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Urban Area Mapping of Meerut City and its Environs using Quickbird Satellite Data and Geographical Information System (GIS) Techniques

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***Abstract* - Over the years satellite based remote sensing data with its improved devices have been successfully utilized for urban area mapping, monitoring and proper landuse planning and management activietis and it is considerd as essential element for monitoring and modelling for understanding the earth as a system. High resolution remote sensing data provides a lucid and effective means for identification and mapping of small objects on earth surface/urban area environment and its change at regular interval. It provide vital information on type and spatial extent of landuse/landcover in any urban area. This paper presents the results based on Quickbird sattelite's (pan plus multispectral) 60 cm high resolution remote sensing data, Geographical Information System (GIS) and Global Positioning System (GPS) Techniques for Meerut city and surroundings, Uttar Pradesh, India. The lattitudinal and longitudinal extent of study area is between $28^0$32'N to $29^0$18' N and 77^0 07' E to $78^0$14' E., which covers an area of 26937hactare. In study area five broad landuse /landcover categories are identified and mapped at level first classification, they are - Built-up (urban-10905.12ha.,40.48 %) , Built-up (rural-546.99 ha., 2.03%), industrial area (463.54 ha., 1.72%), agricultural land (14876.08 ha., 55.23%) and water bodies are occupying (145.27 ha.,0.54%) of total geographical area. Which has been further subdivided up to level three classifications. The digital database created for the study area would be very useful for city planners/decision makers, urban development authorities for future realistic land use planning and management.**

Key Words- Quickbird Satellite's High Resolution Data, Urban Area Mapping, Landuse/Landcover, GIS And GPS Techniques

INTRODUCTION

Urbanization is an index of transformation from traditional rural economy to modern industrial one. It is a progressive concentration of population in any urban unit. At the moment, India is one among the country of low level of urbanization. Number of urban agglomeration/town has grown from the year 1827 in the year 1901 to 5161 in the year 2001. During the last fifty years the population of India has grown two-and-a-half times, but urban India has grown nearly five times. In 2001, 306.9 million Indians (30.5%) were living in nearly 3700 towns and cities spread across the country, compared to 62.4 million (17.3%) who lived in urban areas in 1951. This is an increase of about 390% in the last five decades. It reflects a gradual increasing trend of urbanization. India is at an acceleration stage of the process of urbanization and expected to increase to over 400 million and 533 million by the years 2011 and 2021 respectively. As per census of India, 2011, 7933 cities are reported in our country, only few cities had up to date land-use map and this is the need of the day to prepare a detailed map on urban area geo-information for future planning because urban is a compound system of human and nature. It is also a high-dense geographical synthesis of population, resources, environment, social, economic and as one sign of civilization and social progress, the city's effects on national politics, economics and culture become prominent increasingly. In other words, the urbanization's level is a significant parameter to measure a country's extent of civilization, social progress and economic. So it is very important to make reasonable and fit urban planning and management (Fan Wenbing, 2006). According to the urban development aims, urban planning constitutes the urban character, scale and development direction, makes use of the urban land reasonably. Urban planning relates to politics, economic, society, technology, art and comprehensive domains of human life. It is not only integrated, but also concerned with the policy and practice (Zheng Chaogui, 2004). The primary phase of urban planning is present situation investigation. In the past, it always consumed a lot of labour force, material and money. The result was not timely and exact. Nowadays, the remote sensing technology can be used to investigate rban terrain, physiography, lakes, plants, sights, traffic, land utilization and building distribution quickly. As a main method to obtain and update urban geometric information and some

attribute information, the remote sensing technology is quick, exact and economical (Xu Zhenhua, 2005).

