Urban Open Spaces and Urban Sustainability: A Case Study of Patna Municipal Corporation

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ABSTRACT: **Urban open space is defined as any urban ground space, which is not covered by any concrete structures or that is not roofed by an architectural structure. These include food production areas, parks, gardens, recreational spaces, road/street side plantings, private farms etc. Some like governmental or municipal parks etc., within the city are permanent and cannot be converted to other land categories. While others like agricultural farms on the outskirts of city as well as within the city are easily converted to other land categories due to indiscriminate urban growth. The city of Patna (in Bihar, India) seems no exception. One of the obvious indicators of sustainable urban development is the quality and quantity of urban green spaces. In a recent report released by the World Health Organisation (WHO), Patna has been ranked at sixth place out of 795 cities in 67 countries across the globe in terms of air pollution.**
For this study, an outline map of Patna Municipal Corporation area was obtained from the Municipal department and georeferenced in QGIS with the help of reference points from Open Street Map (OSM) of the study area. Besides this, Landsat imageries of the region of three different years (1988, 2009 and 2017) were downloaded from GLCF (Global Land Cover Facility) site. Area of Interest was demarcated for all the imageries based on the geo-referenced map of Patna Municipal Corporation. Spatio-temporal change in land use was found out with the help of unsupervised classification using Erdas Imagine 9. The results were compiled to find the unsustainable growth of the city leading to the decline of urban open spaces especially the green space. Lastly some suggestive measures were given to ensure sustainable growth of the city in times to come.

KEY WORDS*: Urban Open Space, Sustainability, Patna Municipal Corporation, QGIS, OSM, Unsupervised Classification, Erdas Imagine, Land use*

I. INTRODUCTION

During the recent decades, there has been rapid urbanisation in the world. As per United Nations, 2018 reports, the world's urban population has grown to 55 per cent which was only 30 per cent in 1950. In India about 34% of the population lives in urban areas. There has been an increase of about three percentage points since the 2011 Census. It is further projected that by 2050, India will add another 416 million urban dwellers (United Nations, 2018). This will result in expansion of urban built-up areas at the cost of urban open spaces. It will severely deteriorate the quality of urban life here and will have an adverse impact on the health of the urban inhabitants. These days we often hear of Air Quality Indices crossing dangerous limits which could be very hazardous for urban inhabitants. The situation worsens during winters, when temperature is low and smog like conditions emerge which results in atmospheric haze and sun remains obscured for long duration. These create conditions for breathing disorders. So, sustainable development of cities is the need of the hour. It though imposes a tough task for city planners, but sustainability cause should be incorporated at least before planning a new colony in the city.

Urban Open Spaces play a critical role in urban sustainability by providing positive environmental, social and economic benefits. They can be defined as any urban ground space, regardless of public accessibility, that is not roofed by an architectural structure (Stanley et. al., 2012). Urban open spaces can be in the form of large urban parks like in London or Manhattan or in the form of small public open spaces like the way found in the densely populated Hong-Kong city. So, urban open green spaces are essential for liveable and sustainable cities (Mehdi. et.al, 2017). They are vital part of urban landscape with its own specific set of functions. Most of the urban open spaces are open to general public access and the local governments manage them. People are usually attracted to public green spaces when it succeeds in becoming an important part of their everyday life and meets their needs and expectations. Urban open spaces and the satisfaction level of public determine the quality of life. They should be accessible, better connected with the neighbourhood and centrally located to make a city lively. So urban open spaces must be incorporated in urban spatial planning (Bele and Wasade, 2018). The functions of urban parks have been evolving over time regardless of the regions and the designs. They were once the private garden of the wealthy and now they become the public recreational place for outdoor activities and events (Lau, 2014). H. M. Lau termed these open spaces as SPUOS-Small Public Urban Open spaces. Open spaces also include food production areas, parks and gardens, recreational spaces, road/street side plantings etc. The definition of open spaces evolved in time embracing all types of opportunities to suit the varying outdoor needs of human beings and needs of plant and animal species. Nowadays, the concept of "open space" in complex urban matrix is not limited only to the urban parks and preserves but

also non park-non natural- places (Ebsah et. al., 2015). Non-natural places such as railways, highways, canals have functional values. According to Thompson (2002) these areas are indeterminate areas of open space and these functional specific spaces are as much necessary as decorative parks. The green spaces can improve the urban climate, abate the urban heat-island effect by their ecological-balancer function and reduce environmental damages.

