# Urban Carrying Capacity Assessment for metropolitan area: Case study of Patna City, Bihar, India

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**Abstract –** *Urban carrying capacity is an important tool to identify the capacity of carrying populations in urban areas. There are numbers of studies dedicated to the broadest sense of the carrying capacity concept. As Urbanization and poverty is walking hand-in-hand in Bihar resulting Patna as a growth pole at the cost of its people. This boost in urbanization has led pressure on Patna which is directly or indirectly affecting the humane life of its citizens. It's also affecting economic equity which is resulting in unbalanced development of the region. In this paper, urban carrying capacity has been estimated with the help of "SAFE" model, developed by IIT Guwahati. This study actually gives an idea how metropolitan cities are Under-pressure.*

*Key Words***:** Urban carrying capacity, SAFE model, Demographic pressure

## 1. INTRODUCTION

Urbanization in India was mainly caused after independence, due to adoption of mixed system of economy by the country which gave rise to the development of private sector. Urbanization is taking place at a faster rate in India. Population residing in urban areas in India, according to 1901 census, was 11.4%. This count increased to 28.53% according to 2001 census, and crossing 30% as per 2011 census, standing at 31.16%.

While rising urbanization is considered a necessary accompaniment of any developing society, Patna is likely to reach the dead end of development sooner than later, since the state's urbanization process has been moving at a pace far below the national average.

Carrying capacity of an area refers to an extreme limit. This limit defines the population carrying capacity of the area. If this limit is crossed then the nature will react by imposing pressure to resist the abrupt growth and development of the people resulting into equilibrium.

Patna, the historical city of PATLIPUTRA is faced with a myriad of problems:
- The city appears to have reached its carrying capacity
- The city appears to have in urgent need for satellite town to divert its pressure
- The city appears to have natural limitations to expand randomly

As we are focusing metropolitan area only, this study shall pertain to Patna municipal corporation area only. This study is aimed to estimate the demographic pressure on Patna City using "Sustainable Accommodation through Feedback Evaluation (SAFE)" model. This model focuses on developable area, non-developable area, residential areas, FAR, etc.

## 2. CARRYING CAPACITY CONCEPT

The concept of Carrying Capacity was spearheaded by Thomas Malthus in the year 1798. He anticipated that the earth can just hold a clear measure of human development for an unmistakable time. This concept holds a crucial position in determining the quality and state of an ecosystem with respect to the pressures meted by the demands of the dwelling population. It is basically an ecological concept that also embraces the socio-economic parameters.
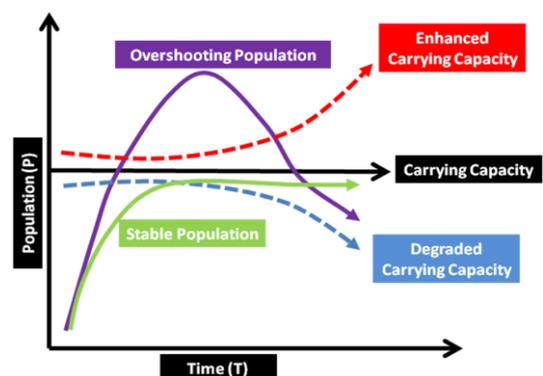


**Fig 1:** Graph showing the relation between population rise & carrying capacity

Carrying capacity is not fixed. It can increase or decrease marvelously. There are many elements that can impact the carrying capacity of a region. For example, the degree of resource utilization serves to be the essential element that influences the carrying capacity to a considerable measure. Furthermore, the utilization of innovation additionally impacts the carrying capacity, i.e. in the event that innovation is utilized as a part of a positive way than certainly the carrying capacity will get expanded complex or might be debased the other way around. Fig-1 demonstrates the plot of population development with time and different ways that the population can achieve the carrying capacity.

