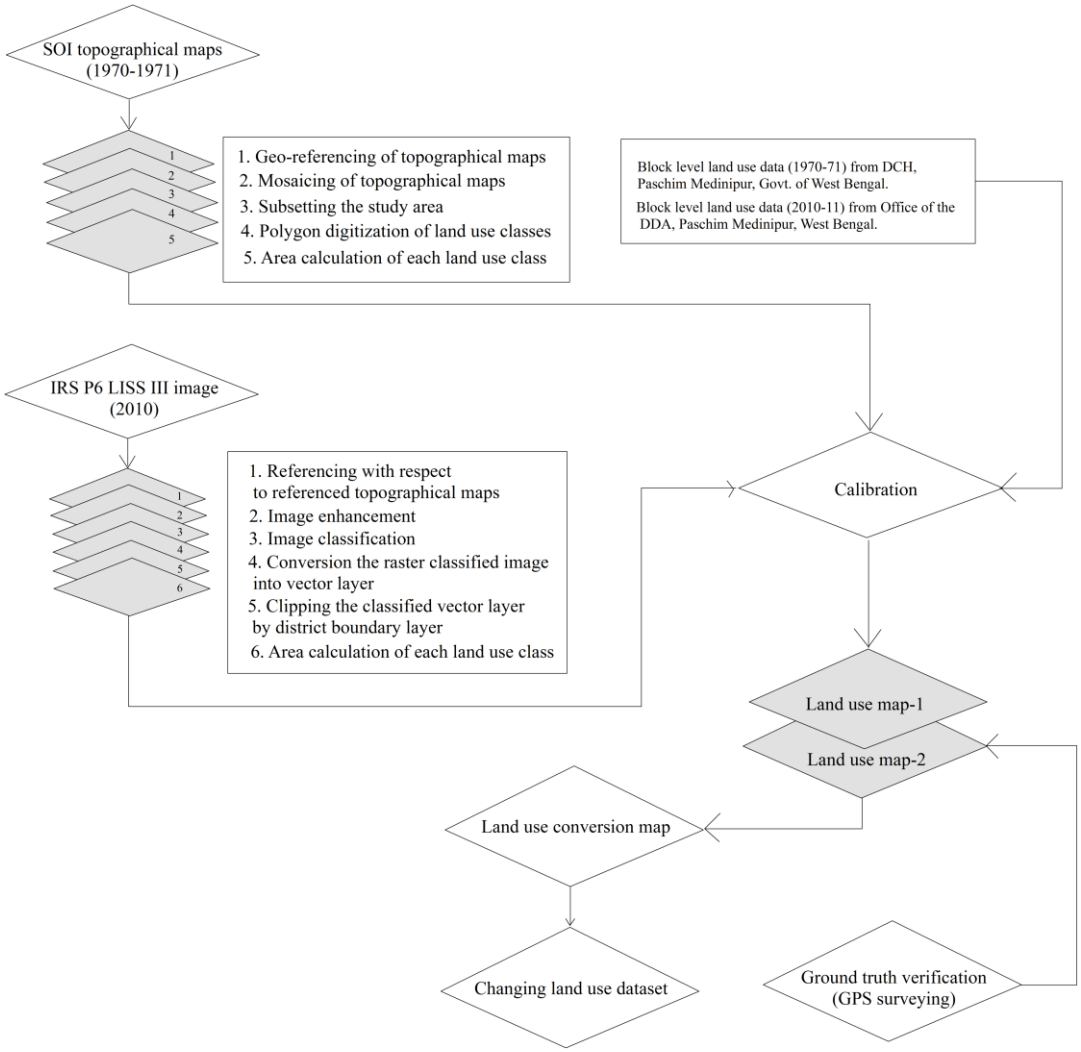


Figure 2. Procedure for generating the changing land use dataset

Before performing the classification of topographical maps and satellite images, it is important to preprocess the data to correct the error during scanning, transmission and recording. Preprocessing refers to the functions which are frequently performed to improve geometric and radiometric qualities of the data. Typically, the preprocessing includes radiometric and geometric corrections of image. In this study, the satellite image (LISS-III) has been geo-referenced by the source in UTM WGS 84 system using image to image registration method. The SOI topographical maps have been used as reference images in this case. The SOI topographical maps were geo referenced by same reference system using image to ground geo correction method. The ground control points (GCPs) were collected from the maps itselves as its have some cross points with known latitude and longitude values. In this study, the radiometric correction has not been adopted. Because, the satellite image of the study area was already corrected.

The study area covers several topographical maps. Thus, it is necessary to combine these maps to create one single topographical map. In the present study, 21 topographical maps covering the study area are mosaicked to create a single topographical map. Subset operations on combined topographical map and satellite image were carried out by creating an area of

interest (AOI) layer in vector format of the district boundary. This AOI layer was extracted from the topographical maps.

The overall intention of image classification is to automatically designate all pixels in an image into finite number of individual classes, based on pixel values (Bhatta 2008). Normally, multispectral images are used to perform in image classification (Lillesand et. al. 2004). In this study, an integrated approach combines visual interpretation and supervised classification has been applied to classify the geometrically rectified LISS-III image of the study area. The band combination of 4-3-2 i.e. near infrared-red-green (NIR-R-G) has been used for land use classification and mapping. Initially, the image has been classified by onscreen visual interpretation technique, based on the available ancillary data and prior knowledge of the multispectral characteristics of different land use classes. In carrying field validation, ground truth verification has been conducted using a GPS receiver (GPSMAP 78s). A total of 40 coordinates together with their respective use categories have been collected from the different parts of the district. The coordinates have been geocoded on the classified satellite image and finally the classified images have been compared with actual field situation. Using the post classification procedure, the classified raster image has been vectorized so that the each polygon holds the class information from the classified image. Finally, the area statistics of various land use categories have been generated using ArcGIS programme. Change detection is the process of identifying differences in the state of an object or phenomenon by observing in at different times (Singh 1989). A wide variety of digital change detection techniques have been developed over the last two decades (Coppin and Bauer 1996). The most commonly used land change detention algorithms include mono-temporal change detection, delta or post classification comparisons, multi-dimensional temporal feature space analysis, composite analysis, image differencing, multi-temporal linear data transformation, change vector analysis, image regression, multi-temporal biomass index, binary masks, principal components analysis, background subtraction and image rationing (Singh 1989; Coppin and Bauer 1996; Walsh et al. 2003). In the present research work, change vector analysis algorithm has been adopted because the study sought to find out the quantitative changes in the areas of various land use categories. Before performing the change detection analysis within a GIS environment, it is important to measure the accuracy of inherent errors of input datasets (Treitz and Rogan 2004). In this present study, the researcher has corrected the errors (boundary, geometry and classification) of two classified land use maps.

4. RESULTS AND DISCUSSION

4.1. Land use pattern in 1970-71 and 2010-11

The static land use patterns (Figures 3 and 4) and distributions of areas under different land use categories for two study year have been derived from the maps and relevant sources. These results (Table 1) show that the most extensive land use category of the district as in 1970-71 was arable land, covered 5763.69 Km^2 (62.28%).