Urban densification poses a threat to urban open space. Effects of urban densification and compact city development on urban green spaces and its planning should be studied (Haaland and Bosch, 2015). Indian cities are no exception. In India some rare exceptions to these are cities established after India's independence, such as Gandhinagar and Chandigarh, where the urban greenery was pre-integrated in the City Masterplan at the initial design phase. The per capita green space in Gandhinagar and Chandigarh is 160 m^2 and 55 m^2 respectively and is far more as compared to even traditional green cities such as Bangalore (Chaudhary and Tewari, 2011). R.N Faragallah (2018) has studied the declining urban open spaces for Egypt in general and Alexandria in particular. He further analyses whether productive and responsive open spaces can be reshaped within Alexandria for making it sustainable. Malik and Gupta (2019) studied selected localities of Jammu province because of its changing demography concluded that green spaces are declining in Jammu mainly because of lack of afforestation programs. Schetke et al. (2010) presented a methodology to integrate the concepts of UES (Urban Ecosystem Services) and QoL (Quality of Life) with special attention to uneven spatial development under conditions of shrinkage. They emphasised on the quantitative urban land use change analysis with special regard to green structure, green quality and property conditions of urban green on the one side and qualitative social science related value and perception analysis of existing and newly emerging green spaces on the other. The condition of open spaces has a direct impact on the development (or, conversely, the degradation) of the urban environment. These factors, in turn, directly affect the well-being of the local residents and their willingness to become active participants in the transformation and development of their surroundings. Open spaces, therefore, play an irreplaceable role in the sustainable development of cities (Palacky et al. 2015).

II.The Study Area

The study area for this paper is Patna Municipal Corporation (PMC). It is the civic body that governs Patna, the capital of Bihar in India and is one of the oldest city of the world. This city was known as Patliputra during the ancient times. Situated on the right bank of the river Ganga, the city has served as the seat of power for several important dynasties of the world. So it has long history of urban civilisation. PMC is located between 25°33'10" N to 25°39'03" N latitude and 85°03'16"E to 85°16'10"E longitude (Ashraf, 2014). Average elevation of the city from mean sea level is 53 m. The east-west extent of PMC is approximately 21.5 km while its north-south extent is 11 km The total area under the Patna Municipal Corporation according to PMC's official website, is about 109.21 km^2. (Ashraf and Ghosh, 2015). There are 75 wards in PMC, of which Ward No. 22 is the most populous ward and Ward No. 73 is the least populous ward. All the 75 wards of the PMC are under the executive control of 6 Circles. Each Circle is administered by an Executive Officer who is deputed by the State Government (PMC website). PMC is the local urban governing body of the city of Patna. Patna has population of about 1,684,222. The density of population of the PMC is about 15,421 persons/km^2 (Census of India, 2011). The location of PMC in Bihar and the location of the state of Bihar in India can be seen in Fig.1

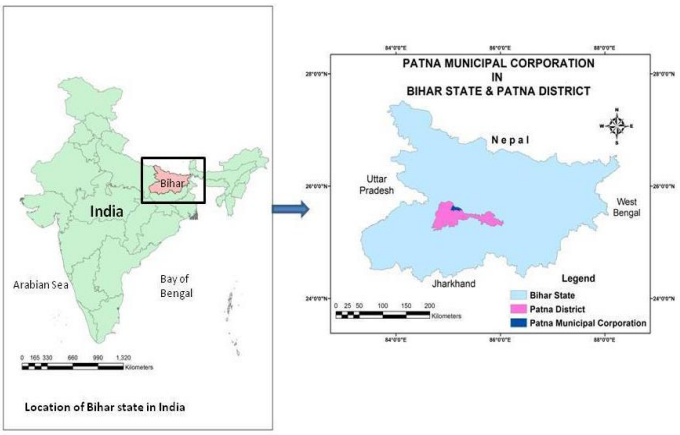

Fig.1. Location of Bihar in India and Location of Patna Municipal Corporation in the State of Bihar & Patna District

As stated above, the city of Patna is one of the oldest river valley civilizations in the world. Though it used to be a planned city in the ancient times, it is highly unplanned and chaotic in the present time. The old city area along the river Ganga already has very narrow congested lanes and very dense population. In the absence of planning interventions since 1981, rapid growth of the city has led to haphazard development. Haphazard development resulted into deterioration of open space and forest area (only 2.34 sq.m. per capita), uncontrolled and unregulated construction activities and brick Kilns in and along the riverbed of Ganga, formation of slums and unregulated construction within core city (Master Plan for Patna-2031).

