Spatio-temporal change analysis of urban land use–A case study of Bidhannagar, West Bengal

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1. Context of the study

Urbanisation and urban land use change detection is one of the focus area of the urban planners and geographers. In post-independent India,there are several planned towns and cities developed in different states among which Chandigarh,Gandhinagar,Bhubaneswar,Noida etc important(Shah,2012).In West Bengal the first two and most important planned townships set up by the government were Kalyani in Nadia district and Bidhannagar(Salt lake) in North twenty four parganas.This study focuses on the changing pattern of land use and land cover in Bidhannagar township and the adjacent area(municipality) from 1990 to 2010 with the help of remote sensing with an objective to detect the urban morphology of modern planned town and the changes that occur with time according to the need of the population. After independence in the late sixties decade it was developed as the most important planned residential town to support the increasing population of Kolkata. It was set up by filling up the wetlands of the moribund river Bidyadhari which was connected to Sundarban region in Ganga Delta.

Land is the most important and basic resource concerning the urban development. Improper land use practice results in an adverse impact on ecosystem. So the two words “Land cover” and “Land use” have important significance in regard to land. Thus urban development is strictly depends upon Land Use/ Land Cover (LULC) of that area. The framework of a national land use and land cover classification system was presented by Anderson, et.al.,1976, for use with remote sensor data which is consulted for the present study.Using remote sensing in urban land use study is preferred by scholars for the advantage of minute analysis and showing spatio-temporal changes simultaneously. One of the main purposes of satellite remote sensing is to interpret the observed data and classify features. In addition to the approach of photo interpretation and quantitative analysis RS(Remote Sensing) and GIS(Geographical Information System) software are commonly used. There are two broads of classification procedures to analyze land cover change in satellite images: supervised classification and unsupervised classification. The supervised classification is the essential tool used for extracting quantitative information from remotely sensed image data.The most commonly used supervised classification is Maximum Likelihood Classification (MLC),

which assumes that each spectral class can be described by a multivariate normal distribution(Richards,1993) followed in this study also.

Land use development in the Study area

Bidhannagar was basically conceived as a planned township of five Sectors-I, II, III, IV and V of 12.5 sq.km. Later, an added area of 20 sq.km has been added to it in 1995. This area is remarkable for its vast wetland resource with pockets of habitable land within. In 2006, Sector V, which is the Industrial Sector, was separated from Bidhannagar to form a new administrative area 'Naba Diganta Industrial Township'(NDITA). In 2015 the municipality became Bidhannagar Municipal Corporation including Dumdum and Rajarhat municipality and the ward demarcation has been changed. But the time frame of the study is up to 2013.Hence the administrative division is considered as per the previous one.

The history reveals that in 1964 the Master Plan of Salt Lake city was drawn up by a Yugoslavian Firm. The actual development has been a modified form. In 1970 the Calcutta Metropolitan Development Authority (CMDA; now KMDA) was created to look into the problems and development of the entire metropolitan region. In 1995 it became a municipal area including added area and now it is a fast growing region in the whole West Bengal (Tosckovic,2010).The planned township enjoys an organized growth due to zoning of land-use whereas the added areas are sprawled with unorganized growth. The slums of Dattabad on the fringe of the planned township, along the E.M. Bye Pass road, are densely populated with deplorable living conditions. The added areas of wards 1,17,18,19 are of completely different character. These areas are within the conservation site of East Kolkata Wetlands. The inhabitants are mostly of BPL class, living in slum pockets within the wetland area. Still a sharp contrast exists between the planned and the added area in respect of landscape and socio-economic features. As the planned part has a hard and fast Regulatory Development control over land, the pressure of population is increasing fast in the slum areas. The unique feature of the town is that the roads are set up in grid iron pattern like Chandigarh to provide highest accessibility. Here the land is under the control of Urban Development(UD) Dept. and all the planning programmes are generally proposed and formulated by both UD Dept. and Kolkata Metropolitan Development Authority(KMDA. The planning has been considered according to people's demand and through technical analysis and duly incorporated in Draft Development Plan(DDP) for the betterment of the municipal function. After 2009-10 the programme focuses more on the process which include: participatory planning, pro-poor

focus, transparency in planning and prioritization and matching plans that can be realized in tune with projected resources(DDP-2007-2012,Bidhannagar Municipality).