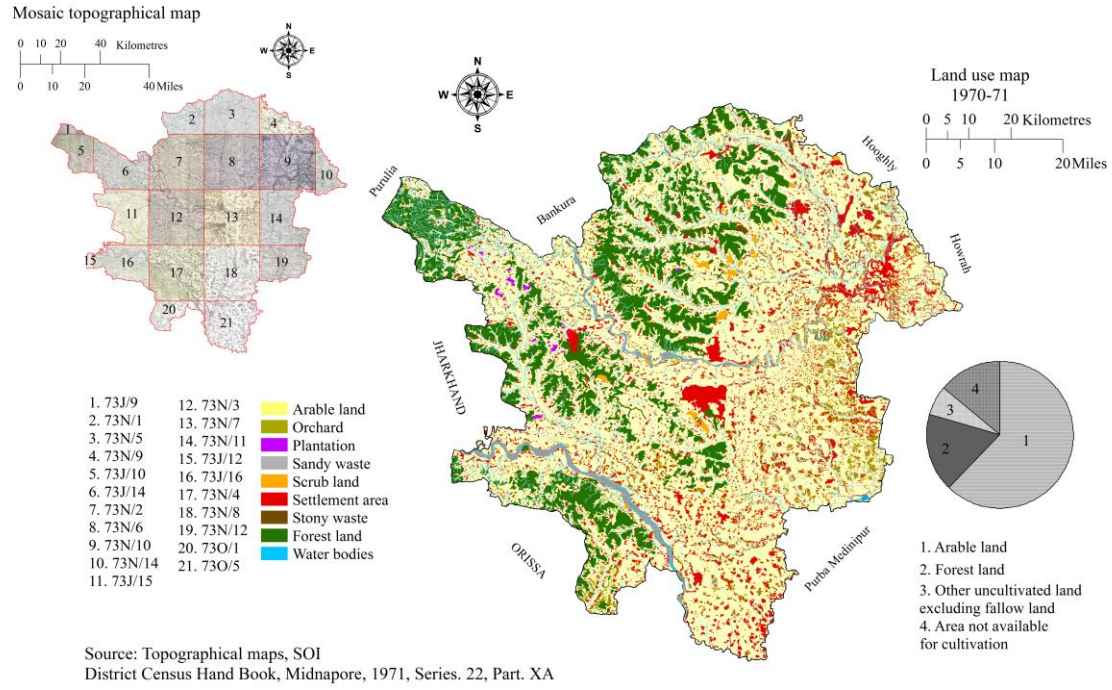


Figure 3. Land use pattern of Paschim Medinipur district (1970-71)

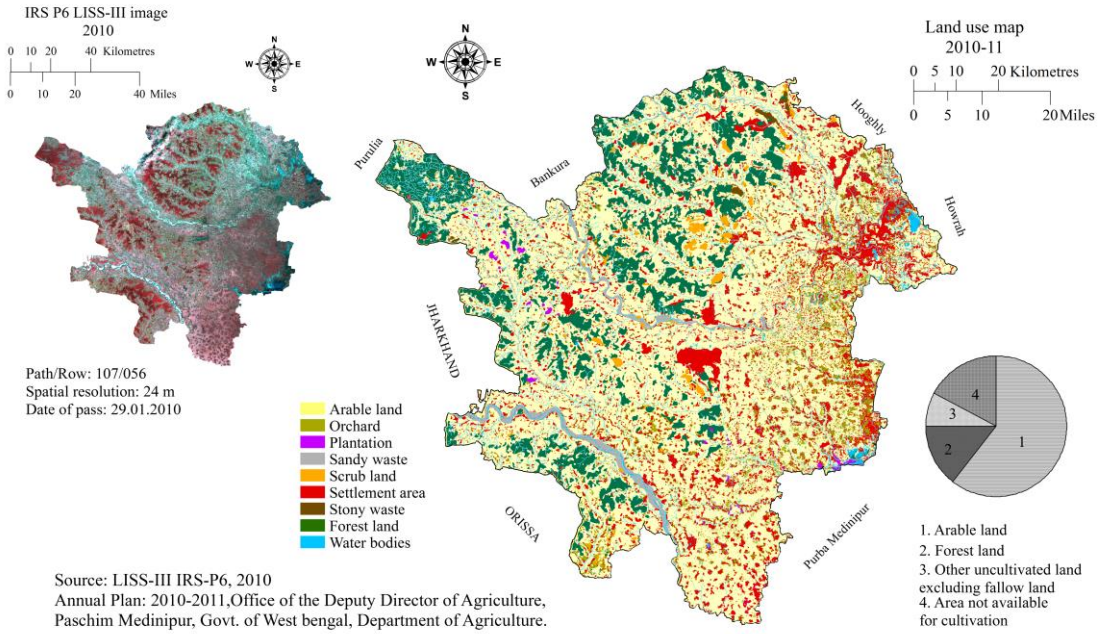


Figure 4. Land use pattern of Paschim Medinipur district (2010-11)

Table 1. Land use pattern of Paschim Medinipur district in 1970-71 and 2010-11

Land use category	1970-71		2010-11	
	Area in Km^2	Area in %	Area in Km^2	Area in %
Arable land	5763.69	62.28	5607.72	60.59
Forest land	1585.49	17.13	1323.73	14.30
Other uncultivated land excluding fallow land	622.47	6.73	723.56	7.82
Area not available for cultivation	1282.99	13.86	1599.63	17.29
District total	**9254.64**	**100.00**	**9254.64**	**100.00**

The second most extensive category was forest land, which accounted for 1585.49 Km^2 (17.13%). Area not available for cultivation occupied 1282.99 Km^2 (13.86%) and this was followed by other uncultivated land excluding fallow land, which covered 622.47 Km^2 (6.73 %). The magnitude of the spatial extent of the land use categories for the year of 2010-11 shows that the most extensive cover being arable land covers 5607.72 Km^2 (60.59 %). Area not available for cultivation is the second most extensive category (17.28 %), while forest land and other uncultivated land excluding fallow land cover 1323.73 Km^2 (14.30 %) and 723.56 Km^2 (7.83 %) respectively. It is evident from the distributions of different land use categories in terms of area that, the land use pattern of the district is more dynamic in nature. The arable land and forest land have been decreased from 5763.69 Km^2 and 1585.49 Km^2 in 1970-71 to 5607.72 Km^2 and 1323.73 Km^2 in 2010-11 showing the net decreases of 2.71% and 16.51%. In contrary, the other uncultivated land excluding fallow land and area not available for cultivation have been increased from 622.47 Km^2 and 1282.99 Sq. Km to 723.56 Km^2 and 1599.63 Km^2 showing the net increases of 16.24% and 24.68% during the span of last four decades.

4.2. Dynamism of different land use categories

4.2.1. Arable land

Arable land includes fallow land[1] and fallow land other than current fallow[2]. This category has decreased to about 2.71% during the period from 1970-71 to 2010-11. In terms of area, the arable land has decreased from 5763.69 Km^2 to 5607.72 Km^2 showing a net decrease of 155.97 Km^2. From the results (Figure 5 and Table 3), an area of about 1351.63 Km^2 of arable land has been subjected to negative change. Out of which 715.51 Km^2 by area not available for cultivation, 263.73 Km^2 by forest land and the remaining 372.39 Km^2 by other uncultivated land excluding fallow land. By contrast, an area of 1195.66 Km^2 has been gained by arable land in the period under review. Out of which, 495.89 Km^2 from forest land, 436.09 Km^2 from area not available for cultivation and the remaining 263.68 Km^2 from other uncultivated land excluding fallow land. The spatial analysis (Table 2) reveals that there has been an increase in the percentage of area under arable land in 9 blocks, out of which a moderate volume in increase (10 to 20 %) is recorded in 4 blocks, whereas the rest 5 blocks register the low volume of increase (below 10 %). A decrease in arable land is noticed in 20 blocks, most of which are located in the eastern part of the district. A high volume in

[1] Fallow lands are those routinely used to grow domesticated plants for livestock production, varying from long fallow and long rotational system to indelible multi-cropping systems.

[2] Current fallow includes all lands which were practiced for cultivation but are provisionally out of cultivation for a period of not less than one year and not more than five years.

decrease of more than 30 % is registered in Daspur-I block. In 3 blocks, the decreases range between 20 to 30 % which are categorized by zone of high increases. In 2 blocks, the decreases range from 10 to 20 percent, which are designated as zone of moderate decrease. A decrease of less than 10 % has taken place in 14 blocks which have been grouped in the category of zone of low decrease.