III.Objectives of the study

Indiscriminate growth of the city is the root cause of shortage of open spaces in the city. In this regard the present research work is conducted for the fulfilment of following objectives:

- To determine the spatio-temporal changes in Land Use Land-Cover from the year 1988 to 2009 and from 2009 to 2017.
- To assess the change in the urban open spaces in Patna Municipal Corporation from the year 1988 to2009 and from 2009 to 2017.

IV. **Methodology**

For this work secondary data in the form of satellite imageries concerning the study area were downloaded from Global Land Cover Facility for the years 1988, 2009 and 2017 (Fig. 2). Landsat imagery of 1988 was TM imagery of Path 141, Row 042 and was dated October 12. For the year 2009 ETM+ imagery dated October 22 having the same path and row as of 1988 imagery was downloaded. For 2017 OLI imagery of the same path and row dated October 9 was downloaded. Further an outline map of PMC area was obtained from the Municipal department. The softwares used for processing of these datasets were QGIS 2.18 and Erdas Imagine 9.1. Since the outline map obtained from the Municipal Department was not having any latitude-longitudinal information, so first of all it was georeferenced in QGIS with the help of reference points from Open Street Map (OSM) of the study area. With the help of this georeferenced map, area of interest, that is, PMC area was subsetted from all the three satellite imageries in Erdas (Fig. 3).

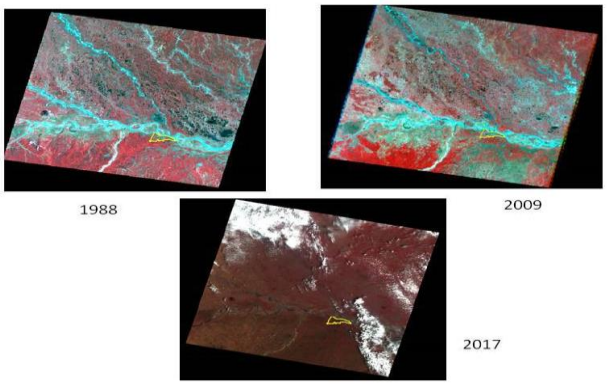

Fig.2. Landsat Imageries of 1988, 2009 and 2017

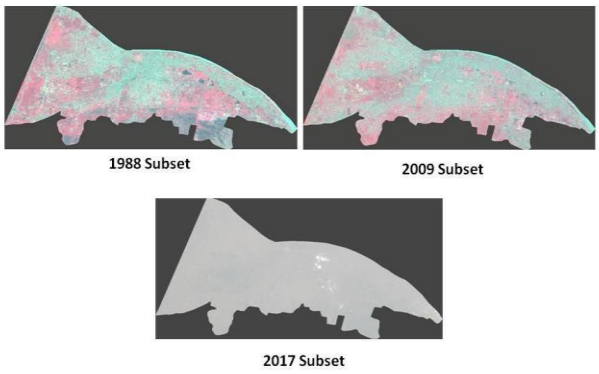

Fig. 3. PMC Subsets from 1988, 2009 and 2017 Landsat Imageries

After subsetting the PMC area from all the imageries, unsupervised classification was performed for all the imageries using ERDAS Imagine 9.1. The number of classes were then finalised by merging or modifying classes in the signature file based on field observations. According to Vigneshwaran and Kumar (2019), urban green extraction by unsupervised classification followed by manual recoding method shows superior performance with overall classification accuracy compared to other classification methods like supervised classification and object based classification.

V. Results and Discussion

Total area of the PMC that was subsetted was came to about 112 km^2 which is very close to area of PMC mentioned in the official website of PMC, that is, 109.21 km^2. Altogether five classes were identified as a result of unsupervised classification. They were waterbodies and moist soil taken together, settlements, trees of dense canopy, park/gardens/agricultural fields and bare soil or fallows. Same classes were identified while classifying all the three imageries, that 1988 imagery, 2009 imagery and 2017 imagery. Fig. 4 shows the classified image of 1988 imagery of PMC. Fig. 5 shows the classified image of 2009 imagery of PMC. Fig. 6 shows the classified image of 2017 imagery of PMC. In all these classified images, it can be seen that waterbodies along with moist soil or swamps have been shown in blue colour. Besides settlements or built up area have been shown in mauve colour. Trees having dense canopy have been shown in dark shade of green, while other urban greens like parks, gardens, agricultural fields etc. have been shown in lighter shade of green. Bare soil or fallowland has been shown in yellow. Although trees having dense canopy, parks, gardens and bare soil or fallowland have been captured separately, they all come under urban open or green spaces.