2. Material and method

Land cover/Land use(LU/LC) mapping is used as the main tool for land use change analysis with the help of remote sensing.Supervised classification has been done showing land use and land cover classification in two different years(20 years duration) to detect the changing scenario of land use and accuracy assessment is also performed.4-5 Thematic Mapper imageries are used with a resolution of 30 m are used for the analysis.The classification is done in Arc GIS (10.1)software. Apart from this, the municipal base map is collected from Bidhannagar Municipality(now corporation) Draft development Plan(2012-17) and with the help of Quickbird image the recent map in detail has been prepared to compare the land use change with wetland and without wetland. The details of the satellite images are given in table 1.

Table 1: Satellite images used for study

Scene Id	Sensor	Date of Acquisition	Sun Elevation (deg)	Path & Row	Used Bands	Spatial Resolution (m)
LT51380441989347BKT00	TM	13/12/1990	34.73	138,44	NIR(4), Red(3), Green(2), Blue(1), And Thermal(6)	NIR& Optical Bands-30 m Thermal Band- 120 m
LT51380442010309BKT00	TM	11/11/2010	45.72	138,44	NIR (4), Red(3), Green(2), Blue(1), & thermal(6)	NIR& Optical Bands-30 m Thermal Band- 120 m

3. Result and analysis

Year wise pattern of land use - The land use classification is done based on six classes identified from the images- *Farmland,Vegetation,Dense Built up* (indicates high density single or multiple dwelling units-high percentage of impervious surface coverage),*Mixed*

built up (indicating low density residential units with commercial area), *Vacant Land and Water Bodies*. The recent land use classification is done in detail(2013) with the help of municipality map and high resolution image with more sub classes. Table 2 and Figs. 1, and 2 indicate the land use pattern of three consecutive years(20 years interval) i.e of the year 1990 and 2010.

1990- It is the time when the town was experiencing very slow rate of development and most of the urban facilities were absent at that time. The population was only 1 lakh then and the infrastructure was not fully developed and ample green space can be seen (4.5sq.km).Area under water body covered 12.72 sq.km which is almost 1/3 rd area of the town.

2010- In this year changes in the land use pattern over a period of time have led to conversion of some of the largest fish farms from pisciculture to paddy cultivation observed in the increased amount of farmland in the wetland area. The population crossed 2 lakh according to census 2011.Due to increased population, both the dense and mixed built up area increased and the vacant land reduced drastically. Vegetation also reduced due to different developmental activities.