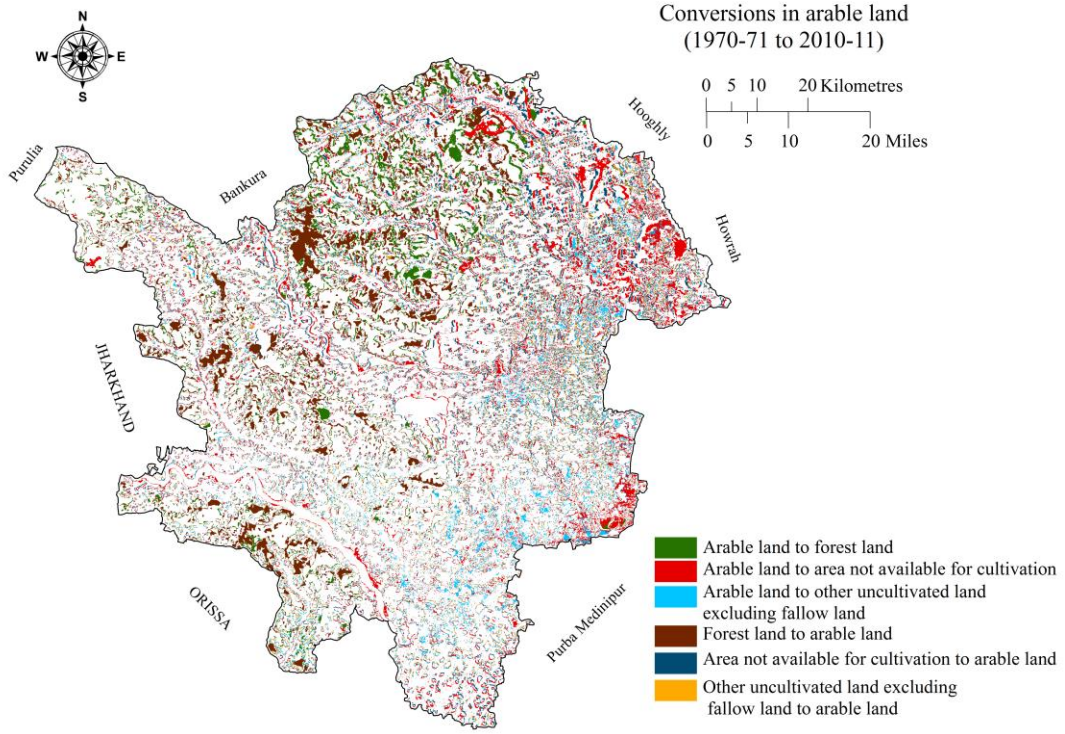


Figure 5. Conversions in arable land (1970-71 to 2010-11)

4.2.2. Forest land

The area under forests[3] in the district has shown a reduction of 16.51% during the period from 1970-71 to 2010-11. In terms of area, the area under forest land has decreased from 1585.49 Km^2 in 1970-71 to 1323.73 Km^2 in 2010-11 showing a net decrease of 261.76 Km^2. The results show that an area of about 547.78 Km^2 of forests has been decreased (negative change) during the span of four decades, of which the significant processes of negative change are losses through conversions to arable land (495.89 Km^2), area not available for cultivation (39.21 Km^2) and other uncultivated land excluding fallow land (12.68 Km^2). These conversions have been achieved due to the increasing demand of land for settlement, extension of road and rail networks and different constructional works. In the men time, forest land has been expanded (positive change) by 286.02 Km^2 in last four decades. Conversion through arable land (263.73%) has been identified here as the key source of this positive change. The spatial analysis reveals that the area under forest land has increased in as many as 5 blocks. The very high volume of increase of more than 40 % is noticed in 2 blocks, located in the eastern part of the district and a very low volume of increase (less than

[3] Forests consist of perennial plants (Baker 1937). Land covering more than 0.005 Km^2 with trees higher than 5 m and a canopy cover of more than 10 percent. It does not append land that is predominantly under agricultural or urban land use. This should include lands classed as forests under any legal endorsement dealing with forests or administrated as forests.

10 %) is registered in 3 blocks. A decrease of forest land is noticed in 15 blocks. Very high decrease of more than 40 % is registered in Binpur-I block and high decrease of 30 to 40% has taken place in 2 blocks.

Table 2. Volume of change in different land use categories (1970-71 to 2010-11)

Sl. No	Block	Arable land		Forest land		Other uncultivated land excluding fallow land		Area not available for cultivation	
		Change in Km^2	% change	Change in Km^2	% change	Change in Km^2	% change	Change in Km^2	% change
1	Midnapore Sadar	2.34	1.17	-12.86	-18.25	0.37	4.25	10.15	17.25
2	Garhbeta-I	-3.69	-1.75	-8.44	-8.74	-2.76	-28.93	14.89	32.92
3	Garhbeta-II	-13.54	-6.16	9.40	7.34	0.14	0.95	4.00	13.34
4	Garhbeta-III	-3.68	-2.14	-3.13	-2.86	0.15	1.66	6.66	30.05
5	Keshpur	-18.69	-5.45	2.34	5.39	0.48	1.184	15.87	28.31
6	Salboni	36.61	12.56	-40.61	-19.29	-0.61	-3.60	4.61	13.42
7	Kharagpur-I	2.43	1.25	-9.14	-23.69	0.32	4.25	6.39	8.74
8	Kharagpur-II	-15.16	-7.14	0.03	100.00	7.76	51.32	7.37	19.35
9	Dantan-I	-12.18	-6.32	0.00	0.00	6.89	36.94	5.29	11.56
10	Dantan-II	-11.9	-8.60	0.00	0.00	5.45	29.90	6.45	22.23
11	Debra	-29.59	-13.73	0.00	0.00	14.63	22.99	14.96	23.66
12	Mohanpur	-1.30	-1.30	0.00	0.00	0.25	4.01	1.05	3.40
13	Pingla	-17.75	-12.70	0.00	0.00	4.01	8.98	13.74	34.35
14	Keshiary	-7.36	-3.67	-3.79	-17.08	2.46	9.20	8.69	20.49
15	Sabang	-61.59	-28.02	0.00	0.00	15.37	32.20	46.22	123.38
16	Narayangarh	-31.76	-8.80	-4.84	-14.67	22.98	51.90	13.62	22.17
17	Jhargram	30.00	9.67	-38.81	-24.09	6.30	98.90	2.51	4.61
18	Binpur-I	34.86	16.74	-42.75	-53.72	1.48	6.50	6.41	13.63
19	Binpur-II	-2.82	-0.95	-9.21	-4.08	0.89	4.12	11.14	29.14
20	Jamboni	30.48	17.59	-41.81	-35.60	3.51	45.76	7.82	39.64
21	Nayagram	37.29	15.81	-44.04	-28.01	1.23	2.83	5.52	8.51
22	Sankrail	3.15	1.61	-7.15	-38.40	-0.18	-0.79	4.18	10.61
23	Gopiballavpur-I	6.97	4.06	-12.01	-20.68	0.44	3.59	4.60	13.61
24	Gopiballavpur-II	-3.56	-2.59	-1.36	-25.23	1.39	18.19	3.53	8.44
25	Ghatal	-36.62	-25.89	0.00	0.00	8.27	24.79	28.35	45.76
26	Chandrakona-I	-10.39	-6.82	0.05	4.46	-0.01	-0.06	10.35	22.37
27	Chandrakona-II	-6.78	-5.62	6.37	73.39	-0.38	-9.41	0.79	2.34
28	Daspur-I	-30.18	-33.48	0.00	0.00	2.44	16.91	27.74	43.53
29	Daspur-II	-21.56	-18.32	0.00	0.00	-2.18	-12.22	23.74	79.27
	District total	**-155.97**	**-2.71**	**-261.76**	**-16.51**	**101.09**	**16.24**	**316.64**	**24.68**

A moderate decrease of 20 to 30% has been experienced in 5 blocks and they are distributed in south western part of the district. In 4 blocks, the decreases range between 10 to 20 %. The decreases of forest land have been accounted as low i.e., below 10 % in 3 blocks, located in extreme north-western and northern parts of the district (Table 2). It shows that these areas have shown considerable amounts of stability in their forest lands. It may be remarked that, almost all blocks showing decreases lie in the western part of the district, possessing extensive patches of forests, the peripheral areas of which have been shared due to the agricultural colonization and felling of trees for meeting the increasing demands for

timber and fire wood as well as different constructional establishments (Figure 6). The slashing down of forests with such a rapid pace is an alarming situation which calls for immediate attention.

