

# **Spatial Analysis of Regional Development : A Block Wise Study, Faizabad District**

**Sadaf and Abdul Munir**

Regional development is a multi-dimensional phenomenon. It represents an overall development of any region. The concept of regional development means the fullest development of any region according to its potentialities. The problem of regional disparities is not found in India only rather it is a global problem. However, in India, it is more common than in any other country. The present paper is an attempt to show the spatial pattern of regional development at block level of Faizabad district for the period of 2010-2011. Twenty two variables have been selected for analyzing the spatial variation of development of 11 blocks of the district. For this study, secondary data have been collected from the statistical bulletin and primary census abstract. Composite index of development and Z score have been used to calculate the agricultural development, infrastructural development, industrial development, socio-economic development and finally the level of overall development. The analysis revealed that Amaniganj holds the first position while Rudauli attains the low level of development.

**Keywords :** Regional development, Z score, Composite index of development

## **Introduction**

Regional development is a multi-dimensional concept. It represents the integrated study of social, economic, agricultural, infrastructure and industrial development of any region. Region is a spatial entity; it can be as large as to resemble a country and at the same time it can be as small as the size of a village. Murty S. (2000) defined regional development as uniform growth and fullest development of any area according to its potentialities and capabilities. Chandna R.C. (2011) said that “the geographic analysis of

development normally begins with identification and analysis of regional disparities.” Identification of regional disparities is very important in making the plan for the development with sustainability. Regional disparity is not a new concept; it originated as early as the human being started to live on the earth surface. Every country either developed or developing is characterised by uneven growth and development due to natural and man-made factors. As a result, it is very important need to study regional development at macro, meso and micro level so that regional

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disparities can be reduced, because regional disparities always enhance the social, economic and political problem. Murty S. (2000) mentioned that "Poverty anywhere is a danger to prosperity everywhere and prosperity anywhere should be shared." So, balanced regional development is very important for the overall development.

This paper attempts to deal with the study of regional development at block level of Faizabad district. Despite the fact that various policies of regional planning have been introduced in India, regional disparities are still very common and can be found at several level- at the level of state, district, block and village. Faizabad district of Uttar Pradesh is one such district where regional disparities can be seen in a very obvious term. This study analyzed that district has witnessed extensive regional disparities among its 11 blocks. Government should introduce organized policies to minimise the inter-block disparity and these policies should not only be introduced but must be implemented. Government should enhance the capacity of each block for balanced regional development.

### **Literature review**

Singh R.C. (2013) analyzed the temporal and regional pattern of development at village level of block Akhnoor (Jammu and Kashmir). He has selected fourteen variables related to infrastructure, agriculture, education and demography. He has been used Composite index of development for showing the overall development. He found that there is much improvement in literacy and demography but infrastructure development shows moderate

level of development whereas agricultural development shows negligible pattern of development in the villages from the year 1981 to 2001.

Kundu K.S., Mondal D. (2012) used 14 indicators for analyzing the spatial patterns of levels of development and Inter-block disparity in Murshidabad district. They adopted simple statistical technique of Deprivation Index. They analyzed that there are wide range of inter-regional disparity where Suti-II block shows the high level of development while Farakka and Kandi blocks belong to low level of development.

Ganguli S. and Guray A. (2015) have made an attempt to study the inter-block disparity of Birbhum district in terms of level of development by using 20 indicators. They calculated Development Index by using the Z score and Composite Z score. They analyzed that Rajnagar block comes under the low level of development whereas Murarai II, Sainthia and Bolpur- Sriniketan show higher level of development.

Mohanty B.B. (2009) examined the regional disparity in agricultural development of Maharashtra district. He used 8 indicators related to agricultural development. He applied these indicators in the four regions of Maharashtra district (Western Maharashtra, Konkan, Marathwada and Vidarbha). He observed that regional disparities in agricultural development is very common in last three decades in these 4 regions of Maharashtra district in which Western Maharashtra shows high level of agricultural development as compared to other regions. He found that due

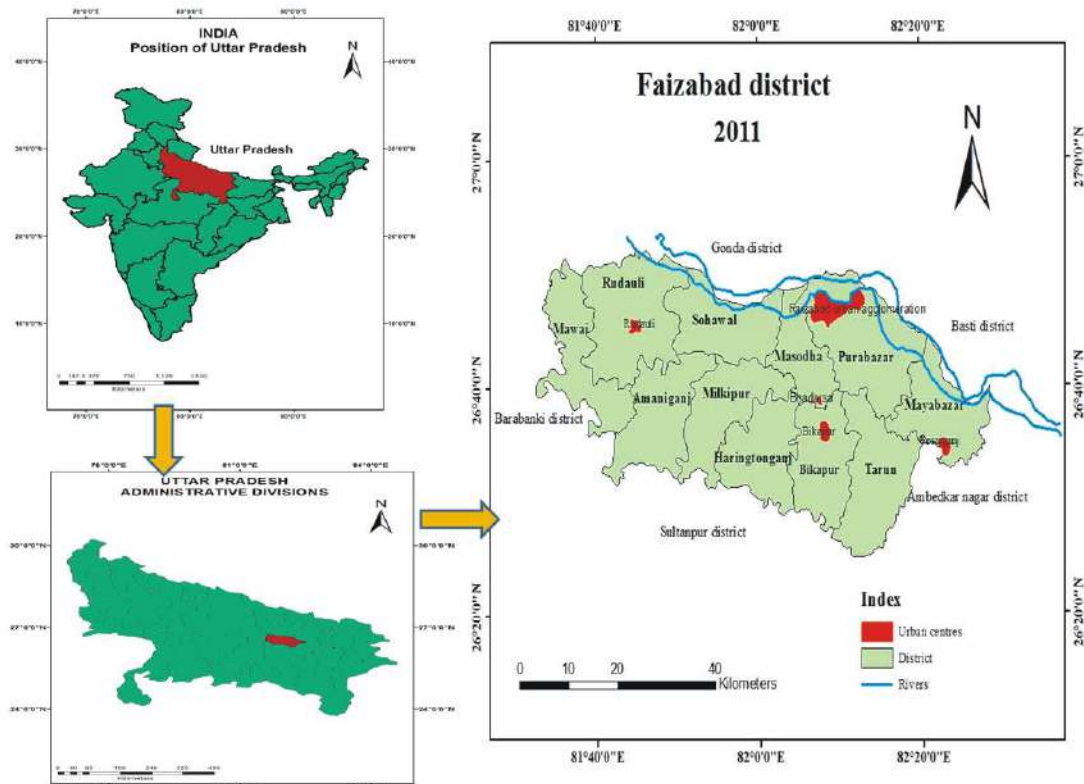


Figure-1

Source: - Census of India, 2001

to the political rise of Maratha-Kumbi peasants, increasing modernisation of agriculture, development of agricultural market and agro-processing industry, Western Maharashtra shows higher agricultural development as compared to the other regions.

Samanta R. (2014) has focused on block level disparity of social development of Paschim Medinipur. He used composite index of development for analyzing the development scenario of blocks. He has taken 8 indicators of social development. He found that Ghatal holds the highest position whereas Nayagram at the bottom among all the blocks in terms of social development.

### Objectives

The present study aims at the following objectives:-

- 1) To analyze the spatial pattern of development in the eleven blocks of Faizabad districts.
- 2) To investigate the inter-block disparities in the development among the eleven blocks of Faizabad district
- 3) To suggest some policies for balanced regional development.

### Study Area

Faizabad district is one of the 71 districts of Uttar Pradesh state in Northern India lies between 26°46' to 45°81'N and 82°14' to

37°26'E . The district has been divided into eleven blocks: Mawai, Rudauli, Sohawal, Masodha, Pura bazaar, Maya bazaar, Amaniganj, Milkipur, Haringtonganj, Bikapur and Tarun. The district extends over an area of 2,764 km<sup>2</sup>. Faizabad district (Figure 1) has a population of 2,468,371 in 2011 which is equal to the population of Kuwait and Nevada state of USA. Faizabad district is the administrative headquarter of Faizabad division. (Wikipedia)

#### Data base

The study is mainly based on secondary sources for the year 2010-2011, collected for the spatial analysis of regional development. The following sources have been given below:-

- 1) Primary Census Abstract, 2011
- 2) Statistical Bulletins of Faizabad district, 2011

#### Methodology

For this study all the indicators of regional development among the blocks of district analyzed with the help of Z-score technique for the year 2011. Z- Score technique has been explained as follows:-

$$Z_{ij} = \frac{X_i - \bar{X}}{S_d}$$

Z<sub>ij</sub>= standard score of the ith observation

X<sub>i</sub>= original value of the observation

X= mean for all the values of x

S<sub>d</sub>= standard deviation

Further composite standard score has been used so that the regional disparities in the levels of development of the blocks may be obtained on a common scale. The technique

has been explained as follows:-

$$(CSS) = \sum z_{ij} / N$$

Where Z<sub>ij</sub> denotes the Z score of an indicator j of blocks i, N refers to no. of indicators. Mean and standard deviation method has been used for dividing the blocks based on levels of development. After that blocks are ranked into three categories i.e. high, medium and low based on the different levels of development.

High= Above (Mean+ ½ S.D.)

Low= below (Mean-1/2 S.D.)

Medium= between (Mean+1/2 S.D. to (Mean-1/2S.D.)

Finally coefficient of Correlation has been used for analyzing the relationship among socio-economic, industrial, agricultural and infrastructural development with each other.

#### List of selected variables

##### Variables of Agricultural Development

- X1 Percentage of agricultural labourers
- X2 Percentage of net sown area
- X3 Fertilizer consumed per hectare of gross area
- X4 Percentage of net irrigated area on gross cropped area
- X5 No. of implements per 100 sq km
- X6 Percentage of area under grain on gross area sown

##### Variables of Socio-Economic Development

- X7 Percentage of Literate person to the total population
- X8 No. of schools per lakhs population
- X9 No. of colleges (Degree & Master) per lakhs population

**Table 1.1: Level of Agriculture Development**

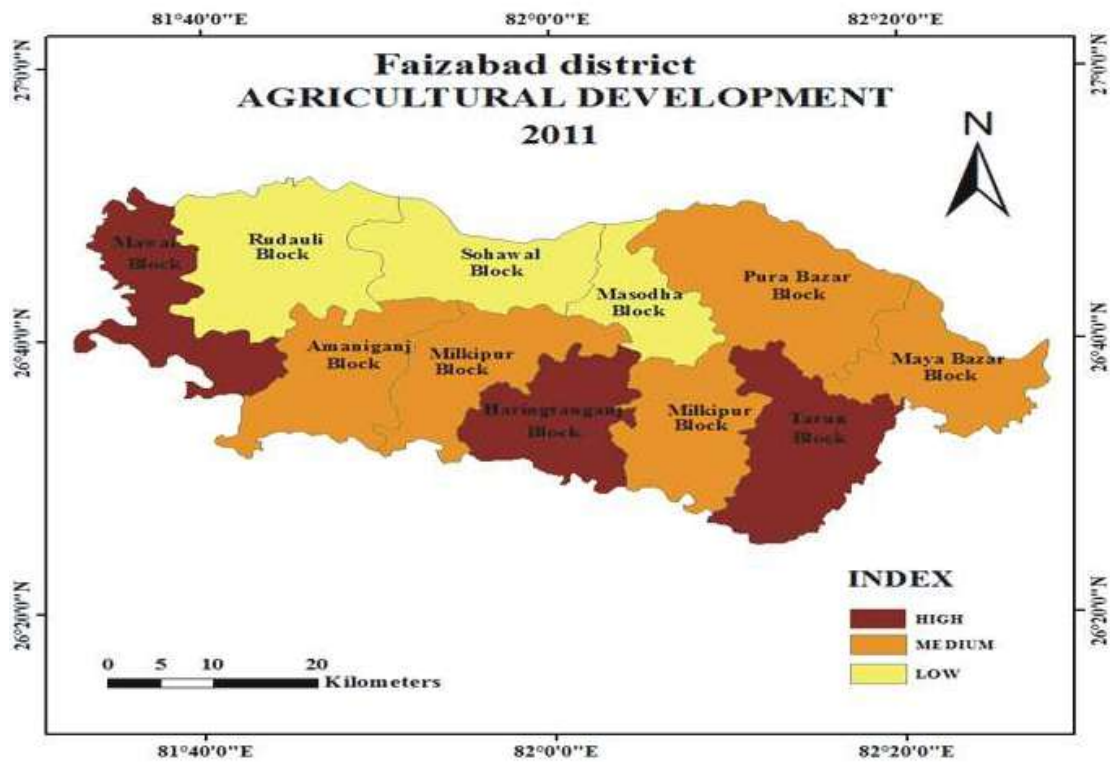
Category	Index value range	Name of the block
High	Above 0.16	Mawai, Haringtonganj, Tarun
Medium	-0.16- 0.16	Amaniganj, Milkipur, Purabazar, Bikapur, Mayabazar
Low	Below -0.16	Rudauli, Sohawal, Masodha

- X10 No. of Allopathic hospitals & primary health centre
- X11 No. of Ayurvedic & Unani hospitals per lakhs pop
- X12 Work participation rate
- X13 Percentage of non-agricultural workers
- X14 Length of pakka road in km per lakhs

**Variables of Infrastructure Development**

- X15 No. of post office per lakhs population
- X16 No. of railway station per lakhs population
- X17 No. of bus stop per lakhs population
- X18 No. of banks per lakhs population
- X19 No. of telephone per lakhs population
- X20 No. of small industries units per lakhs non

**Variables of Industrial Development**



**Figure-2**



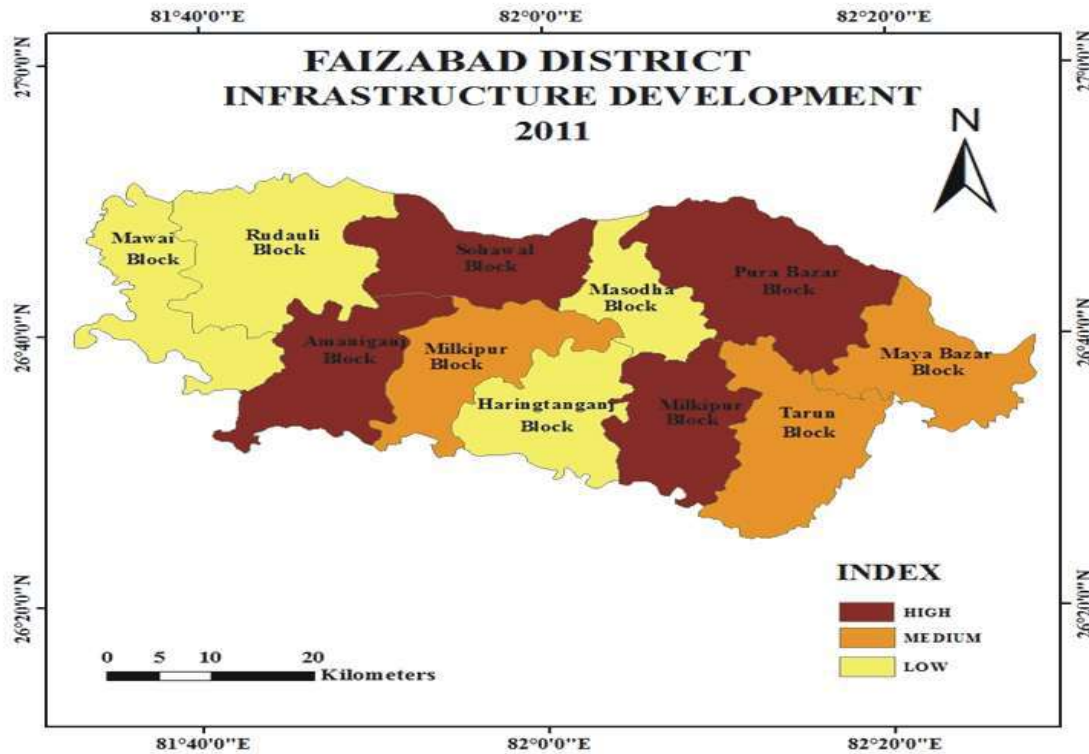


Figure-4

development of India. Agriculture is backbone of Indian economy.

