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QUANTIFICATION OF URBAN EXPANSION BY GEOSPATIAL TECHNIQUES: A MICRO-LEVEL STUDY

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Abstract: Urbanization is shaping and or changing the cultural landscape at a faster pace in developing as well as developed countries. It is associated with a substantial change in urban land use along with its fringe areas. This is a common scenario in Indian states also. The western part of Paschim Bardhaman district of West Bengal, which is predominantly recognized by mining and industrial area is also experiencing the same nature of land dynamics. It was started in late 18th century with the advent of coal mining in the Raniganj and Barakar measures and triggered by industrial development with the establishment of IISCO in Kulti and Burnpur, Chittaranjan Locomotive Works, Hindustan Cables and other industries around Asansol, being the district head quarter of Paschim Bardhaman. Presently, Asansol is the second largest city of West Bengal and one of the fastest growing urban centers in India. Rapid population growth caused by large scale immigration, economic development and market forces over last few decades leads to the unrestricted and unplanned growth of peripheral areas along with its rural counterparts with uneven land use pattern.

The present paper aims to analyze the spatial transformation of the Land Use and Land Cover (LULC) due to urbanization since last two decades over the Asansol city and its surrounding areas. It also accounts the nature of land changed by the expansion of built-up areas. For the analysis, supervised classifications of Maximum Likelihood Algorithm have been followed along with the post-classification change detection techniques. A haphazard growth of the built-up areas has been identified in the southern part of the study area, which was previously occupied by monoculture land with low productivity. Certainly it has a huge impact on urban environment like pollution, water crisis, landscape fragmentation, adverse effects on urban ecological balance, reduction of urban green space, micro-climate change etc. Hence, the working paper may help in policy making for management and planning for sustainable use of land in the study area.

Index Terms **- Urbanization, Cultural landscape, Urban fringe, LULC, Supervised Classification**

I. INTRODUCTION

Urbanization is a complex process of becoming urban associated with the concentration of people and activities, gradual change from traditional rural economy to modern industrial and market based economy; a progressive change of 'structural characteristics' of people including birth rate, death rate, migration status etc.; a spread of urban character or 'urbanism' beyond the pre-existing built-up area of a city or town towards its peripheral areas (Siddhartha & Mukherjee 2006). Urbanization or urban expansion is a global phenomenon but its nature and rate are variable everywhere, in developed as well as developing countries. The twentieth century witnessed a drastic change of population from rural to urban areas in most of the countries of the world. Only 13 per cent of the global population lived in urban areas in 1900, which increased to 29 per cent in 1950 and crossed the 50 per cent mark (50.1 per cent) in 2009 (UN, 2009). But on an average 75 per cent population of developed countries lives in urban areas compared to 45 per cent in the less developed countries of the world (Bhagat, 2018). But in India, the rate of urbanization is 31 (31.20) per cent, which is almost same with West Bengal (31.89) also (Census, 2011). The western part of Paschim Bardhaman district has also experienced a rapid population growth since late 18th century with the beginning of coal mining in the Raniganj- Asansol coal belt. After that, the industrial development started around Asansol city and its surrounding areas with the establishment of IISCO, Chittaranjan Locomotive Works, Hindustan Cables and other industries. Presently, Asansol, is the second largest city of West Bengal and one of the fastest growing urban agglomerations in India. Rapid population growth due to large scale immigration, centralization of industrial activities, high volume wholesale and retail trade during last few decades leads to the unrestricted and unplanned growth of its adjacent areas. The diffusion of urbanism results an uneven pattern of land use in the city and its country sides with uneven pattern of land use transforming the original nature of land cover. Actually the term 'land cover' is used to represent the natural use of land by forest, rivers, mountain areas, barren land etc., whereas the 'land use' refers to human interference of land or in other words the utilization of lands for their own purposes (Prasad & Ramesh, 2018). Land use and land cover (LULC) change analysis is the essential aspect to portray the spatial transformation of land within a specific period of time. In the present context, rapid rate of urbanization in Asansol creates a huge land use conflict in the fringe areas due to the conversion of land from its rural nature to urban use.

