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Critical Evaluation of Urban Population distribution of Maharashtra state in India

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Abstract: Maharashtra is the second most populous state of India with 45.23% population urbanized(India, 2011). It is the third largest state in terms of area. Urban population is dispersed in 35 districts. The aim of this paper is to evaluate urban population distribution among towns and cities. It also checks whether the population is statistically normally distributed within the urban areas. The objective is to study the city/town size distribution for the state of Maharashtra, India based on 2011 Census.
Keywords: Urbanization, Urban distribution, city ranking, city size

I. INTRODUCTION

City size distribution is essential to understand the dynamism exhibited by the urban centers.(Benguigui & Blumenfeld-Lieberthal, 2007) . First such effort was made by Auerback for German cities. In his study double logarithmic graph paper was used (log P/log R) to plot the city size in terms of city's population and its rank.(Auerback, 1913). It gives 'S' shaped curvilinear trend. Pareto's principle (1913) and Zipf's law (1949) are other commonly used theories of city size distribution.

As per rank size rule (Zipf's Law):

$$P_r \approx \frac{P_i}{r}$$

Where $P_r = Population of r'th$ rank city

P_i = Population of the largest city

r = rank of the city

As per Pareto's principle eighty percent of urban population resides in top twenty percent of cities, which is known as eighty-twenty rule. City size distribution is largely guided by power laws distribution. Settlement characteristics have been interpreted by Christaller in his Central Place Theory (1933).

The basic concepts discussed in Christaller's theory are centrality, threshold, and range. *Centrality* is the focal element to a particular place. The *threshold* is the minimum market that is needed to bring a new firm or service provider or city into existence and keep it running, and *range* is the average minimum distance that people will travel to buy these services or goods. (Christaller, 1972)Christaller developed a hexagonal pattern to include various orders of central places and computed the population, their distances apart and their tributary areas. (Sharma) He envisioned three criteria known as i) The marketing principle (k=3), ii) The transportation principle (k=4), and iii) The administrative principle (k=7).Christaller projected these models as hierarchical, with all higher order places in the hexagon surrounded by other higher-order places to explain not only local but regional economics and specialization of urban centers.(Christaller, 1972)(Berry, 1970)(Heilbrun, 1987)(Von B'ter, 1969)(Preston, 1983)(L, July 1938)

Walter Christaller was able to explain the size, number and location of settlement in a region. It was different from earlier theories which interpreted only the rank and size of cities. It added two more dimensions, i.e. the number of such settlement and its spatial location. Spatial Economic Theory by Fujita, Krugman and Venables (1999) further explored the city size in a region based on economics.

The Rank size rule states that n^{th} largest city in a country will have $\frac{1}{n}$ of the population of the largest city in that country. If the largest city has the population 1,000,000 and we want to know the population of the fourth largest city, it will have $\frac{1}{4}$ of the population of the largest city. $\frac{1}{4}$of 1,000,000 is 250,000 people.

Rank size rule gives birth to concept of Primate Cities. Concept of Primate City was introduced byThomas Jefferson. A primate city is not only the largest city but it is also larger than twice the second largest city in the region and demonstrates a command over political, economic and cultural fabric of the country. None of the Indian Cities are Primate in nature. However Regional Primacy exists in the case of India. Urban agglomeration of Mumbai exhibits a primacy in the Western region. It has a Primacy Index of ($Pop_{(Mum)}$ / $Pop_{(Pune)}$) =2.90. (Kumari, 2015)

This paper examines city size distribution for the state of Maharashtra, India, based on Census of India data 2011. Objective of the study:To study the city/town size distribution for the state of Maharashtra, India, based on 2011 Census.

Maharashtra has population of 11.24 Crores according to 2011 Census. The population of Maharashtra forms 9.28 percent of India in 2011. The density of Maharashtra state is 365 persons per sq km. Maharashtra State is spread over 307,713 sq.km(India, 2011).It is the third-largest state by area. It is now home to the highest number of people living in urban areas. With an urban population of 45.23%, Maharashtra is third most urbanizedamong major states. It is the most industrialized state in the country and the state's capital, Mumbai is India's financial and commercial hub.