Above table shows that high development is found in the blocks of Mawai, Haringtanganj and Tarun. Amaniganj, Milkipur, Purabazar, Bikapur and Mayabazar registered moderate level of agriculture development. Rudauli, Sohawal and Masodha represent low level of agriculture development.

Socio-economic development is very important sector of development which reflects the standard of living and quality of life of human being. It represents the overall development.

Above table shows the level of socio-economic development. Amaniganj and Tarun

Table 1.4: Level of industrial development

Category	Index value range	Name of the block
High	Above 0.31	Sohawal, Mayabazar
Medium	-0.31-0.31	Masodha, Mawai, Purabazar, Amaniganj, Milkipur, Bikapur
Low	Below -0.31	Rudauli, Haringtanganj, Tarun

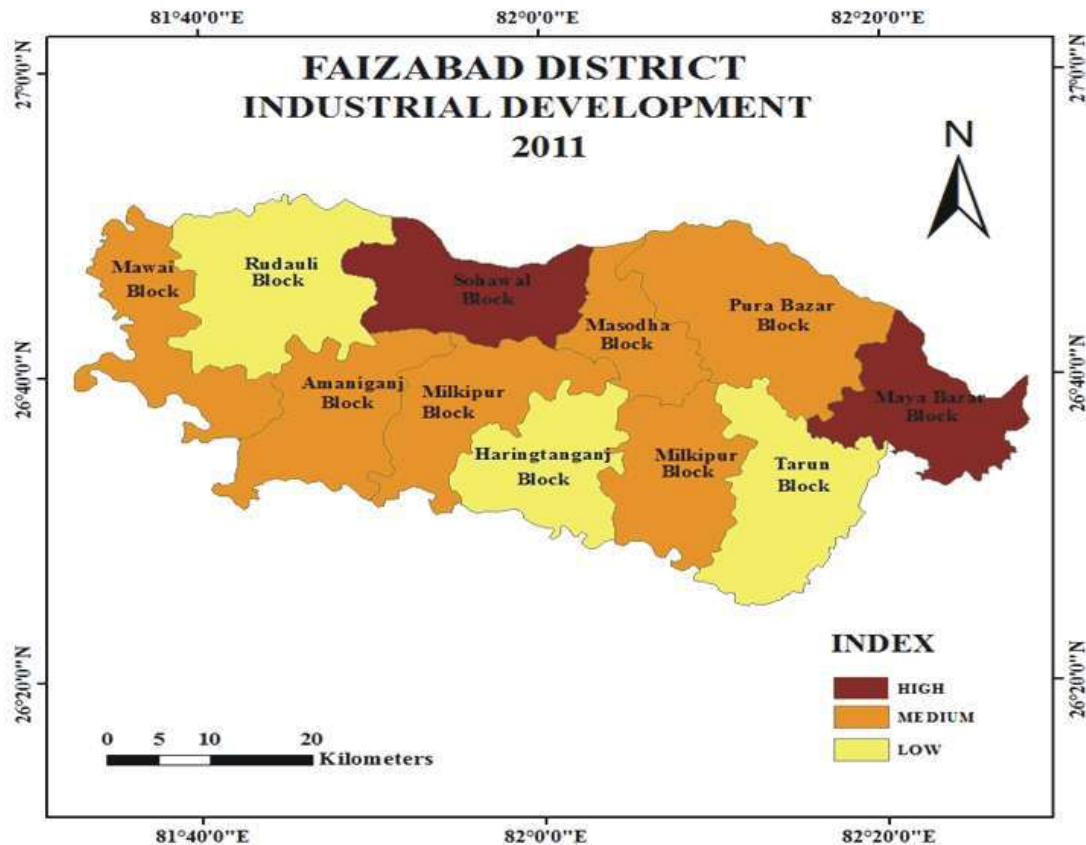


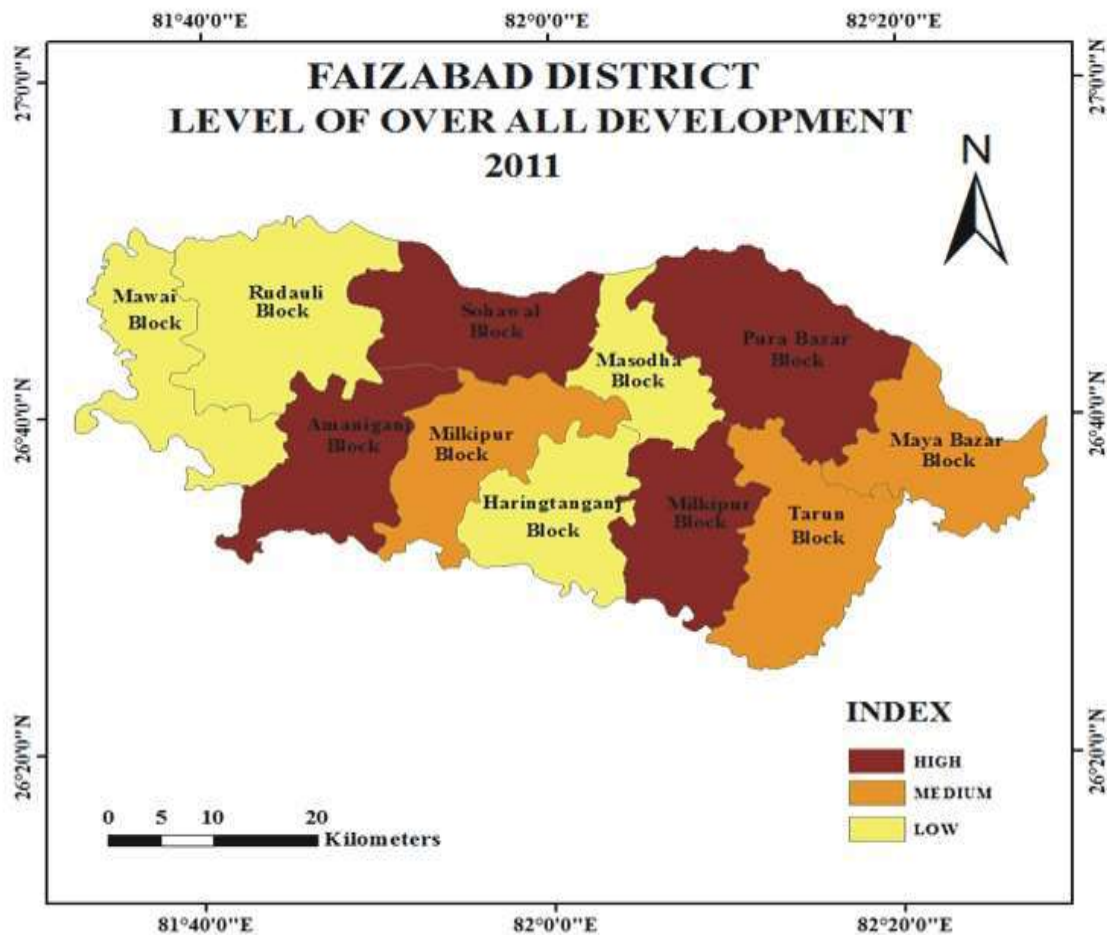
Figure -5

show the higher level of socio-economic development. Milkipur, Purabazar, Bikapur, Mayabazar, Sohawal, Haringtonganj, Masodha depict the moderate level of socio-economic development. Low level of socio-economic

development is found in Mawai and Rudauli. Availability of infrastructure facilities is very important tool for socio-economic development. Availability of Post office, railway station, length of pakka road, bank, and

Table 1.5: Level of overall development

Category	Value	Rank	Blocks
Above Mean+1/2 S.D.	>4.25	I	Amaniganj, Sohawal, Pura bazaar, Bikapur
Between (Mean+1/2 S.D. to Mean-1/2 S.D.)	4.25- (-2.04)	II	Tarun, Milkipur, Maya bazaar
Below Mean -1/2 S.D.	2.04	III	Mawai, Haringtonganj, Masodha, Rudauli



**Figure-6**

telephone connection are very important infrastructure facilities.

Above table shows the infrastructure development of blocks. High level of infrastructure development is found in Sohawal, Purabazar, Amaniganj and Bikapur. Moderate level of infrastructure development is found in Milkipur, Mayabazar and Tarun. Mawai, Rudauli, Masodha and Haringtonganj represent the low level of infrastructure development.

Industries play a very crucial role for the economic development and it is important

source of employment.

Above table depicts the level of industrial development among the blocks of district. Sohawal and Mayabazar are showing higher level of industrial development. Masodha Mawai, Purabazar, Amaniganj, Milkipur and Bikapur represent the moderate level of industrial development, Rudauli, Haringtonganj and Tarun show low level of industrial development.

For analyzing the overall development in the district at block level 22 variables are taken

**Table 1.6: Composite Index of Development of Four Sectors**

S. No.	Blocks	Agriculture Development		Socio-economic Development		Infrastrcuture Development		Industrial Development		Overall Development	
		C.i.	Rank	C.i.	Rank	C.i.	Rank	C.i.	Rank	C.i.	Rank
1	Tarun	0.48	1	0.29	2	0.08	7	-0.48	10	3.542	5
2	Mawai	0.26	2	-0.38	9	-0.18	8	-0.22	5	-1.038	8
3	Haring-tonganj	0.25	3	0.05	6	-0.49	10	-0.46	9	-2.602	9
4	Milkipur	0.15	4	0.07	5	0.26	5	-0.10	6	2.468	6
5	Amani-ganj	0.14	5	0.58	1	0.97	1	-0.16	7	10.605	1
6	Purabazar	0.02	6	0.12	4	0.69	3	0.10	3	4.480	3
7	Bikapur	0.02	6	0.04	7	0.71	2	0.03	4	4.373	4
8	Maya-bazar	-0.08	7	0.13	3	0.20	6	0.41	2	2.150	7
9	Sohawal	-0.26	8	-0.09	8	0.57	4	1.64	1	5.894	2
10	Masodha	-0.37	9	0.07	5	-0.21	9	-0.25	8	-4.615	10
11	Rudauli	-0.62	10	-0.87	10	-0.58	11	-0.52	11	-13.06	11

Source: - Computed By Researcher

**Table 1.7: Correlation Of Agricultural (x1), Infrastructural (x2), Social (x3) And Industrial (x4) Development of The Blocks**

	X1	X2	X3	X4
X1	1			
X2	.575	1		
X3	.214	.641*	1	
X4	-.250	.077	.481	1

\*. Correlation Is Significant At The 0.05 Level (2-tailed).

Source: - Computed By Researcher, 2011

collectively:-The Composite Standard Score of all indicators at block level show that (1.5) there are 4 blocks in high category having the value

above (Mean+1/2 S.D.). It is clear that higher the value of Composite standard score higher will be the development.

Above table depicts the overall development among the blocks. There are 4 blocks namely, Amaniganj, Sohawal, Pura bazaar and Bikapur come under the higher level of development. These blocks show the better facilities of schools, bank, registered factories, hospitals and communication. Moderate level of development is found in Tarun, Milkipur and Mayabazar. Mawai, Haringtonganj Masodha and Rudauli represent the low level of development.

The correlation table indicates that agricultural, infrastructural and social development are positively correlated with each other in all the blocks.. Better agricultural

development increases the level of income which automatically improves the social conditions. Industrial development and agricultural development is negatively correlated. The basic reason is that most of the industries are located near to the towns, where the agricultural practices are very low in Faizabad district. Infrastructural development and social development are positively and significantly correlated. Better infrastructure facilities like roads, railways and banks enhance the socio-economic development. Industrial development is positively correlated with infrastructure and social development. Infrastructure facilities such as better transport routes, banking facilities are required for the establishment of industries. In Faizabad district, Industries are generally located where all these facilities are available.

### **Conclusion and suggestions**

By examining the overall development, the study reveals that there are great disparities among the blocks. There are lots of variations in all the sectors (agriculture, socio-economic, industrial and infrastructure development) among all the blocks. Rudauli block is less developed related to other blocks in Faizabad district. Analysis revealed that the regional disparity of the blocks is due to the under utilisation of natural and human resources. It is essential to reduce the regional disparities among the blocks. It is the need of the hour to reduce the disparities in the level of development of the blocks of Faizabad district by using their development potentials. In India regional disparities is continuously increasing in every sectors at macro, meso and micro level. Government and planner should given the priority to the underdeveloped blocks for making the development policies.

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# Measuring Quality of Life: A Case Study of Jabalpur City

**Rambooshan Tiwari and Jagadish Singh**

Ever-increasing populations in urban areas in general and metropolitan cities in particular, especially in developing countries including India has created myriad urban problems. As a result, quality of urban life has deteriorated significantly. In measuring quality of life (the good life) two approaches i. e. objective and subjective/ perceptual approach have been adopted by scholars in various disciplines. However, in the present paper objective approach based on empirical reality has been adopted to measure quality of life (QoL). Here, objective indicators such as type of house, ownership of house, number of rooms per household and availability of basic facilities within premise of house have been used to calculate quality of life index (QoLI). Based on this index, quality of life has been analyzed across a cross-section of space and society in Jabalpur – a million+ city of India. The paper also brings out some useful suggestions towards improvement in quality of life of the citizens of the city.