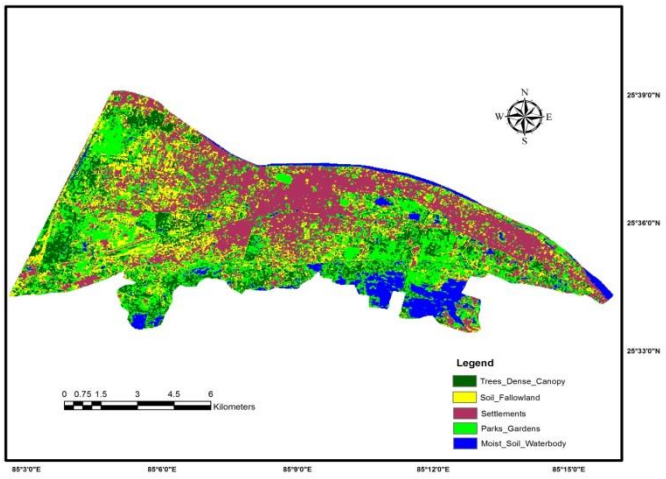

Fig. 4. Classified Image 1988

It is very evident from all the classified images (Fig. 4, Fig. 5 and Fig. 6) that urban built up areas are increasing at the cost of urban greens. A look at these classified images reflects that the built-up area is increasing phenomenally especially towards the southern and western portion of the city (the north portion of the city is bounded by river Ganga).

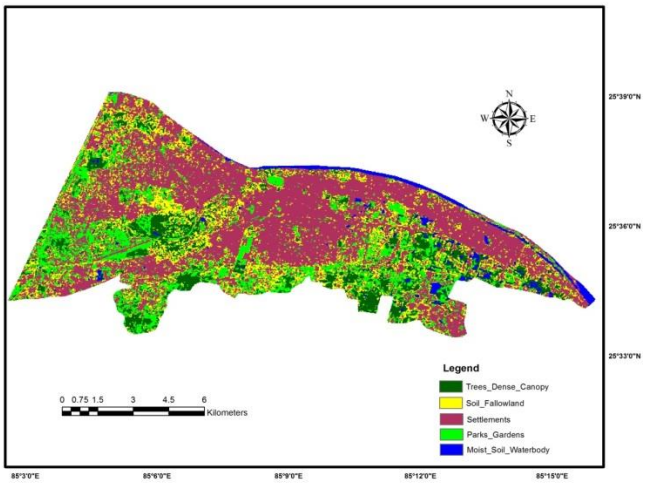

Fig. 5. Classified Image 2009

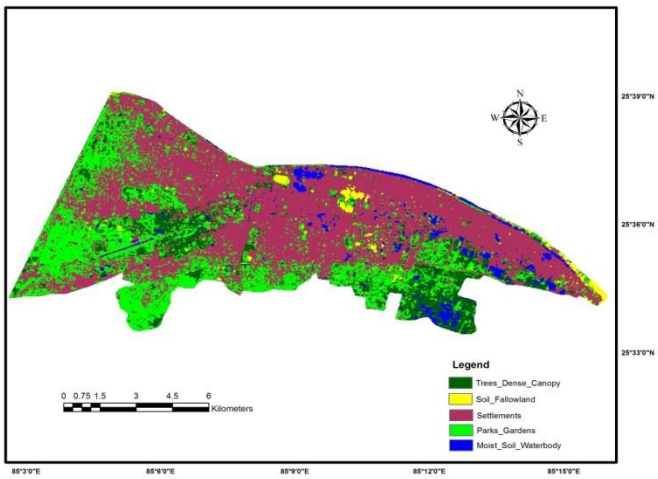

Fig. 6. Classified Image 2017

Table 1 shows the area of different land cover classes and also their percent area of the PMC. The same has been reflected in Fig. 7.