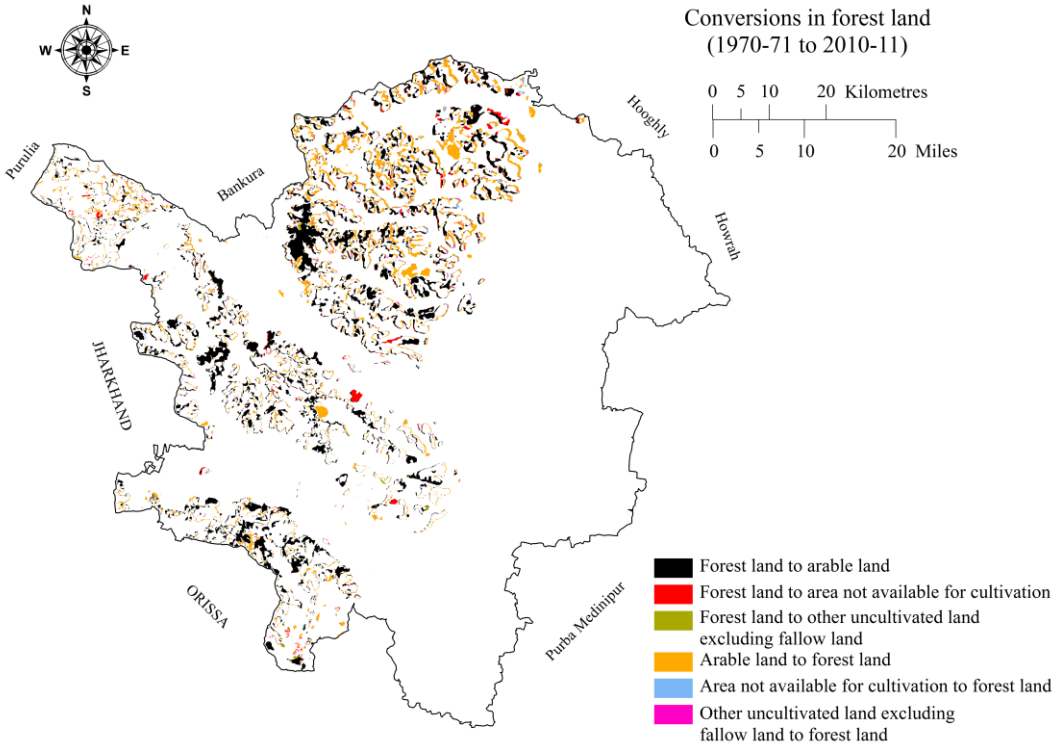


Figure 6. Conversions in forest land (1970-71 to 2010-11)

4.2.3. Other uncultivated land excluding fallow land

This category includes areas devoted to permanent pasture and other grazing lands[4], land under miscellaneous tree crops and groves[5], orchard and plantation[6] and cultivable waste land[7] There have occurred significant changes in the 'other uncultivated excluding fallow land' and its sub-categories (Figure 7). It may be mentioned here that, due to non availability of the data of different subcategories for the early period (1970-71), other uncultivated land excluding fallow land has been considered here as a broad land use category. This category has increased from 622.47 Km^2 in 1970-71 to 723.56 Km^2 in 2010-11 showing a net increase of 101.09 Km^2. It is indeed a positive trend. The principal processes of positive change are gain through arable land (372.39 Km^2) and area not available for cultivation (117.20 Km^2), while the processes decreasing the negative change are loss through conversion to former two

[4] Pasture includes a vast diversity of plants having the one common characteristic of being grazed by livestock.
[5] This category includes all cultivable lands which are not included in 'net sown area' but is put some agricultural uses. Land under Casurina trees, thatching grasses, bamboo bushes and other groves for fuel etc should be classed under this category.

[6] The orchard lands include the lands devoted to the cultivation of fruit or nut trees. The garden developed in settlement area to serve an aesthetic or productive purpose should de classed as orchard land. The plantation lands include the lands which are used for the cultivation of a group of trees.

[7] This should include lands available for cultivation, whether not taken up for cultivation or practiced for cultivation once but not cultivated during the current year and last five years or more in progression for one reason or the other.

categories (263.68 Km^2 and 131.72 Km^2). Regional variations indicate as many as 23 blocks have shown an increase in the volume of this category. Out of which increase with very high amount (above 40 %) is recorded in 4 blocks, 2 blocks are recorded as high amount (30 to 40 %) of increase, 3 blocks as moderate volume of increase (20 to 30 %), 2 block as low amount (10 to 20 %) of increase and 12 blocks record a very low volume (less than 10 %) of increase. On the other hand, 6 blocks have shown some decreases. Out of which, a moderate volume of decrease (20 to 30 %) is recorded in only one block, low volume of decrease (10 to 20 %) is recorded in one blocks and 4 blocks display very low volume of decrease (below 10 %).

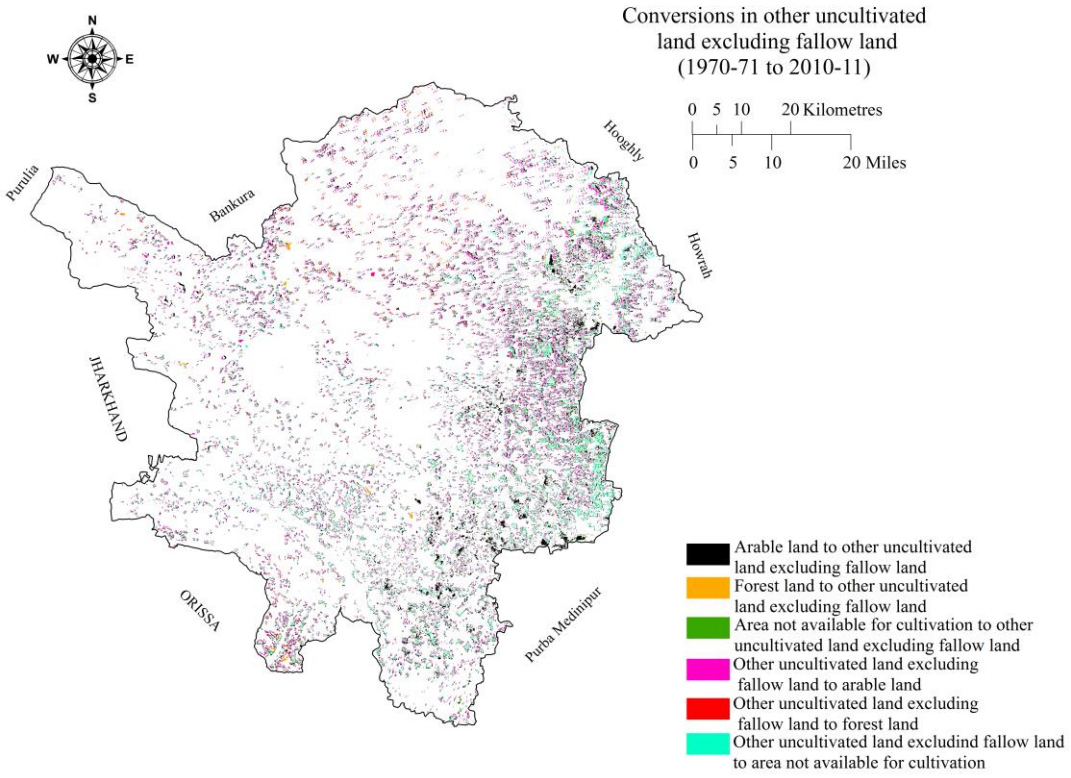


Figure 7 Conversions in other uncultivated land excluding fallow land (1970-71 to 2010-11)

