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Tasseled Cap Transformation for The Detection of Change in Major Land Use and Land Cover of New Town and People's Perception about the Development of The Township

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Abstract : *Over the past few decades, most of the developing countries have undergone an unprecedented increase in levels of urbanization. The landscape of North and South 24 Parganas district of West Bengal is also undergoing through rapid change in urban growth as because of its nearness to Kolkata city. New Town, Kolkata started to build in the adjacent part of North 24 Parganas and South 24 Parganas since 1990s. In this paper the changing land use and land cover have been studied using remote sensing techniques. Tasseled Cap transformation of Landsat satellite data of 1990 and 2011 are used to study major changes. The distributions of Green space, Water bodies and built-up areas have been delineated within New Town area. Perceptional variation of the existing dwellers about different facilities and infrastructure of this planned township have been analyzed. The existing infrastructural facilities are evaluated from the beneficiaries' point of view. Residents' satisfaction index (RSI) has been calculated on the basis of perception survey.*

Keywords : *New town development, Land use change, Tasseled Cap transformation, Perception study*

Introduction

To meet the increasing needs of urban infrastructural facilities in a sustainable way, satellite townships are came into existence all over the world. In Asia, urban development policies in 1960s and 1970s were concentrated on slowing down the urbanization rate by the control of expanding metropolitan cities (Shaw, 1995). The concepts of 'Green city' and then 'New Town' have come in late 1970s. Among the Asian countries, Japan was the first country who had implemented National Capital Regional Development Law in 1956 (Shaw, 1995). In West Bengal, the West Bengal Town and Country Planning and Development Act, 1979 (WBT & CP & D Act, 1997), have the statutory provisions to control unplanned development and

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undesirable spontaneous growth by imposing land use zoning regulation. It was formulated and came in operation in the Calcutta Metropolitan Area and the Durgapur to provide a uniform act and for the entire state. The power and functions of the West Bengal Housing Infrastructure Development Corporation (WBHIDCO) was stated under relevant section of WBT & CP & D Act, 1997.

The West Bengal Housing Infrastructure Development Corporation Ltd. (WBHIDCO), a wholly owned Govt. Company set up by the Govt. of West Bengal in 1999 for developing "New Town", very close to the City of Kolkata (WBHIDCO, 2012). The main objective was developing an eco friendly green New Town. It was also designed to develop the area in different phases. The area has been divided into three Action Areas. Due to development of New Town, existing old land use/ land cover were changed dramatically (Saradar and Hazra, 2013).WBHIDCO has proposed many infrastructural developments and has already developed some of them. Due to this urbanization a huge amount of agricultural land transformed into urban utilities (Saradar and Hazra, 2013). Aesthetical views are proposed by dedicating large open space, greeneries and water bodies of about 50 per cent of the project area (WBHIDCO, 2012). The basic planning approaches was to encourage a diverse economic base with an intention to achieve social equity for promoting the distribution of economic benefits among all section of people in this area without putting much stress on the natural resources (WBHIDCO, 2012).

As urban environment typically consists of heterogeneity and mixture of land use and land cover (LULCs) types, the successful monitoring of urban areas are more necessary for sustaining the eco-friendliness. The approaches for monitoring LULCs can be summarized into two categories, one is classification of LULCs and their comparison, and another is the analysis of different indices (Lu et. al, 2004, Singh, 1989). The most challenge in monitoring of open space, green space and water bodies is the selection of methods.

Objectives

For the above mentioned importance and reason, the central objective of this paper is to present a practical and cost effective approach for mapping and monitoring of green space, water bodies and built-up areas. Secondly, we have tried to draw perception of the residents about developmental factors at New Town.

The Study Area

New Town has been started covering in part of Rajarhat Block of North 24 Parganas and Bhangar Block of South 24 Parganas. There are twelve numbers of mouzas of Bhangar block and thirty three numbers of mouzas of Rajarhat block. It is located to the north of East Calcutta Wetland and north-east of Salt Lake City. The geographical location is between 22º30´32´´ N to 22º38´03´´ N of latitude and 88º26´29´´ E to 88º32´57´´ E of longitude. Total area of New Town is about 6712 hectares. The study area is located only 7 km. from B.B.D Bag area of Kolkata city

and only 2 km. from Kolkata Netaji Subhas Chandra Bose International Airport.

Materials and Methods

Data acquisition

1. For the study, Landsat satellite imageries of New Town area were acquired for November, 1990 (Fig. 1A) and November, 2011 (Fig. 1B). Both the images are used here were obtained from Global land cover facilities (GLCF) website. New Town project area map is collected from BijonBhavan, WBHIDCO, Govt. of West Bengal.