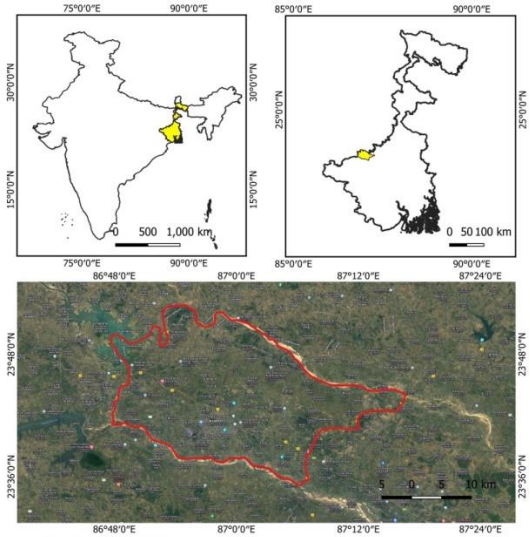
II. OBJECTIVES

The major objectives of the present research work are

- To analyse the spatio-temporal transformation of the Land Use and Land Cover during last two decades in Asansol city and its surrounding areas.
- To identify unplanned growth of periphery with expansion of Built up area within this period.

III. STUDY AREA

The study area is situated at the western part of Paschim Bardhaman District (West Bengal, India) which is physiographically the extension of Chotanagpur Plateau and more specifically it belongs to the transition zone where the dissected plateau of north-western side gradually merges into the alluvial plain towards south-east (Pal, 2015). The area comprises Asansol Municipal Corporation, western part of Jamuria and Raniganj, Barabani and Salanpur CD Block (Map 1). Geographically it is located in between $86^0$47'39" E to $87^0$16'34"E and from $23^0$34'48"N to $23^0$52'52" E. Total area is approximately 821.23 sq. km. among which the administrative area of Asansol Municipal Corporation (AMC) is 326 sq. km. covering 106 wards. In 2015, the municipalities of Kulti, Ranjganj, and Jamuria has been dissolved and included within the jurisdiction of AMC according to the notification of June 3, 2015, by the Kolkata Gazette. The Paschim Bardhaman district has been bifurcated from former Barddhaman district in 2017 as a mining-industrial area with Asansol being the head quarter of the district.



Map 1: Location of Study Area

IV. DATABASE AND METHODOLOGY

The study is primarily based on data obtained from Landsat Enhanced Thematic Mapper (ETM) image, and Landsat Operational Land Imager (OLI) image which were collected from the United States Geological Survey (USGS) Earth Explorer portal. Detailed descriptions of the images are given in Table1. As the climate of Indian sub-continent is predominantly controlled by Monsoon, the sky remains nearly clear in winter season from November to February. Thus the imageries of winter season for both the years have been collected assuming a minimal seasonal and spatial variation in terms of agricultural practices. Besides, the GPS data were also collected during winter period for ground truth verification for supervised image classification and post-classification accuracy assessment. CD Block maps have been collected from Census data and Google Satellite Image.

Table 1: Satellite images used in the present study

Types of Image	Sensor	Path/Row	Date of Acquisition	Band used	Spatial Resolution	Source
Landsat-7	ETM	139/ 044	2001-12-29	Visible (B1, B2, B3) NIR (B4)	30M	U.S. G.S.
Landsat-8	OLI	139/ 044	2021-11-10	Visible (B2, B3, B4) NIR (B5)	30M	U.S. G.S.

For the spatio-temporal change analysis from 2001 to 2021 Supervised Image Classification techniques have been followed with Maximum Likelihood Algorithm in QGIS 3.18.0 version. After the classification, GPS data were also collected from selected points of the study area to remove the confusions originated from the image classification. After that, accuracy assessment technique has been followed with high resolution satellite image of Google Earth Pro to get the maximum area as properly classified with present algorithm. Producer's accuracy, user's accuracy, overall accuracy, and Kappa statistics of the classified image have been analysed. After that, Necessary changes were performed to achieve the better results. Finally, the kappa coefficients of the classified images are obtained as 0.81 for 2001 classification and 0.87 for 2021. Then, Post-classification change detection technique has been followed to get the new classes from the reference classes, i. e. the conversion of nature of LULC within two decades. Thereafter, only the built-up areas were extracted from classified images using the vectorization techniques to properly delineate the area under changes within this time span (Map 6). The entire methodology is given in the flow chart 1.