Uttar Pradesh is most populous state in the country which has 724 cities as per census of India, 2011, i.e Nagar Panchayat / Nagarpalika Parishad / municipal corporations. In the entire state of Uttar Pradesh 0.06 lakhs sq. km area comes under urban built up land, which is around 1.0% of the total land of the state. (Kumar, V. 2012) Due to excessive pressure of population, rapid urbanization took place and as resultant, numbers of colonies has been developed by development authorities. These colonies has been taken up by urban local bodies and as a results the urban density of the state is now reported around 4937 persons per sq. km, whereas overall population density of the state is only 473 person/sq. km. In the beginning of 20th century, 548 cities were reported in the state of Uttar Pradesh, which rose up to 724 towns/ cities includes chhavani parishad &Industrial Township **(Fig.2)** in a span of 110 years accordingly, in this connection the role of planning agencies is very important and it is increasingly more complex and is extending to a wider range of activities. (Minakshi Kumar et. al, 2002), Consequently there is an increased need for these agencies to have timely accurate & cost effectively data of various forms. (Gopalan A.K.S. 2009) High resolution remote sensing data of various satellites including of our country and United States of America, coupled with Global Positioning System (GPS)/mobile mapper can be used to identify and delineate the small land parcels for generation of detailed information (Kumar, V. et al 2009). In order to achieve such data in time, satellite based remote sensing techniques has proved its potentiality with high resolution data. The importance of this technique in urban settlement and landuse/landcover mapping is established and accepted worldwide too, to know the present actual status as well as trend of changes in city and its environs, Remote Sensing, GIS and GPS Technology is a vital tool to create the detailed information of any city and its changes. An endeavor has been made to prepare a detailed digital database on various categories of urban landuse/landcover i.e. built-up-urban- residential/planned/unplanned/mixed built-up, built-up-rural (village settlement), commercial area, industrial area-industries, public utilities/facilities/ govt. offices- state/central govt., semi-govt., institutes-universities technical/colleges and parking spaces, non-built-up land/agricultural land- orchard/plantation/open spaces, cantonment/defence land, land with/without infrastructure, water bodies-canal/distributaries, drainage/nala and lake/ponds,which has been demarcated in study area using Quickbird satellite and GIS. This is an original work created in GIS domain using Quickbird satellite data acquired in 2008. This digital database would be very useful for proper city/ land use planning & management.

OBJECTIVES

The broad objective of the present study is to prepare detailed urban landuse/landcover map, area estimation of various land use categories of Meerut city and its environs using high resolution remote sensing data of Quick bird satellite and Geographical Information System (GIS) techniques.

HISTORY OF STUDY AREA

The Meerut district is a commissionary of U.P. which is situated in the upper Ganga- Yamuna Doab, in shape, it is roughly rectangular it's length from east to west varying between 15 to 18 kms. and its breadth from north to south is about 25 kms. On the north it is bounded by the district of Muzaffarnagar and in south with Bulandshahr and in the south-west, it is bounded by the Delhi state. The Ganga river forms its natural boundary on the east and separates it on the district of Bijnor and Moradabad. The total geographical area of the Meerut city and its environs which has been taken up for the study is 26937 hactare.

LOCATION OF STUDY AREA

Meerut city is located in western Uttar Pradesh. It lies between latitude $28^0 32'$ to $29^0 18'$ N and longitude $77^0 07'$ to $78^0 14'$ E **(Fig.1).** Meerut city and surroundings is spread over an area of 26937 hectare. The town is divided into 70 wards as per Meerut Nagar Nigam.

MATERIALS & DATA USED

- Survey of India topographical map sheet No.53G/4 & 8, 12, 16, 53H/9 & 13 of Meerut city & its environs on 1:25,000/ 1:50,000 scales surveyed between 1966-67 & 1972.
- Guide map of Meerut city on 1:20,000 scale.
- City/Ward boundary map of Meerut city.
- Ground truth data collected from study area.
- Quickbird satellite's (Pan plus multispectral merged) 60 cm. high resolution data acquired on 18th,June,2008.