In spite of the fact that it is clear that carrying capacity estimation serves to be a standout amongst the most essential responses to the topic of practical advancement and accordingly to the very survival of mankind, yet an irony remains. Carrying capacity is very difficult to estimate or calculate. Arrow et.al. (1995) remark that carrying capacity is not static but rather depends on the complex relation of preferences, utilization of innovation and patterns of production & consumption. So the diverse researchers have thought of different models which give a thought regarding calculation of carrying capacity:

I. Graphical model
II. Uni-constraint model
III. IPAT equation
IV. Ecological Footprint model
V. Energy analysis model
VI. Pressure-State-Response model

## 3. CALCULATION OF CARRYING CAPACITY

Using method of "Sustainable Accommodation through Feedback Evaluation (SAFE)"

In the wake of investigating every single existing idea and techniques for assessing carrying capacity, Center of Excellence (CoE) for Integrated Landuse Planning and Water Resources Management (ILPWRM) at IIT Guwahati has thought of another strategy particularly reasonable for eco-sensitive urban areas. The technique was initially created for figuring carrying capacity of hilly urban area that will ensure hazard free sustainable urban advancement. However the concept can be applied to any urban areas.

To expand the means required in figuring of carrying capacity by the proposed "SAFE" method, well ordered methodology is introduced beneath:

- **Step 1**: Delineation of the urban area

- **Step 2**: Demarcation of the developable & non-developable area

    In this progression, the non-developable regions of the delineated area are outlined utilizing most recent geospatial devices. The non-developable zones for the most part comprise of land with high slope, reserved forest areas, water bodies, stream lines, drainage channels, springs, depressions, etc. Thus the usable areas with respect to various developmental activities can be marked out.

    Therefore,

    $$A_U = A_D + A_{ND}$$

    $$A_D = A_U - A_{ND}$$

    Where, $A_U$ is the total urban area, $A_D$ is the net developable area and $A_{ND}$ is the net non developable area

- **Step 3**: Determination of area required for different infrastructure and facilities

    $$A_D = A_{IF} + A_R$$

Where $A_R$ is the area for residential requirements and $A_{IF}$ is the area for infrastructure development.

Areas designated to different urban infrastructure and facilities development like, water treatment plants, sewage treatment plants, drainage, commercial hubs, heath centers, educational institutions, recreational areas, transport facilities etc can be taken as area under infrastructure development. The standard space requirement index of the UDPFI guidelines of the Ministry of Urban Development, Government of India can also be used as a guideline for calculating the required space for various infrastructure developments.

- **Step 4**: Calculation of the available residential area

    The net residential area available for settlement development can be calculated using the following equation:

    $$A_U = A_{ND} + A_{IF} + A_R$$

    $$A_R = A_U - (A_{IF} + A_R)$$

- **Step 5**: Socio economic survey of the urban region & calculation of the floor area requirement of the people

- **Step 6**: Determination of the Floor Area Ratio

- **Step 7**: Calculation of carrying capacity

    Based on the overall study, the carrying capacity of the area with respect to urban development can be calculated using the following equation:

    $$CC = A_U - (A_{ND} + A_{IF}) \times FAR/S$$

## 4. APPLICATION OF THE CONCEPT TO PRACTICAL FIELD: A CASE STUDY OF PATNA

Patna is located on the south bank of the Ganges River. The whole area of PMC has been divided into 72 wards, which accommodates a population of 1.6 million as per 2011 Census. According to 2011 provisional census data, Patna city had a population of 1,683,200 (before expansion of the city limits) within the corporation limits.

As compared with UDPFI guidelines, Patna is having more residential area which is about 61% of total area. Only 2% of land is for recreational areas which indirectly affect the quality of life in Patna city.

Carrying capacity is calculated as

$$CC = A_U - (A_{ND} + A_{IF}) \times FAR/S$$

Where,

- $A_U$ = Total delineated urban area (13579 ha)

- $A_{IF}$ = Area under infrastructure development (2449 ha) which includes commercial area, public semi-public areas, recreational areas, industrial areas and area under transport sector
- $A_{ND}$ = Non developable land = Total urban area - (developed area + area for infrastructure)
- FAR is taken as 1
- Floor area requirement = Total built up area = 8147 ha (taking ground coverage as 60%)
- Built up area per person = total built up area divided by total population = 0.00484 ha

From the above calculation, urban carrying capacity of Patna was calculated to be 2265702 persons which is much lesser than the projected population of Patna for 2021. So Patna will need more urban areas to house the surplus population which will improve the quality of life of Patna city.

## 5. CONCLUSION

Urban carrying capacity can be easily calculated Using method of "Sustainable Accommodation through Feedback Evaluation (SAFE)". This method has been used for Patna metropolitan areas and it shows that Patna city is holding more demographic pressure than its capacity. So this SAFE method can be used as a tool for calculating the overshooting population and accordingly it can be planned in a better manner.

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