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A QUANTITATIVE ANALYSIS OF RURAL SETTLEMENT SHAPES IN HINGNA TALUKA OF NAGPUR DISTRICT- A REMOTE SENSING AND GIS APPROACH.

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ABSTRACT

Settlement patterns and shapes provide information on current economic and social aspects of human existence and a historical record of the past settlement patterns and processes as well. The shapes of settlements indicate the external factors that influence the deviation from a natural shape that a settlement would tend to form i.e. close to a circle. The analytical study of rural settlements in respect of shapes of settlements has great significance since any scheme of regional development and planning should include and consider rural settlement as the place of residence, concentration of services, nodes of transportation line on growth points, growth centers as well as spatial integrated planning.

The methodology adopted using satellite based remotely sensed data, has proved to be accurate and cost effective and can be effectively applied in the study of shapes of rural settlement in different geographical settings. The Geographical Information System (GIS) provides the solution for mapping and measuring the aspects of settlements from remotely sensed data for a meaningful interpretation and analysis.

The shapes of the rural settlements were studied and analyzed in 95 villages in the Hingna taluka of Nagpur district in central India using high resolution satellite imageries available free in the internet domain a 'Google Earth'. The comparative study of circularity ratios with size and type of dwelling units provide interesting information about the influence of the geographical parameters on the shapes of rural settlements.

KEYWORDS :*Settlement, circularity ratio, settlement shape, dwellings.*

INTRODUCTION :

Rural settlements are the most characteristic form of the cultural landscape. It is man-made

habitat on the earth's surface and study of the shapes of rural settlements has occupied an important position in the historical development of geography.

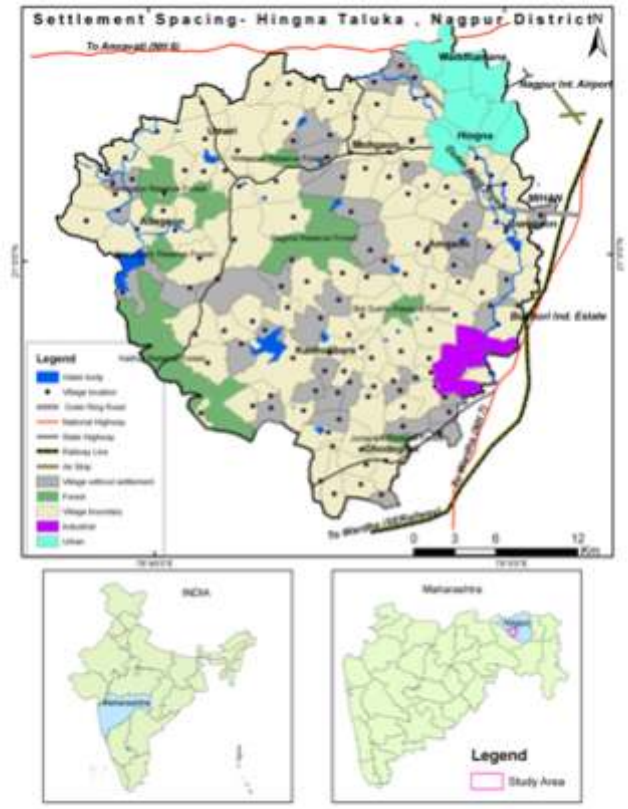
The main objective of this paper is to measure the aspects of rural settlements using high resolution satellite images in Hingna Taluka of Nagpur district to understand the deviation of the shapes of settlements from a natural regular shape of a circular pattern that any settlement would like to attain without the influence of external factors and to investigate and analyse the factors which influence this deviation. It is important that decision makers involved in rural development have at their disposal information which will identify the impact of various economic, demographic and social factors which influence settlement shapes and thereby impact on the cost and nature of service.

Circularity is the measure of compactness of a shape. A circle is the most compact shape, so the more compact a shape is, the more closely it resembles a circle. Circularity is a ratio and therefore a dimensionless number. This compactness measure has common applications in planning and coordinating developmental activities by local authorities. The circularity ratio may be calculated for any two dimensional shape as long as its area and perimeter are known.

This investigation is an attempt to study the influence of settlement size and type of dwelling units on the shapes of rural settlements in the study area. The shape of settlements is defined on the basis of circularity ratios.