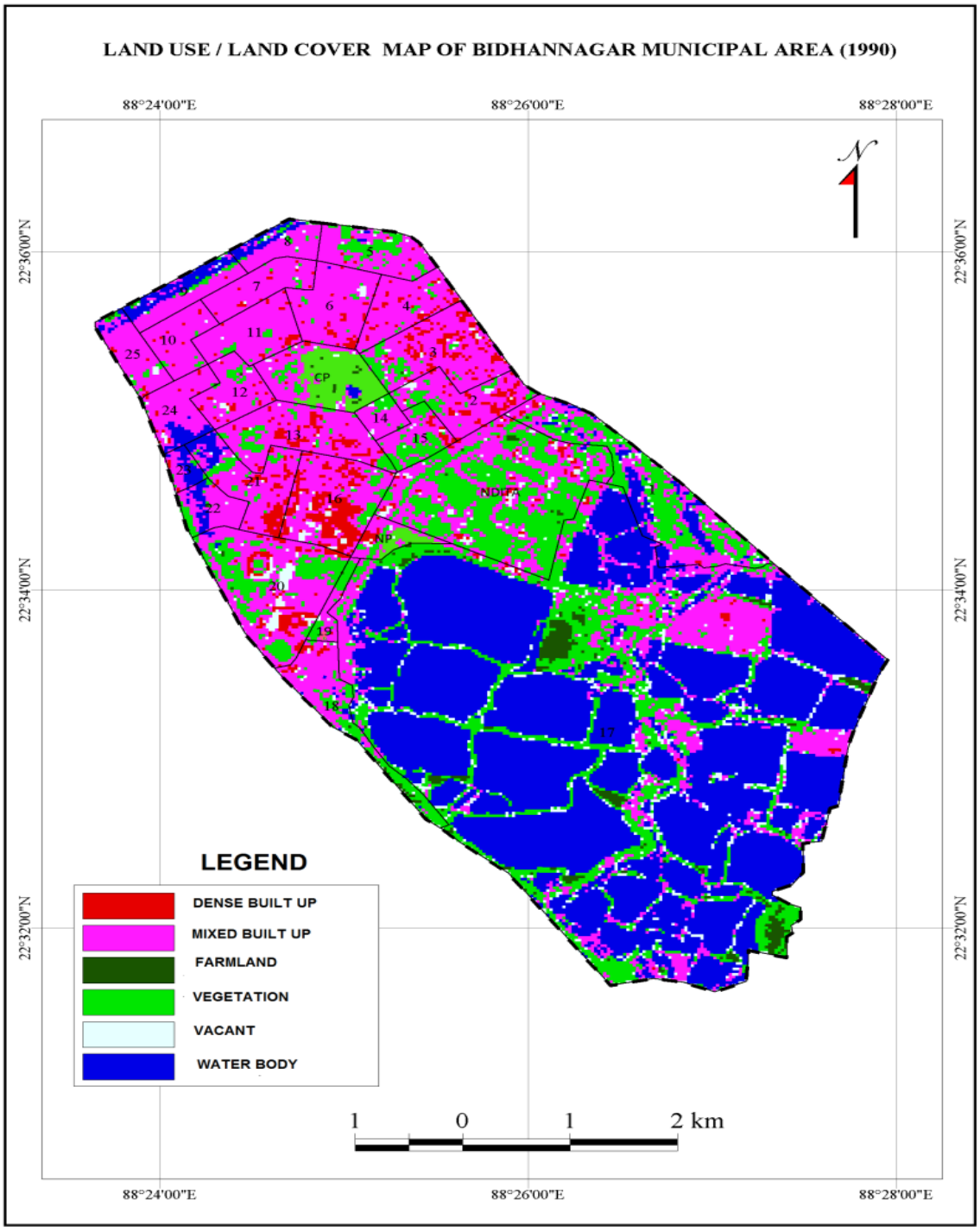
Table 2 Land use analysis and changes in BMA(1990-2010)

Year	Farmland	Vegetation	Dense Built Up	Mixed built up	Vacant	Water body
1990	1.18	5.30	1.56	10.27	1.24	12.72
2010	2.57	3.71	5.09	11.1	0.83	9
Change(%)	**4.30**	**-4.91**	**10.82**	**2.57**	**-1.27**	**-11.51**

Source: Computed by researcher from Landsat(TM)images**(**acquired on 13/12/1990, 9/11/2000,11/11/2010)