**Keywords:** Basic facilities, objective approach, subjective approach, quality of life and urban problems.

## Introduction

The arrival of the new millennium was marked by a major milestone in human history. For the first time over half of the world's population lived in urban areas and by 2050 this will rise to even 70 per cent. It is significant to note that the bulk of this growth will be taking place in developing regions (UN, 2009). In pursuit of economic opportunities and social security people move to cities and towns. After arrival people struggle for easy availability of and access to infrastructural facilities and public amenities. Mismatch in demand and supply of basic services such as drinking water supply,

garbage disposal, toilet facility, electricity and roads poses many challenges before the government and urban administration. No doubt, cities have always been the pace setter of economic growth and cultural change but their unprecedented growth in a relatively small space has also brought with it numerous problems such as violence, poverty, overcrowding, slums and pollution.

Many cities particularly in developing countries are growing too rapidly where a good number of people are unable to find jobs and are forced to live in slums and blighted areas. The concentration of population in small area

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on the one hand and haphazard and unorganized development on the other has created many problems for the good life and healthy living. In recent years with increasing urbanization and concern to the kind of urban environment, focus of urban research has shifted from study of urban problems and urban amenities to their impacts on the well being and quality of life of the urban dwellers. Genuinely, study on the quality of life in cities and towns is receiving attention in the geographical investigation.

### **Approaches to Study Quality of Life**

Two approaches i. e. objective and subjective have been adopted in studies to the quality of life in urban places. Quality of life is the sum of all living conditions - this was the Scandinavian approach of quality of life which had dominated during the early years of quality of life research (Hagerty, et al, 2002). Definition under reference looks very sound but the approach of defining living condition was materialistic. The approach can be compared with the income approach of development. Objective approach to study quality of life is directly or indirectly based on standard of living or income of households. In this approach mostly objective indicators were used to define quality of life. The objective approach is currently central in the Scandinavian countries, particularly in the Swedish 'level of living' studies. From the beginning the basic tenet has been that social policy needs hard facts in the first place (Johansson, 2001). Hence Scandinavian social surveys do not involve items on matters like 'trust' and 'happiness'. Similarly, the Dutch 'welfare-index' also focuses on material living conditions (Boelhouwer, 1999). The approach was criticized by scholars on the ground that only

objective indicators are not enough to represent the person's quality of life. There was a strong opinion against this approach; however, those who are in favour of subjective indicators accepted that material well-being is important determinants of all well-being (Noll, 2002). Although, the research in the field of quality of life goes far beyond the objective indicators but no index without them is considered as complete index. Therefore, in the present paper objective approach based on empirical reality has been followed for measuring quality of life with an assumption that person's feelings of satisfaction or dissatisfaction, happiness or unhappiness with life by and large depends on 'how we live'.

### **Study Area**

As per census 2011, Jabalpur with a population of 12, 67,544 ranks at 38<sup>th</sup> place among 53 million + cities of India. The city under study spreads over an area of 100. 66 sq. km. For convenience of civic administration/ management the city is divided into eight zones and 70 wards. It had added over 8 lakh people during the last six decades and has emerged as one of the most important urban centers of the Central India. The city under reference is headquarters of the division, district and tehsil of the same name. The city carries the great legacy of history. It is dotted with historical monuments belonging to ancient, medieval and modern periods. Jabalpur city is located on the right bank of river Narmada at an average altitude of 393 m above mean sea level (Fig. 1). The city is surrounded with Kariapather ridge to the north, Sita Pahad and Kandhari hills to the east, and Madan Mahal hills to the south-west with plains towards west and north-west. The city is well connected with other parts of the state and country. National

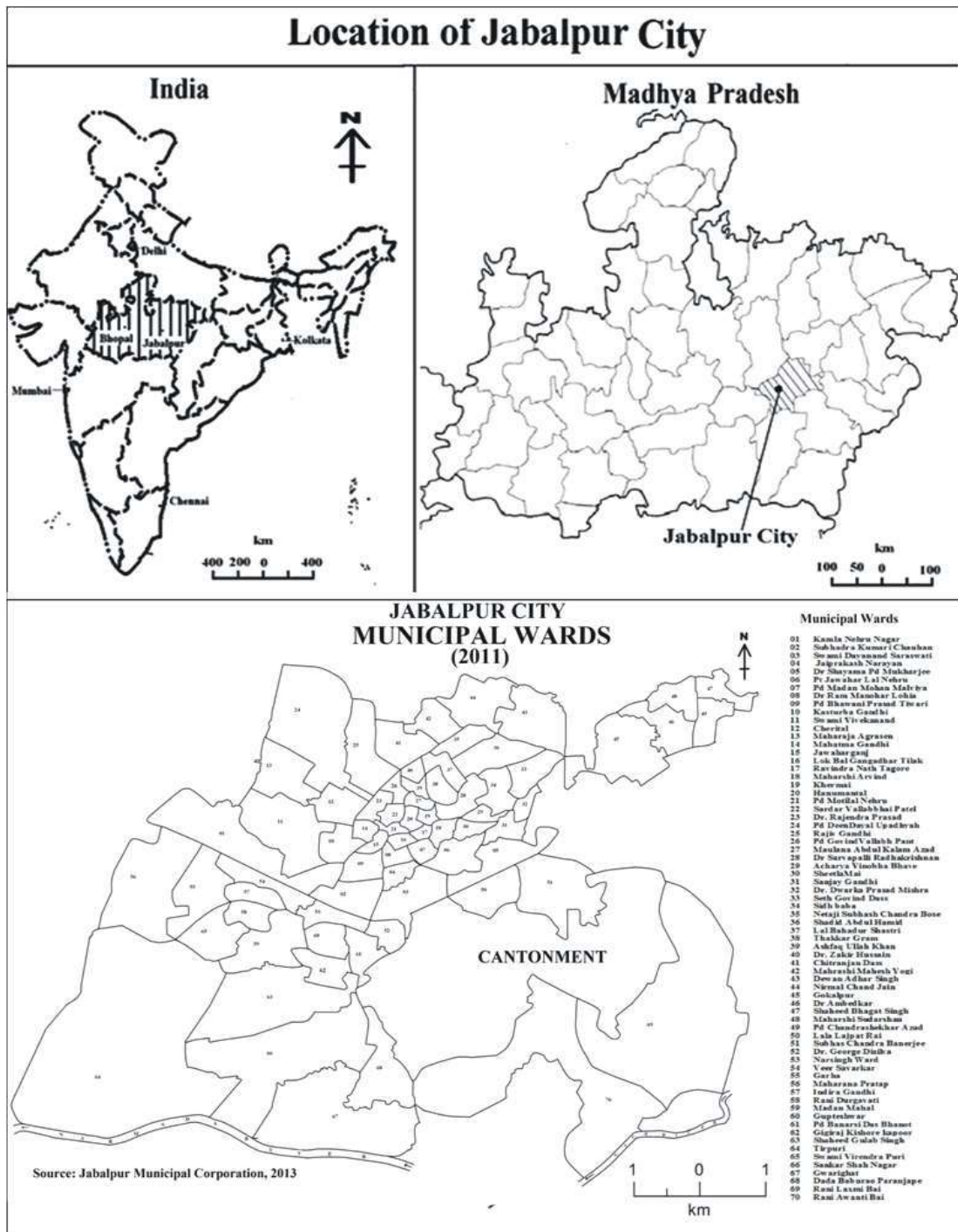


Fig. 1

Highway -7 connecting Varanasi and Kaniyakumari (via Nagpur) traverse the city from north to south whereas National Highway -12 leading to Jaipur links the city with Bhopal. The city is also well connected to other regional nodes of the state like Damoh, Dindori, Amarkantak and Mandala. In terms of railway linkage, the city is situated on Mumbai-Kolkata (via Allahabad) trunk rail route.

### **Objectives**

The three -fold objectives of present study are:

1. to measure quality of life across a cross- section of space and society in study area,
2. to examine the spatial variation in quality of life among different zones of the city and
3. to identify the important predictors which are significantly associated with quality of life.

### **Data Base and Methodology**

The city is divided into eight administrative zones by Municipal Corporation. These zones have been used as spatial unit to generate primary data. To examine the quality of life, a field survey has been conducted during November- December, 2010 with the help of a structured interview schedule. Altogether 480 households (60 households from each zone) have been selected following purposive sampling method and from each household one adult member was interviewed. It may be noted here that the interview schedule contains altogether 64 questions excluding background characteristics of respondents but of the various parameters, information on availability of basic facilities and consumer durable goods to

households are only used here to calculate quality of life index (QoLI).

The presence / availability of basic facilities within premise of house and possession of physical assets (durable goods) apparently reflect the standard of living of urban households/ residents and improvement in standard of living can greatly contribute to raising the quality of life. As such they have been considered as key indicators to understanding quality of life. Their presence make places more attractive for living and working.

Altogether 30 indicators related to type of house, ownership of house, number of rooms in the house, availability of basic facilities and consumers durable goods have been used to measure QoLI (Table 1). 'Factor analysis' has been used to calculate the composite index which is termed as 'Quality of Life Index'. On the basis of results it is divided into three categories i. e. 'Low', 'Moderate' and 'High'. Mean value of QoLI is calculated on the basis of weighted score (on a scale of 1 to 3). For low, moderate and high categories 1, 2 and 3 score are assigned respectively. Later, mean value for each category is obtained by averaging the actual score thus obtained. Further, Multivariate analysis is applied to examine the relationship between socio-economic variables and quality of life. After recarding of variables into two categories the binary logistic regression analysis has been applied to examine the degree of association between the background characteristics of the surveyed respondents and quality of life. It also helps in identifying the important predictors of quality of life. Besides, at places secondary data have been used to supplement the facts.

**Table1: Indicators used to measure Quality of Life**

Sl. No.	Indicators	Sl. No.	Indicators
1	Type of House: Pucca	19	Goods possessed by household: Cooler
2	Type of House: Semi Pucca	20	Goods possessed by household: Radio/ Transistor
3	Type of House: Kachcha	21	Goods possessed by household: Black & White TV
4	Ownership of House: Own	22	Goods possessed by household: Colored TV
5	Ownership of House: Rented	23	Goods possessed by household : Washing Machine
6	Number of rooms available in house: One	24	Goods possessed by household: Basic Telephone (Landline)
7	Number of rooms available in house: Two to three rooms	25	Goods possessed by household: Computer/ Laptop
8	Number of rooms available in house: Four and above	26	Goods possessed by household :Refrigerator
9	Type of toilet facility: Own	27	Goods possessed by household: Watch/ Clock
10	Type of toilet facility: Shared	28	Goods possessed by household: Bicycle
11	Type of toilet facility: Open	29	Goods possessed by household: Motorcycle/Moped/Scooter
12	Availability of separate bathroom	30	Goods possessed by household: Car
13	Mode of drinking water supply: Municipal piped water		
14	Mode of drinking water supply: Tube well		
15	Mode of drinking water supply: Well Machine		
16	Type of fuel used for cooking: LPG		
17	Type of fuel used for cooking: Kerosene		
18	Goods possessed by household: Pressure Cooker		

### Background Characteristics of the Surveyed Respondents

The quality of life varies by socio-economic characteristics of male and female respondents, as well as the characteristics of their households such as income, size of family and number of persons per room. The background characteristics portrayed in Table 2 indicates that respondents belong to varied socio-economic and cultural groups. However, during the field survey an attempt has been made to make the representation of all broader

groups of population residing in the city.

Out of 480 respondents, 67.70 percent were male while 32.30 percent were female. More than 55 percent of respondents are in the age group 30-59 years. Highest percentage of households belongs to the other backward class (35.00) followed by general (31.88), scheduled castes (21.04) and scheduled tribe (12.08). Similarly, religion of surveyed households also varies. Among the surveyed households Hindu (79.17%) dominate followed by Muslims (12.71%) and others (8.12%),

**Table 2: Background Characteristics of the Surveyed Respondents**

Background Characteristics		Number	Percent
<b>Sex</b>	Male	325	67.70
	Female	155	32.30
<b>Age (in years)</b>	Below 30	74	15.42
	30-39	137	28.54
	40-49	128	26.67
	50-59	83	17.29
	60 & above	58	12.08
<b>Caste / tribe</b>	General	153	31.88
	Other Backward Class	168	35.00
	Scheduled Caste	101	21.04
	Scheduled Tribe	58	12.08
<b>Religion</b>	Hindu	380	79.17
	Muslim	61	12.71
	Others	39	08.12
<b>Education</b>	Illiterate	25	05.21
	Primary	102	21.25
	Secondary	126	26.25
	Higher Secondary	133	27.71
	Graduation & above	94	19.58
<b>Occupation</b>	Unemployed	55	11.46
	Daily wager	121	25.21
	Industrial worker	71	14.79
	Self-employed	114	23.75
	Service	119	24.79
<b>Monthly Family Income (in ₹)</b>	Below 5000	72	15.00
	5001-10000	99	20.62
	10001-15000	103	21.46
	15001-20000	121	25.21
	Above 20000	85	17.71
<b>Total</b>		<b>480</b>	<b>100.00</b>

Source: Based on field survey, 2010

mostly Jain. Educational background of respondents shows that majority of the respondents (94.79%) have 5 or more years of education. However, only small percentage of respondents (19.58) has studied up to graduation or above. Occupational composition of survey respondents depicts that daily wager (25.21%) and unemployed (11.46 %) together constitutes 36.67 per cent of total workforce whereas only 24.79 percent respondents work in service sector. 14.79 per cent of workers are engaged in various industries. It was also evident during the survey that a good number of workers are engaged as daily wager in industries. Household income seems the most important determinant in measuring quality of life. Households with higher income have better access to basic facilities and durable goods than those who are relatively poor. Of the total, 15 per cent of households possess income less than 5000 rupees per month and living in abject poverty while 17.71 percent of households have monthly income above Rs. 20000.

Percentage distribution of respondents w.r.t. some selected background characteristics in different zones of the study area shows that Bhan Talaiya has relatively higher number of respondents belonging to scheduled caste and scheduled tribe while Muslims dominate in Ghanta Ghar. Educational attainment of respondents also show high variability in their

distribution as in case of Civil Line a fairly large number of respondents were recorded having higher education while in case of Bhan Talaiya percentages of respondents having higher education is very low. Similarly, percentage of respondents with high family income is marked relatively high in Civil Line whereas other zones record poor percentage.

It is pertinent to mention here that the size of family and number of persons per room (occupancy) - a measure of household congestion, also affect the quality of life. In the study area about 37 per cent of households have seven or more persons where as 18 per cent of households have five or more persons per room. In 63 per cent of households, three to four persons share a single room.