   Landsat imageries were converted to at-satellite reflectance except the panchromatic and thermal bands and to at-satellite temperature of thermal band (Markham and Barker, 1987). Normalization of at-satellite reflectance conversion had been adopted to convert digital number (DN) values to reflectance values of the pixels for better inter-relation from the images.

2. To analyze the perception of the population about the changes in respect to land use change and changes in infrastructure, perception survey has been conducted. For the selection of the potential respondents, stratified sampling method has been followed. A total of 150 sample households were surveyed during 2017-18. As the New Town is developing in areas with existing rural areas (mostly), the households were mostly selected from those areas. The sample size have been determined by 95 per cent significance level with confidence interval of 8. The total no of population of those45 mouzas are 232153 and they are residing at 51262 households (Census 2011). Out of the total households, 150 households were selected.

The **confidence interval** (also called margin of error) is the plus-or-minus figure usually reported in newspaper or television opinion poll results. For example, if we use a confidence interval of 8 and 46 per cent percent of our sample picks an answer we can be "sure" that if we have asked the question of the entire relevant population between 38 per cent (46-8) and 54 per cent (46+8) would have picked that answer. The **confidence level** tells how sure we can be. It is expressed as a percentage and represents how often the true percentage of the population who would pick an answer lies within the confidence interval. The 95 per cent confidence level means we can be 95 per cent certain; the 99 per cent confidence level means we can be 99 per cent certain. Most researchers use the 95 per cent confidence level (https:// www.surveysystem.com/sscalc.htm).

When we put the confidence level and the confidence interval together, we can say that we are 95 per cent sure that the true percentage of the population is between 38 per cent and 54 per cent. The wider the confidence interval we are willing to accept, the more certain we can be that the whole population answers would be within that range. For example, if we asked a sample of 1000 people in a city which

brand of Cement they preferred, and 60 per cent said Brand A, we can be very certain that between 40 and 80 per cent of all the people in the city actually do prefer that brand, but we cannot be so sure that between 59 and 61 per cent of the people in the city prefer the brand. Here are the formulas used in our Sample Size Calculator:

$$\text{Sample Size} = \frac{Z^{2*}(P)*(1-P)}{C^2}$$

Where:

Z = Z value (e.g. 1.96 for 95 per cent confidence level)

p = percentage picking a choice, expressed as decimal

(.5 used for sample size needed)

c = confidence interval, expressed as decimal

(e.g., .04 = ±4)

$$\text{New Sample Size} = \frac{SS}{1+\frac{SS-1}{HH}}$$

Where, SS = Sample Size, HH= Household

For collecting data, stratifications have been made through gender age, house type, occupation and level of education of the respondents.

3. For best supervised classification of land use and land cover of New Town area, intensive GPS survey has been carried out to identify major land use and land cover e.g. Arable land, settlement area, water bodies etc. Different land use and land cover has been demarcated in polygon manner so that those land uses can be supervised in software platform for better results. In some cases Google Earth image and knowledge of old people were referenced.

4. Supervised classification was performed on both images using Maximum Likelihood Algorithm (MLA) in TNT mips professional software. The supervised classification technique is preferred, because the author has a prior knowledge of the area and GPS data of the study area are used for that work. From there the land use land cover maps were derived with the following six classes: 1. Old settlement, 2. Developed land, 3.Open/Green space, 4. Water bodies, 5.Arable land and 6.Waste land/fallow land. From the error matrix of land use and land cover classification it reveals that the overall accuracies are 91.02 per cent and 93.2 per cent respectively for the