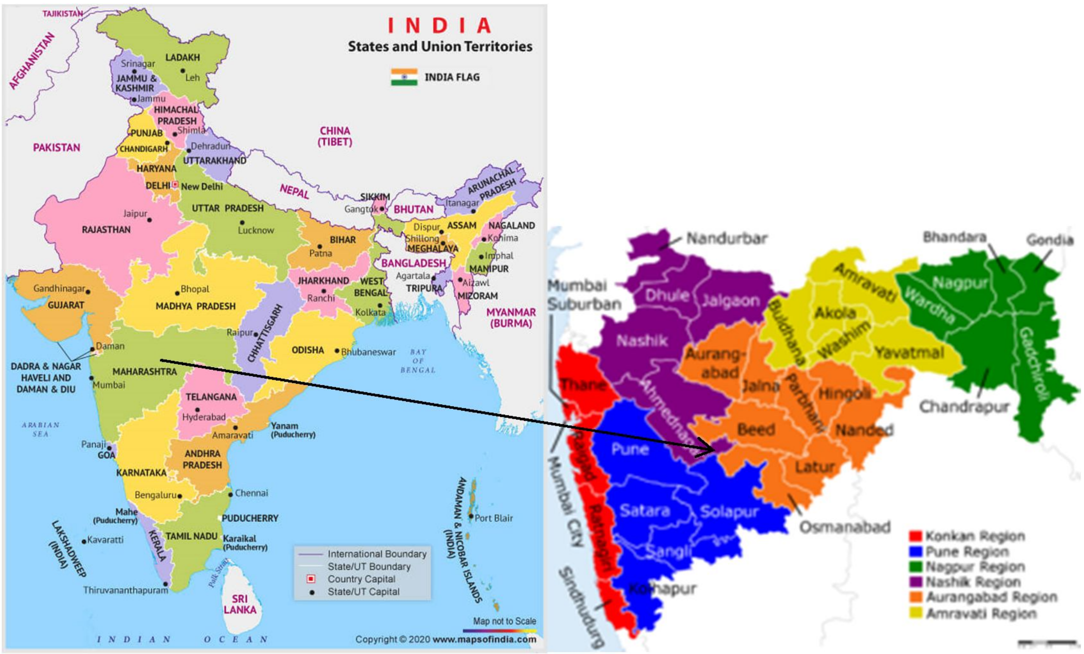

Figure 1 Location of Maharashtra in Map of India

The state has played an important part in the country's social and political living and widely taken into account as a first in terms of farming and to do with industry producing, trade and transport, and education. Maharashtra is one of the most developed and prosperous Indian states and continues to be the single largest contributor to the national economy with a share of 15% in the country's GDP. The economy of Maharashtra is the largest in India, with a gross state domestic product (GSDP) of ₹28.78 trillion and has the country's 13th-highest GSDP per capita of ₹207,727. Maharashtra is the fifteenth-highest ranking among Indian states in human development index.

According to Census 2011, Maharashtra has 35 districts, within which there are 355 Tehsils, 534 Towns, and 43,665 Villages. Maharashtra is divided into 6 administrative divisions; Konkan, Pune, Nashik, Aurangabad, Amravati and Nagpur for administrative purposes.

Census definition of Town and Cities (2011)

(A) Statutory towns - All places with a municipality, corporation, cantonment board or notified town area committee, etc.

(B) Census towns - A minimum population of 5,000,

At least 75 per cent of the male main working population engaged in non-agricultural pursuits;

Average density of 400 persons per sq. km

Table 1 Maharashtra State Urban Scenario (2011)

Administrative Divisions	6	Urban Agglomerations	17
Districts	35	Municipal Corporations	6
Talukas	355	Municipal Councils	208
Cities	534	Census Towns	236
Villages	43,665	Nagar Panchayats	5

Greater Mumbai is the megacity in Maharashtra. Mumbai, Pune, Nagpur, Nashik and Aurangabad are the five metropolitan cities in the state. The state consists of 35 Class I cities that have population more than 1,00,000. 49 Class II towns having population 50,000 to 99,999 , 156 Class III towns having population 20,000 to 49,999 , 125 Class IV towns having population 10,000 to 19,999 and 107 Class V towns having population 5000 to 9,999.