### Results and Discussion

It may be mentioned here that QoLI is based on objective criterion which includes availability of facilities/amenities and physical assets in the household. Availability of and access to these services and possession of durable goods not only reflect the living standard of population but also indicate the level of quality of life. Table 3 provides information on household access to basic facilities that affect living condition. Around 60 per cent households had a separate toilet in the house whereas three fourth of households have separate bathroom

**Table 3: Availability of Basic facilities in Surveyed Households**

Available Facilities	No. of Households	Percentage of Households
Separate Toilet	289	60.21
Shared/Public Toilet	179	37.29
Separate Bathroom	373	77.71
Separate Kitchen	364	75.83

Source: Based on field survey, 2010

as well as a separate room for cooking. However, 2.5 per cent of household had no access to a toilet (neither shared nor a public facility).

### Status of Quality of Life

It is apparent from Table 4 that 31.88 per cent of the households do not have access to even basic facilities at home as such they come under low QoLI. It is important to mention here that almost a similar percentage of population in the city was living in slums and squatters during 2001 (Census of India, 2001). More than half of the surveyed households enjoy these facilities at satisfactory level and so are placed in the category of moderate QoLI. It is an indicator of presence of high number of middle class, especially lower middle class families in the city. Only a small section of households (17.29%) find place in the category of high QoLI. Such households possess almost all listed amenities at home in a reasonably good condition.

### Inter Zone Variation in Quality of Life

It is notable that different localities (zones) of the city are inhabited by people belonging to different socio-economic background and as such there are found variation in QoLI within and across the zones (Table 5).

Table 5 and Fig. 2 portray zone wise comparative picture of quality of life in the city.

**Table 4: Status of Quality of Life in the City**

Quality of Life (based on QoLI)	No. of Households	Percentage of Households
Low (-2.580699 to -1.10842)	153	31.88
Moderate (-1.10842 to 0.363859)	244	50.83
High (0.363859 to 1.83613)	83	17.29
Total	480	100.00

Source: Computed by authors (based on field survey, 2010)

It is evinced that highest percentage of households belonging to high QoLI and as well moderate QoLI inhabit in Civil Line. This is perhaps due to concentration of upper middle class working in service sector. It is followed by Garha and Gorakhpur with more than 20 per cent households belonging to high QoLI. These areas also have the cluster of population working in service sector such as medical and railway services. In six zones more than half of the sampled households lie in the category of moderate QoLI. It reveals that these zones of the city are characterized by lower middle class population. Bhan Talaiya has fairly high concentration of slum population. Consequently, highest percentage of households i. e. 56.66 per cent find place under low QoLI. Areas such as Cherital and Ghanta Ghar also contains high concentration of households (above 40 per cent) having low QoLI.

### Quality of Life by Background Characteristics of the Surveyed Respondents

Levels of quality of life increase with increase in availability of amenities to households. Household possession (ownership) of durable goods reflects the living standard of the population. Table 6 shows the variation in quality of life of the household by background characteristics of surveyed respondents. **Caste** is an important determinant of quality of life. It

**Table 5: Inter Zone Variation in Quality of Life**

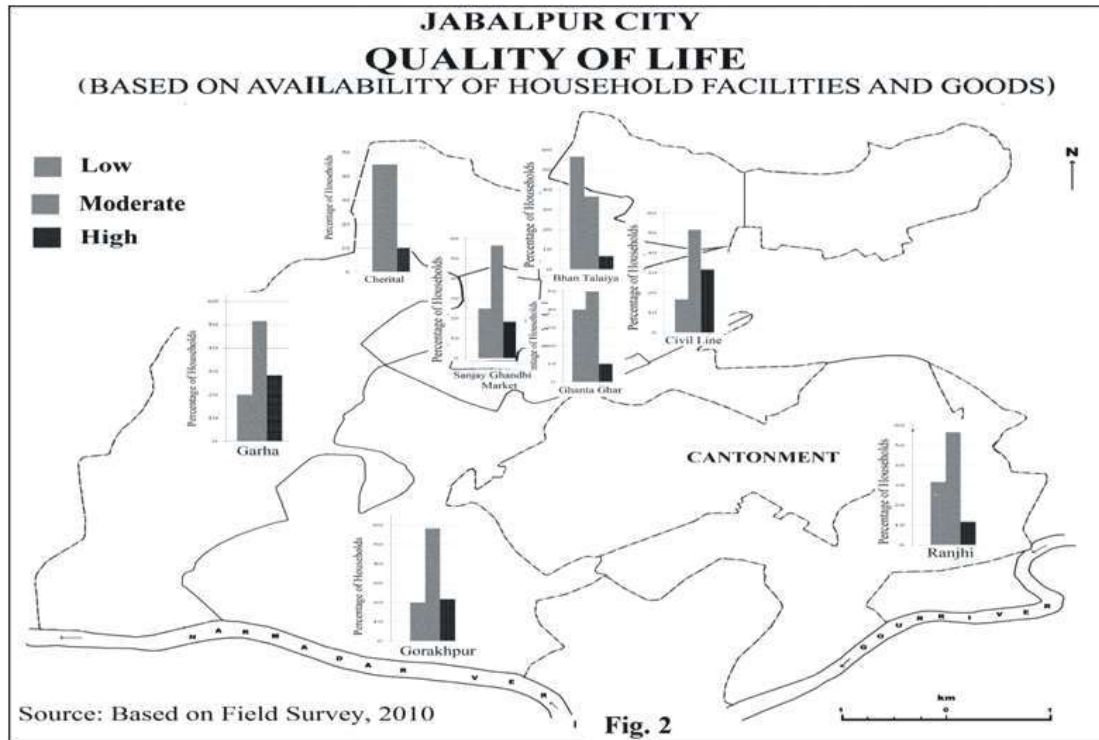
Sl. No.	Zone		Quality of Life		
			Low	Moderate	High
1	Garha	Number	12	31	17
		Per cent	20.00	51.67	28.33
2	Gorakhpur	Number	12	35	13
		Per cent	20.0	58.33	21.67
3	Sanjay Gandhi Market	Number	15	34	11
		Per cent	25.0	56.67	18.33
4	Civil Line	Number	10	31	19
		Per cent	16.67	51.66	31.67
5	Ghanta Ghar	Number	24	30	06
		Per cent	40.0	50.0	10.0
6	Bhan Talaiya	Number	34	22	04
		Per cent	56.66	36.67	6.67
7	Cherital	Number	27	27	06
		Per cent	45.0	45.0	10.0
8	Ranjhi	Number	19	34	07
		Per cent	31.67	56.66	11.67
<b>Total</b>		<b>Number</b>	<b>153</b>	<b>244</b>	<b>83</b>
		<b>Per cent</b>	<b>31.88</b>	<b>50.83</b>	<b>17.29</b>

Source: Based on field survey, 2010

is generally presumed that upper caste is generally better off being at top in social hierarchy. There is marked a declining trend in quality of life by caste. Upper caste household enjoys better quality of life among social groups as 23.53 per cent of households of this group recorded high quality of life while only 17.65 per cent of households are categorized under low quality of Life. In contrary, only 10.35 per cent of the ST households enjoy high quality of life while almost two-third of households falls in the category of low quality of life.

A very interesting trend is observed from Table 6 that there is not marked any significant variation between General (Mean QoLI: 2.06)

and OBC (Mean QoLI: 1.95) population in terms of quality of life but when it is compared with the scheduled caste and scheduled tribe households the upper two caste groups show big differences in quality of life. More than half of the scheduled caste households and about two-third of the scheduled tribe households belong to the category of low quality of life while only 17.65 per cent households of general and 20.83 per cent households of other backward class find place under it. Similar trend can be observed in case of moderate quality of life category as 58.82 per cent households of general and 61.90 per cent households of other backward class population are categorized



under this while corresponding figures are 35.64 per cent and 24.14 per cent for scheduled caste and scheduled tribe respectively.

By **religion**, again, peculiar trend is observed in reference to quality of life. Hindus and Muslim show almost identical pattern in terms of quality of life. However, Hindu households (mean QoLI: 1.82) have an edge over Muslims (mean QoLI: 1.80). On the other hand, others (mostly Jain followed by Christian and Sikh) enjoy relatively better quality of life as compared to Hindus and Muslims. Only 5.13 per cent of their population falls in the category of low quality of life while 34.47 per cent of Hindus and 32.79 per cent of Muslims belong in this category. In contrast, 28.20 per cent of their population (Other religion) comes under high quality of life category while corresponding

figures are 16.85 and 13.11 per cent for Hindus and Muslims respectively.

**Education** significantly influences the quality of life of a person. Even a minimum level of education can enhance the ability of individuals in such a way that he or she can enjoy a better living condition. There is observed clear tendency that quality of life in the surveyed households increases with an increase in educational attainment. Families of respondents with no education possess low quality of life (84% households) whereas only 7.45 per cent of households with 14 or more years of education (graduation and above) belong to this category. A sharp difference has been noticed between illiterate (no education) and persons with 5 years of education (primary education). The only point of satisfaction is that

**Table 6: Quality of Life by Background Characteristics of the Respondents**

Background Characteristics			Quality of Life			Total	Mean Value of QoLI
			Low	Moderate	High		
General	Number	27	90	36	153	2.06	
	Per cent	17.65	58.82	23.53	100		
OBC	Number	35	104	29	168	1.97	
	Per cent	20.83	61.90	17.27	100		
Caste/Tribe	SC	Number	53	36	12	101	1.60
	Per cent	52.48	35.64	11.88	100		
ST	Number	38	14	6	58	1.44	
	Per cent	65.51	24.14	10.35	100		
Religion	Hindu	Number	131	185	64	380	1.82
	Per cent	34.47	48.68	16.85	100		
	Muslim	Number	20	33	8	61	1.80
	Per cent	32.79	54.10	13.11	100		
	Others	Number	2	26	11	39	2.23
	Per cent	5.13	66.67	28.20	100		
Education	Illiterate	Number	21	3	1	25	1.2
	Per cent	84.00	12.00	4.00	100		
	Primary	Number	54	42	6	102	1.52
	Per cent	52.94	41.18	5.88	100		
	Secondary	Number	41	60	25	126	1.87
	Per cent	32.54	47.62	19.84	100		
	Higher secondary	Number	30	76	27	133	1.97
	Per cent	22.56	57.14	20.30	100		
	Graduation and above	Number	7	63	24	94	2.18
	Per cent	7.45	67.02	25.53	100		
Occupation	Unempl- oyed	Number	36	16	3	55	1.40
	Per cent	65.45	29.10	5.45	100		
	Daily wager	Number	53	54	14	121	1.68
	Per cent	43.80	44.63	11.57	100		
	Self- employed	Number	29	71	14	114	1.86
	Per cent	25.44	62.28	12.28	100		
	Industrial worker	Number	22	31	18	71	1.94
	Per cent	30.99	43.66	25.35	100		
	Service	Number	13	72	34	119	2.17
	Per cent	10.92	60.50	28.58	100		

Family Income ( in r )	Below 5000	Number	68	3	1	72	1.06
		Per cent	94.44	4.17	1.39	100	
	5001-10000	Number	62	32	5	99	1.42
		Per cent	62.63	32.32	5.05	100	
	10001-15000	Number	21	68	14	103	1.93
		Per cent	20.39	66.02	13.59	100	
	15001-20000	Number	2	94	25	121	2.19
		Per cent	1.65	77.68	20.67	100.1	
	Above 20000	Number	0	47	38	85	2.44
		Per cent	0	55.29	44.71	100	
	Total	Number	153	244	83	480	1.85
		Per cent	31.88	50.83	17.29	100	

Source: Based on field survey, 2010

their numbers are very low (only 5.21 per cent) which is expected to reduce in the future.

There is found strong association between educational attainment and the quality of life but effective education (graduation and above) have more significant impact on it. Only effective education can enhance the quality of life as it is evident from Table 6 that merely 7.45 per cent of the households where respondents are graduate and above are classified under low quality of life which is about three times lower than the immediate category of 12 years of education (22.56% respondents having low QoLI).

**Occupation** (employment status) determines the level of living condition and subsequently the quality of life of a household. Families of unemployed persons have low quality of life followed by daily wagers. Some of the daily wagers working in organized sector enjoy better living conditions than their counterparts working in unorganized sector.

Persons engaged in service sector and industrial workers enjoyed relatively better quality of life as regular salary ensure affordability of minimum household possessions

for them. It is notable that quality of life of those industrial workers who work in the low paid private industries such as Biri industry and small scale industries do not enjoy same quality of life as enjoyed by their counterparts working in public sectors.

Another notable trend is that 25.44 per cent of the households under self-employment category recorded low quality of life and only 12.28 per cent of them come under high quality of life. It may be because of the fact that a fairly large number of self-employed persons are street vendors.

**Income** is the most significant variable which affects quality of life of an individual. It gives the strength to purchasing power for goods we consume and services we enjoy. A person belonging to any social category or having any other personal traits; if income is high, he or she can ensure a minimum living standard of life for himself or herself. It is best explained by the fact that not a single household bracketed in very high family income (above ₹20,000) are categorized under low quality of life. In contrary, those households with lowest income group (below ₹5,000) have worst

quality of life as 94.44 per cent of households of this income group are categorized under low quality of life.

It may be summarized here that if other variables remain constant, the quality of life of a person or household improves with an increase in wealth (income). The statistics show two very interesting trends which need explanation. There are two levels of income: one is termed here as threshold income and second one as effective income.

It is already mentioned that with an increase in income the quality of life of a household also increases; but it is the threshold income which is needed to enhance the quality of life at a reasonable level. The threshold income is that income which ensures compliance of minimum human needs for everyone. It is evident from Table 6 that once a family entered in the threshold income group of ₹15,001-20,000, there is a very low probability of remaining him in a category of low quality of life. Only 1.65 per cent households of this income group are graded under low quality of life. By contrast, 20.39 per cent of households lying in income group of ₹ 10,001-15,000 are found in the category of low quality of life.

Another point is worth to mention here that effective income (above ₹ 20,000) is necessary for the improvement in quality of life as threshold income fulfills only minimum human needs. The statistics reveal that percentage of households (with effective income) classified under high quality of life is more than twice as compared to its nearby category of threshold income.

### **Determinants of Quality of Life**

Logistic regression is a technique used to

determine which predictor variable most strongly and significantly associated with the probability of a particular category in the criterion variable occurring. The odd ratio showed in Table 7 depicts the relationship between quality of life and the socio-economic characteristics of the respondents.