2. STUDY AREA

The study area covering 156 villages is situated within the Hingna taluka of Nagpur district in the eastern part of Maharashtra state. It is located at south-west of Nagpur city and lies between National Highway No. 6 (Nagpur to Amravati) running east-west at the north of area and NH-7 (Nagpur to Hinganghat) running north to south at the east of the area. It is bounded by 20^0 49' and 21^0 09' latitudes and of 78^0 40' and 79^0 02' longitudes, and falls within the Survey of India toposheet numbers 55K/12, 55K/16, 55L9, 55L/13, 55O/4, 55P/1 and covering an area of 775 sq. km. The area is basically an agrarian region, densely populated and well connected with major roads and railway. However there are large portions of forested areas and a few water bodies within the study area. The climate of the study area is sub-tropical and characterized by hot and dry summer, assured rainfall and pleasant to cold winter. The general topography in the area is represented by an undulating plateau with elevation varying from about 600m above msl. along the southwestern margin at Kondhali in Jam watershed and lowest of 260m above msl. near Butibori in the southeast corner of the study area. The topography in the western part is typical of the Deccan traps having flat topped hills, terraced slopes, low buttressed sides and isolated knolls.



2. Pattern and shape of rural settlement in Hingna taluka

The shape and pattern of human settlement of rural areas has two separate but related components: the way in which the land is divided among its owners and the way in which the owners arrange buildings on their land. Thus, types of the settlement are determined by the extent of the built-up area and the inter-house space. There are various factors and conditions responsible for different shapes of rural settlements. These are: physical features such as nature of terrain, altitude, climate and availability of water, cultural and ethnic factors like social structure, caste, and religion, and the security factors such as defence against thefts and robberies. The settlements once formed may continue for centuries, long after the original advantages of the site have become irrelevant.

2.1 The circularity ratio

Circularity ratio is the ratio of area of the test shape (settlement) with the area of a circle that has the same perimeter as the test shape. It defines the compactness of the shape.

Let $C = A/B$....(1)

where C is the circularity ratio, A is the area of the test shape (settlement) and B is the area of the circle.

Calculate the area of B. Since B is the area of a circle, we have $B = \pi r^2$ ....(2)

where r is the radius of the circle.

Express the area of a circle in terms of its circumference. If p is the circumference, then $p = 2\pi r$

and r = p/2p. By substituting p/2p for r in the equation obtained in step 2, we have $B = pr^2 = p(p/2p)^2 = pp2/(4p2) = p^2/4p$. Therefore, $B = p^2/4p$. ....(3)

Substitute the equality $B = p^2/4p$ obtained in step 3 into the equation C = A/B for the circularity ratio given in Step 1.

This gives us $C = A/B = A/(p2/4p) = 4pA/p^2$. Thus, the circularity ratio is given by $C = 4pA/p^2$....(4) where A is the area of the shape and p is the perimeter.

2.2 Interpretation of the circularity ratio

The circularity ratio C will be greater than 0 and less than or equal to 1. A long, thin shape has a circularity that approaches 0 and a circle has a circularity of 1.

3. METHODOLOGY

The village boundaries within Hingna Taluka of Nagpur district were digitized and imported in 'ArcGIS' software. The villages were tagged with names and unique codes including the forest polygons. The projection system adopted was 'Lambert Conformal Conic (LCC)' with 'WSG 1984' datum. The 'shapefile' of the village boundary was exported to 'KML' format using 'Xtools Pro'. The 'KML' file of the village boundary was imported in the "Google Earth" software and the features of the extent of settlements, water bodies and roads were delineated. The measurement of extent of built-up area of each settlement and estimation of number of dwelling units within each settlement was done using the 'ruler' tools in 'Goggle Earth Pro'. The villages without any settlements and villages with high influence of urbanization and industrialization were recorded and coded. The 'KML' file was imported back to 'ArcGIS 'as 'shapefile' for further analysis and map composition.

3.1 Measurements

The 45 "rithi villages" (uninhabited villages) as well as 8 urban areas, and 7 industrial villages within the study area consisting of total 157 villages, have been excluded for further analysis. The circularity ratio was therefore computed for 95 rural settlements. The perimeter and area of each of these 95 rural settlements were measured and the circularity ratio was calculated using the equation # as defined in methodology.