Table 1. Area of different land cover classes for PMC for the years 1988, 2009 and 2017

Land cover classes	Area in km^2 (1988)	Area in Percentage (1988)	Area in km^2 (2009)	Area in Percentage (2009)	Area in km^2 (2017)	Area in Percentage (2017)
Moist_Soil_Waterbody	8.15	7.26	3.43	3.05	4.30	3.83
Trees_Dense_Canopy	16.86	15.02	15.04	13.40	13.90	12.39
Parks_Gardens_agricultural fields	32.32	28.79	18.90	16.84	31.60	28.16
Soil_Fallowland	19.13	17.04	19.58	17.45	2.04	1.83
Settlements	35.77	31.86	55.27	49.24	60.37	53.79
Total Area Studied (Ha)	112.23	100	112.23	100	112.23	100

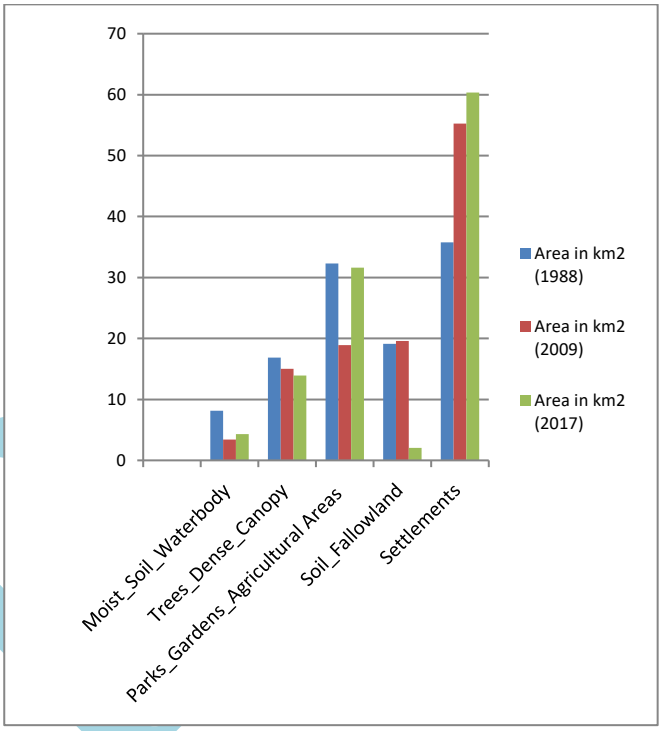

Fig. 7. A Comparison of Area of Different Landcover Classes for the years 1988, 2009 and 2017

From Fig. 7 we can interpret that over the years, settlements or the built-up areas have expanded consistently, that is, from 35.77 km^2 in 1988 to 55.27 km^2 in 2009 and 60.37 km^2 in the year 2017. It is also evident that there is a decrease in area of the trees with dense canopy from 16.86 km^2 in 1988 to 15.04 km^2 in 2009 and 13.9 km^2 in the year 2017. Other category of green spaces are parks, gardens as well as agricultural fields and a class separately represented by bare soil and fallow land. One interesting feature seen that there was a decrease in area of open spaces relating to parks, gardens and agricultural fields from 32.32 km^2 in 1988 to 18.90 km^2 in 2009. However, in 2017 its area increased to 31.60 km^2. This increase in the area of parks, gardens and agricultural fields was related to the significant decrease in the area of fallow land from 19.58 km^2 in 2009 to 2.04 km^2 in the year 2017. This increase could also be due to non-harvest of crops in the agricultural fields in the year 2017 due to which there is an increase in the area of class represented by parks, gardens and agricultural fields in the year 2017. However, if we combine all the open green spaces, that is, areas having trees of dense canopy, parks gardens, agricultural fields and bare soil or fallow land areas, we get the total urban open space or green space of PMC and then the picture become more evident. Thus in Table 2, the number of classes have been reduced to three as the urban open or green spaces captured in the form of trees of dense canopy, parks gardens, agricultural fields and bare soil or fallow land areas have been added.

Table 2. Broad Land Cover classes obtained by combining Different Urban Open/Green Spaces for the years 1988, 2009 and 2017

Broad Land cover classes	Area in km^2 (1988)	Area in Percentage (1988)	Area in km^2 (2009)	Area in Percentage (2009)	Area in km^2 (2017)	Area in Percentage (2017)
Moist_Soil_Waterbody	8.15	7.26	3.43	3.06	4.30	3.83
Urban Open Spaces	68.31	60.87	53.53	47.7	47.56	42.38
Settlements	35.77	31.87	55.27	49.25	60.37	53.79
Total Area	112.23	100	112.23	100	112.23	100

The contents of Table 2 have been plotted in the form of a line graph in Fig. 8 to get a clear understanding of the change in land use or land cover of PMC.