Table 2 Number of Cities in each Class

Class	Population	No. of Cities/ Towns
I	100,000 and above	35
II	50,000 – 99,999	49
III	20,000 – 49,999	156
IV	10,000 – 19,999	125
V	5000 – 9,999	107

Normal distribution, also known as the Gaussian distribution, is a probability distribution that is symmetric about the mean, showing that data near the mean are more frequent in occurrence than data far from the mean. In graph form, normal distribution will appear as a bell curve.The standard normal distribution has two parameters: the mean and the standard deviation. For a normal distribution, 68% of the observations are within +/- one standard deviation of the mean, 95% are within +/- two standard deviations, and 99.7% are within +- three standard deviations.

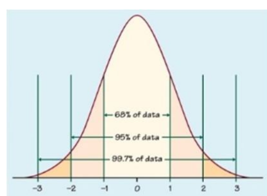

Figure 2 Gaussian's Distribution Curve

II. METHODOLOGY

Census data of all the towns were collected from Census of India 2011 and cities/towns were sorted as per the population and class. Classification from Class I to Class V was done and then number of cities/towns was tabulated and descriptive analysis statistics, mean and standard deviation of each type of cities/towns were calculated. With standard deviation the percentage of cities lying within first standard deviation was calculated and checked whether it was within 68% or not.

Table 3 Cites lying in One, Two & Three Standard Deviation

Class	No. of Cities	No. of Cities in Range of One Standard Deviation	No. of Cities in Range of Two Standard Deviation	No. of Cities in Range of Three Standard Deviation
I	35	22	6	5
II	49	32	48	49
III	156	99	152	156
1V	125	78	101	125
V	107	61	106	107

Table 4 Class I (Population of 1 Lakh and above)

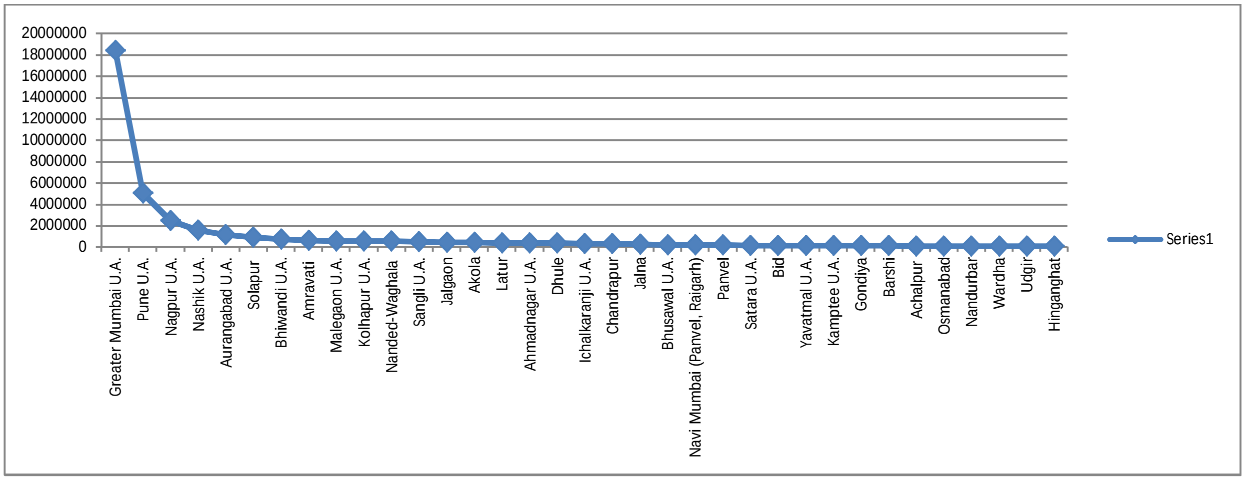

Table 5 Class II (Population from 50,000 to 99,999)