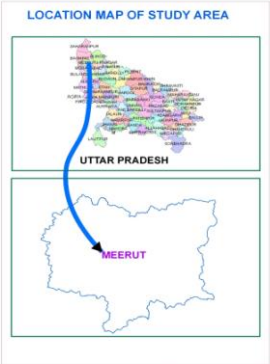

Fig.1

METHODOLOGY

To create the digital database for urban land use/land cover of Meerut city and surroundings as a base map for master plan map of the area, the high resolution 60 cm. imagery of Quick bird satellite (Pan + multispectral) has been used to identify and demarcate the different landuse/landcover categories. Apart from this survey of India topographical map sheet no. 53 G/4 & 8, 53 H/9 & 13, 53 G/12 & 16 on 1:50,000 scale has also been used for identification, mapping and ground truth/G.P.S. data collection purpose for the study area. All available maps has been assigned the Universal Transverse Mercator (UTM) and World Geodetic System (WGS_84) projection parameters. At first base map **(Fig.-3)** including road/ transport-network, city major/minor roads, railway line, canal/distributaries, river, drainage/nala, water bodies were interpreted on 1:1,000 scale and the final land use maps has been composed on 1:8000 and 1:16,000 scale. The ground truth data collected during field survey on utility/facilities to know the exact location of each and every category using Global Positioning System (G.P.S.) has been converted into tabular format using MS Excel software. It has been matched and linked with map in GIS environment and it has been overlaid on Ouickbird satellite data **(Fig.-4)**. After preparation of base map five major land use/ land cover categories are identified and mapped in the study area. They are - Built-up (urban), Built-up (rural), Industrial area, Agricultural land, Water bodies. These five categories are further classified up to level three classifications. They are **Urban built-up** (residential area) – planned/ unplanned/mixed built-up, transportation/ communication, public utilities/facilities, government offices/educational institutes, commercial area, open spaces, cantonment area, land with/without infrastructure. **Rural built-up**-rural settlement/villages are mapped in between/areas near to agricultural land, **Industrial area**-built-up land primarily engaged in manufacturing, processing and packaging of products and commodities as a dominant activity are classified under this category, are identified and mapped. In **Agricultural land**-cropland and orchard/plantation are demarcated, similarly, in **Water bodies**-canal/distributaries and ponds/lakes are delineated and mapped in study area.

RESULTS AND DISCUSSION

Results obtained in study area on various landuse/ landcover categories are summarized and **(Table-1)** shows the details related to area estimate and their percentage of each and every category, are explained as- built-up land (urban)-planned- The areas identified and mapped under planned residential colonies are Vivek vihar, Shastri nagar, Brahmpuri, Nehru nagar, Shatabdi nagar, Sadar bazar, Prabhat nagar, Civil line area, Gandhi Ashram, Parbatinagar, Lalkurti, Victoria park, Saket, Phoolbagh, Begham bagh, shergarhi, Vikaspuri, Surajkund, Civil court colonies are occupying 644.14 ha.,which is (2.39%) of total study area. Similarily, the categories of commercial area occupy as 327.69 ha. (1.22%), Public utilities/facilities/govt. offices/Educational institutes 440.65 ha. (1.65%), cantonment 3407.92ha. (12.65%), similarly, open spaces/vacant plots 451.23 ha. (1.67%), and land with/without infrastructure occupy 141.47 ha. (0.52%) accordingly, unplanned/mixed built-up land is occupying 4828.01 ha. and (17.92%) of total geographical area. **(Fig-5)** shows the urban landuse map of study area based on Quickbird data. The total area comes under planned residential including all sub-categories of built-up (urban), excluding the unplanned /mixed built-up, open spaces and land with/without infrastructure is 20.38% approximately of total geographical area. The area under open space/vacant plots and land with/without infrastructure are identified within/without urban area and in its surroundings areas. In transportation- bus depot, railway station, state highway/national highway and city major roads, in public utilities/ facilities/govt. offices/ educational institutes- in this category all educational institutes like schools, colleges, universities and Apex (institute), Govt. office/semi govt. organizations, 6th battalion PAC camp, district collectorate, govt. & private Hospital/nursing homes, police line/thana and playground/park/ stadium was demarcted. In commercial area-market area/ shopping complexes, in cantonment-military area are identified mapped and given their names in the map. The land under habitation in surrounding/outskirts of urban built-up is classified under rural built-up, which occupy 546.99 ha.(2.03%), similarly the categories ie. industrial area occupy 463.54 ha.(1.72%). The land under non built-up is classified as agricultural land and it is sub-categorized as crop land and orchard/plantation in which agricultural land-cropland is occupying 14118.18 ha. (52.41%) and

orchard/plantation occupy as 757.90 ha. (2.82%) accordingly. The lands under surface water bodies are sub-categorized as canal/distributaries and ponds/lakes. In this category-canal/distributaries are occupying 67.59 ha which is 0.25% of total study area, whereas, ponds/lakes occupy 77.68 ha. (0.29%) respectively. The urban landuse map of study area has been overlaid on satellite data to know exact location of each and every category, **(Fig.5)** shows the details of each and every categories/ location. The entire study area is splitted into **11** parts to show the details of each and every category. **Fig.6** shows the **Part-1** of study area on 1:8000 scale, similarly **Fig.7** and onwards up to 16 represents the **Part-2** to up to **Part-16** of study area continuously**.** The area estimate of linear features and some categories, which was negligible, is not given in statistics.