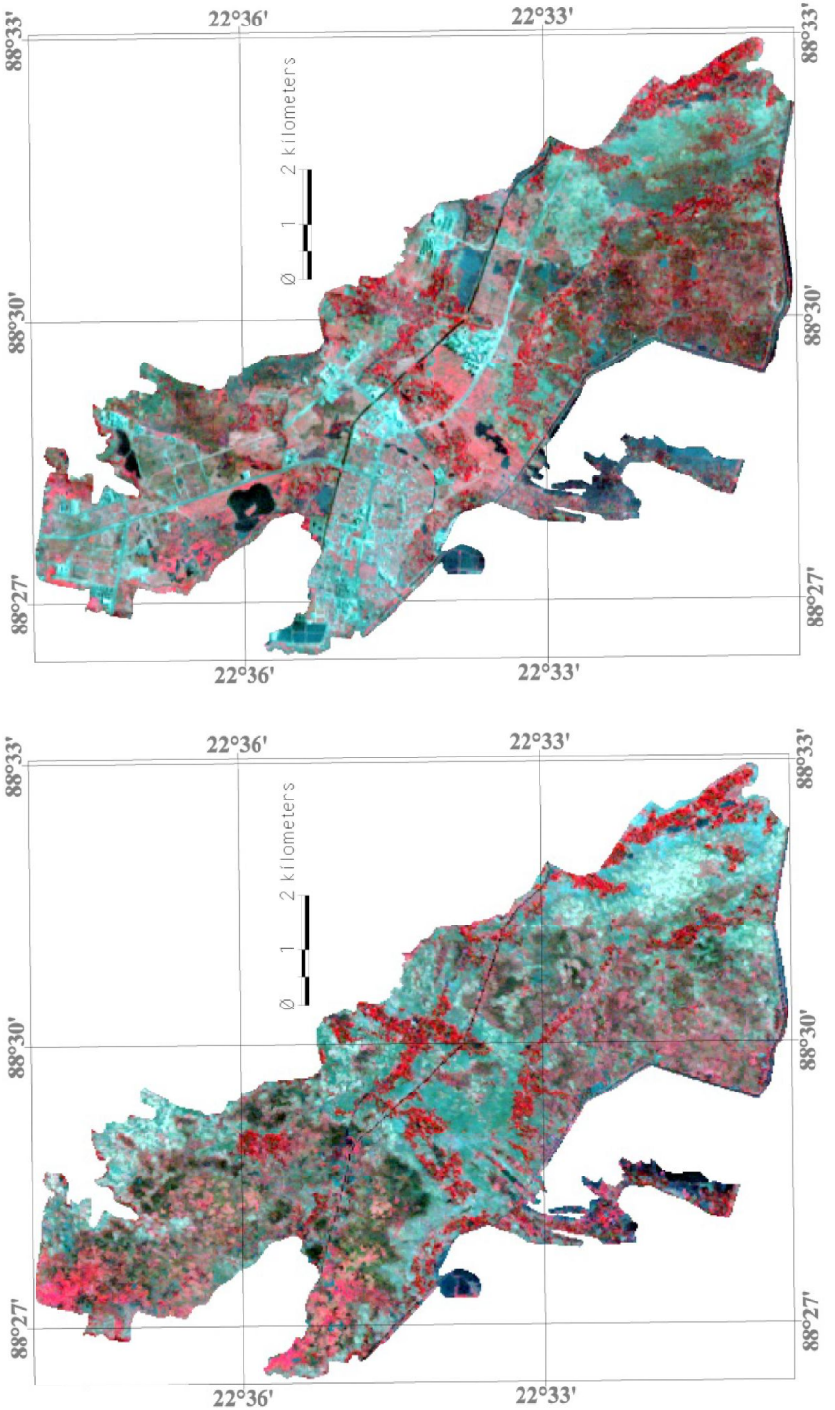


Fig. 1: Standard False Colour Composite image of New Town, (A) 1990 and (B) 2011

year 1990 and 2011. The Khat statistics was 82.13 per cent and 87.42 per cent for the respective years.

5. Tasseled cap analysis for the detection of built-up, Green and Wet areas; the concept of "tasseled cap" transformation was coined in 1976 by Kauth and Thomas for understanding crop development phenomena in spectral space. In theory, the "*tasseled cap*" transformation is a work procedure facilitating the in-depth interpretation and study of satellite data, aiming at reducing the amount of data layers (dimensionality). It is a useful tool compressing spectral data into a few new bands associated with physical scene characteristics (Crist and Cicone 1984)

   In practice, the procedure is based on a linear transformation of data from the original image into three new axes which become features of the transformation and may be described as follows: Brightness, capable of changing the total reflectance and the physical processes affecting it, so that the new image shows surfaces with little or no vegetation and with built-up land; Greenness, records visible spectra caused by plant pigments including chlorophyll and by the high reflectance in infrared due to the internal structure of leaves. By way of consequence, areas with vegetation shall obviously show in green; Wetness, defining the water and moist areas.

Results and Discussion

Supervised classification of land use of imageries of 1990 and 2011

The result of supervised classification shows there was four main land uses in 1990 (Fig. 2A). Due to this township project arable land and waste land area were vanished from this area in 2011 (Fig. 2 B). It indicates loss of agricultural land and job transformation of the cultivators and agricultural labours. Water bodies decreases 3.06 percent (205.39 hectares) due to this planned town within these years, in other hand aesthetic green and open space generated in 14.69 percent (986 hectares) area (Table 1).