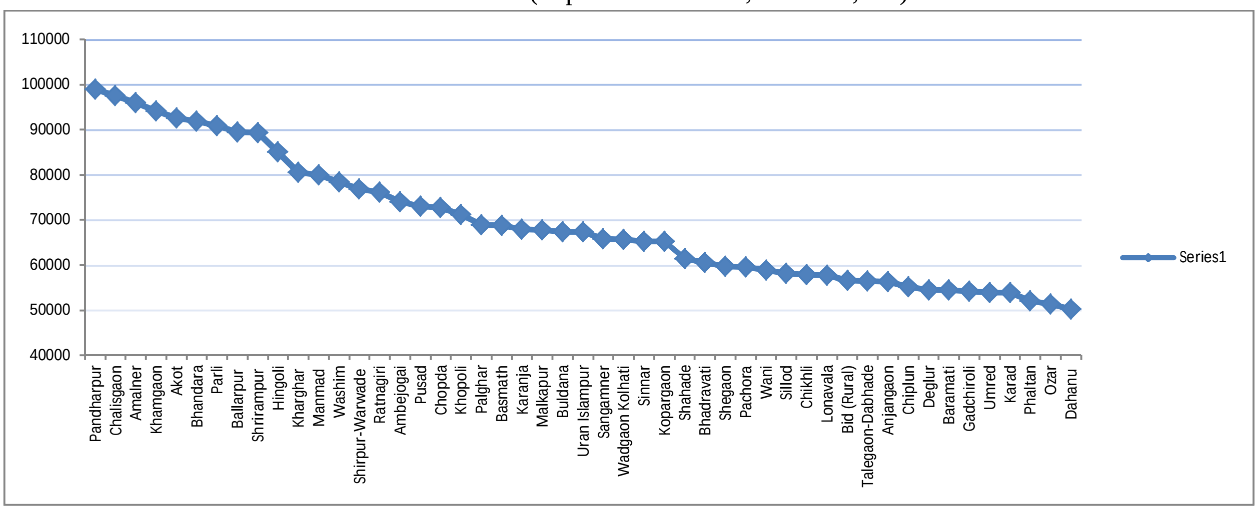

Table 6 Class III (Population from 20,000 to 49,999)

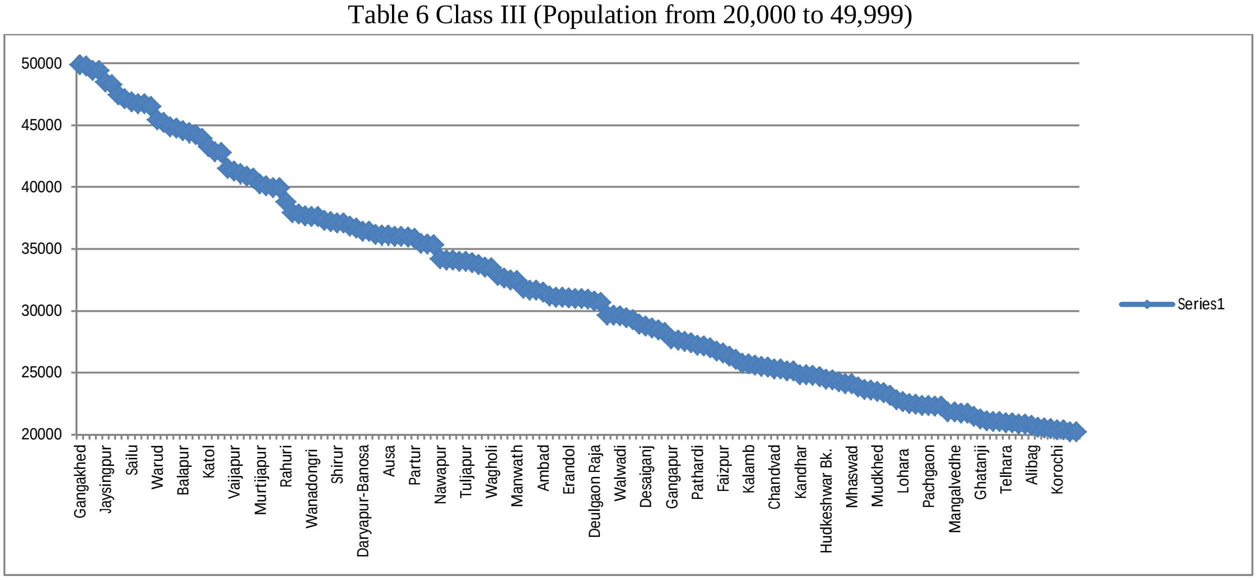

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Table 7 Class IV (Population from 10,000 to 19,999)