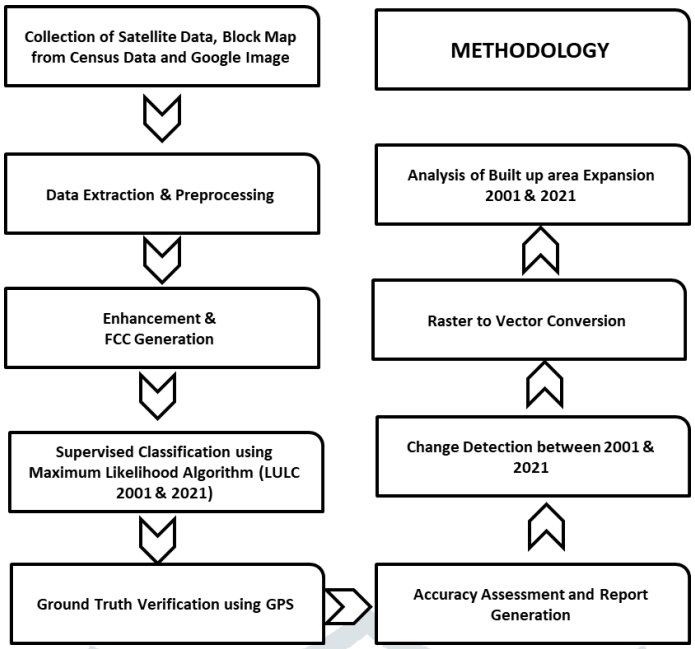


Chart 1: The steps followed in the Methodology

V. RESULTS AND DISCUSSION

5.1 LULC Classes

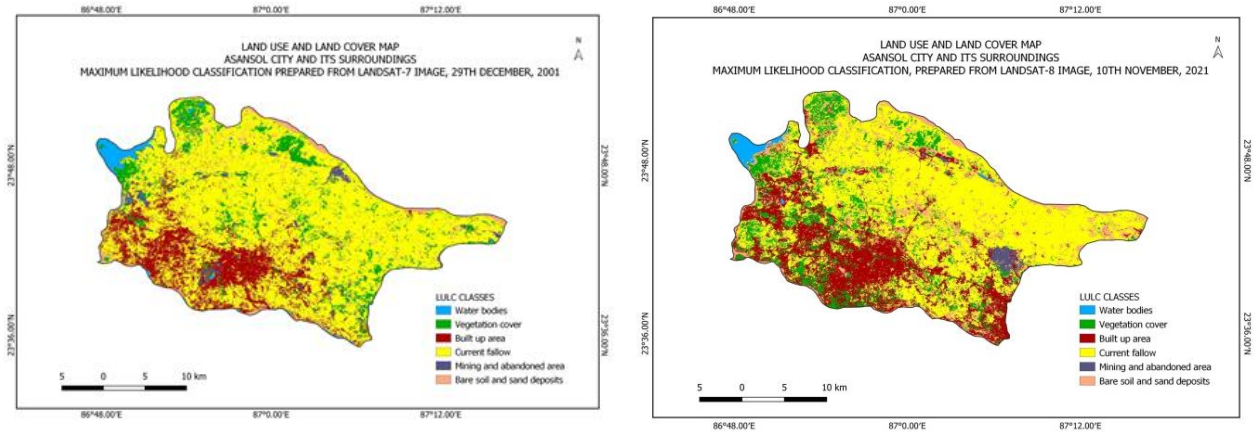
For the present research work, six land use and land cover categories have been selected to run the process of supervised image classification (Map 2 & Map 3). These are water bodies, vegetation coverage, built-up area, Current fallow/ monoculture area, mining/ abandoned area and sand deposits/ bare soil.

The spatial signature of water bodies have been collected from reservoir, ponds and rivers. Vegetation coverage includes the dense forest coverage as well as the green space around the built-up areas. The signatures of built-up areas have been collected from solely settlement and industrial areas.

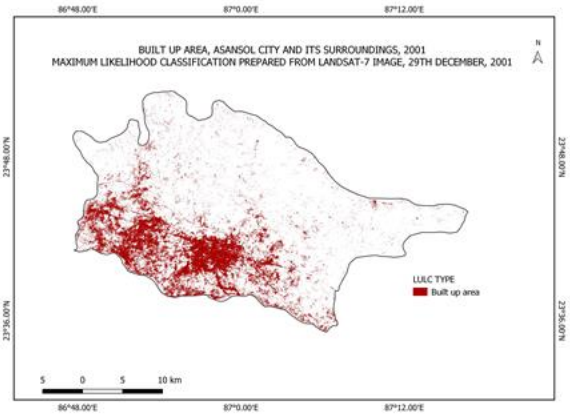
It is noteworthy to mention that the fourth class is considered as current fallow which is a mixed type of land use with monoculture practice. Actually the current fallow lands are those which can be taken up for cultivation but are temporarily out of cultivation for not less than one year and not more than two years (Pal, 2015). Simultaneously, during monsoon, a small proportion of land is also used in the study area for agricultural practices with low productivity. Thus, the nature of this kind of land is changing regularly from current fallow to monoculture land and from monoculture to current fallow. As the acquisition time of satellite imagery during winter season in both the years, there is a minimal seasonal variation of agricultural practice.