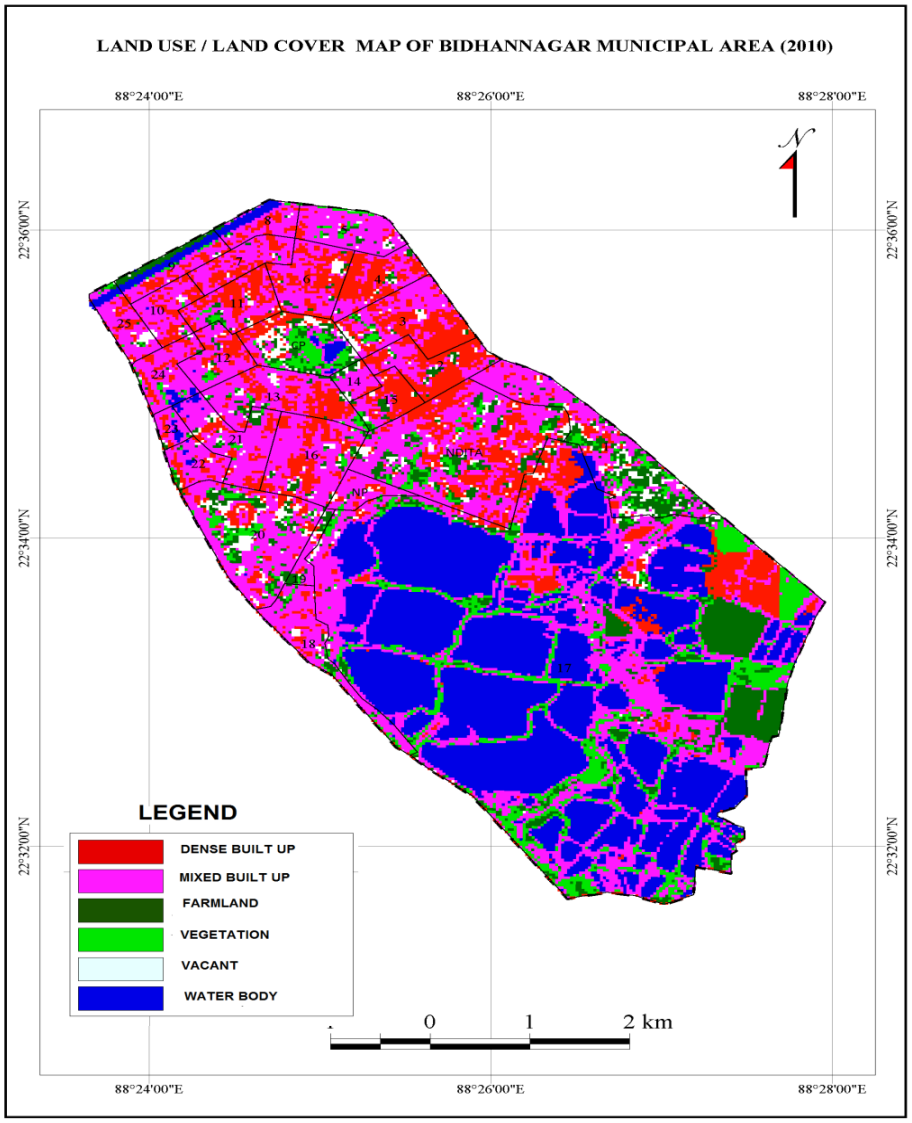
***Accuracy Assessment* -** The accuracy of any map may be tested by comparing the positions of points whose locations or with corresponding positions as determined by surveys of a higher accuracy (Adam,2013). One of the most important steps at classification process is accuracy assessment. The aim of accuracy assessment is to quantitatively assess how effectively the pixels were sampled into the correct land cover classes. Moreover the key emphasis for pixel selection was on areas that could be clearly identified on Landsat (TM) high resolution image and Google earth and Google Map (Rwanga et al.2017).

Figure 1 :LU/LC map of BMA(1990)



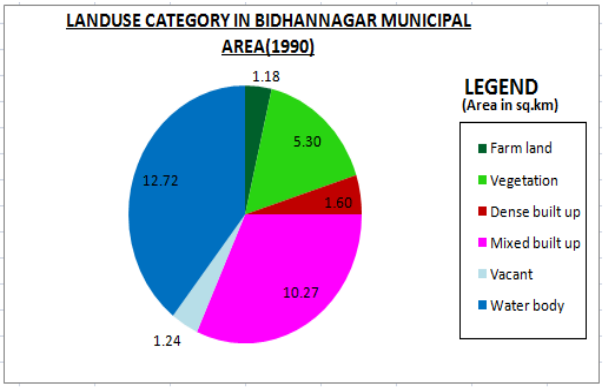
Source: Landsat TM image acquired on 13/12/1990