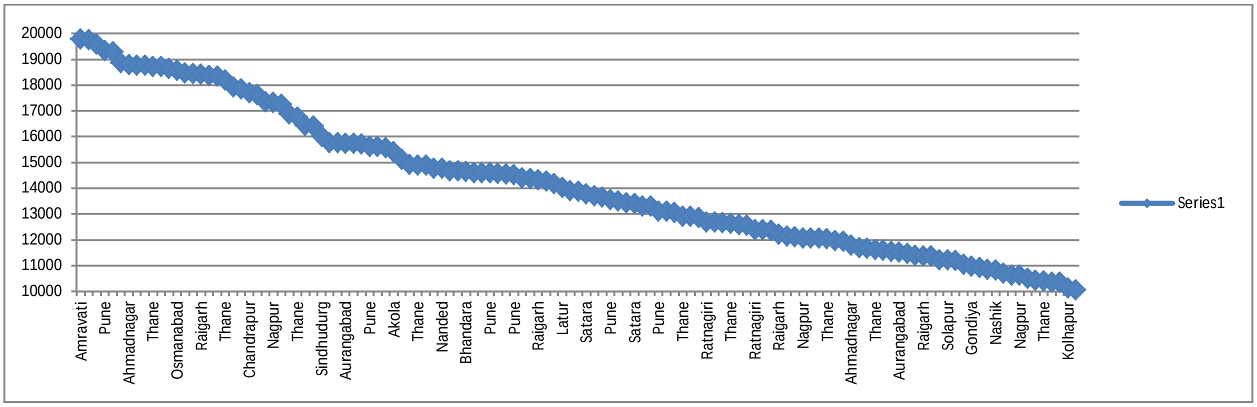


Table 8 Class V (Population from 5000 to 9,999)