The binary logistic regression analysis evinces that the quality of life is affected by several factors. Among the caste/tribe, people of other backward class ( $\beta=7.220$ ,  $CI=3.742-13.972$ ) and general category ( $\beta=8.867$ ,  $CI=4.480-17.547$ ) are 7.2 and 8.8 times more likely to have high quality of life respectively in comparison to scheduled tribe. The Scheduled Caste people has also slightly higher likelihood ( $\beta=1.721$ ,  $CI=0.883-3.355$ ), although insignificant, to better quality of life.

The quality of life also varies across the religious groups. In reference to Hindus, Muslims ( $\beta=0.979$ ) are likely to have lower quality of life. But the probability of quality of life is significantly higher ( $p < 0.001$ ) among the other religious groups ( $\beta=9.733$ ,  $CI=2.309-41.018$ ). It may be noted that others consist of mainly Jains.

Occupational status of the respondents also appears to be the significant predictor of quality of life. The odd ratios of having better quality of life are 2.43, 4.22, 5.55 and 15.45 times higher among the daily wagers ( $\beta=2.431$ ,  $CI=12.54-4.712$ ), industrial workers ( $\beta=4.220$ ,  $CI=1.494-8.930$ ), self-employed ( $\beta=5.554$ ,  $CI=2.765-11.556$ ) and people in services ( $\beta=15.449$ ,  $CI=6.939-34.397$ ) as compared to unemployed respondents.

Of the several variables, education is considered to be the most significant predictor of quality of life. In reference to illiterates, the people educated up to primary level ( $\beta=4.667$ ,

**Table 7: Binary Logistic Regression Showing the Odd Ratios (unadjusted) and Confidence Interval of Quality of Life by Background Characteristics of the Respondents**

Background Characteristics		Odd Ratio (Exp- $\beta$ )	95.0 per cent Confidence Interval for Exp- $\beta$	
			Lower	Upper
Caste	ST (RC)	1.000		
	SC	1.721	0.883	3.335
	OBC	7.220**	3.742	13.927
	General	8.867**	4.480	17.547
Religion	Hindu (RC)	1.000		
	Muslim	0.979	0.587	1.718
	Others	9.733*	2.309	41.018
Occupation	Unemployed (RC)	1.000		
	Daily wage	2.431	1.254	4.712
	Industrial worker	4.220**	1.494	8.930
	Self employed	5.554**	2.765	11.556
	Services	15.449**	6.939	34.397
Education	Illiterate (RC)	1.000		
	Primary	4.667*	1.496	14.559
	Secondary	10.884**	3.508	33.772
	Higher Secondary	18.025**	5.742	56.583
	Graduation & above	65.250**	17.472	243.687
Family Income (in ₹)	Below 5000 (RC)	1.000		
	5001-10000	5.145*	1.710	15.049
	10001-15000	12.127**	4.032	35.881
	15001-20000	38.407**	12.974	113.022
	above 20000	92.349**	31.864	415.691

Note: Significant at  $p < 0.005^*$ ,  $p < 0.001^{**}$ ; (RC) Reference Category

CI= 1.496- 14.559) and secondary level ( $\beta=10.884$ , CI= 3.508- 33.772) are 4.6 times and 10.8 times more likely to have better quality of life. The people educated up to higher secondary ( $\beta=18.025$ , CI= 5.742- 56.583) and graduation & above ( $\beta=65.250$ , CI=17.472- 243.687) are 18 times and 65.2 times more likely to have higher quality of life.

Similarly, income has also been found to

be significantly associated with the quality of life of people. Households having income of ₹5000-10000 are 5.1 (significant at  $p < 0.05$ ) times more likely to have better quality of life than the people having income below ₹5000. But the probability of having high quality of life is (significant at  $p < 0.001$ ) 12.12, 38.40 and 92.34 times higher among the income groups ₹10000-15000, ₹15000- 20000 and above

₹ 20000 respectively (Table 7).

### What is required?

A concerted effort by all actors in urban area is required to provide a reasonably similar quality of life to all urban residents irrespective to 'who they are' and 'how they live'. People move to cities and towns in pursuit of a better quality of life (satisfactory living conditions) so quality of life improvement programmes should not be delayed any further otherwise it may not keep pace with fast urbanisation in future. Of the various factors, availability of and access to infrastructural facilities and public amenities (the places we live), education, employment and household income are the most critical variables/components to be considered in prioritizing our efforts towards improvement in quality of life. It will help in making our cities and towns a place of varied opportunities rather

than challenges.

### Concluding Remarks

There is observed variations in quality of life across a cross-section of space and society. It varies according to nature of locality and background characteristics of the surveyed households. It means much more remains to be done. The results of logistic regression show that education, income and nature of employment are the important predictors of the quality of life. The results obtained will help in identifying the grey areas and target groups with poor quality of life. A better quality of life to all citizens including the poor through improved infrastructure availability and basic facilities within premise and outside of house is likely to make the urban areas economically more competitive / efficient and socially satisfying.

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# Prevalence of Diabetes in South Asian Countries with special reference to India

Parmendra Narayan Singh and R. S. Yadava

Diabetes is one of the non-communicable chronic diseases which is generally characterized by high blood glucose level and its associated complications like hypertension, renal failure and blindness. With largest number of diabetes patients in the world, India is earning the dubious distinction of being termed as the “Diabetes capital of the World”. The present paper focuses on the spatial pattern of incidences of diabetes in India as compared to top ten diabetic nations including south Asian nations. In addition to this, paper also focuses on the relationship between socio-economic factors and self-reported cases of diabetes. We have attempted to explore the geographical variation in the prevalence of diabetes between different states of India. In this paper researchers have made an attempt to reveal the association between obesity and self-reported diabetes in the different states of India. The analysis is based on data published by National Family Health Survey-III. The result shows that older age group, male, higher educated and wealthy people appear to be at greatest risk for diabetes. The data also reflects the substantial geographical controls in diabetes prevalence. The study is having its strength due to the fact of large nationally representative survey to assess the socio-economic condition of patient and conspicuous pattern of this disease.

**Keywords:** Socio-economic, Prevalence of diabetes, Spatial analysis, Sedentary behaviors

## Introduction

Recently, diabetes has emerged as a major health care threat in India and south Asian countries. According to Diabetes Atlas published by the International Diabetes Federation (IDF), there were 58 million people who are suffering from diabetes in India (2009) and this number is likely to escalate to nearly 70 million by 2025. Thus, India is regarded as the “diabetes capital of the world” and every fifth person suffering from diabetes will be an

Indian. The major proportion of population that is suffering from diabetes is classed under type 2 diabetes (51 million in 2009). Type 2 diabetes is a complex metabolic disease that is primarily characterised by insulin resistance, relative insulin deficiency and hyperglycemia (Kraegen, Cooney and Turner, 2008). It is mainly caused due to a defect in insulin secretion, insulin action, or both. Insulin deficiency, in turn leads to chronic hyperglycaemia with disturbances related with carbohydrate, fat and protein

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metabolism. Once diabetes is diagnosed, it is considered expensive to treat as a result of higher medication costs, regular clinic visits, lab based testing, glucose monitoring and treatment linked with associated complications. Type 2 diabetes is associated with many complications such as cardiovascular diseases, renal diseases, advanced skin, muscle, bone infections, impaired quality of life and psychological effects such as depression or anxiety. It is largely the result of excess body weight and physical inactivity, and is commonly found in individuals over the age of 40 years. There is a higher incidence of type 2 diabetes in urban population than in rural ones. This disease is mainly associated with population whose life style has largely changed from traditional pattern to a modern "Westernized" model. Often, India is referred as the diabetes capital of the world. It is currently experiencing an epidemic of type 2 diabetes mellitus and has the largest number of diabetic patients (Diabetes Atlas, 3rd Edition). The study of prevalence of diabetes in India as reported in age-standardized prevalence is 4.3%, 4.4% and 4.5% for all adults, and males and females, respectively (Sadikot SM, Nigam A and Das S., 2004). This disease imposes a considerable burden on health care systems and societies in our country and the region. The cost implications of diabetes to society are multi-fold: direct costs to people suffering with diabetes, budget of their families and ultimately to the health care sectors where as indirect costs to society and government which included productivity cost including intangible costs that means adverse effects on quality of life of people and society. Very little is known about the economic impacts of diabetes in the developing world where predicted increase in

number of patients/prevalence are highest. With increasing concern among providers about the rising cost of health care, economic assessment of the impact of various diseases are rapidly growing in importance. In assessing the economics of diabetes, however, a number of questions must be addressed, including the definition and measurement of incidence, identification and measurement of economic impact, and an appropriate method by which incidence of disease and economic impact may be suitably linked. Diabetes clearly affects the budget of individuals, families, providers of medical care, and the concerned governmental ministries that pay for health care. These effect probably also impair communities and retard national economic growth.

Since complications in diabetes incur high health-care costs, waiting for the pandemic to run its course is unsatisfactory. South Asian countries can not afford the increasing burden of chronic renal failure and early blindness. The large size of poor population has lower prevalence rates than to the rich, but that have higher rates of complications due to later detection and diagnosis, in action on risk factors, and poor management ( A. Ramchandran and Snehlata, 2002) .

India has the dubious distinction of highest diabetes population and the prevalence rate is also increasing. It is due to this fact that IDF considered India as a diabetes capital of the world. The Indian population is more susceptible to diabetes as compared to the other ethnic communities. The main reason behind this phenomena is thrifty gene hypothesis which focuses on the possible reason behind, why Asians are more prone to diabetes? The hypothesis states that the 'thrifty' genotype would have been advantageous for hunter and

**Table 1 : Prevalence of Diabetes in World Top Ten countries**

World Rank	2010		World Rank	2030*	
	Country	Population (In Million)		Country	Population (In Million)
1	India	50.8	1	India	87.0
2	China	43.2	2	China	62.6
3	Unites State	26.8	3	United State	36.0
4	Russia	9.6	4	Pakistan	13.8
5	Brazil	7.6	5	Brazil	12.7
6	Germany	7.5	6	Indonesia	12.0
7	Pakistan	7.1	7	Mexico	11.9
8	Japan	7.1	8	Bangladesh	10.4
9	Indonesia	7.0	9	Russia	10.3
10	Mexico	6.8	10	Egypt	08.6

Source : International Diabetes Federation, 2011

\*Projected on present growth rate.

gather populations, especially child-bearing women because it would allow them to fatten more quickly during times of abundance. Fatter individuals carrying the thrifty genes would thus better survive times of food scarcity. However, in modern societies with a constant abundance of food, this genotype efficiently prepares individuals for a famine that never comes. The result of this mismatch between the environment in which the brain evolved and the environment of today is widespread chronic obesity and related health problems like diabetes. Thus, if we see in the total world diabetes population share of Asian population is much higher. Among the top ten world diabetes prevalence countries five are from Asian continent.

Diabetes among the South Asians is distinct in its etiopathogenesis, clinical presentation and complications. Endocrine morbidity is increasing rapidly in SAARC

nations and includes obesity, metabolic syndrome, and thyroid disorders (Hari and Mishra, 2013). According to report of Nepal Health Ministry, one in ten Nepalese is suffering with diabetes where women are slightly more affected with diabetes (59.1% vs. 56.8%). The clinical studies show that overall diabetes prevalence in rural and urban population has increased to 25.9% in 2009 which was 19% in urban population in aged 40 years and over (Shrestha U.L., Singh D.L. and Bhattari M.D.). The genetic studies show that south Asian people are more susceptible with diabetes due to thrifty gene factor. The countries like Pakistan and Bangladesh are also having the higher prevalence of the chronic disease but its proportion is found higher among the people of Bangladesh as compared to the Pakistan. There is a lack of diabetes base data of Bhutan and Maldives so the comparative study of these two nations of SARRC is not possible.

**Table 2: Prevalence of diabetes among SAARC nations**

Countries	Number of People with diabetes in 20-79 age group (millions)		Number of people with diabetes in 60-79 age group (millions)	
	2010	2030	2010	2030
India	50.76	87.03	15.58	31.83
Pakistan	7.15	13.83	1.65	3.56
Bangladesh	5.68	10.42	0.99	2.36
Bhutan	0.01	0.03	0.004	0.08
Nepal	0.51	1.07	0.16	0.35
Sri Lanka	1.53	2.16	0.50	1.02
Afghanistan	0.86	1.73	0.20	0.34
Maldives	0.01	0.03	0.002	0.01

Source: Based on World Diabetes Federation diabetes Atlas

### Objectives

➤ To analyse the spatial variation of prevalence of diabetes among States of India.

➤ To demarcate the socio-economic factors like age, residence, religion, caste, marital status, educational status and wealth index related inequalities which cause to spatial variation in prevalence of diabetes in the study area.

➤ To reveal the association of diabetes with the obesity factors of the population.

### Data Base and Methodology

The present study is based on the data of National Family Health Survey-III conducted in 2005-06 among all states of India and diabetes data released in 2011. It is the most recent major national health survey in India that collected demographic, socio-economic and health information from a nationally representative probability sample of 124,385 women (62.6%) aged 15-49 years and 74,369 men (37.4%) aged 15-54 years, residing in 109,041 households. The data was obtained at

the individual level by face-to-face interviews, conducted in the respondents' homes. An uniform multistage sampling strategy was adopted in all the states, with separate sampling in urban and rural areas. The overall household response rate in NFHS-3 was 98%. The chi-square test is also applied for the testing of confidence interval of the existed data. The researcher attempted to analyse the compiled data with the help of SPSS software and generated the thematic map of diabetes through Arc GIS 10.3 software.