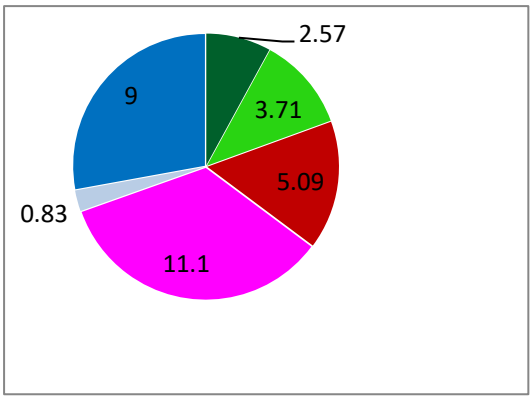
Figure 2 LU/LC map of BMA(2010)



Source: Landsat TM image acquired on 11/11/2010

Figure 3 and 4: Land use category in Bidhannagar Municipal Area(1990 and 2010)





Source: Landsat TM image acquired on 13/12/1990 and 11/11/2010 (Figure values in sq.km)

The process of accuracy assessment is done by the software after selecting the error matrix option which uses a ground truth raster with sample areas of known class to evaluate the accuracy of the current class raster. The class of each sample area cell is compared to the class assigned to the corresponding cell in the class raster. The overall accuracy value is calculated by dividing the total number of correctly classified raster cells (the sum of the leading diagonal values) by the total number of cells in the ground truth raster, and expressing the result as a percentage. The results are shown in the Error Matrix .The result of performing a Kappa analysis is a Khat statistic(actually Kˆ, an estimate of Kappa), which is another measure of agreement or accuracy.It is estimated as Kˆ reflects the difference between the actual agreement and the agreement expected by chance. Here in the supervised classification of Landsat(TM) images of the year 1990 and 2010 Accuracy Assessment is 82.99% and 94.62% which are quite high percentages indicating less error by the user in classification as well as Kappa values are also better showing better agreement than by chance alone.(Table 3).

Table 3 Accuracy Assessment of land use classification in BMA

Year	BMA	
	Accuracy Assessment	**Kappa/Khat statistics**
1990	82.99	77.82
2010	94.62	93.44

Source: Calculated by Researcher

***Changing pattern of land use* –** The changing pattern of land use has been discussed in two parts-

Land use planning in Master Plan–Fig. 5 shows the land use category in the Master Plan conceptualised by Toskovic in 1966,the planner of the town. Residential land was allotted 50% of the total land area and 23% for road which is quite higher than any other town or city in India .Apart from that, 12% area was demarcated for planned greenery and there was also provision for health, education, administrative and commercial areas. But one thing is noticeable that there was no provision for water body in the township though there is one big and several small wetlands existing from the beginning.

Changing pattern from 1990-2010 -Table 2 and Fig. 6 show the changing pattern of the land use from 1990-2010.It is observed that water body, greenery and vacant land reduced in 20 years. But reduction of water body is remarkable i.e. 11.5% which is due to encroachment,

pollution and conversion of fish farm to farmland. Dense built up area increased to 10.82% specially from 2000 to 2010 as the facilities and amenities along with infrastructure were developed after the year 2000; population increased to double that of 1990 due to in-migration of Non-Bengali community as well as the residents of the town. Though the target population(according to Master Plan) is yet to be reached, environmental changes have already been noticed overruling the plan of the town leading to future threats like depletion of ground water, consequence of land subsidence, reduction of greenery etc.

Present land use pattern- Present land use pattern in detail from high resolution image and municipal map has been prepared (Fig. 9) to identify the detailed categories of land cover. For proper identification the researcher has made two classifications - *with and without the water bodies(wetland in the added area)* as the planned township has mainly changed its character drastically from its inception but including the huge water body of the later added area ,the change cannot be focussed accurately. Table 4 describes the present situation of the township by both inclusion and exclusion of the outer water body and cartographically shown in Figs. 7 and 8.