4.2.4. Area not available for cultivation

This category includes area put to non agricultural uses and waste land[8]. Theoretically, this category of land use should show an increase due to productive human uses (Meyer and Turner, 1992) such as settlement, roads, rail networks, reservoirs and industrial establishments. The study indicates an increase of 24.68 % from 1970-71 to 2010-11. Conversion through arable land (715.51 Km^2) has been widely identified as a major process of positive change associated with excessive demand of land for non agricultural uses. Spatial variations show that very high volume of increase of above 40 % has been experienced by 4 blocks, located in the eastern plain region. Conversion through water bodies is the key proximate source of this change. In 4 blocks, the increases range between 30 to 40 %, which are grouped as zone of high increase. A moderate volume of increase of 20 to 30 % are found in 7 blocks, of which 6 blocks are located in the eastern part and 1 block in extreme

[8] This should include all barren and uncultivable land like mountains, deserts etc. These lands are generally infelicitous for agricultural uses because of badlands, soil and topography.

western part of the district. Low volume of increase (10 to 20 percent) is witnessed in 8 blocks, most of which are located in the plateau fringe area. A very low volume in increase (below 10 percent) is experienced in 6 blocks, of which 5 blocks are located in the south western part and 1 block is located in north eastern part of the district (Figure 8 and Table 2).

Table 3. Total volume of change in land use in Paschim Medinipur district (1970-71 to 2010-11)

Sl. no.	Block	Total area (Km^2)	Area subjected to change (Km^2)	% change
1	Midnapore Sadar	338.42	81.50	24.08
2	Garhbeta-I	361.87	149.80	41.40
3	Garhbeta-II	392.55	144.24	36.74
4	Garhbeta-III	312.12	124.21	39.80
5	Keshpur	483.15	171.27	35.45
6	Salboni	553.39	211.07	38.14
7	Kharagpur-I	313.31	65.37	20.86
8	Kharagpur-II	265.63	77.92	29.33
9	Dantan-I	257.07	58.65	22.81
10	Dantan-II	185.56	45.58	24.56
11	Debra	342.41	156.01	45.56
12	Mohanpur	137.49	33.22	24.16
13	Pingla	224.48	81.90	36.48
14	Keshiary	292.09	62.20	21.29
15	Sabang	305.00	120.50	39.51
16	Narayangarh	499.48	150.72	30.18
17	Jhargram	532.15	100.00	18.79
18	Binpur-I	357.60	143.06	40.01
19	Binpur-II	583.50	121.25	20.78
20	Jamboni	318.13	91.88	28.88
21	Nayagram	501.44	122.31	24.39
22	Sankrail	276.80	56.89	20.55
23	Gopiballavpur-I	275.83	61.57	22.32
24	Gopiballavpur-II	192.17	29.73	15.47
25	Ghatal	236.77	117.45	49.61
26	Chandrakona-I	215.45	84.03	39.00
27	Chandrakona-II	167.02	61.37	36.74
28	Daspur-I	168.31	80.92	48.08
29	Daspur-II	165.45	65.77	39.75
	District total	**9254.64**	**2870.39**	**31.02**

It is remarkable to note that all blocks are experienced by positive changes of land not available for cultivation, but very high to high positive changes in those blocks where due to some development schemes, the area under settlement, roads and irrigational canals etc. have increased or due to floods, waterlogging and erosional hazards, some areas have gone out of cultivation. Similarly, the rolling topography, dense forest land, reclamation of waste land etc. have caused for low to very low volume of increase in some blocks.

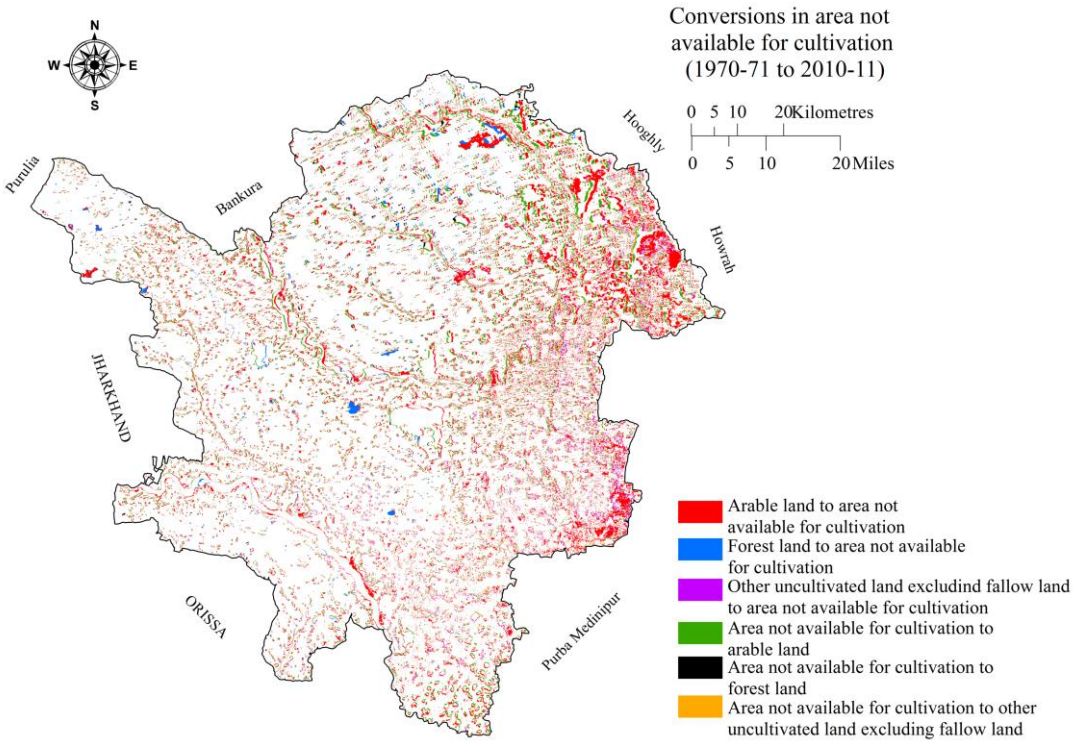


Figure 8. Conversions in area not available for cultivation (1970-71 to 2010-11)

4.3. Total volume of change in land use

Total volume of change i.e. the intensity of land use change provides a comparative view of land use ranging between more dynamic to more stable nature. From the results, although the district has experienced an overall change of 31.02 % during the span of four decades, there are sub regional variations have taken place (Table. 4). It varies from a maximum of 49.61 % in Ghatal block to a minimum of 15.47 % in Gopiballavpur-II block. A high volume of change ranging between 40 and 50 % in land use has taken place in five blocks (Garhbeta-I, Binpur-I, Ghatal, Daspur-I and Debra). These blocks have been grouped in the category of 'highly dynamic land use zone'. A change of 30 to 40% in land use has taken place in 10 blocks, most of which are concentrated in the northern and eastern parts of the district (Table 4). These blocks have been categorized as 'dynamic land use zone'. A change of 20 to 30% in land use has registered in 12 blocks which are mostly found in middle and southern parts

of the district. These blocks have been grouped as the 'zone of moderately dynamic land use', while only two blocks occurring in the western part are designated as 'low dynamic land use zone'. In these two blocks, the overall volume of change ranges between 10 and 20 %.