### Spatial variation in prevalence of Diabetes

The spatial pattern of diabetes is strongly rooted in modified life style choice and local physical characteristics of the place. Place includes the physical characteristics of a location (e.g. climate, terrain etc.) and the culture, institution, tradition and life style to which people are exposed on daily basis (Creswell, 2013). According to recent estimates, approximately 285 million people worldwide (6.6%) in the 20-79 year age group

**Table 3: Spatial Inequalities in the Prevalence of Diabetes in India**

State	Women		Men	
	Number per lakh	Diabetes %	Number per lakh	Diabetes % in Male
Andhra Pradesh	838	0.83	2116	2.11
Arunachal Pradesh	537	0.53	606	0.60
Assam	402	0.40	601	0.60
Bihar	1024	1.02	940	0.94
Chattisgarh	659	0.65	932	0.93
Goa	1921	1.92	3016	3.01
Gujarat	968	0.96	524	0.52
Haryana	1169	1.16	608	0.60
Himanchal Pradesh	1048	1.48	344	0.34
Jammu and Kashmir	540	0.54	278	0.27
Jharkhand	652	0.65	629	0.62
Karnataka	681	0.68	973	0.97
Kerala	2549	2.54	3078	3.07
Madhya Pradesh	558	0.58	555	0.55
Maharashtra	479	0.47	906	0.90
Manipur	1006	1.00	1059	1.05
Meghalaya	910	0.91	641	0.64
Mizoram	1189	1.18	315	0.31
Nagaland	577	0.57	1217	1.21
Odisha	556	0.56	1179	1.17
Punjab	849	0.84	802	0.82
Rajasthan	282	0.28	362	0.36
Sikkim	1160	1.16	1698	1.69
Tamilnadu	2188	2.18	1351	1.35
Tripura	1656	1.65	2392	2.39
Uttar Pradesh	383	0.38	461	0.46
Uttarakhand	825	0.82	965	0.96
West Bengal	1641	1.64	2323	2.32
India	881	0.81	1051	1.05

Source: Based on data from National Family Health Survey-III, 2005-06 and personal calculation.

will have diabetes in 2010 that is likely to increase by 2030, to 438 million people (7.8%) of the adult population (*Diabetes Atlas, 4th edition, 2009*). The snapshot view of India

reveals that the southern states and north-eastern states are more affected with diabetes in comparison to central and western states. In depth analysis of data highlighted that

prevalence of diabetes is mainly associated with genetic, environmental, demographic and life style factors. According to National Family Health Survey-III data southern and coastal states of India like Kerala (2,549 per lakh), Tamilnadu(2,188), West Bengal (881) and Andhra Pradesh (883) are having higher prevalence of diabetes due to their fooding habits and demographic causes. Most of the north-eastern states like Manipur, Nagaland, Meghalaya, Mizoram, Sikkim and Tripura are having the higher morbidity of diabetes, excepting Arunanchal Pradesh where in it is found to be lower. The average prevalence of diabetes among north-eastern people is found higher than the national average. Lower prevalence of diabetes is recorded in central states of India namely Madhya pradesh, Uttar Pradesh and western states like Rajasthan. The northern states like Jammu and Kashmir and Himanchal Pradesh are also having the diabetes population less than the national average. The economically prosperous states of India namely Punjab, Haryana, Maharashtra and Gujarat are having the moderate prevalence of this chronic disease. So on the basis of data, it can be inferred that the alarming situation of diabetes is found in Southern coastal and north-eastern states of India.

**Rural-Urban Differentials :** Diabetes is no longer a disease of the affluent class of people. Rate of undiagnosed cases in the rural areas is much higher than the urban areas so we cannot say that diabetes is only related with urban areas and rich people. But most of the studies show that prevalence of diabetes is found higher in the urban population due to their sedentary life style, with more use of mechanized mode of transport. Pollution also adversely affects to the health of the people

and sometimes become the cause of chronic ailments like hypertension which in turn leads to diabetes and associated phenomena. The 6-fold higher prevalence of diabetes in the urban population as compared to rural (12% vs 2%) with periurbans or suburbans, having intermediate rates (6%) have been reported from South India (Ramachandran and Snehalatha, 1999). The peri-urban population was having largely sedentary lifestyle. Sedentary lifestyle appears to be an important determinant for the higher prevalence of diabetes in an urbanizing population. The data shows that prevalence of diabetes is found lower in both female and male population of rural area while it is recorded higher in the urban area. Among urban females it is recorded 1,374 per lakh, more than double of the rural females (641 per lakh). The similar trend is also witnessed in the male population where rural males are having only 860 per lakh while among urban males it is 1,383 per lakh.

**Age-**The prevalence of diabetes increases with age in all the population of the world. But in South Asians, it shows an early development of symptoms of the disease, with diabetes occurring at least 15-19 years earlier in comparison with many other ethnic groups. The National Family Health Survey data also corroborates the association of age and incidences of diabetes where lowest prevalence of diabetes occur in 20-34 age group with 0.43% prevalence rate, moderate prevalence of diabetes in 35-49 age group with 2.2% and its highest incidences found among the 40-49 age group where prevalence of diabetes is more than 5.6 % in male population. The major cause behind this early onset of diabetes is related with genetic and environmental factors but modern life style like consumption of more fast

food, using mechanized mode of transportation and restraining physical activity that are rapidly contributing to tendency of obesity in the early age of life. Among the urban middle income families the waist-hips ratio is increasing in the younger generation which becomes the very significant and prominent cause of diabetes. Thus, on the basis of following data one can state that there is natural potentiality of diabetes increasing with the age but it is interrupted by the modern fooding and life style.

### **Education**

There are some controversial associations found between certain variables of socio-economic status such as education level and self-reported diabetes. The illiterate males are more suffering from diabetes (1,172 per 100,000) in comparison to the people who have completed their primary education (1,111 per 100,000). Contrary to this fact there is unclear/vague relationship found among women who completed primary education are more prone to diabetes (1,358 per 100,000) than illiterate (690 per 100,000). The males who have completed matriculation are having more diabetes (1,033 per 100,000) than those who did not complete matriculation (713 per 100,000). The similar trend is witnessed in female population as well. The females who completed matriculation are having prevalence of 958 per 100,000 in comparison to 929 per 100,000 who did not complete their matriculation. Education is one of the significant parameters of socio-economic status that significantly affects awareness and consciousness to this chronic disease. Educated people are quite aware and conscious to those people who have poor education. The main cause behind this phenomena is that educated people in general are engaged mainly in

secondary and tertiary activities that require lesser physical activity. Some of them, specially highly educated people are shifting from their traditional to sedentary life style, using mechanized mode of transportation, consuming more fatty food items and beverage and do not involve in proper physical activity. This phenomena has become the integral part of life of educated people. Thus, after sometime they fall in the higher vulnerability zone of diabetes. The presence of stress/ hypertension in their place of work accentuate them to become diabetic. However, data to be considered for better interpretation should have treated graduate/ post graduate/ others separately.

### **Gender**

A positive and strong gender-based differential is also witnessed in the prevalence of diabetes all over the country. Globally, females are more prone to this chronic disease but in India, situation is totally different. Here, more than half number of states are such wherein males are more suffering with diabetes in comparison to female population. Bihar (1,024), Gujarat( 968), Himanchal Pradesh (1,048), Jammu and Kashmir (540), Jharkhand (652), Madhya Pradesh(558), Mizoram (1,189), Odisha (556) and Tamilnadu (2188) are the states of India where the female prevalence of diabetes is found to be higher than male diabetes. If we see in the specific age group of 15-19 it is found higher in females but it is recorded lower in the other age groups. On the residual basis, we also found that females are less effected with diabetes in comparison to their male counterpart. In certain religious groups namely Christian, Buddhist, Jain and other category women are more prone to diabetes while Hindu, Muslim and Sikh women are less effected with diabetes than

their male counterpart. The main reason behind this phenomena is Christian and Jain women are having higher life expectancy and life style. In the case of all the castes females are less effected with diabetes than males (Table no.4). According to wealth index it is found that higher wealth index males are more diabetic.

#### **Wealth Index**

Diabetes is a non-communicable chronic disease that is prominently found among the higher income group people so it is popularly known as *raj rog*(kingly disease). According to NFHS data, highest wealth index income group is having the highest prevalence of diabetes (1,503 per lakh in females and 1,957 per lakh in male). The main reason behind this phenomena is that most of the people of highest wealth index are engaged in variety service and quinary activities. These people are attuned to sedentary life style. If we look into the residual status of these population, most of them reside in urban areas where they are mostly using mechanised transportation and consuming rich diet with more fat/protein in their food (due to fast food and beverage). The analysis of data reveals that highest incidence of diabetes is recorded in the highest category of wealth index of male (1957 per lakh) while lowest incidence was found in lowest wealth index of female population (371 per lakh). Thus, it could easily be inferred that there is a strong positive correlation between wealth index and Diabetes prevalence.

#### **Marital Status**

The survey considered and collected the diabetes data based on the marital status based as well. The data shows that there is a significant difference in the prevalence of DM between widows/divorcees and the other marital status subgroups. Some findings suggest

that single, divorced and widowed status individuals constitute persons who may easily get adverse health effects (Ikeda and Sibai, 2007). Marriage may buffer against stress and thereby reduce the activation of the neuroendocrine system, which may lead to a reduction in the progression of atherosclerosis and other pathological processes (Ikeda, 2007). It is observed that never married people are less effected with diabetes, due to the fact that this group constituted of very younger age with lesser stress whereas prevalence of diabetes increases with the progression of age. Currently married people are suffering with moderate type of diabetes prevalence while it is recorded highest among widows/divorcees/ separated/ deserted ones. The main reason behind higher prevalence in higher age is more exposure with hypertension. Among widows/divorcees/ separated/deserted group females are more vulnerable due to the fact of patriarchal society and higher life expectancy. The females are having the 1,470 per lakh prevalence as compared to male which are having only 1,288 per lakh. Thus, on the basis of data base and existing studies we can say that marital status is not an independent deterrents of diabetes while it is mostly regulated through other variables like age, and socio-economic factors.

#### **BMI and Diabetes**

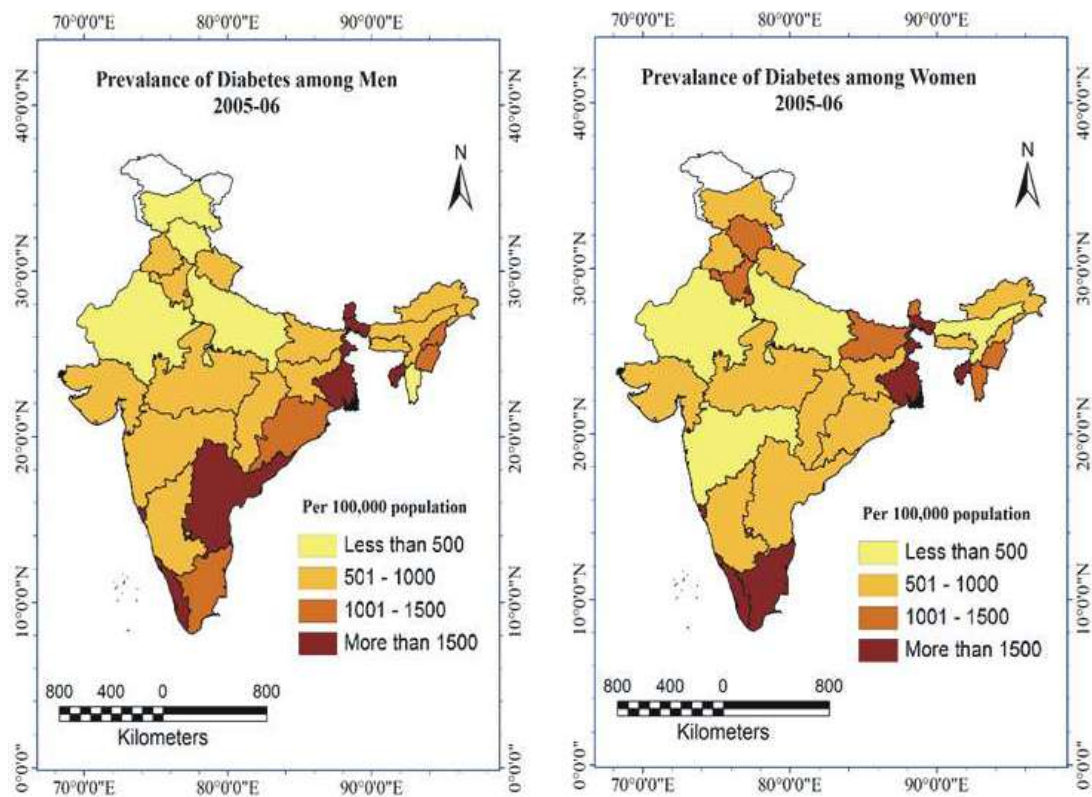
An increase in body mass is intimately associated with an increase in the risk of metabolic disorders such as diabetes. Body Mass Index (BMI) criteria are currently the primary focus on understanding the pathogenesis of life style diseases. Most of the clinical and non-clinical studies show that an increase in BMI is generally associated with a significant increase in prevalence of diabetes. Defining the relationship between body weight

**Table 4: Prevalence of Diabetes among different demographic background**

Background characteristic	Female per 100,000 Population	Male per 100,000 Population	X <sup>2</sup> P Values
<b>Age</b>			<0.0001
15-19	191	101	
20-34	403	442	
35-49	2075	2385	
50-54	NA	5641	
<b>Residence</b>			<0.0001
Rural	641	860	
Urban	1374	1383	
<b>Religion</b>			<0.0001
Hindu	824	1020	
Muslim	1037	1237	
Christian	1849	1238	
Sikhs	963	1318	
Buddist	684	683	
Jain	1600	1025	
Others	462	97	
<b>Caste</b>			<0.0001
Schedule caste	798	991	
Scheduled Tribe	379	477	
Other Backward Caste	774	955	
Others	1189	1336	
Don't Known	950	1307	
<b>Marital status</b>			<0.0001
Never Married	149	247	
Currently Married	1045	1514	
Widowed/ Divorced/ Separated /deserted	1470	1288	
<b>Education</b>			<0.0001
No education	690	1172	
<5 years complete	1358	1111	
5-7 years complete	1050	713	
8-9 years complete	929	817	
10-11 years complete	958	1033	
12or moreyears complete	878		
<b>Wealth Index</b>			<0.0001
Lowest	371	705	

Second	657	801
Middle	651	566
Fourth	1068	1001
Highest	1503	1957

Source: National Family Health Survey: 2005-06



**Map1: Prevalence of Diabetes among Men and women in the different states of India**

and metabolic diseases is critical towards better understanding of the underlying pathophysiological processes leading to these diseases. Data from the national health surveys reported support the common clinical observation that patients with higher BMI are at higher risk for having diabetes mellitus. The risk of diabetes was significant at BMI  $>23$  kg/m<sup>2</sup> for urban Indians of both sexes. Although

an increasing trend with BMI  $>22$  kg/m<sup>2</sup> had been indicated in our previous studies in urban southern Indians, the cutoff values had not been derived with age-adjusted BMI using appropriate statistical procedures (Ramachandran and Snehlata, 1997). The data shows that highest diabetes is found in  $> 24.9$  BMI while it is lowest recored in BMI less than 18.5. Thus, diabetes increases with the increase

**Table5: Prevalence of Diabetes among different life style habits with anthropometric background**

Characteristics	Participants		Diabetes Cases Diagnosed			
	Number	Percentage	Number	Percent	Prevalence	X <sup>2</sup> P Value
Body Mass Index ( Kg/m <sup>2</sup> )						<0.0001
< 18.5	46021	30.9	694	14.6	0.8	
18.5-22.9	67836	45.5	295	33.2	0.5	
23.0-24.9	15089	10.1	347	16.4	2.1	
>24.9	20050	13.5	691	35.8	3.2	
Tobacco Smoking						<0.0001
Yes	23156	14.8	335	16.3	1.3	
No	133160	85.2	1736	83.7	1.0	
Alcohol Consumption						<0.0001
Never	133067	85.1	1705	83.3	1.1	
Ever	23250	14.9	385	16.7	3.2	
Watching Television						<0.0001
Not at All	45916	29.4	403	20.7	0.7	
Less than once a week	21859	14.0	232	10.8	0.8	
At least once a week	20033	12.8	257	12.0	1.0	
Eveready	68480	43.8	1198	56.5	1.4	

Source: National Family Health Survey: 2005-06

of BMI that is indicative of a positive co-relation between Diabetes and Body Mass Index (BMI).