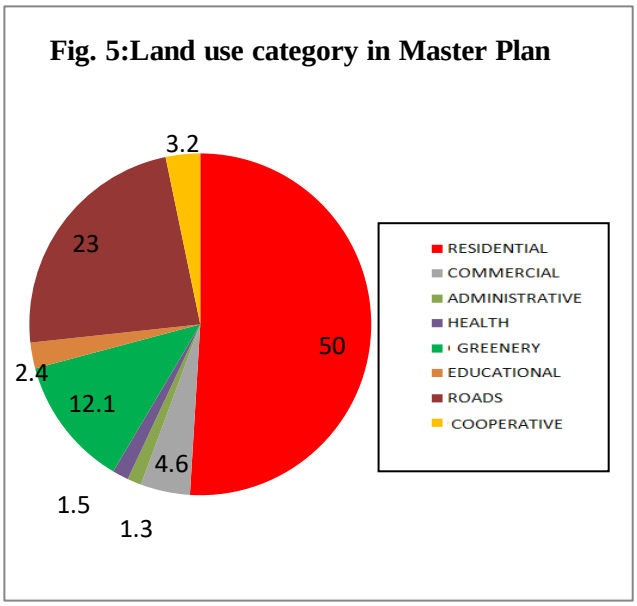
- **Characteristics of present land use pattern-**

Table 4 shows the existing land use pattern of Bidhannagar Municipality has the following characteristics:-

1. In the town huge difference in land use pattern is observed in planned and added wards. The upper and upper middle class people reside exclusively in planned area residential blocks whereas the lower income group people live in the slums demarcated in specific wards. The slum colonies mainly cover the wards 1,17,18,19 and part of wards 22-24 of the municipality.
2. Mainly the planned wards have residential along with commercial, education, health and administrative areas and added area wards have mainly slum and wetland area.
3. A small part of the huge fish farm or wetland area is under agricultural practice in Ward 17. Actually it is the part of fishing practice in the wetland done alternatively, so sometimes the area increases due to temporary conversion of fish farm into farmland(mainly vegetable and paddy).
4. It has a fixed area under software industry(IT Park)in sector V or NDITA**(**eastern part) which is excluded in the administrative area of the municipality.

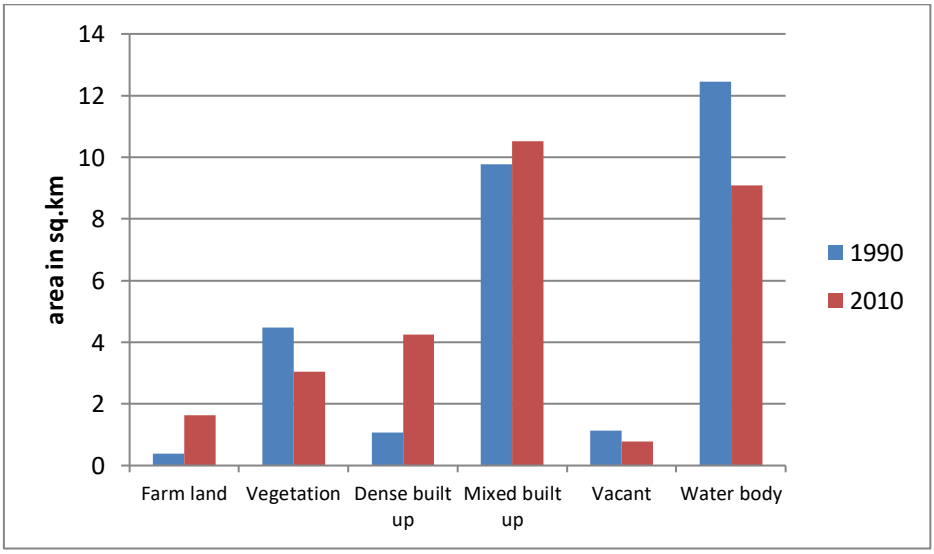
Table 4: Present land-use category of Bidhannagar Municipal Area(2013)