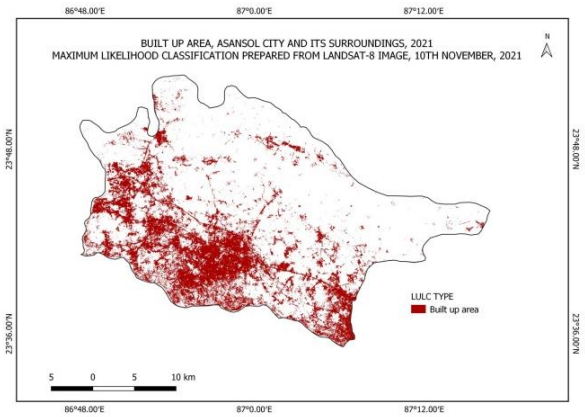
The next category has been considered as the mining and abandoned area. In fact these are the area of open cast mining zones which is very common in the study area. Mostly, these areas are abandoned after adequate coal extraction or in other cases these are the result of sudden closure due to some litigation. In certain areas, closure of factories or plants left their distinctive imprints upon the landscape with dark spots, being considered as the abandoned area deliberately.

The last category is the sand deposits and bare soil. By nature, these two are completely different and of distinctive origin. But the reflectance values of these two are almost same in satellite imagery. At the same time, a huge number of brick kilns have been developed in the study area in a haphazard manner amidst the current fallow areas. Though these areas are developed in human interference but could not be separated from the last category due to almost same reflectance value.



Map 2 LULC in 2001, Asansol City and its surroundings, Map 3 LULC in 2021, Asansol City and its surroundings





Map 4 Built-up areas in 2001, Asansol City and its surroundings, Map 5 Built-up areas in 2021, Asansol City and its surroundings

5.2 LULC Status

The net changes in LULC status (Table 2 and 3, Figure 1) during last two decades in different categories as mentioned earlier have been summarized below.

- The area coverage of water bodies have reduced from 2.13% to 1.38 % from 2001 to 2021. This is mainly due to periodical shifting of river course of Ajay and Damodar flowing in the southern side. But as per classification report 2.42 sq. km. of water bodies has been converted to built-up area within this period.
- This is indeed a good sign that the overall vegetation coverage has been increased by 4% in two decades. Approximately 21.63 sq. km. of vegetation area has been converted to current fallow but at the same time 33 sq. km. of current fallow land has been converted to vegetation coverage. In this context, this is a matter of concern that 20.41sq. km. land has been converted to built-up area within this period which clearly indicates the expansion of built-up area at the cost of vegetation coverage in the study area.

Table 2 Land use and land cover status in 2001 and 2021

LULC Classes	Area Coverage in 2001		Area Coverage in 2001	
	Area (Sq. Km.)	Area (%)	Area (Sq. Km.)	Area (%)
Water bodies	17.49	2.13	11.32	1.38
Vegetation cover	79.00	9.62	111.86	13.62
Built up area	125.57	15.29	171.46	20.88
Current fallow/Monoculture land	551.18	67.10	409.92	49.91
Mining and abandoned area	17.64	2.15	11.54	1.40
Bare soil and sand deposits	30.49	3.71	105.28	12.82

- The built-up area has been increased by 5.59% from 2001 to 2021 as per image classification report. The large percentage approx., 79% of conversion to built-up area is shared by current fallow and monoculture land. The total area of this category is 137.80 sq. km (Table 4). Secondly, 20.41 sq. km. of vegetation area has been converted to built-up area within this time span. Approx. 6% of conversion to built-up area is contributed by mining and abandoned area (Map 6).
- A significant change is also detected in the category of current fallow/ monoculture land as it has been decreased by 17.20% in this tenure. The major causes behind this change is the conversion of current fallow to built-up area by 25% and current fallow to bare soil by 9%. Approx. 6% of current fallow areas have been converted to vegetation coverage that may be considered as a positive step towards sustainability.
- Mining and abandoned area has also been decreased by 1.53% within two decades. But this must be mentioned that approx. 10.87 sq. km. of mining and abandoned area has been converted to built-up area within this period. It is also noticeable fact that mining activities has been increased within this time span in the city surroundings CD Blocks and a large number of industries have also been closed at the same time. But the overall percentage is reduced due to the shifting of mining area to other categories.
- The last category, bare soil and sand deposits have been increased by 9.11% of total area under study within two decades. About 49.61 sq. km. of current fallow has been converted to bare soil and sand deposits. From the classified image and ground truth verification by GPS survey, this is also worthy to mention that a huge number of brick kilns have been developed haphazardly in study area to fulfill the ever increasing demands of city and nearby city dwellers due to urban expansion.

