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Urban Agricultural Land Use Planning For Delhi Central National Capital Region (CNCR)

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Abstract

Urban agriculture is an informal activity which is practiced in and around an urban area. It is a very dynamic concept as after every decade a city change its limit and affect the utilization of land in the peri-urban area. The present paper highlights the changing land use pattern and urban agricultural planning in Delhi-Central National Capital Region (CNCR). To study the changes in the land use pattern as well as urban agricultural planning, Land sat 8OLI and TIRS satellite imageries have been used for two time periods i.e. 2006 and 2016. The imageries have been pre-processed with standardised methods such as radiometric and geometric rectifications then Maximum Likelihood method has been used to categorize the images into seven classes, namely: forest, built-up, plantation, barren land, water bodies, fallow land and agricultural land to analyses dynamics of land use. It has been found that over the period of time natural vegetation and agricultural land are shrinking in this region and have been put to non-agricultural uses due to rapid urbanization and industrialization. The loss is primarily occurred in the south and eastern part of the periurban region whereas northern and north-eastern part still be conserved for urban agricultural planning. The unification of urban farming into urban land use planning is a multifaceted task which requires coordinated approach between all the government authorities and stakeholders.

Keywords: *Urban Agriculture, Remote Sensing, Land use, Peri-urban, Planning*

Introduction

Land use of an area is a very dynamic and complex due to continuous interaction with land, water, air and man (Stamp, 1964; Singh, 1992). Man has been interacting with its milieu since time immemorial and has transmogrified the land to fulfil his ever-changing demands. Land is a natural (Pangaribowo, 2018), most valuable and fundamental resource(Zimmerman, 1964) due to its finite supply and providing base for human development. Agenda 21 has defined "land as a physical entity in terms of its topography and spatial nature thus include natural resources' like the soil, minerals, water and biota existing on the land. These components provide a variety services essential to the maintenance of life support system and the productive capacity of the environment". Man has been utilizing various function of land, ranging from primary utilization to its general utilization. Vink (1975) defined "land use is any kind of permanent or cyclic human intervention on the environment to satisfy human needs and the land use capability or land suitability is the potential capability of given tract or to support different types of land utilization under given cultural and socio –economic conditions" whereas Tuner et.al. (1995) urged biophysical driving forces and shocks are also liable for changing land use. Hence, pattern of land utilization in a region is an effect of long continuous unabridged array of environgenic as well as anthropogenic factors on land and becomes the major driving force of biogeochemical cycles, climate change and food production from regional to global level.

The pattern of land use around a city is very dynamic, changes with space and time. At the global level, urban population primarily increased during 19th and 20th century due to a general progression of the rural area to an urban center because of economic growth and development (Davis 1995).Consequently, creating pressure on the land resources and eventually changing the utilizing of land within as well as periphery of an urban area. In almost all income nations, urbanization is an irrevocable phenomenon and occurrence to rurality seems improbable which has become a major factor leading to a change in the land use of an area and has led to the growth of a large number of cities (Cohen 2006). Another important aspect which has given rise to urban development is the changing nature of agriculture as farming becomes highly mechanized and rationalized fewer people are needed on the land (Davis 1955). This indicates that on an average the more urbanized an area is, the reduced agrarian to civic proportion. It seems like all future growth of population is likely to be absorbed in cities and towns (Shahraki et al. 2011). Therefore, urban agricultural land use and its planning become essential for urban area.

In India, ample of research has been steered on urbanization with relation to land use land cover (LULC) change using GIS and remote sensing technology (Pandey and Nathawat,2006) whereas various scholars study the LULC of Delhi and concludes that geographical information system (GIS) and remote sensing are valuable tool to study urban transformation. As far acknowledge of the authors of the present paper is concerned there is no work done on urban agricultural land use planning for Delhi-CNCR. Hence this topic has been selected for detailed study.

Objectives

The present research has the following objectives;

a) To study the land use change in Delhi-CNCR (2006-2016)

b) To suggest urban agriculture area for future sustainability.