Table 1: Supervised classification of New Town image for the year 1990 and 2011

Land use/ Land cover	Year 1990	Year 2011
	Area in percentage	
Old Settlement	5.72	28.68
Developed area	0	44.69
Open area/ Green space	0	14.69
Water bodies	14.75	11.69
Arable land	13.28	0
Waste land/Fallow land	9.18	0

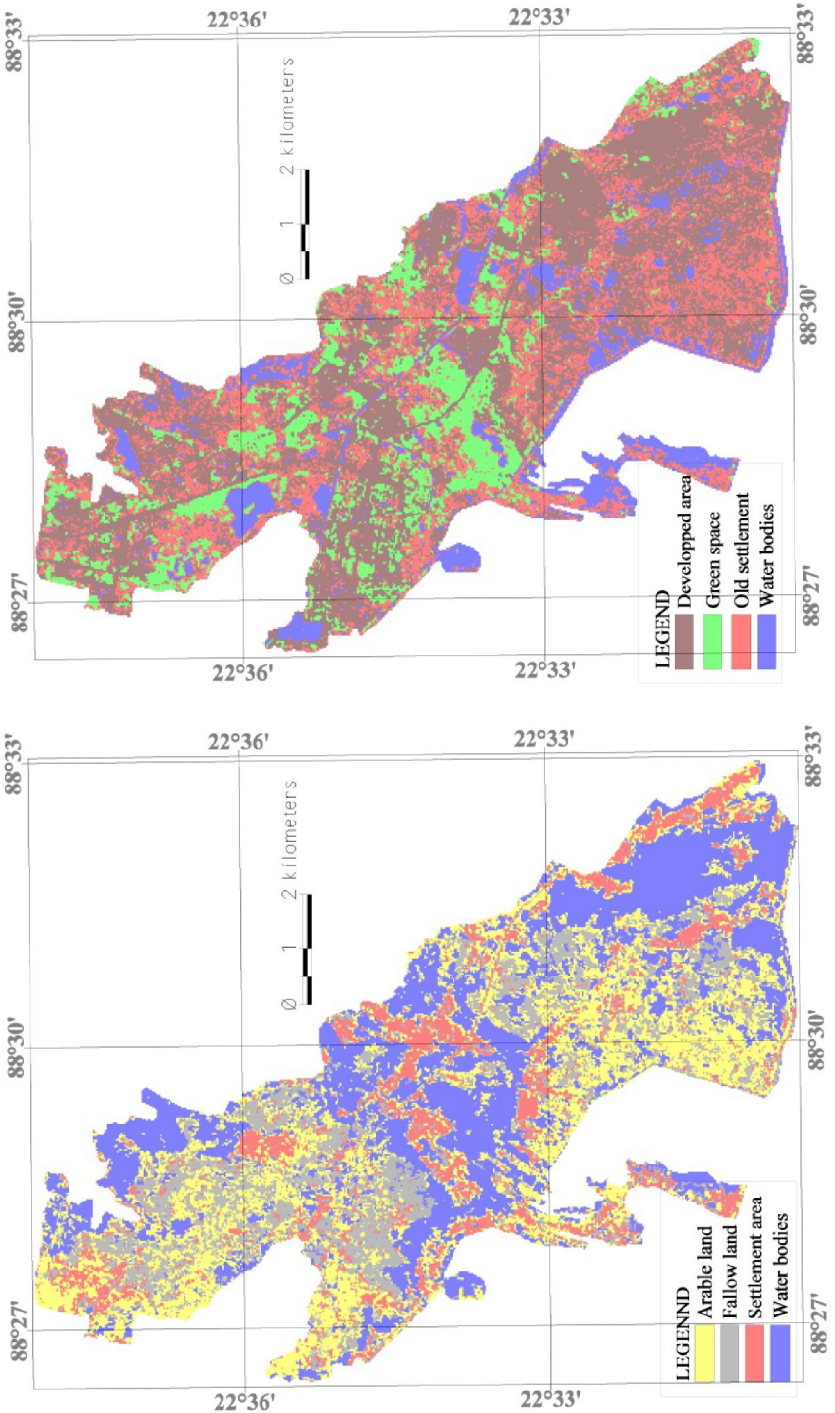


Fig. 2: Supervised classification of LULC of New Town, (A) 1990 and (B) 2011

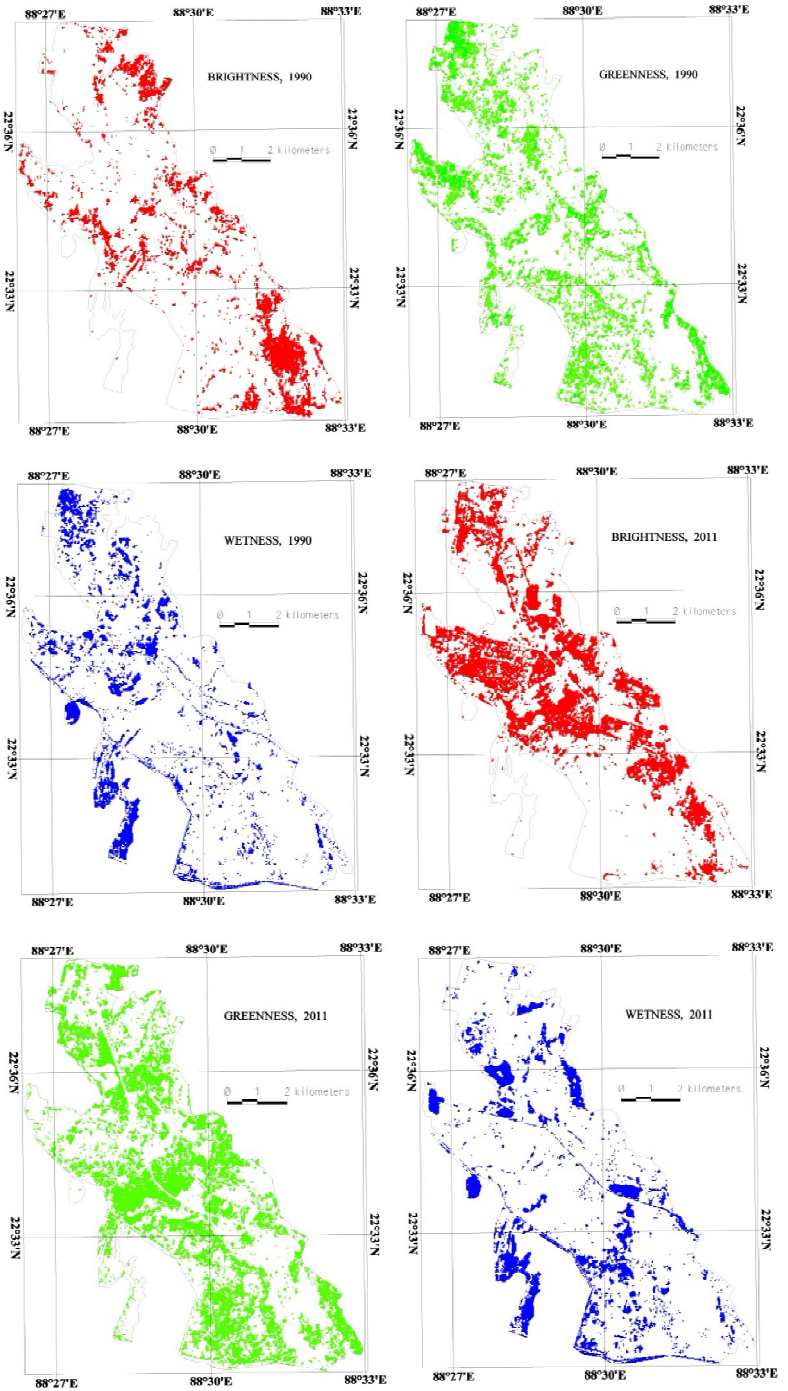


Fig.3: Extracted builtup, green and wet areas of New Town, (A) 1990 and (B) 2011

Tasseled cap analysis for the detection of built-up, Green and Wet areas

Although, tasseled cap transformation is most appropriate for regional applications, when atmospheric correction is not feasible (USGS). Here reflectance factor (Crist, 1985) based tasseled cap transformation has been used. The locations of water bodies, impervious area or built-up areas and green surface areas have been demarcated.

Table 2: Extracted major LULC of New Town, 1990 and 2011

Tasseled cap Transformation	LULC	Year 1990	Year 2011	Year 1990	Year 2011
		Area in percent		Area in hectare	
Brightness	**Builtup area**	15.27	28.63	1024.922	1921.646
Greenness	**Green space**	29.42	37.64	1974.67	2526.397
Wetness	**Water bodies**	14.46	16.22	970.5552	1088.686