Table 4. Conversions of selected land use categories in Paschim Medinipur district (1970-71 to 2010-11)

Land use category	Gain from (Km^2)	Loss through (Km^2)	% change
Arable land	Forest land (495.89), Other uncultivated land excluding fallow land (263.68), Area not available for cultivation (436.09)	Forest land (-263.73), Other uncultivated land excluding fallow land (-372.39), Area not available for cultivation (715.51)	-2.71
Forest land	Arable land (263.73), Other uncultivated land excluding fallow land (5.78), Area not available for cultivation (16.51)	Arable land (-495.89), Other uncultivated land excluding fallow land (12.68), Area not available for cultivation (39.21)	-16.51
Other uncultivated land excluding fallow land	Arable land (372.39), Forest land (12.68), Area not available for cultivation (117.20)	Arable land (-263.68), Forest land (-5.78), Area not available for cultivation (-131.72)	16.24
Area not available for cultivation	Arable land (715.51), Forest land (39.21), Other uncultivated land excluding fallow land (131.72)	Arable land (-436.09), Forest land (-16.51), Other uncultivated land excluding fallow land (-117.20)	24.68

5. POPULATION CHANGE AND ITS IMPACT ON LAND USE DYNAMICS

Various aspects of population modify land use. A variety of factors related with the increase in human population affect the supply and demand of land and its use in a particular area (Hook et al. 2012). Man and his cultural attainments play an important role in the extent and degree of land utilization and therefore, it seems logical to discuss the population change and their impact on changing land use pattern of the study area. Density of population is a better measure of understanding the variation in the distribution of population (Khullar 2010). It is a parameter for ascertaining population pressure. It provides a sound basis for calculating the direct measure of population pressure in a particular area for a particular period. Density of population is a reflection of growth of population as well as the determinant of human pressure on land. Therefore, Population density, which is expressed as number of persons/$Km^{2,}$ has been taken here as a driving force by which the changes of different land use categories including the total volume of change in land use can be determined. Firstly, changing volume of population density has been considered as an independent variable (x) and the changing volume of different land use categories including total volume of change have been considered as dependent variables (y_1, y_2,..... y_n). Secondly, using the spatial distribution of each factor significant correlations have been established by a number of scatter diagrams (Figure 9). A scatter diagram may be defined as the graphical representation of two variables (x and y) to show the relationship between them. In addition to graphical representation by scatter diagram, regression line and correlation coefficient (r) have also been computed for showing the nature of relationship (Table 6). The density of population for the district as a whole has increased by 86.42 % during the span of four decades showing a quantum jump of 296 persons per square kilometre. It is evident from the study (using census data) that, a very high volume of increase of above 125 % is observed in two blocks, located in the northern part of the district. A high volume of increase (100 to 125 %) is experienced in eight blocks. In nine blocks, the increase is recorded as moderate volume (75 to 100 %). While, low (50 to 75 %) and very low (below 50 %) volume of increase is recorded in nine blocks and one block respectively (Table 5). It is evident from the above

discussion of the spatial variation of increase in population density that, all blocks in the district have recorded some increase in their population densities during 1971 to 2011. However, such an increase is lower in the blocks of western part than the other parts of the district. This is signifying that the growth of population is comparatively lower in these blocks.

Table 5. Population density and its changing pattern in Paschim Medinipur district (1971 to 2011)

Sl. no.	Block	1971		2011		% change
		Total population	Population density (persons/ Km^2)	Total population	Population density (persons/ Km^2)	
1	Midnapore Sadar	230,558	681.28	360,969	1066.63	56.56
2	Garhbeta-I	91,946	254.09	228,513	631.48	148.53
3	Garhbeta-II	76,061	193.76	148,410	378.07	95.12
4	Garhbeta-III	73,582	235.75	169,528	543.15	130.39
5	Keshpur	153,594	317.90	339,248	702.16	120.87
6	Salboni	98,860	178.64	188,653	340.90	90.83
7	Kharagpur-I	241,618	771.18	465,644	1486.21	92.72
8	Kharagpur-II	90,584	341.02	183,440	690.58	102.51
9	Dantan-I	95,313	370.77	172,107	669.49	80.57
10	Dantan-II	73,898	398.24	155,017	835.40	109.77
11	Debra	150,544	439.66	288,619	842.90	91.72
12	Mohanpur	53,301	387.67	111,901	813.88	109.94
13	Pingla	95,269	424.40	194,809	867.82	104.48
14	Keshiary	76,383	261.51	149,260	511.01	95.41
15	Sabang	132,301	433.77	270,492	886.86	104.45
16	Narayangarh	154,787	309.90	302,620	605.87	95.51
17	Jhargram	139,194	261.57	231,809	435.61	66.54
18	Binpur-I	91,509	255.90	156,153	436.67	70.64
19	Binpur-II	101,491	173.93	164,522	281.96	62.11
20	Jamboni	68,886	216.53	113,197	355.82	64.33
21	Nayagram	82,215	163.96	142,199	283.58	72.96
22	Sankrail	67,610	244.26	115,418	416.97	70.71
23	Gopiballavpur-I	61,099	221.51	108,254	392.47	77.18
24	Gopiballavpur-II	65,338	340.00	104,996	546.37	60.70
25	Ghatal	184,190	777.93	286,264	1209.04	55.42
26	Chandrakona-I	115,066	534.07	172,001	798.33	49.48
27	Chandrakona-II	69,035	413.33	146,898	879.52	112.79
28	Daspur-I	101,957	605.77	203,987	1211.97	100.07
29	Daspur-II	135,987	821.92	238,529	1441.70	75.41
District total		**3,172,176**	**342.77**	**5,913,457**	**638.97**	**86.42**

5.1. Changing population density vs. arable land

In the district, as a whole, the density of population has increased by 86.42 % during the span of four decades. In the mean time, the district has registered a decrease to the tune of 2.71 % in its arable land. Thus, a cursory observation shows that, the volume of change in arable land is negatively correlated with the volume of change in population density. The study

shows that, there are many blocks in the district, where the volume of increase in population density is very high to high, but, the volume of decrease in arable land is very low. For example, in Garhbeta-I and III, the volume of change in population density is very high (above 125 %), but, the volume of decrease in arable land is very low (below 10 %). Similarly, of the eight blocks with high volume of increase in population density, six blocks have recorded a very low volume of decrease, one block has recorded a moderate volume of decrease and one block has registered a high volume of decrease in arable land. In the same way, out of nine blocks with moderate volume of increase in population density, four blocks have recorded a very low volume of decrease and two blocks have registered a low volume of decrease in arable land. While, the remaining three block have registered some increase in their areas under arable land. These blocks are Salboni (12.56 %), Gopiballavpur-I (4.06 %) and Kharagpur-I (1.25 %). On the other hand, from among 10 blocks with low to very low volume of increase in population density, three blocks have recorded a very low volume of decrease and one block has shown a moderate volume of decrease in area under arable land. While, six blocks have displayed some increases in arable land ranging between low and very low volumes. Thus, there exists a weak negative coefficient of correlation (r = -0.21141) between the changing volume of population density and changing volume of arable land.

5.2. Changing population density vs. forest land

During 1971 to 2011, the district displays a decrease of 16.51 % of its forest land. The volume of decrease in forest land is largely associated with the increasing demand of land for agricultural and constructional developments in different parts of the district. Therefore, it is logical to establish a relationship between population growth and the volume of change in forest land. A comparative assessment brings out very clearly that, a very low volume of decrease (below 10 %) in forest land is occurred in three blocks. Of which, two blocks have shown a very high volume of increase in their population densities. Similarly, a very high volume of decrease in forest land has been observed in only one block (Binpur-I), Where the volume of increase in population density is low. By contrast, an increase in area under forest is observed in as many as five blocks. Of which, in three blocks (Keshpur, Kharagpur-II and Chandrakona-II), the population densities have increased at the range between 100 and 125 % (high) and only in two blocks (Garhbeta-II and Chandrakona-I), they have increased by 95.12 % and 49.48 % (moderate and low). Thus, there exists a weak positive coefficient of correlation (r = 0.36446) between these two factors.