Study Area

Geographically, the study area extending from 28°24'N to 29°07' N and 76°83'E to 77°66'E and positioned in a narrow strip of the Indo-Gangetic plain covering the total area of 3814 sq. km. The region is located at an altitude of 233 meters and around 160km south of Himalayas. Administratively, the region comes under the three states in which Delhi as a core area and the peripheral areas comes under Haryana and UP. But functionally it has been administered by National Capital Region Planning Board(NCRPB) (Fig.1

See page 269). According to Census of India, 2011 there are 112 villages in Delhi whereas Sharma and Sen (2011) overestimated the number of settlements in CNCR.

Physically, Bhangar, Khadar and the Ridge are the three main segments of Delhi-CNCR. Leaving aside the Khadar(Yamuna flood plain) region and the ridge, the whole region is categorized as Bangar or the plain.

Yamuna is the major river of this area and apart from this, there are three artificial water ways viz. Western Yamuna, Hindon and Agra which passes through the territory. The drainage of the area is from north to south which follows the general slope. The region is bestowed with fertile soil.

Total population of the study area is 223.27 lakh in 2011 which is expected to increase by 243.5 lakh by 2021 (NCRPB-2021,pg30). The density of the region is very high and moreover, growing at a very high rate. The decadal growth rate was 83.1% in CNCR whereas NCT of Delhi experienced 21% growth from 2001-11. Out of the total, 34% is the working population and remaining 65% is non-working population. Working population classified in main workers. Furthermore, out of total working population, 30% people are the main workers while just 4% people are marginal workers. Out of which main and marginal cultivators are 2% and 3% respectively (Census of India, 2011).

Data Base And Methodology

For the study, LANDSAT 8 OLI and TIRS satellite images of Delhi-Central NCR have been used for two time periods; 2006 and 2016 acquired from Earth Explorer through the URL: http//earthexplorer.usgs.gov to analyse the changes in the land use pattern. Firstly, satellite images have been pre-processed by executing atmospheric as well as geometric rectifications then Maximum Likelihood Technique and Hybrid classification are used. The former technique used to categorize the imageries into seven land use categories, viz. natural vegetation, water bodies, urban or built-up, plantation, fallow or open areas, barren land and agricultural land whereas the latter technique has been used to identify urban agricultural planning areas.

The detailed methodology adopted for this study is as follows:

i) **Data Acquisition**: LANDSAT images have been acquired from Earth Explorer through the URL:http://earthexplorer.usgs.gov. Band combination of 2, 3, 4 with 30 meters spatial resolution, Path 45 and row 30 are used to analyse the changes in the land use and thermal band has been used to study the temperature variation in Delhi-CNCR.

ii) **Pre-processing**: LANDSAT imageries have been corrected for radiometric and geometric aspects as they are accessible in un-calibrated form. The images have been geo-referenced to Universal Transverse Mercator Projection - Zone 43° N, WGS-84 Datum.

iii) **Processing:** To assess the land use pattern from LANDSAT 2006 and 2016 images, supervised classification has been performed with Hybrid and maximum likelihood algorithm. The major characteristic of former classification is it provides exclusive results for each category and latter, based on the assumption that data for each land use category is normally distributed and groups pixels into a specific class that has maximum probability (Irfan, 2011). Supervised classification method isuseful in the detection of changing land use, moreover, identifying various zones which lead to transformation in the land use configuration that consequently impacts the landscape environment (Long et al, 2008). The accuracy of the land utilization classes has been reckoned by using "Confusion or Error Matrix" from ERDAS IMAGINE 2014 software for both the time periods. Moreover, Google Earth Pro software has been used for getting more accurate and updated results for ground truthing. Urban agricultural planning in Delhi-CNCR, agricultural land map and thermal map has been prepared with the help of LANDSAT 8 images and other secondary data has been used to plan urban agriculture.

Resultsand Discussion

Land use in Delhi-CNCR

Land use is referred to as the "use" to which a particular piece of land is put to at a particular time (Zimmerman, 1964). It indicates the spatio-temporal sequences of area under different uses which is determined by the physical, economic and institutional framework. Land use classification can be defined as the orderly arrangement of a piece of land based on some similarities mainly identifying and understanding their elementary functions. Therefore, to understand the dynamics of land utilization from 2006-2016 in Delhi-CNCR, data has been obtained from the land sat 8 and presented in Table 1.1.