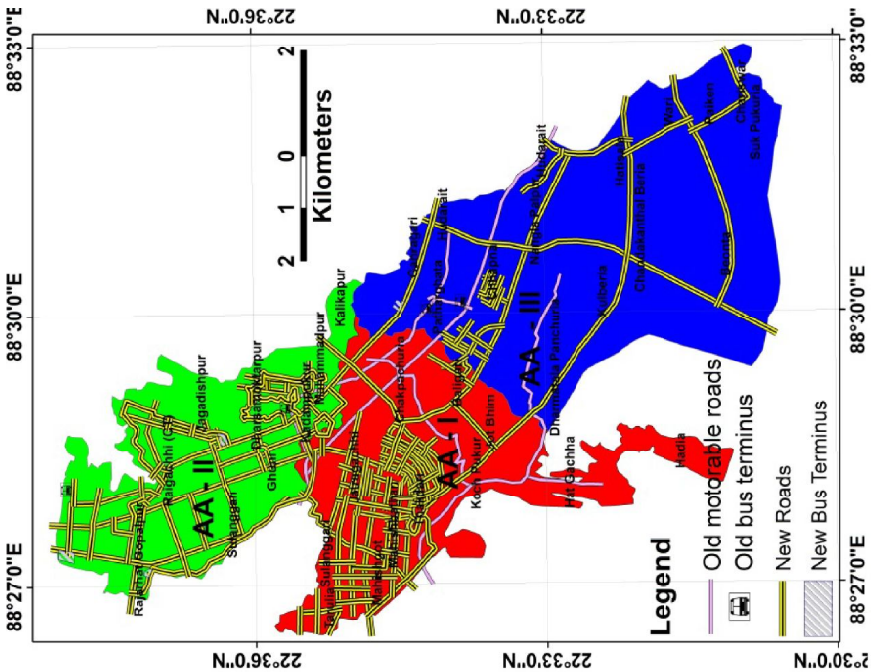
The "*tasseled cap*" transformation was applied to the Landsat 5 TM image for six bands and generated three layers, brightness, greenness and wetness. From the brightness values builtup areas are extracted for 1990 and 2011. In 1990 the bare waste lands which were of no use throughout the year appeared as built-up areas. But in 2011, brightness values straightly depicted the built-up areas of the study region.

Mapping of different Infrastructural development of New Town

Road network of New Town area before and after township has been made (Fig. 4 A & B). 85 per cent places of New Town are now accessable to motorable heavy roads within of 500 meter of walking distance (fig. 5A), previously which was only 10 percent of the area.

New Town and Perception of dwellers

Satisfaction/dissatisfaction regarding road connectivity, health service, educational facility, banking services and other urban facilitieshave been measured. The formula of Index of Satisfaction $IS = \frac{NS - Nd}{TN}$ When, *Ns* is thenumber of satisfied respondents, *Nd* is the number of dissatisfied respondentsand TN is the total number of respondents. Among the major indicators of development, respondents are moderately satisfied for development of road connectivity (0.66) and educational facility (0.52). They are poorly satisfied regarding health services and other urban facilities (Fig. 6). Satisfied respondents are mostly belongs to above higher secondary level of education and dissatisfied respondents are mostly those