#### **Diabetes with Tobacco smoking**

Smoking is now considered to be an independent risk factor for pre-diabetes and diabetes and increases the risk of complications. Actually smoking habit also acts as a risk factor contributing to the condition of insulin resistance. Persons who are insulin resistant cannot use their body insulin properly. Future diabetes complications that have been proven to be aggravated by smoking include

diabetes nephropathy, hypertension, blindness and cardiovascular disease. A study of M.K. Biswas and A.K. Biswas shows that there is a positive association found between smoking and risk of diabetes. The diabetes patients, who are consuming tobacco in any form are more vulnerable as compared to those are not using. In the study, it is found that among the tobacco consumer diabetic patients 45.80 percent were smokers. According to NFHS database, tobacco smokers are having the higher chances of being diabetic in comparison to non-smokers. The prevalence rate of tobacco smokers is 1.3

**Table 6: Spatial Prevalence of Obesity in India**

States	Female		Male	
	(%)	Rank	(%)	Rank
Andhra Pradesh	22.7	10	17.6	05
Arunachal Pradesh	12.5	18	10.6	15
Assam	07.8	20	06.7	23
Bihar	10.5	28	08.5	18
Chattishgarh	07.6	26	06.5	24
Goa	27.0	03	20.8	03
Gujarat	17.7	07	15.4	10
Haryana	17.6	06	14.4	11
Himanchal Pradesh	19.5	12	16.0	08
Jammu and Kashmir	11.1	05	08.7	17
Jharkhand	05.9	27	05.3	27
Karnataka	17.3	09	14.0	12
Kerala	34.0	02	24.3	02
Madhya Pradesh	06.7	22	05.4	26
Maharashtra	18.1	13	15.9	09
Manipur	17.1	11	13.4	13
Meghalaya	08.9	25	08.2	21
Mizoram	20.3	16	16.9	07
Nagaland	10.2	21	08.4	19
Odisha	08.6	24	06.7	22
Punjab	37.5	01	30.3	01
Rajasthan	09.0	19	08.4	19
Sikkim	21.0	08	17.3	06
Tamil Nadu	24.4	04	19.8	04
Tripura	05.3	23	05.2	28
Uttar Pradesh	12.0	17	09.9	16
Uttarakhand	14.4	14	11.4	14
West Bengal	07.1	15	06.1	25
<b>India</b>	<b>16.0</b>	<b>.....</b>	<b>12.1</b>	<b>.....</b>

Source: Analysed from National Family Health Survey- III, 2005-06

percent while it is found 1 percent among non-smokers. The data shows that there is a positive association between diabetes and tobacco smoking.

#### **Alcohol Consumption**

As alcohol is high in kilo joules/calorie (25 K.J/G as compared to 10 K.J/G in carbohydrate). It can increase the much weight. Alcohol in itself has little nutritional value

hence kilojoules found in alcohol are often called “empty kilojoules”. Too much alcohol can increase the risk of developing complications by putting weight, increasing fat and raising blood pressure of persons. The habit of taking alcohol can make it more difficult to manage the diabetes. With occasional drinkers as baseline, risk was lowest in light to moderate drinkers and increased in the heavy drinkers (Shaper and Perry, 1998). Several studies like Joline W.J. Beulens, Ronald P. Stolk, Michiel L. Bots also highlighted that alcohol consumption increase the potentiality of diabetes in all age group but that is recorded higher in old age population. The data reveals that people who are consuming alcohol ever are more susceptible to diabetes in comparison to those who never go for alcohol consumption. But in absence of sufficient data base, further analysis is not yet possible.

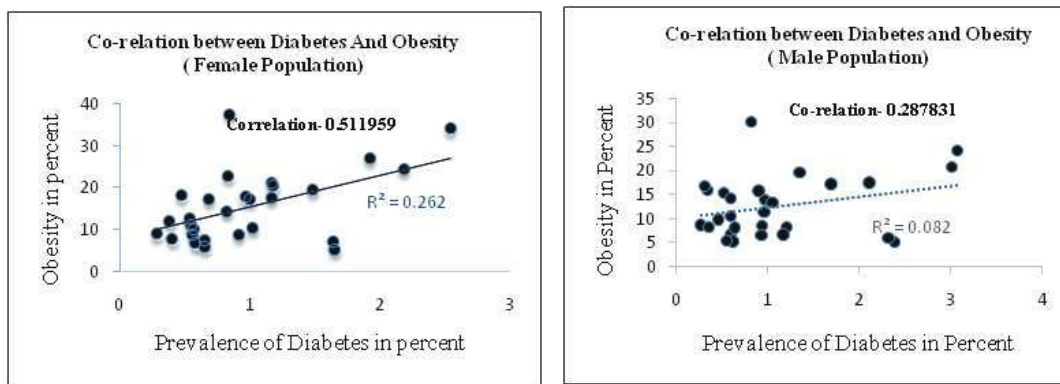
**Watching Television**

Watching television is a condition which reflects the vital aspect of sedentary life style. Persons spending more time on watching television are having higher chances of diabetes. The study, published in the journal Diabetologia, examined the impact of sedentary behaviour

over time on diabetes incidence. For participants in all treatment arms, the risk of developing diabetes increased approximately 3.4 per cent for each hour spent watching TV after adjustment for age, sex, treatment and time-dependent leisure physical activity. This association was reduced when time-dependent weight was added to the model (to a 2.1% increased risk of developing diabetes per hour of watching TV, which was not statistically significant) suggesting that subsequent changes in body weight may account for some of the relationship between sitting behaviour changes and diabetes development. The NFHS data suggested that persons who are watching television every day are having highest prevalence (1.4%) of diabetes and prevalence of diabetes reduces with the reduction of television watching and found lowest in not at all (0.7%). So we can see that NFHS data highlighted a positive association between watching television everyday (means sedentary life) and Diabetes.

**Association between**

**Diabetes and Obesity:** The International Diabetes Federation (IDF) says that, “Diabetes and obesity are the biggest



**Fig1: Co-relation between Diabetes and Obesity (In Female and Male Population)**

public health challenge of the 21<sup>st</sup> century. "Being overweight or obese is the main modifiable risk factor for type 2 diabetes. Currently 90% of adults with type 2 diabetes are overweight or obese (WHO, 2013). People with severe obesity are at greater risk of type 2 diabetes than obese people with a lower body mass index. There is seven times greater risk of diabetes in obese people as compared to those of healthy weight, with a threefold increase in risk for overweight people (Abdullah A, Peeters A, de Courten M.). The path from obesity to diabetes is made by a progressive defect in insulin secretion coupled with a progressive rise in insulin resistance. Both the insulin resistance and defective insulin secretion appear very premature in obese patients, and both worsen similarly towards diabetes (A. Golay and J. Ybarra, 2005). Although both diabetes and obesity risk factors are often associated with race, age, and family history, it's becoming more and more clear that the conveniences of modern life also contribute to the development of both the diseases. Overweight imposes extra stress on human body in different ways including the human body ability to maintain proper blood glucose levels. Another cause is that body fat reduces the working capacity of insulin. The secret behind increasing obesity in alarming rate is high energy diets and reduced physical activity which become the cumulative cause of diabetes. Overweight was defined as having a body mass index between 25 and 29.9; Obesity Class I as a body mass index between 30 and 34.9; Obesity Class II as a body mass index ranging from 35 and 39.9 and Obesity

Class III as a body mass index of over  $\geq 40$ .

There is a positive co-relation found between obesity and self-reported diabetes in India. The value of correlation was found higher amongst female (0.5119) and relatively lower among male population (0.2878). The positive association highlights that if obesity increases the chances of increasing diabetes will be higher in Indian population.

### Conclusion

The study found a significant association between self-reported diabetes and socio-economic determinant like age, sex, residence, religion, caste, marital status, education and wealth index. The highest socio-economic strata appears to be a significant determinant of diabetes where prevalence of diabetes is lower in lower age group and increase with age and highest found in old age population. The male population of the study area is more influenced by this chronic non-communicable disease in comparison to female population. The group of higher wealth index is more affected with diabetes means the co-relation between household wealth and diabetes remained positive and significant in all the demographic parameters. Some southern and northern states were associated with a higher risk for reporting diabetes while several northern and central states were at lower risk after adjusting for individual characteristics and place of residence. The study showed that an increase in BMI is generally associated with a significant increase in prevalence of diabetes mellitus. The study covers the national scenario so it is very fruitful for the Geodemographic study of diabetes and its associated factors.

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# Women and Common Property Resources: A Case Study of Rural Awadh Tarai

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Rural women and men share different tasks and responsibilities which results in different needs, priorities and concerns. Although these responsibilities vary across regions and cultures, but rural women often follow similar gender division of labour. In most of the cases, rural women have the responsibility for the collection of fuel-wood, food and fodder for animals for which they are heavily dependent on common property resources. Men seldom have responsibility for collecting and using natural resources for household use. Based on primary data generated through fieldwork, the present paper delves into role played by CPRs in the lives of rural tribal women of Awadh Tarai.

**Keywords:** Common Property Resource, Common Property Resource Management, Forest, Land, Water.

## Introduction

Common Property Resources (CPRs) constitute a very important part of rural life. CPRs perform various functions in the rural economy by supplying physical products in the form of fuel, food, fodder, etc. as well as employment generation and income generation (in the form of collection of varied products from CPRs), and asset accumulation—directly or complementing the private resource based activities (Jodha, 1986). CPRs help in reducing prevailing inequality in rural areas whose impact is greatly minimized by them as the poor can supplement their meagre resource free of cost from CPRs. CPRs also contribute to the quantity and quality of nutrition of the poor by facilitating his/her food gathering from forests,

ponds and other sources (Rudra, et al. 1991).

Poor rural women lacking secure land tenure often depend on CPRs for fuel-wood, fodder, and food; and, therefore, for the well-being of their households. The depletion of CPRs poses a severe threat to the livelihoods and food security of the rural poor. Due to gender based division of labour the women of rural India are much closer to their local natural resources rather than men. Societal structure of rural India is strictly patriarchal. So, to satisfy their practical gender needs and to fulfil their inherent responsibilities towards the family, availability and access to the commons make women less dependent on their male counterparts. In the existing socio-economic structure of the country, rural Indian women

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seldom own any property but they have to perform all household duties whether male member in the family earns or not. According to the United Nations, women have equal rights to own property in 115 out of 193 countries and equal inheritance rights in only 93 countries, i.e., less than 50% (UNW, 2011). The women of rural India, as revealed by several surveys, are largely dependent on the CPRs for food, fuel, fodder and so many other items and they use them harmoniously without damaging nature's homeostatic mechanism which helps the natural resources to restore their biomass with time. Due to disguised unemployment, unequal distribution of resources, it is really hard for vulnerable rural population to attain their livelihood. Therefore, it becomes important to identify the role of village commons to reduce their vulnerability and to enlarge their list of choices especially in the areas of difficult geography. CPRs currently contribute some US \$5 billion a year to the incomes of poor rural households in India, which makes about 12% of household income of the poor rural households. This is about two and half times of the World Bank lending to India in fiscal year 1996, about twice foreign direct investment in India in 1996, and more than twice the amount official development assistance in the same year (Beck and Smith, 1999).

The present paper seeks to specifically examine women's use of CPRs in the sample villages' forests and pastures with an accompanying aspect of how women were involved in resource management with special reference to the Tharu women living Awadh *Tarai* region of Upper Gangetic Plain. In this, the objective was to understand women's informal organization and influence over village commons' management.

### **Common Property Resources: Basic Conceptual Frame**

Broadly speaking, CPRs include all such resources that are meant for common use of the villagers. They are non-exclusive resources where members of the community co-share the usage rights and obligations (Bromley and Cernea, 1989; Margrath, 1986; Ostrom, 1988). In simple terms, CPRs could be described as community's natural resources where every member has access and usage opportunity with definite obligations but no exclusive property right to them. In the dry tropical regions of India, CPRs include community forest, pasture, common dumping and threshing grounds, rivers and rivulets, their banks and beds, watershed drainage, village wastelands, etc. In the legal sense, some of them may belong to other agencies (e.g., the village wastelands belonging to the revenue department of the state); but, in *de facto* sense they are used and managed by the village communities. Despite differences in some of their specific uses and the legal nomenclatures in the village revenue records, most of them are less separable in terms of: (i) utility—as sources of varied biomass; (ii) the current vegetative make up consisting of sparse trees, shrubs, grasses and empty patches, seasonality of product flows; (iii) the usage regulations or rather disregard of them and consequent pace and pattern of their degradation; and (iv) the coverage of most of them without discrimination under public programmes like social forestry. Hence, one can use the term “forest-CPRs” without restricting it to community forest, but encompassing all CPRs contributing to natural biomass supplies to the village communities.