Is it necessary to give the image alongside the map? You can give the map and mention that it has been developed after the digital image processing. This way the map can be enlarged to some extent and made readable. It will be printed as a colour image. Prepare large size map just enlarging the map is not proper.

Table 1.1: Land Use Classification, 2006-2016

Land use Categories	2006		2016		% Change
	Area (in Hectares)	%	Area (in Hectares)	%	
Natural Vegetation	12317	3.31	1457.01	0.39	**-2.92**
Plantation	19880.2	5.35	29497.7	7.93	**2.59**
Barren Land	13268.3	3.57	8073.99	2.17	**-1.39**
Water Bodies	2020.72	0.54	2021.22	0.54	**0.000134**
Fallow Land	136233	36.65	145355	39.04	**2.43**
Built up	104111	28.00	111735	30.06	**2.05**
Agricultural Land	83928.9	22.58	73619.2	19.80	**-2.77**
Total	**371759.1**	**100**	**371759.1**	**100**	

Source: Computed by Authors from LANDSAT Imagery

Built-Up

Agricultural land around an urban area is under extreme pressure as proposed infrastructure and development projects will come up in these areas. Therefore, urbanization is considered as one of the prime reasons for the declining area under agriculture (Lopez et.al, 2001) habitat destruction (Alphan, 2003) and decline in forest and natural vegetation.

Land under buildings or settlements, infrastructure includes roads, industries; shops, etc. are included in this category. An expansion in the secondary and tertiary economic activities would lead to an increase in the built-up area. Steady increase in the urban area of Delhi-CNCR has been observed from 28% in 2006 to 30% in 2016 (Table 1.1). The increase has been as a result of rapid development due to meet the economic demands and urbanization.

Plantation

Afforestation is the key to maintain the ecology of this region therefore, planation has been observed in various location in a geometrical form. The area under plantation has also been increased from 5.34% in 2006 to 7.93% in 2016. Increase in area under planation or vegetation is mainly due to efforts of government mainly to NCT of Delhi. Central part of Delhi has maximum green cover (Fig.3) and thermal map 2016 of the region shows low temperature in and around the same area (Fig.5 See page 270).

Water Bodies

There has been an increase in the area of water bodies. Water bodies includes lakes, ponds, rivers and wetlands. In 2006, the area has been only 0.5435% whereas for years 2016, it is 0.5436% a very negligible increase has been observed. The variations are largely due to seasonality of the water bodies.

Natural Vegetation

Forests are considered as avital land use types, according to UN 33% of the total area must be under woods to maintain the ecological balance of that region. Further, very less area has been observed under forest due to semi-arid climate conditions moreover, high demand of land for cultivation and settlement are the main factor less area under forest. There has been a sharp decline in the forest cover in Delhi- CNCR, it was 3.3% in 2006 which has been reduced to 0.36% in 2016.

Barren Land

The barren land is located especially in the southern part of Delhi-CNCR (Fig. 2 and 3 See page 269 and page 270) and that is showing a declining trend due to urban expansion and development activities. It has been observed that the area under this category has been reduced from 3.5% in 2006 to 2.17% in 2016.

Fallow Land and Open area

There has been an increase in the fallow land or open area which could be due to acquisition by government, land has been sold for settlement or decreasing interest of farmers to cultivate land. The fallow land has increased from 36.64% in 2006 to 39.09% in 2016.

Agricultural land

Agricultural includes land on which crops are sown and harvested. It is the total land put to cultivation during a particular year. This represents the area sown with food as well as non-food crops. There has been a decrease in the category from 22.5% in 2006 to 19.8% in 2016 largely because of transformationof cultivatable land into urban uses and moreover, land has been acquired by the government for development purposes which has increased in the fallow land.

