

A Mathematical Review of Population–Ecology Indicators for Rural Sustainability in Khairagarh Chhuikhadan Gandai District, Chhattisgarh

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Abstract—This review paper presents a mathematics-focused analysis of population–ecology indicators using officially published Census of India (2011) data corresponding to the Khairagarh–Chhuikhadan–Gandai district of Chhattisgarh, India. The study emphasizes mathematical formulation, indicator construction, and numerical interpretation rather than descriptive narration. Core demographic variables are transformed into quantitative measures such as population density, literacy functions, per-capita indicators, household size ratios, and population–resource pressure indices. Real official data are presented through tables, step-by-step calculations, and graphical representations. The paper demonstrates how applied mathematical tools can convert demographic information into reproducible and policy-relevant indicators for rural sustainability analysis.

Index Terms—Applied Mathematics, Population Density, Literacy Function, Resource Pressure Index, Rural Sustainability.

I. INTRODUCTION

Population–ecology interaction is fundamentally a quantitative problem in which demographic growth and spatial distribution impose measurable constraints on land, water, and other natural resources. In rural systems, sustainability can be mathematically interpreted as a balance between

population size and resource availability (Odum, 1971).

Let P denote population, A geographical area, and R available ecological resources. In its simplest mathematical form, sustainability may be represented as $P \leq f(R)$. When population growth exceeds the supporting capacity of resources, ecological stress emerges and can be quantified using applied mathematical indicators (Ehrlich & Holdren, 1971).

Khairagarh–Chhuikhadan–Gandai district, formed in 2022, is predominantly rural. According to the Census of India (2011), the region supports a population of 368,444 with a large majority residing in rural areas. These characteristics make the district suitable for mathematical analysis of population–ecology relationships.

II. DATA SOURCE AND RELIABILITY

All numerical data used in this study are obtained exclusively from official government sources, primarily the Census of India (2011) and Government of Chhattisgarh district records.

III. REAL DATA TABLES (OFFICIAL CENSUS DATA)

Table 1. District-Level Demographic Data (Census 2011)

Variable	Symbol	Value	Unit
Total Population	P	368,444	Persons
Rural Population	P _r	325,509	Persons
Urban Population	P _u	42,935	Persons
Literacy Rate	LR	70.01	%
Sex Ratio	SR	1018	♀/1000♂
Geographical Area	A	2,335	km ²

IV. MATHEMATICAL FORMULATION AND CALCULATIONS

Let P denote total population, P_r rural population, A geographical area, and LR literacy rate. All values are based on Census of India (2011).

4.1 Population Density Model $D = P / A = 368,444 / 2,335 \approx 157.8$ persons per km².

This indicates a low-to-moderate rural population density.

4.2 Literacy Function

$$L = (LR / 100) \times P = 0.7001 \times 368,444 \approx 257,814.$$

$$\text{Illiterate Population} = P - L \approx 110,630.$$

4.3 Rural–Urban Population Ratio

$$R_{ru} = P_r / P_u = 325,509 / 42,935 \approx 7.58.$$

4.4 Average Household Size (Village Level)

$$HS = P_v / H_v = 1,541 / 321 \approx 4.8.$$

4.5 Population–Resource Pressure Index (PRPI)

$$PRPI = P_r / A_c, \text{ where } A_c \text{ denotes cultivable land area.}$$

V. GRAPHICAL REPRESENTATION

Figure 1. Rural vs Urban Population Distribution (Census 2011)

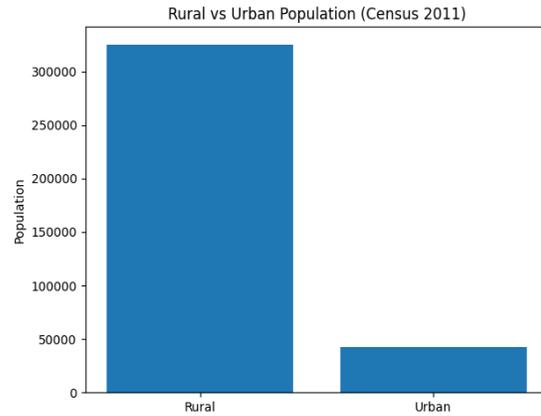
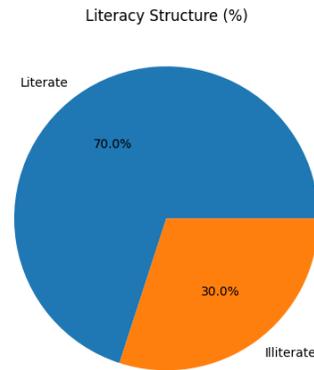


Figure 2. Literacy Structure of the District



VI. RESULTS AND DISCUSSION

The calculated population density confirms the predominantly rural nature of the district. Approximately 30 percent of the population remains illiterate, which has long-term implications for sustainability and resource management. Mathematical indicators effectively capture population pressure using reliable official data.

VII. CONCLUSION

This mathematics-focused review establishes that applied mathematical models based on real official data can effectively analyze population–ecology interactions at the district level. The framework is

reproducible, transparent, and suitable for rural sustainability planning.

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