RECOMMENDATIONS:

Before preparation of Master Plan map of city, the following should be considered:

- Prime Agricultural land should be avoided for future urban growth/ expansion.
- To develop any colony in urban periphery, at first wastelands should be used if non availability of wastelands, the 'c' quality of land can be used for residential use as well as for commercial use.
- From environmental point of view, all large scale industries should be at a minimum distance of five kilometers and wastelands should be used for establishment of industry.
- Govt. institution/ schools/ college/ universities, which also occupies large area should also not be established in fertile land.
- The four lane Express ways may be constructed to reach the Delhi, Roorki, Muzaffarnagar, Hapur and to borders of other state like Haryana, So that population pressure on inner part of the city may be reduced.
- In state of U.P., here is only two express way like Noida to Greater Noida (24.53 kms.) and Delhi to Noida direct Flyway (9.20 kms.). The total distance in our country covered by the express ways is only 736.19 kms.(9 August, 2012,Dainik Jagran Newspaper, Lucknow edition)

CONCLUSION

The remotely sensed data and Geographical Information System (GIS) have proved an effective tool in urban land use/land cover mapping, monitoring and analysis. The spatial extent of various urban land use/land cover categories prepared for the study area will be useful for planners and decision makers at city level planning & management. Furthermore, the development of intelligent GIS with high resolution panchromatic & multispectral data from Quikbird, IKONOS, Worldview, Resourcesat-I, Resourcesat-2, cartosat-I & cartosat-2 & Geoeye may enable generating parcel level land use/land cover inventories necessary for future/ sustainable development of land resource and may facilitate monitoring the input of implementation of suggested land use programs in urban areas.

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URBAN CENTRES IN UTTAR PRADESH

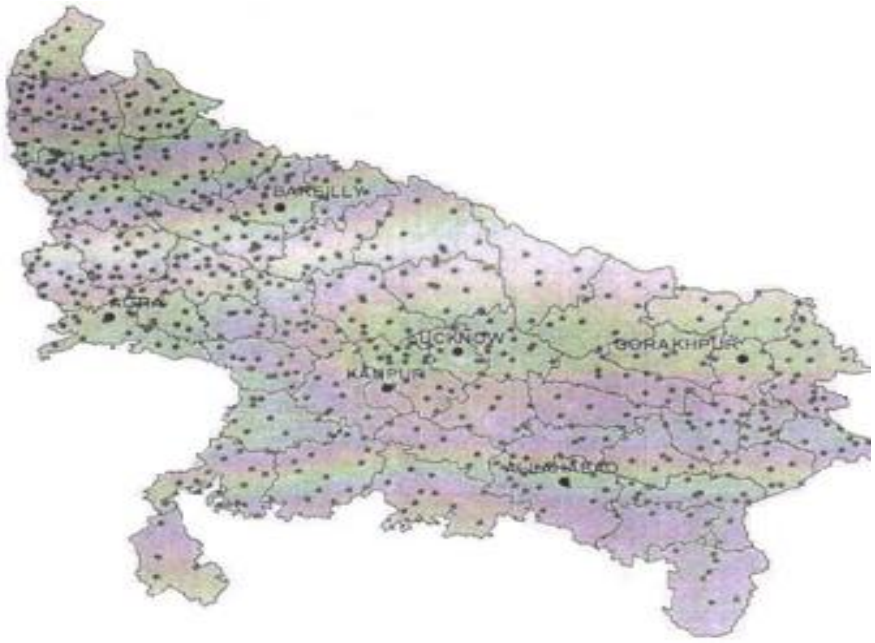
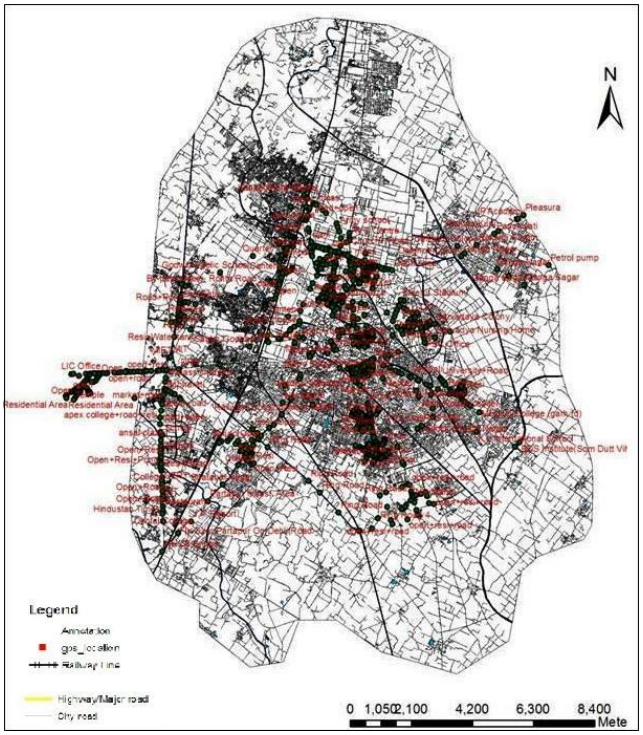