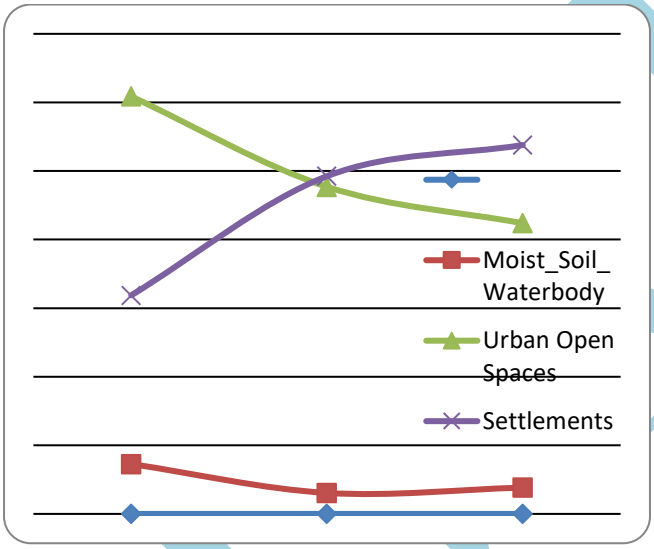

Fig. 8. Trends of Change in Area of Classes for the years 1988, 2009 and 2017

In Fig. 8, it is quite evident that urban open spaces have declined from 60.87 per cent area of PMC in 1988 to 47.7 per cent area of PMC in 2009 to 42.38 per cent area of PMC in the 2017. Settlements or built-up area of the city is increasing from 31.87 per cent area of PMC in 1988 to 49.25 per cent area of PMC in 2009 to 53.79 per cent area of PMC in the 2017. Both the line graphs representing urban open spaces and settlements are showing reverse trends in Fig. 8.

Thus it can be seen that total area of urban green/open space of PMC was 68.31km^2 in the year 1988 which decreased to 53.53 km^2 in the year 2009. This accounts for 21.64 per cent decrease (Table 3) in urban open space from 1988 to 2009. The urban open spaces decreased further to 47.56 km^2 in the year 2017 which accounts for 11.15 per cent decrease (Table 3) in its area from the year 2009 to 2017. The overall per cent change in the area of urban open spaces from 1988 to 2017 was -30.37 per cent. The overall per cent change in the built-up area or settlements from 1988 to 2017 is 68.78 per cent, which is phenomenal.

Table 3. Per Cent Change in Area of Broad Land Cover Classes

Broad Land cover classes	Per cent Change (1988 to 2009)	Per cent Change (2009 to 2017)	Per cent Change (1988 to 2017)
Moist_Soil_Waterbody	**-57.92**	**25.45**	**-47.21**
Urban Open Spaces	**-21.64**	**-11.15**	**-30.37**
Settlements	**54.53**	**9.22**	**68.78**

Table 3 also shows that waterbodies or marshy waterlogged areas have also shown a decline of 47.21 per cent from the year 1988 to 2017.

A glimpse of the classified images (Fig. 4, Fig. 5 and Fig. 6) also gives us an idea that the settlements or built-up concrete area of the city is very dense. It is having very few urban open spaces. The open spaces are basically towards the outskirts or away from the centre surrounding the densely settled area of the city.

VI. CONCLUSIONS

Thus we conclude that the indiscriminate growth of cities have led to concretisation at the cost of urban open spaces. This is led to myopic growth of cities, clustering of settlements and economic activities which has not only deteriorated the quality of existing urban open spaces but also reduced them significantly. Besides, in a country like ours the need of developing open spaces has not yet been fully recognised. The situation is worst for cities like Patna which has a long history of civilisation. Though it used to be a planned city in ancient times, in the current circumstances, it has been transformed into a complete urban chaos. The non-availability of sufficient green cover in cities leads not only to ecological imbalance but also leads to serious physical and mental stress. So, there is an urgent need not only to rejuvenate the existing open spaces within the densely settled areas but also to integrate the development of new open spaces in the planning of new colonies that are coming up in the outskirts of the city. There should be an Urban Green Space Policy which should assess future changes in green space policy and management (Wilson and Hughes,2011). The work of professional organisations developing new housing projects should be monitored so as to include ample open spaces in the projects (Balogh and Takacs, 2011). There is a need of integrative approach such as environmental, social, cultural, political, management and planning aspects for the development of urban open space to improve its facilities, services and benefits (Elgizawy, 2014). It is required to have people's participation for the development of

urban open space. Personal and collective actions and responsibilities towards urban green can influence wellbeing benefits, and the health and extent of urban green itself (Kleyn et al. 2019).

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