The total number of dwelling units (both 'kutcha' and 'pucca') within each settlement was counted in the 'Goggle Earth Pro'. The 'kutcha' dwellings consisting of mud walls and clay tiled roofs are clearly identified as dark brown tones and individual dwellings separated by roads, by-lanes and shadows between two dwellings on the true colour high resolution satellite imagery. The 'pakka' dwellings built with brick walls and concrete roofs are identified by bright light tones on the satellite imagery. The total dwellings within each settlement including the 'pucca' types were counted and recorded.

Fig.1 True Colour Satellite Imagery of Rural Settlements

Neri village with majority mud houses- low *'pakka '* percentage

Khapri Moreshwar village with majority concrete houses- high *'pakka '* percentage

Fig.2 Field photographs of Different Types of Dwelling Units in Hingna taluka, Nagpur district.

Picture 1 in Figure 1 shows a typical concrete house, a typical mud house is seen in picture 2 and typical villages with mixed type of houses are seen in picture 3 & 4.

4. RESULTS:

The results of circularity ratios defining the shapes of rural settlements are compared with the size of settlements as well as the proportion of 'pakka' dwellings in settlements to understand their influence on the shape of settlements.

4.1 Size of settlement and type of dwellings

The settlements have been categorized into small, medium and large settlements based on the number of dwelling ranges as shown in table 1. Additionally, the authors are advised to refer the Census of India (2001 and 2011) for demographic data such as population and number of households. At district level or taluk level, they may also get H series data (Census of India, 2001) with information on housing characteristics.

Table.1 Distribution of settlement size in study area

Settlement size (Unit?)	Number of settlements	Percentage
Small (0-78)	44	46%
Medium (79-217)	48	51%
Large (218-879)	3	3%
Total	95	100%

"There are 44 small settlement with number of dwellings in the range of 0- 78 (46%), similarly medium settlements within the range of dwellings (79-217) is 48 (51%), whereas the large settlements are very few to the extent of 3%." (Sentence requires grammatical error correction)

What criterion was adopted for the categorization of household size?

The spatial distribution of the various sizes of settlements does not show any definite pattern, thereby indicating that the population is evenly distributed in the study area irrespective of influence of urban and industrial areas as shown in Figure2. Table2 shows the proportion of pucca houses in the study area. It may be observed that 51% of settlements have less than 13% of pucca houses (Again requires clarification on ranges of categorization 13%, 35% etc.). Most of the settlements in the study area are made of traditional mud houses with clay rooftops. The high percentage of 'pakka' houses are concentrated towards the eastern part of the study area probably due to proximity to urban areas in the North-East part of the study area as well as industrial clusters in South-East region as shown in Figure1.