Figure: 2

Fig.3 Base/ Transport Network Map of Meerut City &
its Environs Based on Quickbird Satellite's 60cm Res.
Data Acquired on 18th June, 2008



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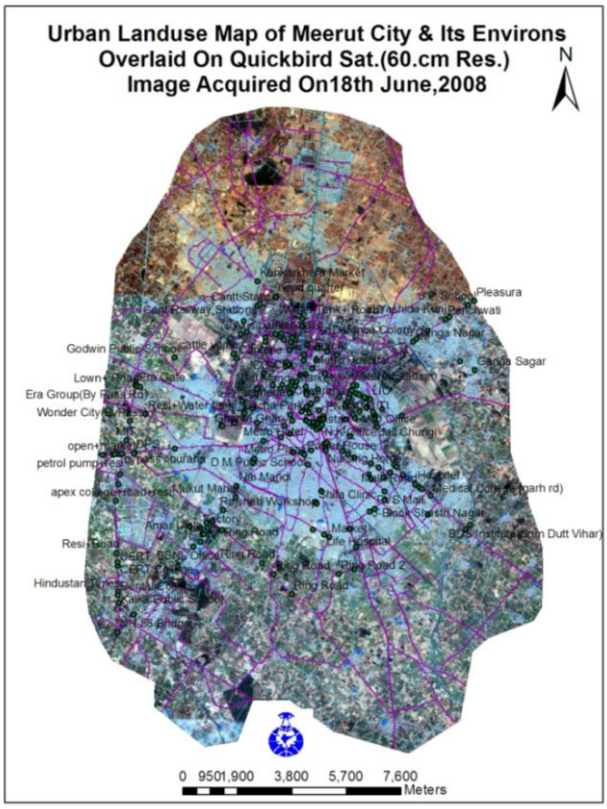

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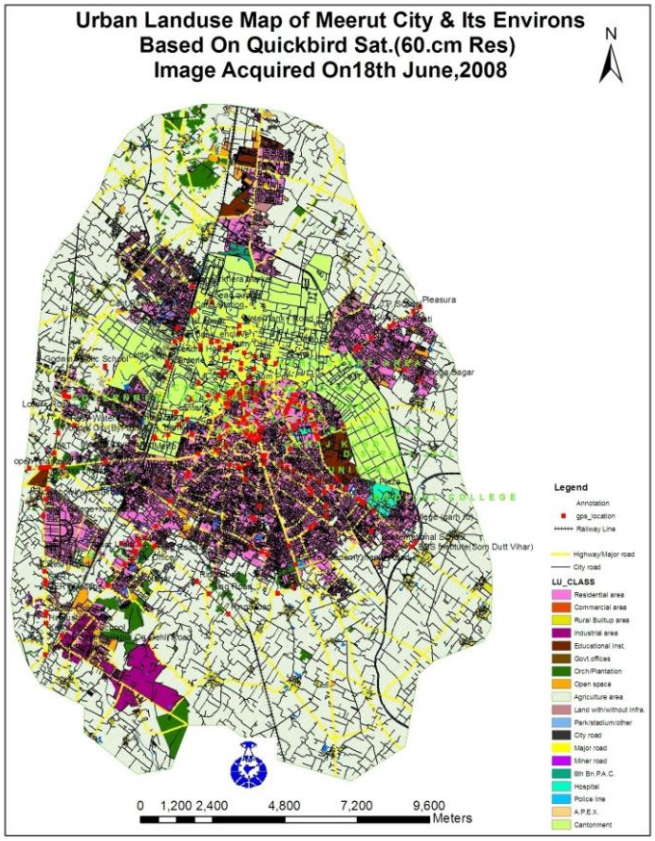