Table 1.2 Error/Confusion Matrix-2006

Land use	**Natural Vegetation**	**Plantation**	**Barren Land**	**Water Bodies**	**Agriculture**	**Fallow land**	**Urban**	**Total**
Natural vegetation	103	0	0	0	0	0	0	**103**
Plantation	0	29	0	0	1	7	0	**37**
Barren	0	0	416	0	0	0	10	**426**
Water Bodies	0	0	0	67	0	0	0	**67**
Agriculture	0	0	0	0	371	1	0	**372**
Fallow land	0	0	2	0	1	677	5	**685**
Urban	0	0	1	0	0	2	984	**987**
Total	103	29	419	67	373	687	999	**2677**
Overall Accuracy - 98.8%. Kappa Coefficient - 0.98								

Source: Computed by Author from LANDSAT Imagery

Table 1.3: Error/Confusion Matrix- 2016

Land Use	Natural Vegetation	Plantation	Barren Land	Water bodies	Agriculture	Fallow land	Urban	Total
Natural Vegetation	220	0	0	0	0	0	0	**220**
Plantation	3	436	0	0	3	1	0	**443**
Barren Land	0	0	1137	0	0	0	0	**1137**
Water Bodies	0	0	0	67	0	0	0	**67**
Agriculture	0	0	0	0	139	2	0	**141**
Fallow land	0	5	5	0	1	652	10	**673**
Urban	0	0	1	0	0	0	970	**971**
Total	**223**	**441**	**1143**	**67**	**143**	**655**	**980**	**3652**
Overall Accuracy - 99.1%, Kappa Coefficient-0.99								

Source: Computed by Author from LANDSAT Imagery

Accuracy Assessment

The accuracy assessment is avital part of a classification, without this it is not considered complete (Lillesand and Kiefer, 2000). To assess the accuracy of a classified image Kappa coefficient and Overall accuracy has been calculated with the help of confusion matrix, also known as error matrix which is a software generated matrix quantitative method. The table shows number of pixels for all the probable correlation between classified results and reference image. The accuracy results have been obtained by using ERDAS Imagine 2014 software which showed an overall accuracy of 98.8% for 2006 and 99.1% for 2016(Table 1.2 and 1.3) whereas Kappa Coefficients for 2006 and 2016 are 0.98 and 0.99 respectively. Both Kappa coefficient and overall accuracy were achieved above the standard level of accuracy i.e.>0.85 and >0.85% respectively.

Urban Agricultural Planning

High population growth and imbalanced urbanization is creating a lot of pressure on the existing infrastructure of Delhi-CNCR (NCRPB-2021, pg, 129). It is clear from the above discussion that Delhi-CNCR is converting its fertile agricultural land for non-agricultural uses. Therefore, integrating urban agriculture in the land use planning of Delhi and CNCR has become very essential for the sustainability of region.

Madaleno (2000) defined urban agriculture as an agriculture which is practiced in both intra and peri-urban surface. Urban agricultural planning has two components viz. Intra urban and peri-urban. To plan urban agriculture for Delhi-CNCR, intra and peri-urban area, will play an equally important role as it plays a vital role not only in supplementing the food supply (Lintelo, et al 1999) but also achieving the sustainable development goals such as providing employment, food security, nutrition security, make cities sustainable, combat climate change etc.

i) **Periurban Agricultural Planning:** Land is primarily available for agriculture in the peripheral areas especially the northern and north-eastern part of the region (Fig 4 See page 270). Delhi peri-urban areas are facing lot of problems such as changing land use, environment degradation, high population pressure etc. (Lintelo, et al. 1999) eventually putting more and more land to non-agricultural purposes and consequently de-stabilization of the rural economy and food demand of the region (Suzanchi, et al 2006; Kaur et.al 2008). Fig. 5 shows the thermal map of the region, which heralds an alarm especially for the peripheral regions which are showing rise in temperature due to massive developmental activities taking place. Although, general perception is coreof a city is warmer than the periphery but here the trend is reversed. It is a major cause of concern for the impending sustainability of urban agriculture as temperature is one of the crucial and controlling factors of agriculture, affects the pressure, wind, rainfall pattern etc. moreover, any change in the temperature hampers the growth cycle of a crop.

The region can supplement with healthy and nutritious food supply only if proper planning and policy guidelines reinforced with adequate legislation and guarantee rights for farmers for these peri-urban areas. Hence, the region requires intervention of proper land management policies to reduce the threatening of the local milieu and sustainable peri-urban agricultural planning and development.