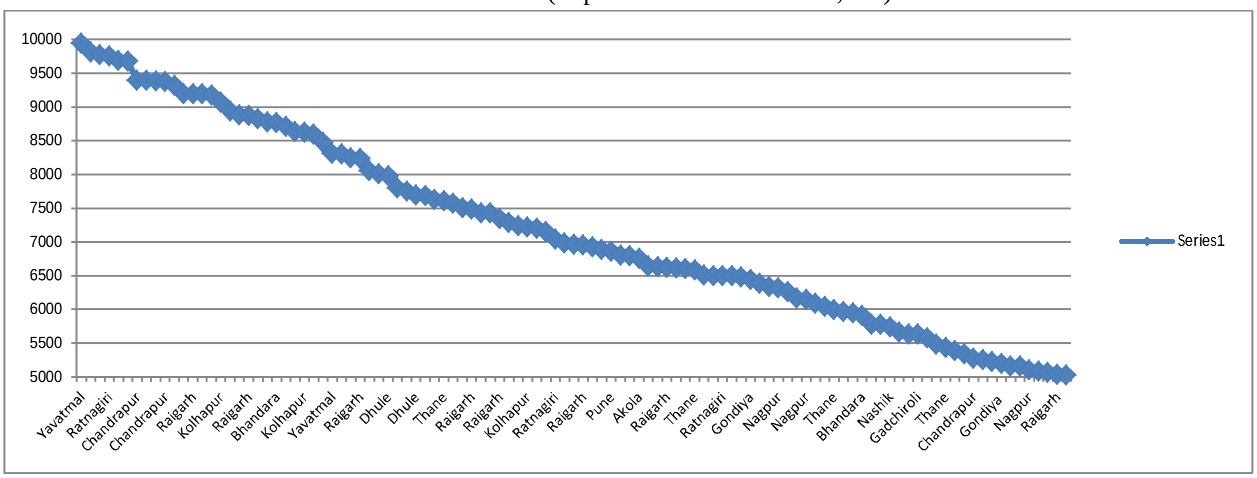


Table 9 Descriptive Statistics

Descriptive Statistics	Class I	Class II	Class III	Class IV	Class V
Mean	10,92,756	6,94,34	3,17,46	1,42,31	7204
Median	3,25,499	6,7,391	30,993	13,877	6962
Skewness	5.23	0.63	0.45	0.43	0.25
Standard Deviation	31,47,139	14,274	8426	2730	1418
Range of Pop. for 1^{st} Standard Deviation	42,39,895 to 20,54,383	83,709 to 55,160	40,172 to 23,319	16,961 to 11,501	8,622 to 5,785
% Normal Distribution (68 %)	57%	65%	64%	61%	58%
Range of Pop. for 2^{nd} Standard Deviation	-20,54,383 to -52,01,522 (Invalid Data) & 42,39,895-73,87,034	40,886-55,160 & 83,708-97,982	14,894-23,320 & 40,172-48,598	8,771-11,501 & 16,961-19,691	4,368-5,786 & 8,622-10,040
% Normal Distribution (95 %)	17.14%	97%	99%	80%	99%
Range of Pop. for 3^{rd}	-52,0,1522 to	26,612-40,886	6,468-14,894	6,041-8,771	2,950-4,368

Standard Deviation	-83,48,661(Invalid Data) & 73,87,034 -1,05,34,173	& 97,982-1,12,256	& 48,598-57,024	& 19,691-22,421	& 10,040-11,458
% Normal Distribution (99.7 %)	14.28%	100%	100%	100%	100%

Hypothesis testing using Chi-square (χ^2)
H_0 = Cities/Towns are normally distributed. (Null Hypothesis)
H_1 = Cities/Towns are not normally distributed. (Alternate Hypothesis)

Table 10 Hypothesis Testing using Chi-square (χ^2)

	Class I		Class II		Class III		Class IV		Class V	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
1st Std.Dev	33	24	32	33	97	106	77	85	63	73
2nd Std.Dev.	1	11	15	14	55	42	47	34	44	29
3rd Std.Dev.	1	0	2	2	4	8	1	6	0	5
(χ^2)	12.46		0.1		6.78		54.72		14.11	
Critical Value from Table	9.21		9.21		9.21		9.21		9.21	

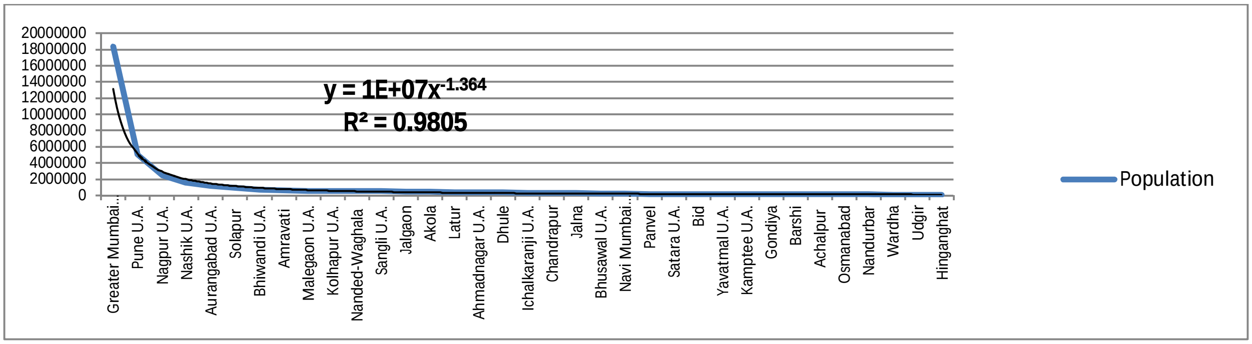
Calculating critical value of $\chi^2 = \sum \frac{(o-e)^2}{e}$
Here, o = Observed value
e = Expected value
Checking for Log - Natural Logarithm for Normal distribution of Class I Cities
Hypothesis testing using Chi-square (χ^2) for Class I Cities
H_0 = Class I cities are normally distributed.
H_1 = Class I cities are not normally distributed.

Table 11Hypothesis testing using Chi-square (χ^2) for Class I Cities

	Class I	
	Expected	Observed
1st Std.Dev	24	27
2nd Std.Dev.	9	6
3rd Std.Dev.	2	2
(χ^2)	1.375	
Critical Value from Table	9.92	

Since the value of chi square is 1.375 less than 9.92 hence null hypotheses is accepted.