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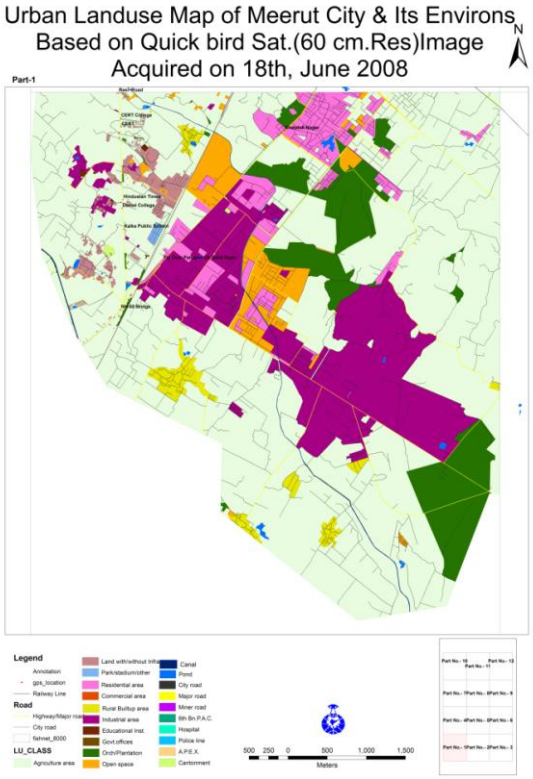

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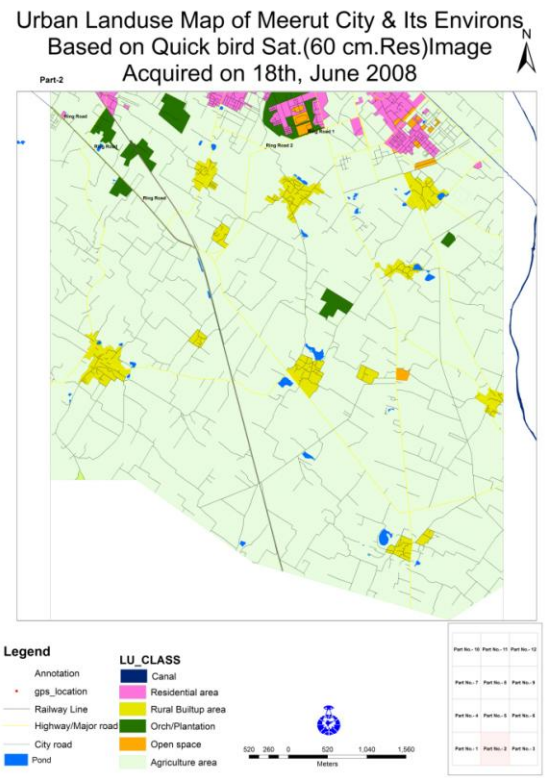

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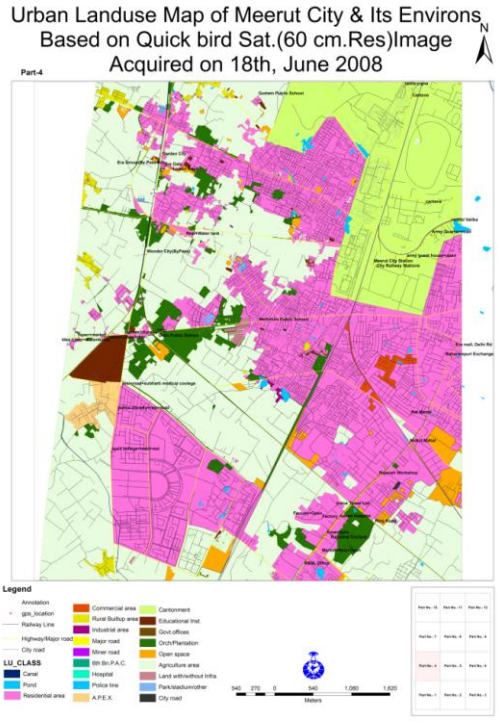

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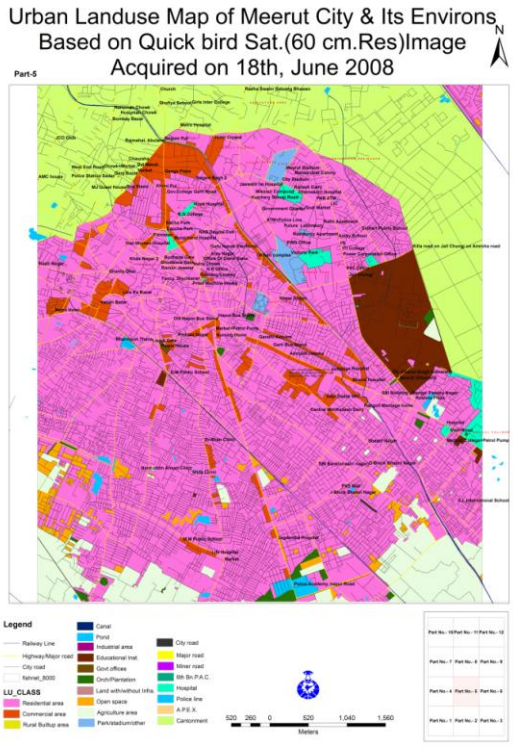