5.3. Changing population density vs. other uncultivated land excluding fallow land

In the district as a whole, the area under ‘other uncultivated land excluding fallow land’ has increased by 16.24 % with its increased volume of population density. Nevertheless, the above ratio does not remain same all over the district. For example, of the two blocks with very high volume of increase in population density, one block (Garhbeta-I) records a decrease of 28.93 % (moderate) and another one shows a very low volume of decrease in area under this land use category. Similarly, among 8 blocks with high volume of increase in population density, 3 blocks record an increase of below 10 % (very low), one block shows a low volume of increase (10 to 20 %), one block displays a moderate volume of increase (20 to 30 %) and 2 blocks register some increase ranging between high and very high volumes in area under this land use category. While, the remaining one block displays a low volume of increase of its area under this land use category. By contrast, of the 10 blocks with low to very low volume of increase in population density, 4 blocks have shown a very low volume

of decrease, 2 blocks have registered some increase ranging between moderate and low volumes, 2 blocks have displayed an increase of above 40 % (very high) in their areas under 'other uncultivated land excluding fallow land'. While, two blocks have recorded very slight volume of decrease (below 1 %) in area under this land use category. Thus, the preceding fact proves that the volume of change in area under this category of land use is negatively correlated (r = -0.25102) with the volume of change in population density.

Table 6. Correlations between percentage change of population density and volume of change in different land use categories in Paschim Medinipur district

Block	changing population density (x) and volume of change in arable land in % (y_1)	changing population density (x) and volume of change in forest land in % (y_2)	changing population density (x) and volume of change in other uncultivated land excluding fallow land in % (y_3)	changing population density (x_1 and volume of change in area not available for cultivation in % (y_4)	changing population density (x) and total volume of change in land use in % (y_5)
	Y_C	Y_C	Y_C	Y_C	Y_C
Midnapore Sadar	-0.6322	-19.2944	22.9821	22.4074	27.8886
Garhbeta-I	-10.6135	21.9303	-0.8331	31.9532	38.3948
Garhbeta-II	-4.8170	-2.0104	12.9972	26.4096	32.2935
Garhbeta-III	8.6448	13.7991	3.8642	30.0704	36.3225
Keshpur	-7.6116	9.5318	6.3293	29.0823	35.2350
Salboni	-4.3514	-3.9334	14.1080	25.9644	31.8034
Kharagpur-I	-4.5565	-3.0862	13.6186	26.1605	32.0193
Kharagpur-II	-5.6190	1.3021	11.0836	27.1767	33.1377
Dantan-I	-3.2379	-8.5324	16.7648	24.8995	30.6314
Dantan-II	-6.4069	4.5564	9.2036	27.9302	33.9670
Debra	-4.4480	-3.5345	13.8776	26.0567	31.9051
Mohanpur	-6.4254	4.6326	9.1596	27.9478	33.9865
Pingla	-5.8328	2.1851	10.5734	27.3811	33.3627
Keshiary	-4.8485	-1.8804	12.9221	26.4397	32.3266
Sabang	-5.8296	2.1717	10.5812	27.3780	33.3593
Narayangarh	-4.8593	-1.8356	12.8962	26.4501	32.3380
Jhargram	-1.7153	-14.8213	20.3978	23.4432	29.0287
Binpur-I	-2.1602	-12.9835	19.3361	23.8688	29.4970
Binpur-II	-1.1245	-16.8070	21.5449	22.9834	28.5226
Jamboni	-1.4754	-15.8119	20.9701	23.2139	28.7762
Nayagram	-2.4120	-11.9436	18.7354	24.1096	29.7621
Sankrail	-2.1678	-12.9521	19.3180	23.8761	29.5050
Gopiballavpur-I	-2.8700	-10.0520	17.6426	24.5476	30.2441
Gopiballavpur-II	-1.0815	-17.4391	21.9100	22.8371	28.3615
Ghatal	-0.5084	-19.8058	23.2773	22.2891	27.7584
Chandrakona-I	0.1362	-22.4684	24.8154	21.6725	27.0798
Chandrakona-II	-6.7347	5.9101	8.4216	28.2436	34.3120
Daspur-I	-5.3542	0.2084	11.7154	26.9234	32.8590
Daspur-II	-2.6779	-10.8454	18.1010	24.3639	30.0419
R	-0.28507	0.36446	-0.25102	0.10156	0.28527

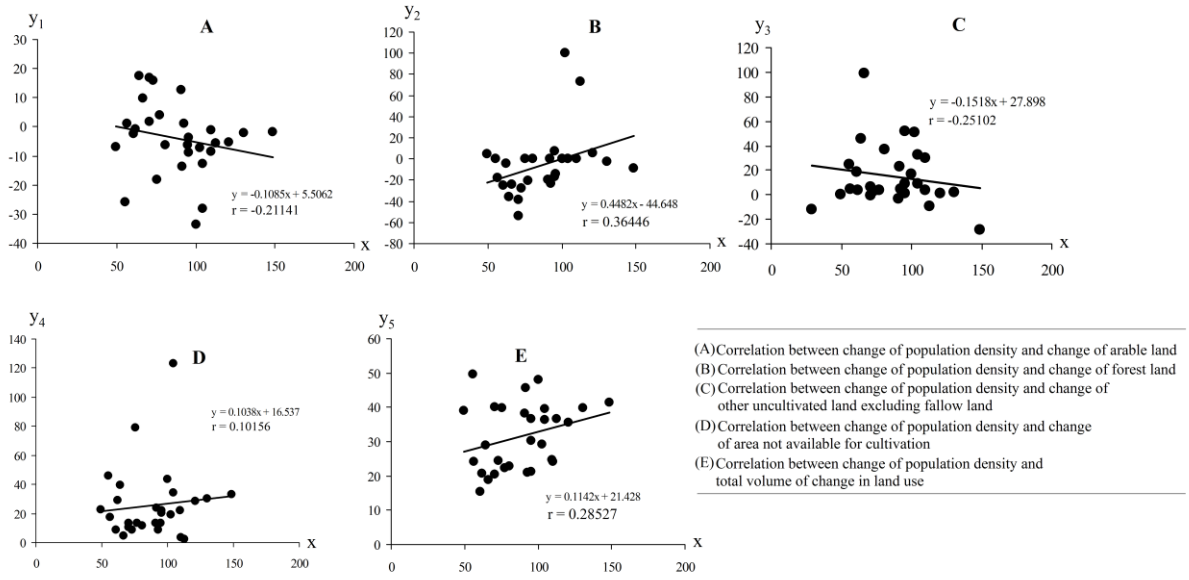


Figure 9. Correlations between changing population density and changing volume of different land use categories

5.4. Changing population density vs. area not available for cultivation

It is theoretically true that, the volume of increase in land under 'area not available for cultivation' in any area is positively correlated with its increasing volume of population density. The study displays that in the district as a whole, this category of land use has increased by 24.68 % (moderate) during the span of four decades. In the mean time, the density of population has also increased by 86.42 % (moderate). It is observed that two blocks with very high volume of increase in population density have recorded an increase in area not available for cultivation ranging between 30 and 40 % (high). From among 8 blocks with high volume of increase in population density, 2 blocks record a high volume of increase (above 40 %), one block registers a high volume of increase (30 to 40 %), 2 blocks display a moderate volume of increase (20 to 30 %), one block records a low volume of increase (10 to 20 %) and remaining one block registers a very low volume of increase (below 10 %) in this land use category. Similarly, out of 10 blocks with low to very low volume of increase in population density, the volume of increase in area under this category is very high in one block, high in one block, moderate in 2 blocks, low in 3 blocks and in one block it is very low. The preceding description implies that, the volume of change in area not available for cultivation is positively correlated (r = 0.10156) with the volume of change in population density.