Intra Urban Agriculture Planning: According to FAO, around 800 million urban residents are involved in urban agriculture across the globe and around 10-90%food originate within the cities (Fig. 6). According to Singh et al (2016), "A family can easily cultivate most of their required vegetables at their *verandha*, balcony and rooftop". They have estimated vegetable production through soilless cultivation (Table 1.4) which isa very innovative technique. Similarly, Delhi-CNCR can also produce fresh and nutritious crops from their open spaces, rooftop, balcony, kitchen garden, community garden etc. within the limit of urban area.

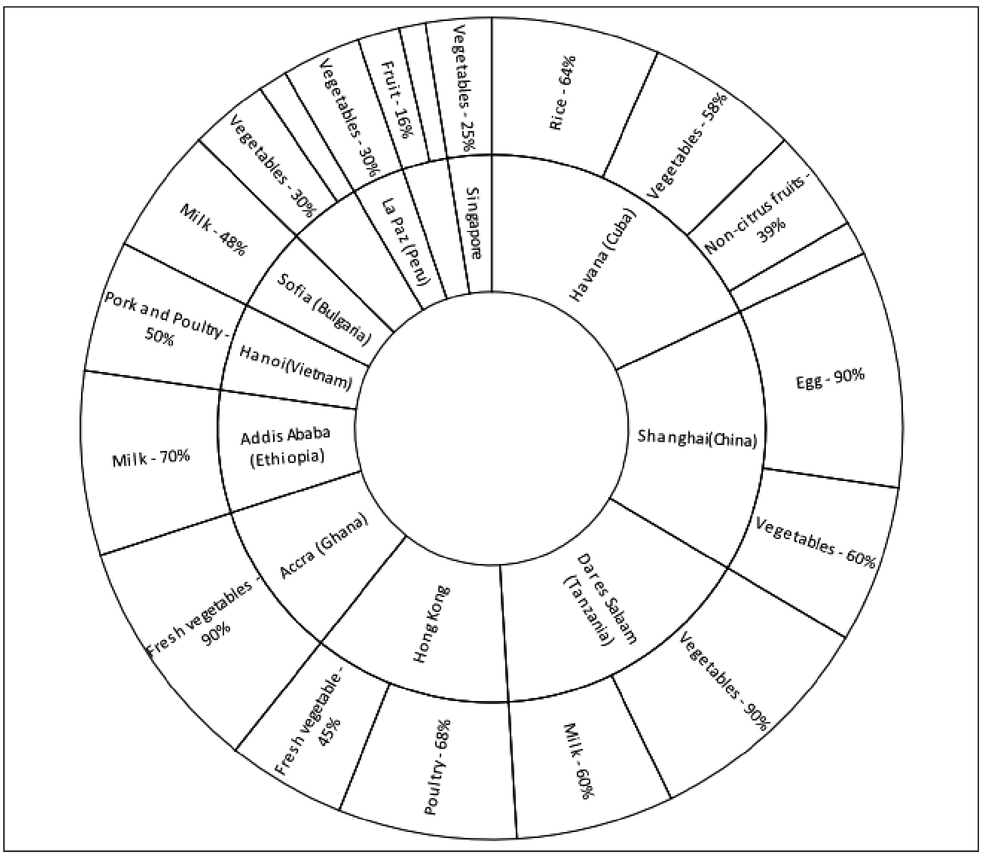

Fig.6: Percentage of Food comes from Urban and Perti-Urban Agriculture in Different Cities of the World.

Source: FAO, 2007:

Table 1.4: Vegetable Productions under Soilless Cultivation

S. No.	Vegetables	Production (g/m3/day or kg/m2)
1	Carrot	56.5
2	Cucumber	226
3	Garlic	57
4	Green Beans	113
5	Lettuce	226
6	Salad Green	226
7	Tomato	113
8	Greens	113
9	Spinach	2.65
10	Red Amranthus	2.9
11	Green Amranthus	2.6
12	Pokchoi	6.5

Source: Singh, et.al.2016

The unification of urban agriculture into urban land use planning is a multifaceted task requiring multi-stakeholder and coordinated approach as falling under the jurisdiction of several different levels and types of authorities, e.g. agriculture, parks and gardens, public works and urban planning (Mubvami and Mushhamba, 2006). The concept can be unified rationally at each level of city planning process i.e. Master plan, Local plan, Subject plan, Site plans and Residents Welfare Association (RWA) in Delhi-CNCR. Moreover, Coordination between all the government authorities and stakeholders are very essential to give a meaning approach to urban agriculture. The region requires an empowering strategic plan and policy framework guiding the development of city farming such as by incorporating into municipal developmental projects and programmes.