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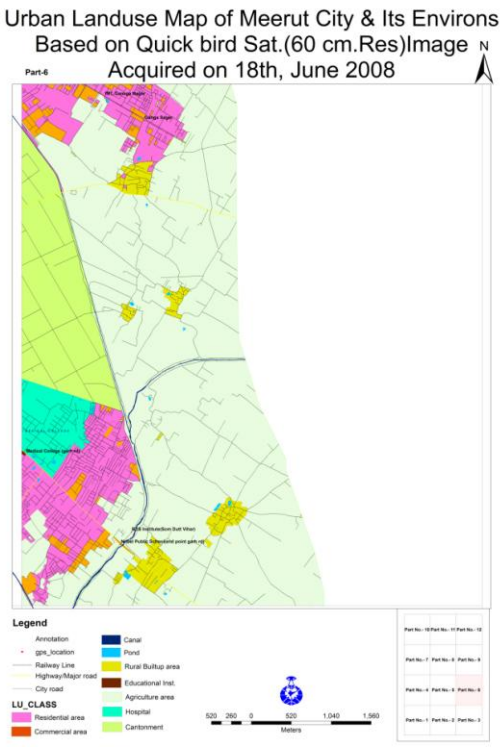

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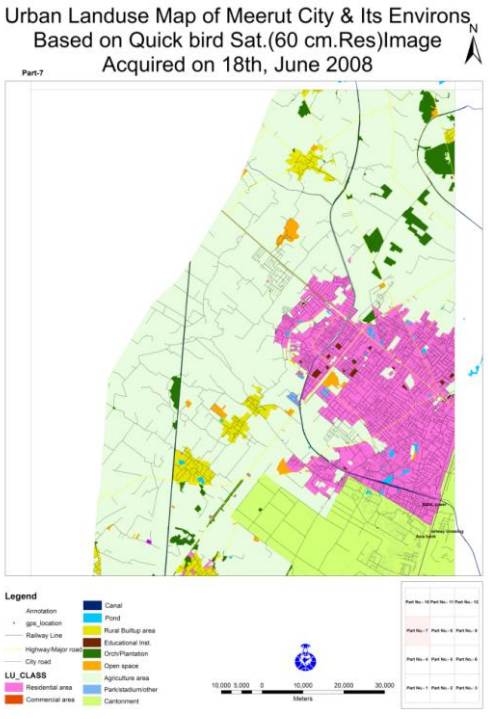

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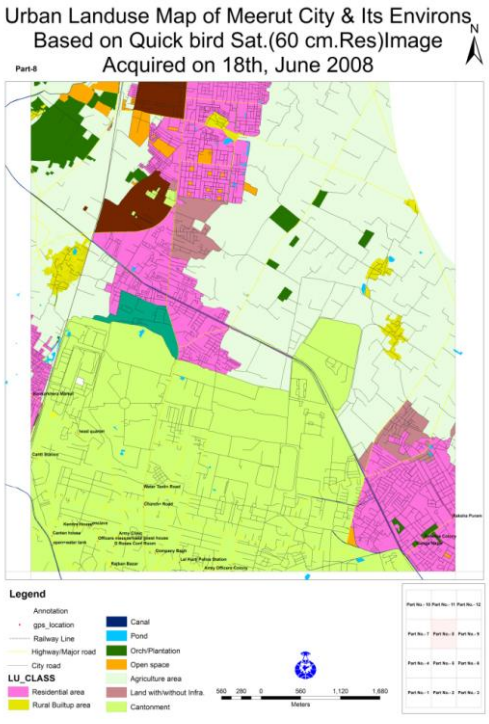