Table 3 Land use and land cover change status from 2001 to 2021

LULC Classes	Area (Sq. Km.)	LULC Classes	Area (Sq. Km.)
Water bodies (No Change)	10.42	Water bodies to Current fallow	0.12
Vegetation to Water bodies	0.01	Vegetation to Current fallow	21.63
Built up to Water bodies	0.08	Built up to Current fallow	11.17
Current fallow to Water bodies	0.36	Current fallow (No Change)	322.21
M & A area to Water bodies	0.29	Mining area to Current fallow	3.00

Sand deposits to water bodies	0.06	Sand deposits to Current fallow	9.09
Water bodies to Vegetation	0.15	Water bodies to M & A area	0.27
Vegetation (No Change)	29.76	Vegetation to M & A area	2.32
Built up to Vegetation	7.36	Built up to M & A area	0.23
Current fallow to Vegetation	33.00	Current fallow to M & A area	8.17
M & A area to Vegetation	1.35	M & A area (No Change)	0.32
Bare soil to vegetation	0.33	Bare soil to M & A area	0.20
Water bodies to Built-up area	2.42	Water bodies to Sand deposits	4.11
Vegetation to Built-up area	20.41	Vegetation to Bare soil	4.87
Built up (No Change)	101.79	Built-up area to Bare soil	4.92
Current fallow to Built-up area	137.80	Current fallow to Bare soil	49.61
M & A area to Built-up area	10.37	M & A area to Bare soil	2.31
Bare soil to Built-up area	3.85	Bare soil and Sand Deposits (No Change)	16.96

5.3 Expansion in Built up area

The wholesale and retail trade, market force and increasing services and modern amenities are the major attraction of immigration in the Asansol city and its surrounding areas. To accommodate the immense pressure of population, urban expansion has become inevitable. As a result, the peripheral area has been considered as a suitable place for the development of new township. A large number of Mini Township and housing projects have been introduced into the scenario of urban landscape within this time span. A few examples are Shristinagar, Sugam Park, Kalyanpur Satellite Township, Riverside Township, New Town, J. K. Nagar Township etc. Most of these areas were either current fallow or monoculture land with low agricultural return. But the increasing connectivity by road network provides ample opportunities for the easy conversion of this land to built-up area (Map 4 & Map 5). As mentioned earlier, that 79% of shifting to built-up area is shared by current fallow and or monoculture land (Table 5, Figure 2). In most of the cases, the transformation of this land is promoted by Aansol Duragapur Planning Area (ADPA) for the public interest and in favour of the growth of Asansol City.