5.5. Changing population density vs. total volume of change in land use

During 1971-2011, the district has experienced an overall volume of change in its land use to the tune of 31.02 % (dynamic). A comparative study displays that, there are two blocks in the district with very high volume of increase in population density, where the total volumes of changes in land use vary between dynamic and highly dynamic. Similarly, of the eight blocks with high volume of increase in population density, one block has registered a highly dynamic land use pattern, four blocks have displayed dynamic land use pattern, and remaining three blocks have shown moderately dynamic land use pattern. In the same way, of

the nine blocks with moderate volume of increase in population density, one block has shown a very dynamic land use pattern, four blocks have come under dynamic land use pattern and four blocks have depicted moderately dynamic land use pattern. By contrast, out of 10 blocks with low to very low volume of increase in population density, two blocks have witnessed highly dynamic land use pattern, five blocks dynamic land use pattern and three blocks low dynamic land use pattern. Thus, there exists a weak positive coefficient of correlation (r = 0.28527) between these two factors. This also substantiates the preceding fact.

6. CONCLUSIONS

The present analysis imparts a comparative view of population change and land use dynamics in Paschim Medinipur district during the last forty years. The results have manifested significant alterations in the land use categories during the study period. The major changes incorporate the losses of arable land and forest land (-2.71 % and -16.51 %), expansions of area not available for cultivation and other uncultivated land excluding fallow land (24.68% and 16.24%). The results drawn from the present study make it clear that growth of population (86.42%) becomes one of the most important proximate driving forces for the conversion of arable land and area not available for cultivation during 1971 to 2011. Besides, the loss of forest land is positively correlated with the growth of population during the period under review, which tells us that the dynamic nature of land use pattern is not only the function of population change but is also controlled by a number of physical and socio economic determinants . In future studies this method could be applied for understanding the impact of driving forces on land use dynamics at different administrative levels in introduction to different physiographic and socioeconomic variables.

REFERENCES

Baker OE, 1937. A Graphic Summary of Physical Features and Land Utilization in the United States, United States Department of Agriculture, Miscellaneous Publication, No. 260, Washington, D.C.

Basu P, 1986. Laterites of Medinipur and their morphology. *Geographical Review of India*, 48(2): 57-62.

Bhatta B, 2008. Remote Sensing and GIS, Oxford University press, New Delhi.

Bhattacharya LN, 1995. Land Utilization and Its Impact on the Rural Development of Jhargram Sub-Division of the District of Medinipur, Ph.D. Thesis (Unpublished), Dept. of Geography, University of Calcutta.

Briassoulis H, 1999. Analysis of Land Use Change: Theoretical and Modeling Approaches. *The Web Book of Regional Science*, Regional Research Institute, West Virginia University, USA.

Commoner B, 1972. The Closing Circle: Confronting the Environmental Crisis. London: Jonathan Cape.

Coppin PR, Bauer ME, 1996. Digital change detection in forest ecosystems with remote sensing imagery. *Remote Sensing Reviews*, 13(3-4): 207–234.

https://doi.org/10.1080/02757259609532305

Directorate of Census Operation, West Bengal 1971. *District Census Hand Book,* Midnapore, Series. 22**(**XA, XB and XC)

Directorate of Census Operation, West Bengal, 2011. *Primary Census Abstract*, Paschim Medinipur

District Planning Committee, Paschim Medinipur, West Bengal, 2009. *District Annual Plan: 2008-09*

Ehrlich PR, Ehrlich AH, 1990. The population explosion. New York: Simon and Schuster.

Goldewijk K K, Ramankutty N, 2004. Land cover change over the last three centuries due to human activities: The availability of new global data sets. *GeoJournal*, 61(4): 335–344. https://doi.org/10.1007/s10708-004-5050-z

Halder JC, Das P, 2010. The changing pattern of basic inputs and their impact on crop productivity in Paschim Medinipur district, West Bengal. *Geographical Review of India,* 72(1): 91-105.

Herold M, Latham JS, Digregorio A, Schmullius CC, 2006. Evolving standards in land cover characterization. *Journal of Land Use Science*, 1(2- 4): 157–168.

https://doi.org/10.1080/17474230601079316

Hooke RL, Martín-Duque JF, Pedraza J, 2012. Land transformation by humans: A review. *GSA Today,* 22(12): 4-10. http://www.geosociety.org/gsatoday/archive/22/12/pdf/i1052-5173-22-12-4.pdf

Jansen LJM, 2006. Harmonisation of land-use class sets to facilitate compatibility and comparability of data across space and time. *Journal of Land Use Science*, 1(2-4):127-156. https://doi.org/10.1080/17474230601079241

Jansen LJM, Carrai G, Petri M, 2007. Land use change at Cadastral parcel level in Albania: An Object Oriented Geo-Database Approach to Analysis Spatial Developments in a Period of Transition (1991-2003). In: Koomen E, Stillwell J, Bakema A, Scholten HJ (eds). Modelling Land-Use Change, 90: 25-44. https://doi.org/10.1007/978-1-4020-5648-2_2

Khullar DR, 2010. India: A comprehensive geography. Kalyani Publishers, New Delhi.

Kummer DM, Turner II BL, 1994. The Human Causes of Deforestation in Southeast Asia. *BioScience*, 44(5): 323- 328. http://www.jstor.org/stable/1312382?origin=JSTOR-pdf

Lambin EF, Geist HJ, Lepers E, 2003. Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources*, 28: 205–241.

http://dx.doi.org/10.1146/annurev.energy.28.050302.105459

Lillesand TM, Kiefer RW, Chipman JW, 2004. Remote Sensing and image interpretation, 5th edition, John Wiley & Sons: New York.

Meyer WB, Turner II BL, 1992. Human Population Growth and Global Land Use/Cover Change. *Annual Review of Ecology and Systematics*, 23: 39-61.

http://www.public.asu.edu/~bturner4/HUmanpopgrowth.pdf

Ojima DS, Galvin KA, Turner, II BL, 1994. Global Impact of Land-Cover Change. *BioScience*, 44(5): 300-304. https://doi.org/10.2307/1312379

Ramanaiah YV, Reddy NBK, 1990. Land Use Pattern and Dynamics of Land Use in Andhra Pradesh. In: Mishra BN, ed. Land Utilization and Management in India. Chugh, Allahabad, India: 37-62.

Ramankutty N, Foley JA, 1999. Estimating historical changes in global land cover: croplands from 1700 to 1992. *Global Biogeochemical Cycles,* 13(4): 997-1027.

Singh A, 1989. Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing,* 10: 989-1003. https://doi.org/10.1080/01431168908903939

Tian H, Banger K, Bo T, Dadhwal VK, 2014. History of land use in India during 1880–2010: Large-scale land transformations reconstructed from satellite data and historical archives. *Global and Planetary Change*, 121: 78–88.

Treitz P, Rogan J, 2004. Remote sensing for mapping and monitoring land-cover and land-use change-an introduction. Progress in Planning, 61(4): 269–279.

https://doi.org/10.1016/j.gloplacha.2014.07.005

Turner II BL, Kates RW, Meyer WB, 1994. The earth as transformed by human action in retrospect. *Annals of the Association of American Geographers*, 84(4): 711-715; 729-731. http://www.rwkates.org/pdfs/a1994.02.pdf

Turner II, BL, Meyer WB, Skole DL 1994. Global Land-Use/Land-Cover Change: Towards an Integrated Study, *Ambio*, 23(1): 91-95.

https://bioenergykdf.net/system/files/1/KC_090916160509.pdf

Vishwakarma CA, Thakur S, Rai PK, Kamal V, Mukherjee S, 2016. Changing Land Trajectories: A Case Study from India Using A Remote Sensing Based Approach. *European Journal of Geography*, 7(2): 61-71

Walsh SJ, Rindfuss RR, Prasartkul P, Entwisle B, Chamratrithirong A, 2003. Population Change and Landscape Dynamics: The Nang Rong, Thailand, Studies. In: Entwisle B, Stern P C, ed. Population, Land Use, and Environment: Research Directions. National Research Council, Washington, D.C: The National Academic Press.