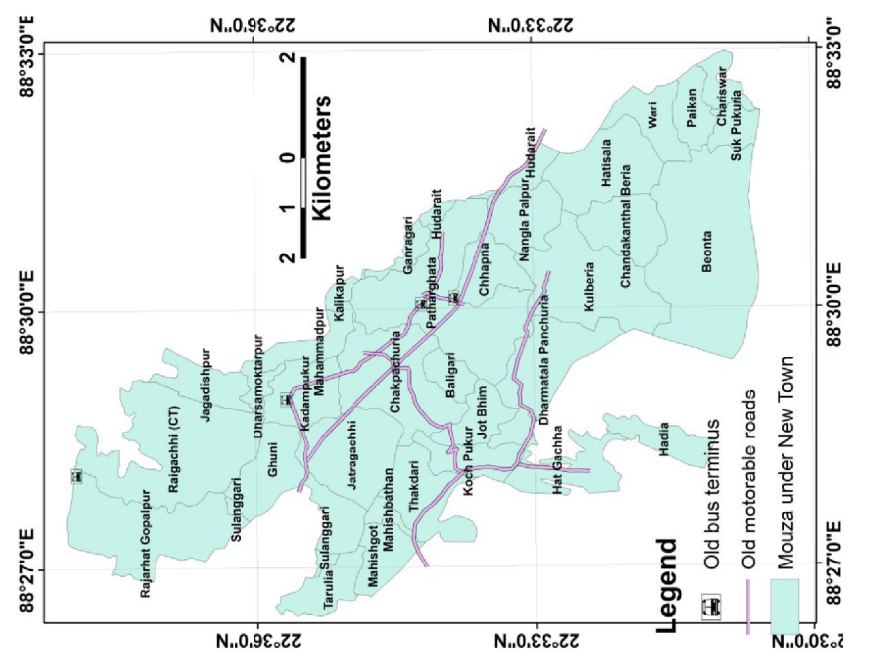


Fig.4: Road network of New Town from (A) 1990 to (B) 2011

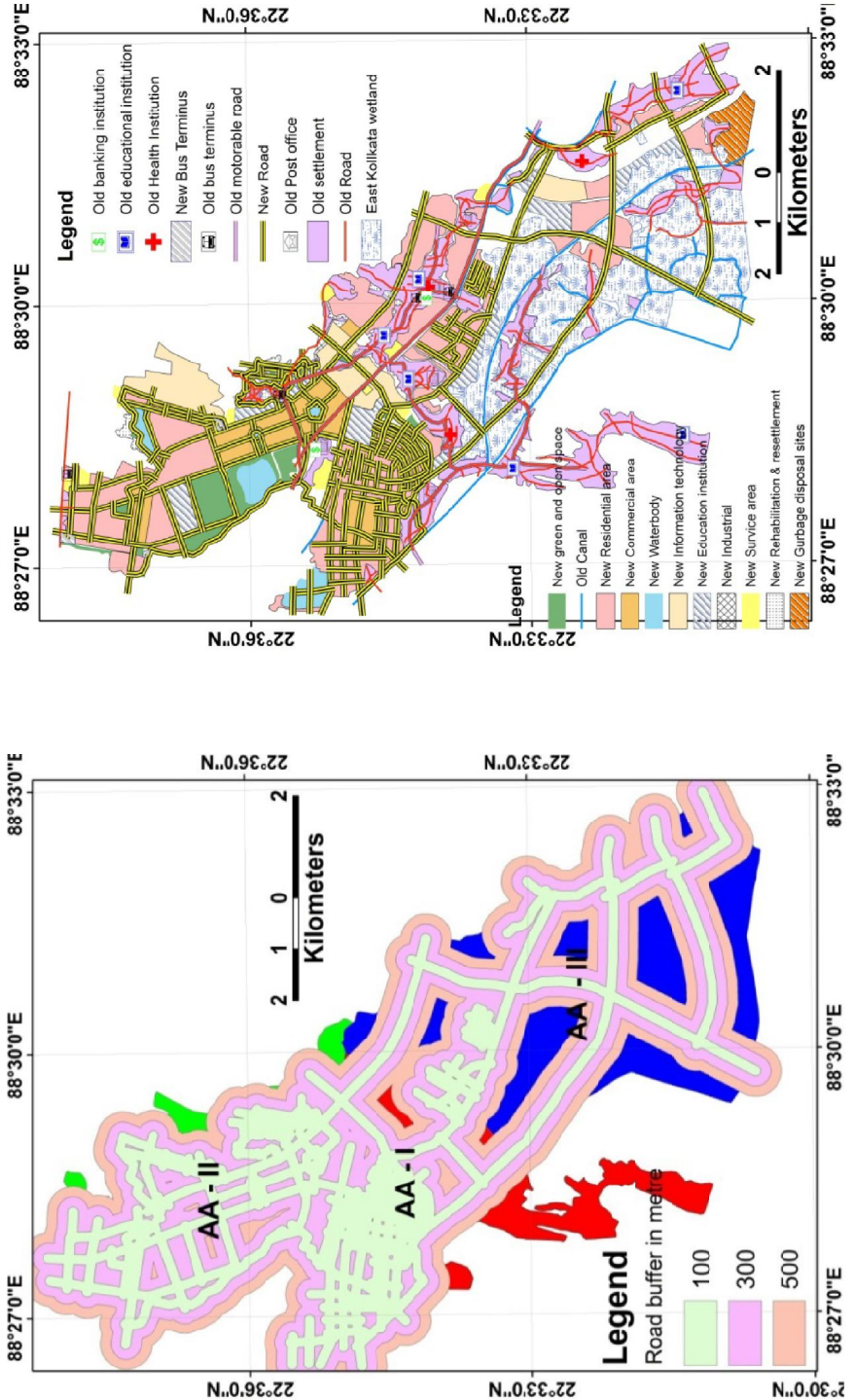


Fig. 5: Road buffer (A) and different urban amenities (B) of New Town, 2011

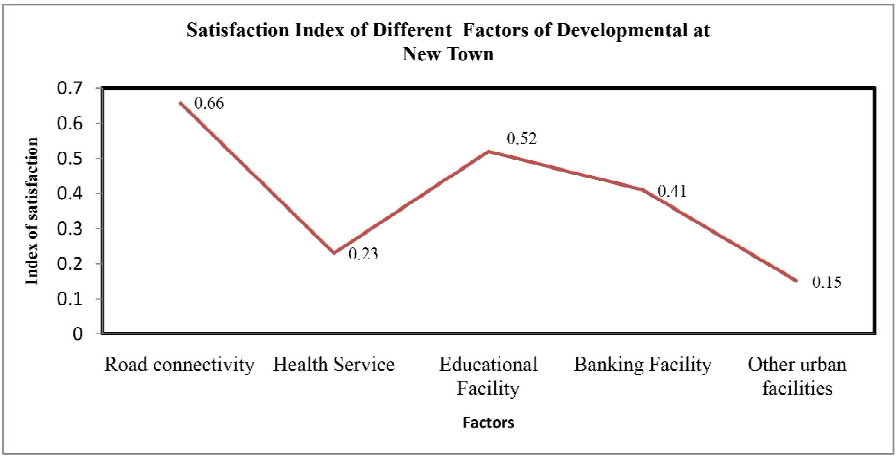


Fig. 6: Satisfaction index of different factors of development at New Town

who are above sixty years of age (Fig. 7). According to the respondents, major problems facing in this area are insufficient public transport in other than major arterial roads, inadequate amusement facility, unavailability of doctor's clinic, encroached pavements etc.