Table 12 Graph representing Power growth in Class I Cities



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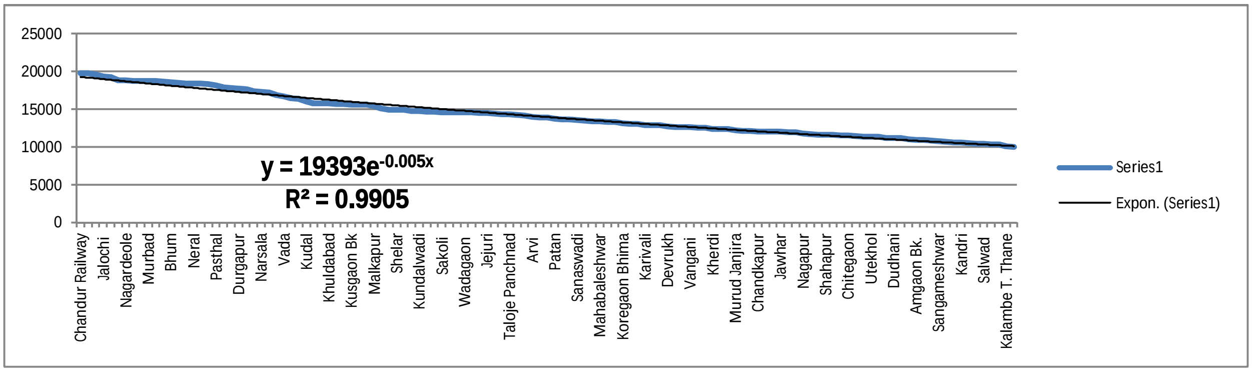
Doing the Regression analysis of Class I cities with population plotted on 'Y' axis and city rank plotted on 'X' axis we get R^2 = 0.9805 for power regression type.
The equation we get is Y = 1E + 07 $x^{-1.364}$

Table 13 Graph representing Exponential growth in Class IV Cities



Doing the Regression analysis of Class IV cities with population plotted on 'Y' axis and city rank plotted on 'X' axis we get R^2 = 0.9905 for power regression type.
The equation we get is Y = 19393$e^{-0.005x}$

Table 14Distribution of Cities

Class of Cities	Normal Distribution	Log Normal Distribution
Class I	✗	✓
Class II	✓	✓
Class III	✓	✗
Class IV	✗	✓
Class V	✗	✗

Checking Pareto's Principle for Urban Population of Maharashtra

$$\frac{P_{top\ 20\%\ of\ Cities/Towns}}{P_{all\ Urban\ pop.of\ Maharashtra}} = \frac{4,21,32,461}{4,91,50,917} = 85.72\%$$

85.72% of Total Urban Population resides in 20% of top Cities and towns of Maharashtra. It shows slight deviation from Pareto's law.

III. RESULTS

Class II town's shows a normal distribution of 65%, while Class III and Class IV towns show a normal distribution of 64% and 61% respectively. They are close to normal distribution of 68% and hence normally distributed in the state of Maharashtra. Class I and Class V cities/towns show a normal distribution of 57% and 58% respectively. They are not close to normal distribution of 68% and hence are poorly distributed in the state of Maharashtra.
Skewness of Class I Cities shows 5.23, which is highly asymmetrical. This is because of presence of Mumbai Urban agglomeration. Rest of the skewness is between -1 & +1 indicating a symmetric distribution of data along mean. Class I cities are Log Normally Distributed.
On application of chi square test for all the cities/towns we observed that Null Hypothesis (H_0 = Cities/Towns are normally distributed) is rejected for Class I , Class IV and Class V cities as the chi square value lies in the rejection region for α value of 0.01 (9.21) for two degree of freedom. Alternatively, Alternate Hypothesis (H_1 = Cities/Towns are not normally distributed) is accepted which shows Class I , Class IV and Class V cities are not normally distributed.
For Class II and Class III cities value of chi square is within the acceptance zone, hence Null Hypothesis is accepted. It shows that Class II and Class III cities are normally distributed.

IV. CONCLUSION

Class I Cities are log normal distributed. Class II Cities are both log normal and normally distributed. Class III Cities shows normal distribution. Class IV Cities shows log normal distribution. Class V Cities are neither log normal distributed nor normally distributed.