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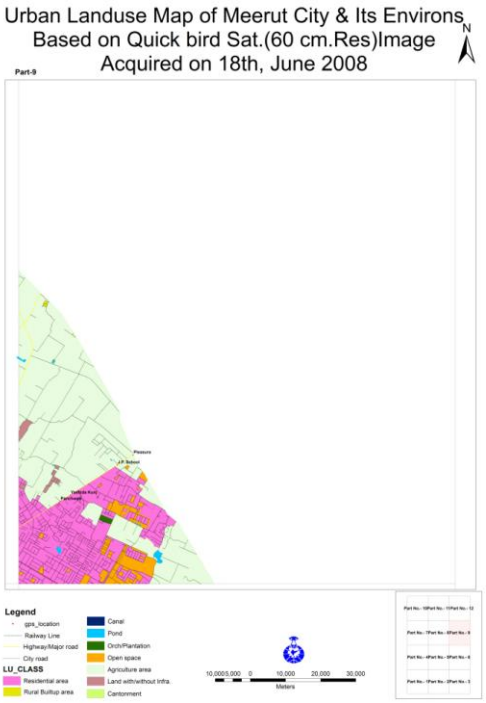

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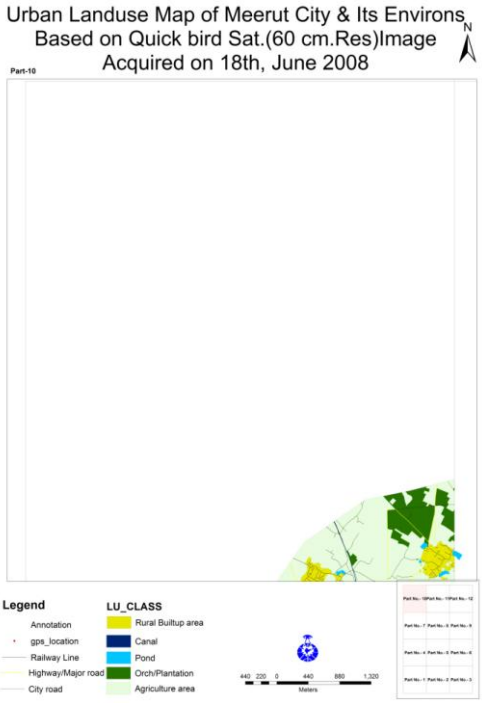

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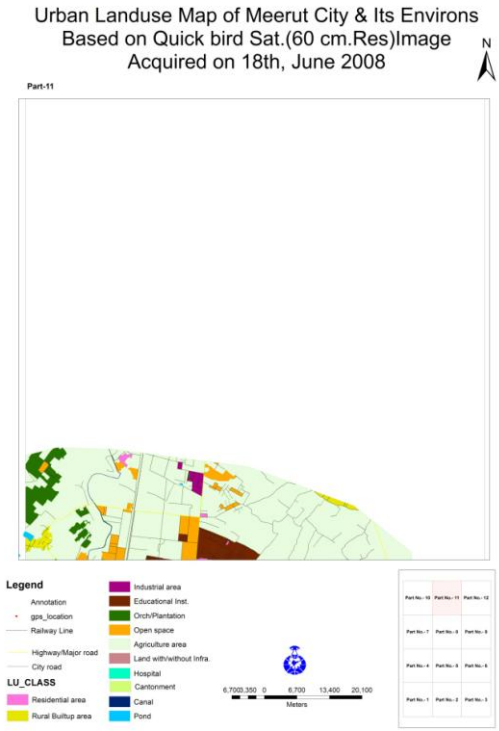

Figure: 16

TABLE-1: LANDUSE/LANDCOVER STATISTICS OF STUDY AREA

Sl. No.	LANDUSE CLASSIFICATION LEVEL			Area	%
	L-I	L-II	L-III	(in hac.)	
1	Built-up	Urban	Planned Residential	644.14	2.39
			Unplanned/Mixed Built-up	4828.01	17.92
			Transportation/ Communication/	664.01	2.47
			Public Utilities/ Facility/Govt. Offices/Educational Institutes	440.65	1.65
			Commercial	327.69	1.22
			Open spaces	451.23	1.67
			Cantonment	3407.92	12.65
			Land with/without infrastructure	141.47	0.52
2	Rural	Rural	Rural Built-up	546.99	2.03
3	Industrial	Crop Land	Industrial	463.54	1.72
4	Agricultural Land		Crop Land	14118.18	52.41
		Orchard/Plantation	Orchard/ Plantation	757.9	2.82
6	Water bodies	Water bodies	Canal/Distributaries	67.59	0.25
			Ponds/ Lakes	77.68	0.29
			Total	26937	100