Conclusion

To analyse the urban agricultural land use pattern, LANDSAT 8, Thermal Infrared sensor (TIRS) and Operational Land Imager (OLR) have provided useful statistics for the analysis. It has been observed that due to speedy urbanization in the area, the area under settlement has increased from 2006 to 2016. Plantation and fallow land are showing gain primarily due to inclusion of fallow land or forest area. Water bodies (as a result of seasonal variations) changed marginally whereas natural vegetation, barren land and agriculture are shrinking in this region and have has been put to non-agricultural uses due to rapid urbanization and industrialization. The loss is primarily occurred in the south and eastern part of the region whereas northern and north-eastern part can still be conserved for agricultural purposes. Moreover, for peri-urban agricultural planning, thermal map and agricultural map also provide different perspective. The unification of urban agriculture into urban land use planning is a multifaceted task. As it requires participation and coordination between various government authorities, non-government organisations and other stakeholders to give a meaning approach to urban agriculture. Hence, interposition of proper land management policies and planning is very essential to reduce the endangering of the local environment and urban agricultural planning.

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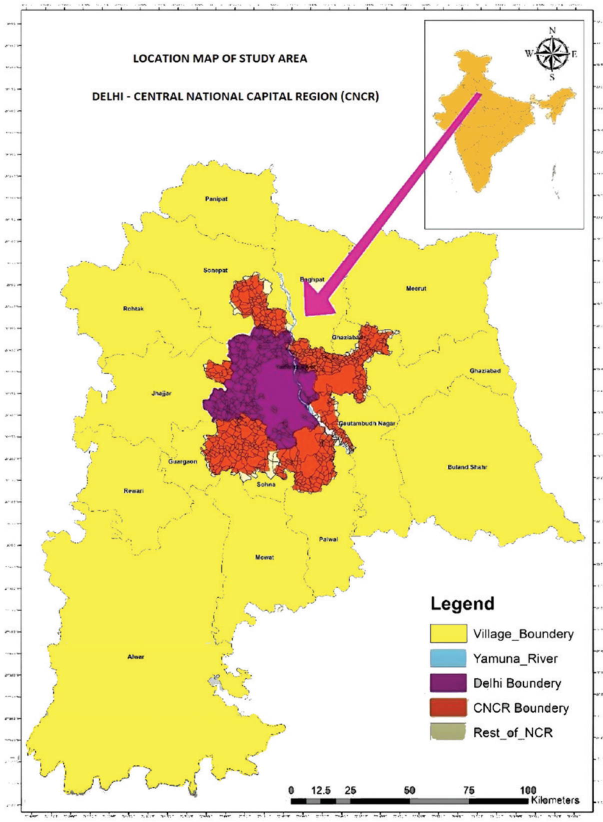

Fig.1 Location of Study Area

(See page 258 for the text)