Urban Agglomeration Mumbai is the Primate city of the region, with a Primacy index of 3.63. Mumbai Urban Agglomeration accounts for 37% of total urban population of Maharashtra. 85.72% of Total Maharashtra population resides in top 20% of cities.

We have analyzed the population distribution of cities/towns of Maharashtra based on 2011 Census. After 2021 Census is released relative change in the population of the cities can be further analyzed to check the population distribution in these classes of cities.

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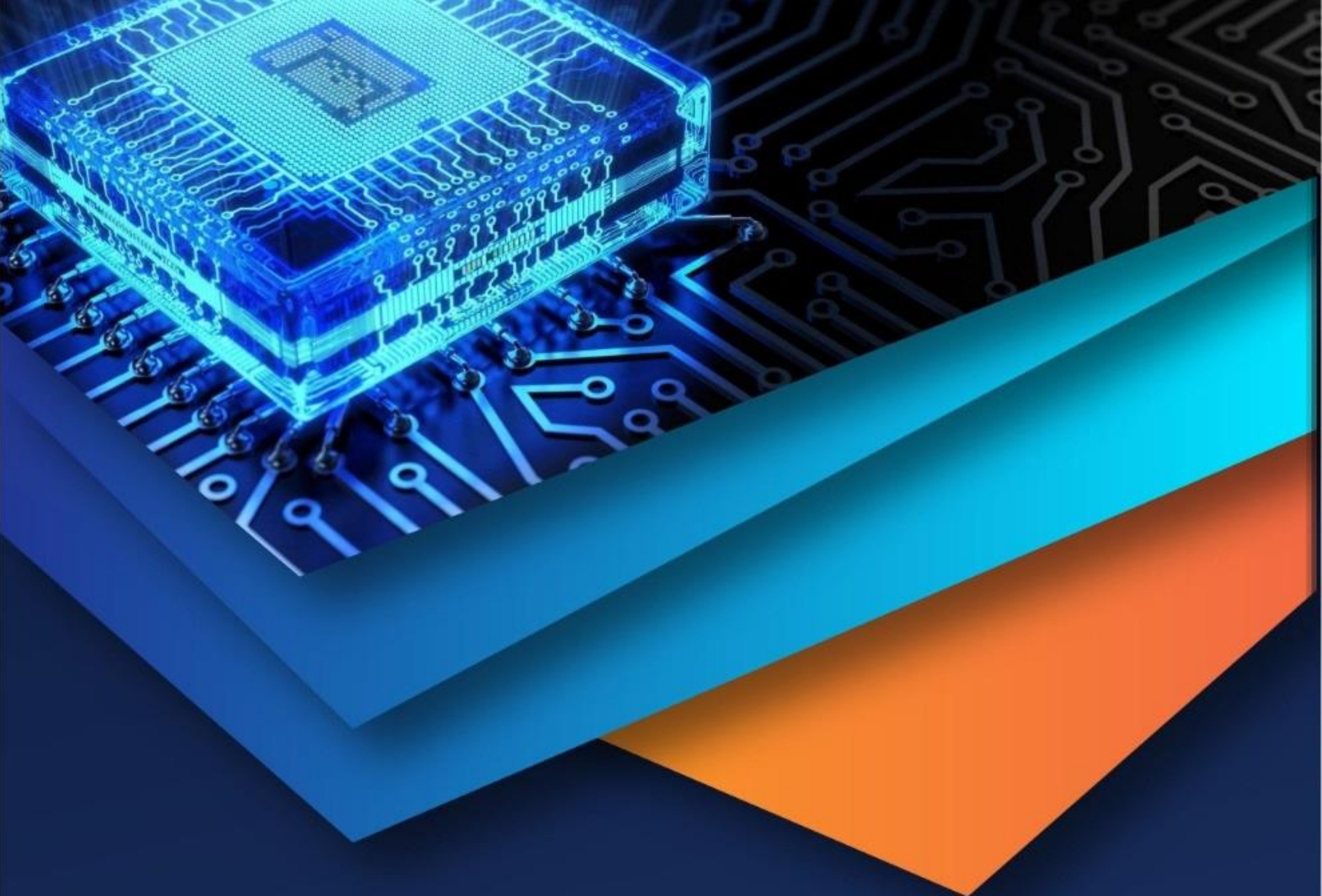

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