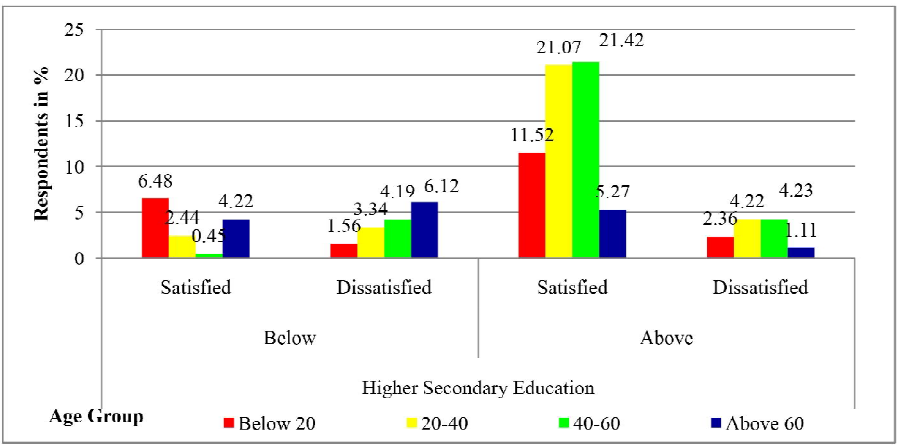


Fig. 7: Satisfaction/ dissatisfaction of different age group

Priority wise perceptions regarding major problems have been measured. In this step, the score are weighted by their rank (e.g. 1...4, indicating level of dissatisfaction) and then makescorefor comparative status of different sectors (Fig.8). Residents'dissatisfaction index (RDI), $RDI = \frac{\sum Piri}{P1R}$ Where, *RDI* is theresidents dissatisfaction index of problem *Pi* (Priority) = 1…4, *ri* is the number of respondents

in the i^{th} priority for the particular problem, *P1*is the maximum priority number and R is the total number of respondents. The highest score is 0.68 indicting that the residents are highly dissatisfied due to insufficient public transport facility in other than major arterial roads (Fig. 8).

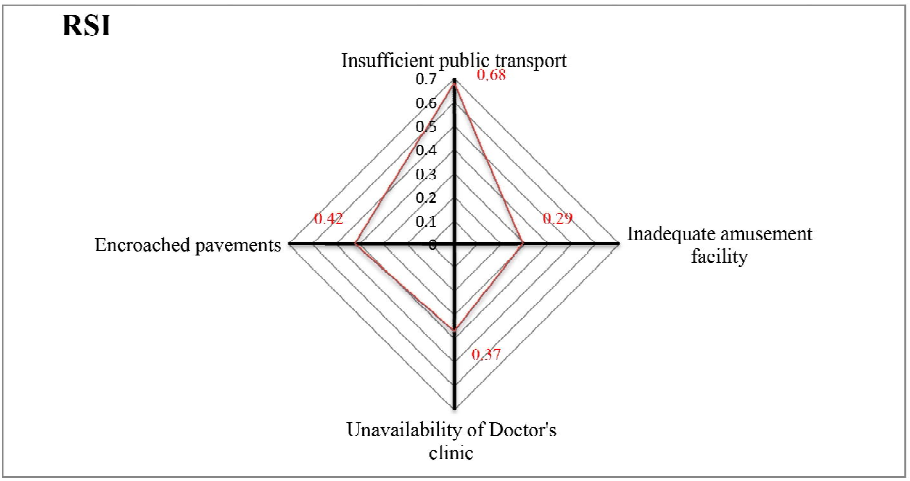


Fig. 8: Residents Dissatisfaction Index on major problems.

Conclusion

In conclusion it can be say that the tasseled cap transformation is highly useful for monitoring of green space, water bodies and built-up areas in case of planned towns with very high accuracy. The spatial distribution and extension of green space and water bodies may be monitored. The fragmentation of water bodies and green space may also be mapped very clearly with the help of tasseled cap transformation. From perception survey, it is very clear that the people who belong to low educational level and high age group are dissatisfied. It is due to their poor technical skill to get chance in good job in urban activities. As this township is under construction, it may be hopped that the dissatisfaction will minimized when it will be completed as it was proposed.

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