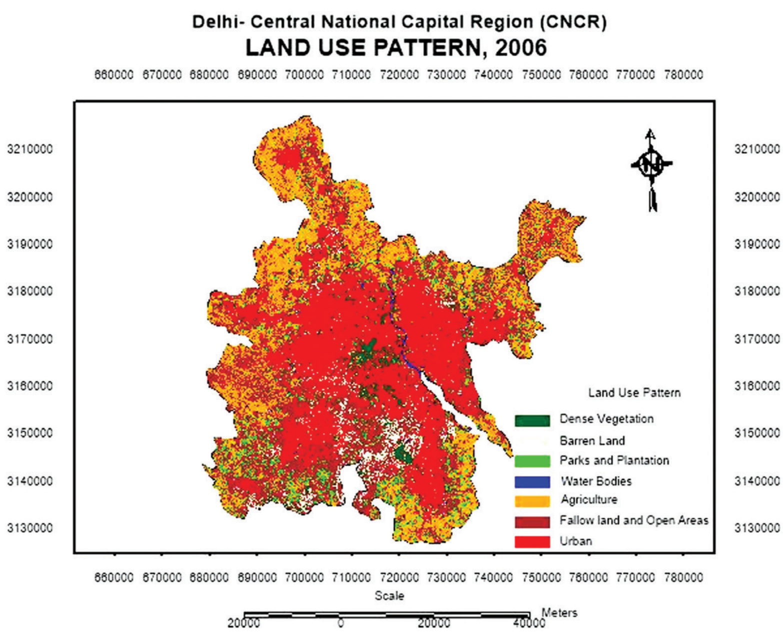

Fig. 2: Land use Classification, 2006

(See page 258 for the text)

Source: Earth Explorer, http://earthexplorer.usgs.gov

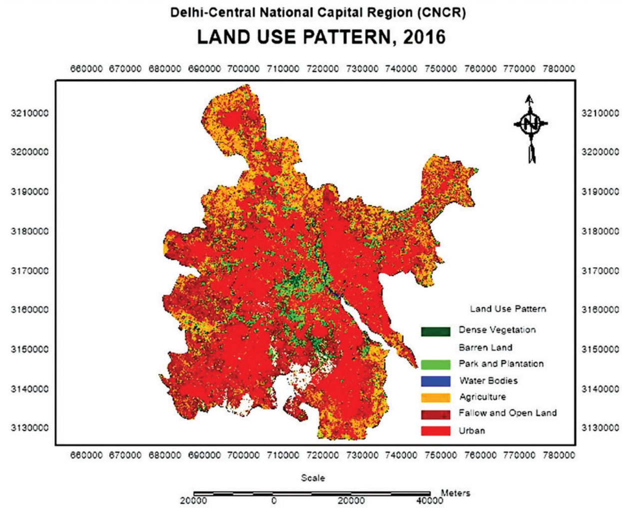

Fig.3: Land use Classification, 2016

(See page 261 for the text)

Source: Earth Explorer http://earthexplorer.usgs.gov

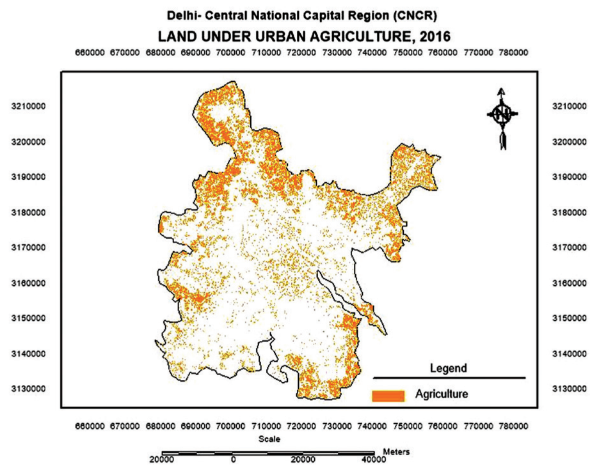

Fig.4: Agricultural Map of Delhi-CNCR, 2016:

(See page 263 for the text)

Source: Classified by Authors, Earth Explorer, http://earthexplorer.usgs.gov

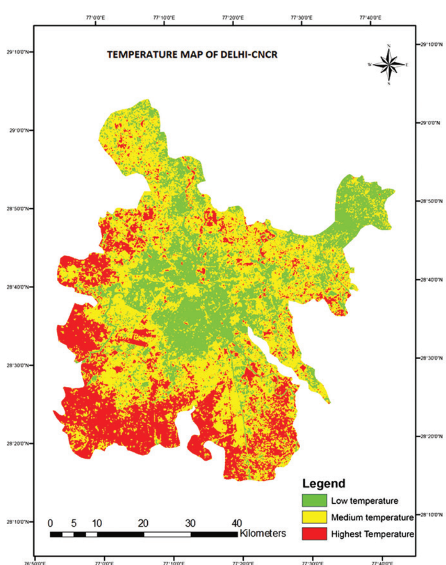

Fig 5:
Temperature Map of Delhi-CNCR, 2016

(See page 261 for the text)

Source: Classified by Authors, Earth Explorer, http://earthexplorer.usgs.gov