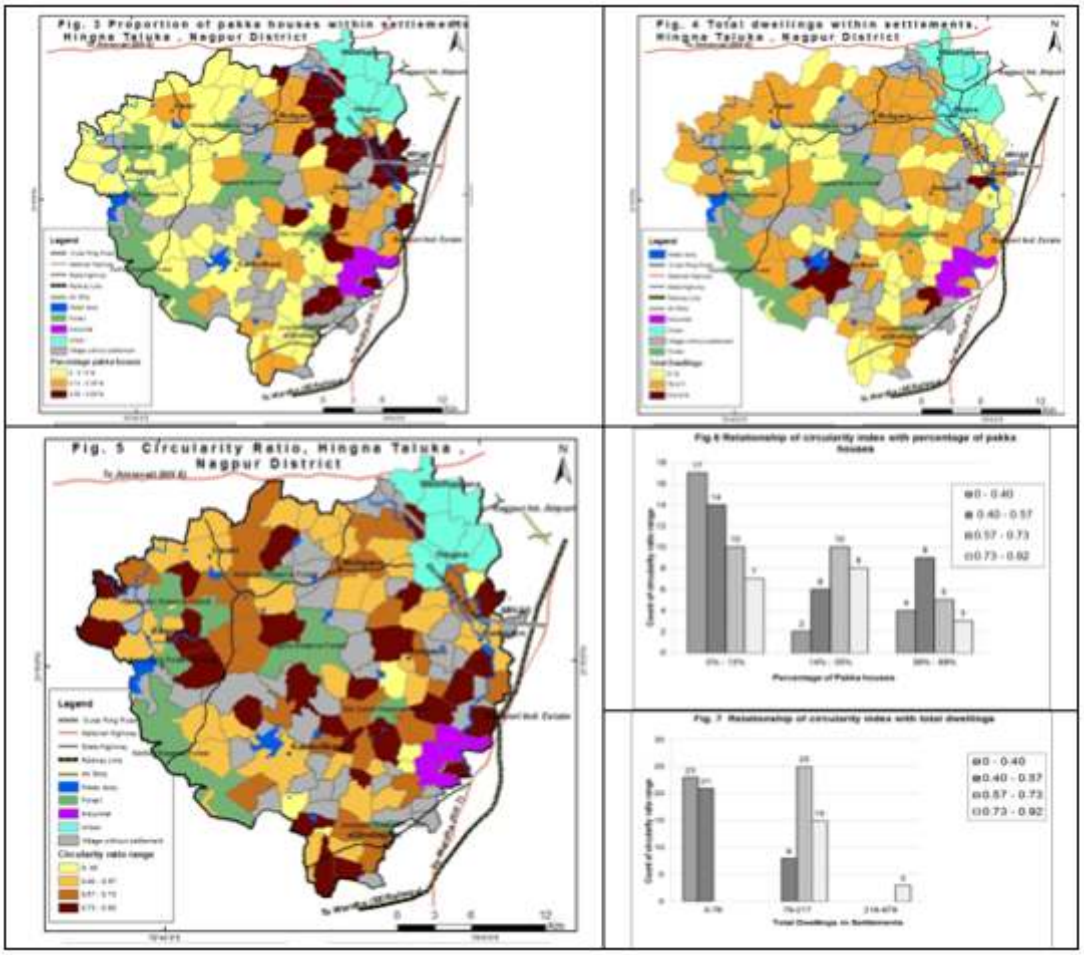
Table. 2 Percentage of 'pakka' dwellings

Percentage of 'pakka' houses	Number of Settlements	Percentage
0% - 13%	48	51%
14 - 35%	26	27%
36 - 89%	21	22%
Total	95	100%

4.2 Dwellings numbers and types versus shapes of settlements

The circularity ratios indicating the shapes of settlements (deviation from a circular pattern) were plotted against the percentage of 'pakka' houses in settlements as well as total number of

dwellings Figure 6 and 7. The circularity ratios were grouped in four ranges: 0-0.4, 0.4 - 0.57, 0.57 - 0.73, and 0.73 -0.92. These were plotted against three range of percentage of 'pakka' houses (0-13%), (14-35%) and (15-89%). However no definite pattern or trend of relationship of circularity ratios and percentage of 'pakka' house is observed Figure 6. Similarly the circularity ranges were plotted against number of dwelling ranges (0-78), (79-217) and (218-879). The circularity ratio in the small settlements is lower whereas the larger settlements have better circularity ratios as shown in Figure 7. However the circularity ratios do not show any definite geographical distribution within the study area Figure 5.



The use of circularity ratio for settlement shapes has certain limitations:

a) The shapes can be defined in several other way like elongation, eccentricity, sphericity, convexity etc.

b) The other factors responsible for defining the shapes of settlement in rural environment need to be considered and included for the purpose of developmental planning.

6. CONCLUSION

a) The settlements with different size are evenly distributed within the study area irrespective of proximity to urban or industrial areas.

b) The influence of the urban and industrial areas is visible in its proximity on the rural settlement in terms of increased percentage of 'pakka' dwellings. However the majorities of settlements have 'kutcha' houses and are present away from the urban and industrial areas clearly indicating 'pakka' dwellings as indicator of urban influence of wealth.

c) Circularity ratios are good indicators of maturity of settlements in terms of its deviation from a circular shape (considered to be a natural shape – can be argued). Shapes can be important factor to be considered for development of settlements in rural settings particularly while planning resources, amenities and disaster management .

d) Settlements in the study area are more close to circular shapes in case of larger settlements. Smaller settlements tend to deviate more from a circular shape.

e) The methodology adopted in the study is cost effective, faster and accurate way of extracting information on rural settlements. Satellite data available in "Google Earth" is good source of information extraction and measurement of rural dimensions and can be easily integrated with external data and desired GIS layers for a meaningful interpretation and analysis.

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