Sl. No.	Land use(in sq.km)	Including Wetlands	Excluding Wetlands
1.	Residential	5.025	10.33
2.	Commercial	0.34	1.09
3.	Administrative	0.36	0.71
4.	Health	0.4	0.54
5.	Greeneries	2.01	4.89
6.	Educational	0.33	0.82
7.	Roads	3.685	5.98
8.	Wetlands/ponds	15.74	0.94
9.	Others	3.685	5.04
10.	Slum	2.01	3.26



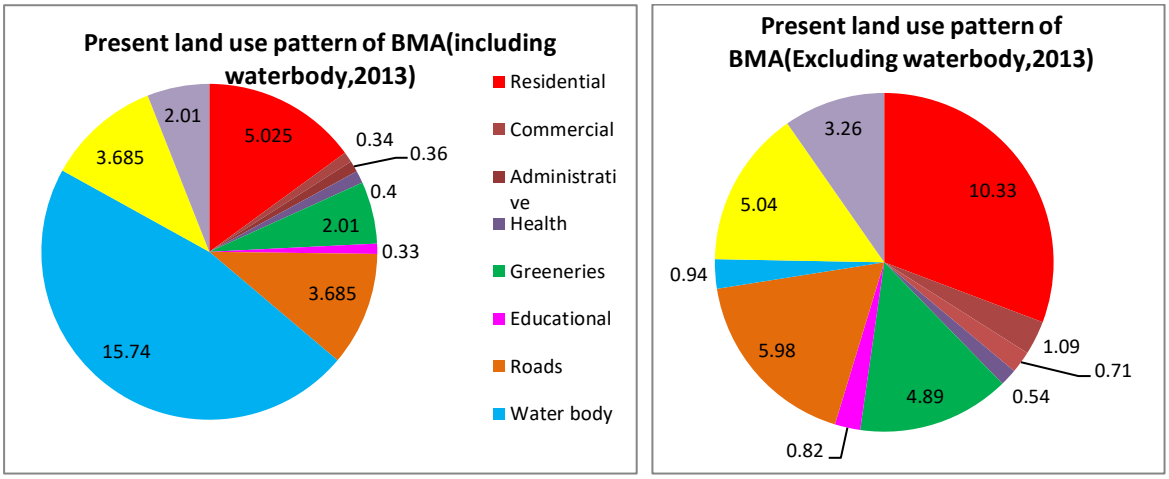
Source: DDP (2007-12) and calculated from Quickbird image(29/11/2013) Source: Toscovic (2010)

Figure 6 :Year wise change of LU/LC category in Bidhannagar



Source of data: Landsat TM images acquired on 13/12/1990 and 11/11/2010

Figure 7 and 8 : Present land use pattern,2013(including and excluding Wetlands)



Source: Bidhannagar Municipality Source: Computed by author (Figure values in sq.km)

4. Conclusion

It is revealed that land use of Bidhannagar has changed with time but not as rapidly as Kolkata because it is a planned township. Present land use category reflects the different morphological pattern of the town. Wetland area(added area),which is a part of East Kolkata Wetland comprises almost half of the total area and excluding this the land use patter is dominated by the residential area.The planned part has a sharp contrast with that of the added one in respect of road network,water body,infrastructure,greenery etc.The people living in these two areas are also socio-economically different but depended mutually as the BPL people from the adjacent slum areas render service to the higher and middle class families in the planned area regularly.

Though the greenery has reduced over twenty years span,it is still in better condition than that of the mother metropolis. Mixed built up areas has increased and vacant land has reduced remarkably as the town experiences rapid growth and development in respect of road, healthcare, education, urban amenities and grow as an alternative administrative centre of Kolkata. The floating population also create pressure on existing service along with the increasing population and settlement. Development of New town adjacent to Salt lake(the planned part) is supposed to absorb the burgeoning population from this area as well as other parts of the city in near future. This can be also due to high land and property value of the area and the gentrification caused by the non-Bengali community since last ten to fifteen years to experience better urban life than the congested metropolis.

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Figure 9 Present land use pattern and morphology of Bidhannagar township