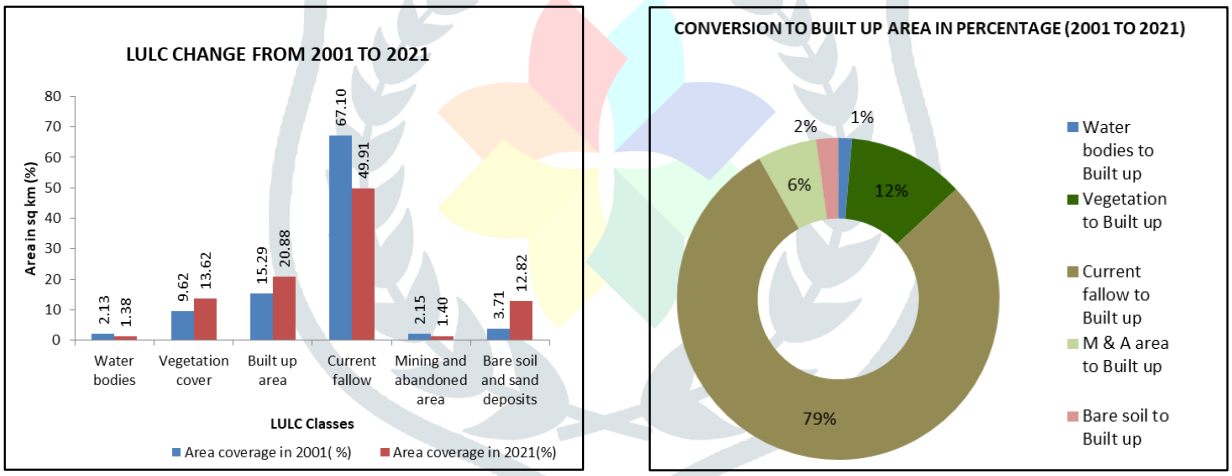
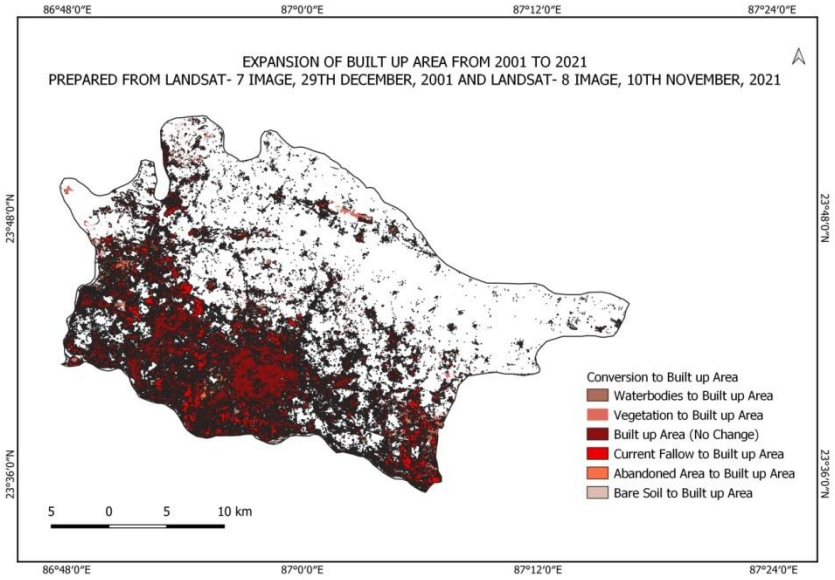


Figure 1 LULC change from 2001 to 2021 in Asansol and its surrounding areas. Figure 2 Conversion to built-up area from other land use categories from 2001 to 2021

Table 4 Conversion to built-up area from 2001 to 2021

Conversion to built-up area	Area (Sq. Km.)	Area (%)
Water bodies to built-up area	2.42	1.39
Vegetation to built-up area	20.41	11.67
Current fallow to built-up area	137.80	78.81
M & A area to built-up area	10.37	5.93
Bare soil to built-up area	3.85	2.20



Map 6 Conversion to built-up area from 2001 to 2021 in Asansol City and its surrounding areas.

VI. FINDINGS

From the above results and analysis the important findings are as follow:

- The Built up area has been increased by 37% (46 sq. km) within two decades from 2001 to 2021 among which the major percentage, 79% of total conversion to built-up area (137.80 sq.km.) is shared by current fallow and or monoculture land. A significant change is also occurred in vegetation coverage transforming to built-up area.
- Small water bodies and vegetation cover are also encroached by the new urban projects in the study area.
- Outward and uneven growth has been occurred in the southern parts of the study area mainly along the NH2 and Asansol-Bardhaman railway linkage.
- Landscape fragmentation is a common phenomenon in the study area due to encroachment of built-up patches in the country sides especially for the development of Mini-Townships.
- Many important manufacturing units have been closed due to obsolescence of production technology which has increased the abandoned area in the city surroundings.
- It is evident from the classified image and GPS survey that a huge number of brick kilns have been developed haphazardly in study area to fulfill the ever-increasing demands of city and nearby city dwellers due to urban expansion.

VII. CONCLUSION

From the above discussion it is obvious that spontaneous increase in population has already encroached the country sides of Asansol being the second largest city of West Bengal. Therefore, it can be expected that the transformation to built-up area will be continued at a same rhythm of population growth in the study area. As per trend revealed from the LULC study of last two decades, a vast amount of current fallow or monoculture land will be converted to built-up area in near future because these lands are not considered as beneficial to the urban administrative authority. But undoubtedly the unrestricted and unplanned growth will promote landscape fragmentation, problems in waste disposal, reduction of urban green space, micro-climate change and overall adverse effects on urban ecological balance. Though it is very difficult to change the current trend, some management strategies like development of services and amenities, introducing green belt project, increasing awareness about the conservation and protection of natural ecosystem can be adopted for the betterment of urban environment health. In future, the study can be continued with the impact assessment of the extension of built-up area towards country sides and formulation of proper management strategies.

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