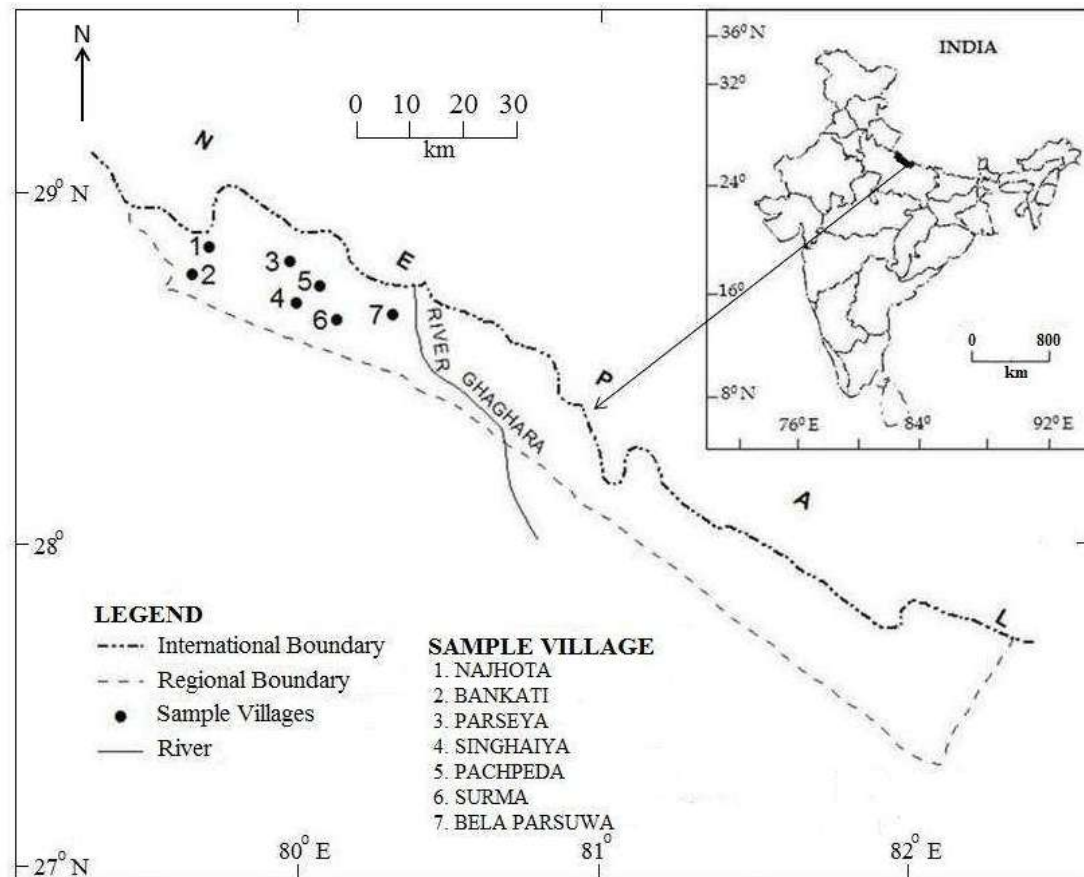
In the pre-British India, a very large part of the country's natural resources was freely

available to the rural population. These resources were largely under the control of local communities. Gradually, with the extension of state control over these resources and the resultant decay of community management system, the CPRs available to villagers declined substantially over the years (NSSO, 1999: 15-25). Today, in almost all parts of the country, the villagers have a legal right of access only on some specific categories of land and water resources. Nevertheless, it is widely held that CPRs still play an important role in the life and economy of the rural population.

### **Women and CPRs**

Local commons or village commons are the local natural resources available to all local users and on which no one has exclusive property rights. CPRs as “institutional arrangements” evolved by communities to collectively manage and use their natural resources. Both of these definitions show how there is a harmonious relationship existing between CPRs and local communities and accordingly, these resources are managed and used by their indigenous knowledge system (cf. Jodha, 1992). This system of community resource management has always been proficient in reducing vulnerability of the subalterns even in the times of natural calamities but has always been denied due importance. Across the world, the commons have been observed to be declining in size and in productivity (Jodha, 1985). Some scholars are of the opinion that the circumstances which historically favoured CPRs have been replaced by those that favour market controlled elitist productions in particular due to trends of privatization and commoditization under conditions of neoliberalism (McCarthy et al., 2001).

Males also use CPRs to a large extent but nature of their utilization is different as they collect timber as well as non-timber products to generate money. Decline in CPRs will certainly affect them but it would be greater in case of females due to persisting gender division of labour and lower mobility of the later. It can be said that from time immemorial these local resources have been a part of the lives of rural Indian society, especially rural women, who due to a gendered division of labour are closer to CPR's. In rural South Asia, women as well as girls typically have longer workdays than men and boys; and, they also bear responsibilities which link them to forests and village commons in particular ways. They gather a lot of items including wood, fuel, food, fodder and locally available building materials from them. Apart from this, they utilize the place for several purposes like marriages and other socio-religious functions. Forest and local commons also provide important supplements to daily subsistence diet and cushions during period(s) of scarcity. A study has revealed that in Andhra Pradesh (South India), village women identified seventy-nine species of uncultivated leafy greens that they gather for food, in addition to roots, tubers, and fruits; and in Bangladesh's Tangain district, such uncultivated plants are found to provide, on average, 65 % of the food weight of poor landless households and 34 % of the food weight of better-off landed households (see, Agarwal, 2010). During the times of natural calamities like flood, dependence of women on CPRs increases. However, in the area concerned, villagers are forced to be alienated from the village commons due to lack of legal entitlement to these resources and in the name of conservation. Unfortunately, the legal system



**Fig. 1. Location of the study area and sample villages**

and policy makers in India either do not identify the role played by CPRs in the lives of the villagers in general, and women in particular or they consider these laws, inherited from colonizers, as more important than promoting the sustainable use of CPRs to make the lives of villagers less vulnerable.

#### **Study Area: A Brief Introduction**

The study area, *Awadh Tarai*, is a sub-region of Upper Gangetic Plain. It runs along Indo-Nepal international boundary in four districts of Uttar Pradesh, namely Pilibhit, Kheri-Lakhimpur, Bahraich and Shravasti.

Immediately south to the Siwalik outer-hills and skirting them there is a dry boulder strewn tract of *bhabar* (literally means 'porous land') where the bulk of moisture contributed by rainfall and small hill streams is absorbed in the loose talus. This tract is followed by a low marshy stretch of land where water, absorbed by the porous soils of the *bhabar*, reappears by symphonic influence and which is conspicuous by the 'ubiquitous' presence of water. It is infected at places with reeds, tall grasses and scrub forests, marked by high water table and fertile though highly leached soils with high moisture and high clay factor.

This is known as *tarai*, which literally means 'moist or wet land' (Sharma, 1991). *Awadh Tarai* lies approximately between 28°33'E-29°25'E, 80°20'N-82°10'N, covering about 4500 km<sup>2</sup> area of Uttar Pradesh. The soil of this region offers a striking contrast to the other soils found in India. Viewed geologically, the *tarai* soils are sub-recent alluvial formation. This feature gives the soil a homogenous character. The soil throughout consists of heavy clay admirably suited for the cultivation of paddy. The mineral content of this area is very insignificant and practically confined to *kankar* and brick each. There is scarcity of iodine in water (Mathur and Midha, 2008). Drainage lines hold in the region as not only do they provide redeeming topographic breaks in the general flatness of the plain and provide individuality to the plain, but they also govern to a great extent the human occupancy of land, particularly the agricultural land settlements. The whole of *tarai* tract is a network of rivers and streams which drain the area and follow its general slope (cf. Sharma, 1991).

### Data Source and Methodology

*De facto* approach has been adopted for collection of data in this study on the use of CPRs by women. In this approach, the coverage of CPRs was extended to include all such resources which might not be within the boundary of village but supply biomass to the rural people. So, it can be said that all such resources which are used as CPRs by the villagers were treated as 'CPRs' for data collection.

The present study is based on comprehensive field work done on the *Tharus* of *Awadh Tarai* in seven villages named Bankati, Bela-Parsua, Pachpeda, Parseya, Najhota, Surma and Singhaiya of Uttar Pradesh.

The selection of sample villages has been done through purposive random sampling. Villages have been selected first on the basis of greater percentage of tribal population. The villages selected are located in buffer areas of Dudhwa National Park and are inhabited by people of the *Thrau* tribe. In the second step, villages were further shortlisted on the basis of their proximity to the forest. The survey households were then selected on the basis of stratified sampling. The door to door survey was conducted using interview schedule. The households of the sample villages were divided into two economic sections: those who do not have any permanent source of income have been termed 'poor'; and, the rest are categorized as 'others'. Further, two estimations have been done:

#### *Estimation of Income Generation by CPRs*

The total income derived from CPRs by a household has been estimated as the following:

$$ER = X1 + X2$$

Where, 'ER' is the economic returns from CPRs; 'X1' and 'X2' are the imputed values of fish and fuel-wood collected as both of these, on the basis of frequency of collection, have been identified as major activities for income generation for the females.

#### *Estimation of Employment Generated by CPRs*

The employment generated by CPRs has been estimated by evaluating the annual working days spent per woman per household in CPR-product collection. Eight working hours by an adult female have been considered as one full day (cf. Jodha, 1986; Singh, 1993).

### Analysis and Discussion

**Utilization Pattern of CPRs :** India is still a biomass-based society (Gadgil and Rao,

1996); and hence, CPRs have a direct bearing on the life-support systems of people, specifically in the rural areas as the studies emphasize. CPRs have historically provided and continue to provide a wide variety of essential items—food, fibre, fuel, fodder, small timber, manure, medicinal herbs, building materials, raw materials for handicrafts, resin, gum, honey, spices etc. for subsistence, use and sale (Jodha, 1992). In fact, they are so intricately interlinked with other aspects of rural economy that it is very difficult to examine the actual degree of dependence of rural households on them. In our society, men are supposed to earn for the family, whereas women are generally confined to the hearth. For fulfilling their household requirements and to feed the members of the family, women collect fuel, food, and fodder from CPRs free of cost. They are concerned not only with the quantitative value of CPRs but also with the qualitative value, as they use it for several other purposes. Like in North India, several marital and other socio-religious functions are performed at these places.

Since the focal concern of the present section is to examine the contributions of CPRs in the household economy of the rural people mainly based on female based activities, to capture the level and nature of contributions of these resources, the proportions of households utilizing them for different purposes, amount of CPR-products collected by the sample households, and actual extent of employment and income provided by CPRs to the rural women are analyzed. Although women utilize CPRs for variety of purposes but on the basis of field survey fuel-wood collection and fish

collection have been found to be two major female based activities contributing to employment and income generation.

### **Fuel-wood Collection**

The forest resources meet substantial needs of villagers in the form of non-timber forest produce (NTFP) and other forest produce, which they collect from the forest. Fuel wood collection is one of the primary activities performed on CPRs. A large part of country's rural society is still dependant on biomass energy resources to fulfil their household energy needs. During the survey it has been observed that a large number of households, almost around more than 95 %, depended on CPRs for fuel wood. Fuel wood is the primary item collected from the forest on daily basis and it fulfils energy requirements of the village population.

Fuel-wood is collected by females as the gendered division of labour renders the responsibility of food preparation with them. Although due to greater dependence of family on fuel wood, in pre-Monsoon period whole family goes for collection. One very interesting finding is that there is no economic class division observed in the use of fuel wood for cooking. Almost all respondent females (97.14 %) have reported use of fuel wood as the only source used for cooking purpose. Their primitive lifestyle might be the prime reason for this. Distant market, lack of public transport, large-sized families, might be some other reasons responsible for it. Moreover, wood of *sakhu* tree, which is a dominant tree species in surrounding areas of Dudhwa National Park, have very high calorific value so less quantity

**Table 1: Role of CPRs in household energy supply, income and employment generation**

Sample village	Socio-economic class	Household (hh) energy needs (%)				Households reported collection from CPRs (%)	Average annual quantity collected (kg)	Average annual income generated by CPRs (Rs)	Average daily time spent on collection by CPRs (hrs)	Collection- by*	
		Fuel- wood		Both gas & fuel wood						M	F
		No.	%	No.	%						
Bankati(28)	Poor (24)	24	100	—	—	100	1922	7688	3.5	7.2	92.8
	Other (4)	2	50	2	50	75	1570	6280			
Sigahiya(31)	Poor (28)	28	100	—	—	100	1931	7724	4.0	6.5	93.5
	Other (3)	2	66.7	1	33.3	100	1738	6952			
Surma(35)	Poor (32)	32	100	—	—	100	2022	8088	4.5	2.9	97.1
	Other (3)	1	33.3	2	66.7	100	1952	7808			
Pachpeda (25)	Poor (21)	21	100	—	—	100	1896	7584	3.5	7	92.0
	Other (4)	1	25	3	75	100	1838	7352			
Parseya(44)	Poor (38)	38	100	—	—	100	1878	7512	4.0	—	97.7
	Other (6)	1	16.7	5	83.3	100	1734	6936			
Najhota(26)	Poor (24)	24	100	—	—	100	1976	7904	4.0	—	96.1
	Other (2)	—	-	2	100	100	1920	7680			
Bela-Parsua (72)	Poor (63)	63	100	—	—	100	2088	8352	3.5	—	98.6
	Other (9)	2	22	7	77.7	88.9	1895	7580			

Note:

The values in parentheses indicate number of households.

\*Fuel wood collection being one of the major activities performed on CPRs, employment and income generation from it has been calculated to assess its role in the lives of rural women:

Average annual income for poor = Rs.7836

Average annual income for others = Rs.7227

Average daily time spent = 3.9 hours

Employment generation =  $3.9 \times 365/8 = 177.94$ , i.e., 178 days approx.

Source: Based on personal fieldwork, 2014-2015.

and less time is required to cook food. It also protects them from cold in winter season, when other energy sources to protect them from the cold are missing. The villagers stock up the wood collected from forest in their backyard and on the tree(s) in the courtyard of their house and use them at during rainy season as well as for distress sale. Table 1 also reveals that sale of collected fuel wood is not a common phenomenon among the villagers. Although, in

time of need they obtain it from others exchanging some item of the same value. Thus, it is evident that mostly they use it for self-consumption. It is also interesting to know that even the households belonging to other sections, nearly 35.2%, used only fuel-wood for cooking; and, 64.7% responded using both fuel-wood and gas. It clearly shows that people have high dependency on CPRs for their energy related needs.

**Table 2: Fish collection from CPRs**

Village	Socio-economic strata	Average annual quantity per hh (kg)	Average annual income per hh (Rs.)	Average daily time spent (hrs.)	Collection done		
					Male	Female	Both
Bankati	Poor	225	6750	2.1	8.3	62.5	29.2
	Others	235	7050	2.2	—	50	50
Singhayia	Poor	260.7	7821	2.2	10.7	67.8	22.5
	Others	250	7500	2.1	—	100	—
Surma	Poor	235	7050	2.1	9.3	78.1	12.6
	Others	235	7050	2.1	—	66.7	33.3
Pachpeda	Poor	208.5	6255	2.0	9.5	61.9	28.6
	Others	225	6750	2.2	—	75	25
Parseya	Poor	234.6	7038	2.4	10.5	71.0	17.5
	Others	230	6900	2.3	16.7	50	16.7
Najhota	Poor	220	6600	2.1	8.3	54.2	37.5
	Others	225	6750	2.2	—	50	—
Bela Parsua	Poor	250	7500	2.3	13.3	63.4	23.3
	Others	250	7500	2.2	8.3	41.6	25

Note:

Average daily time spent= 2.2 hours; Average annual time spent=2.2 x 365=803 hours; Employment generation for females= 100.3

Source: Based on personal fieldwork, 2014-2015

### Fish Collection

Fishing is another major CPRs based activity performed by females along with fuel-wood collection in the study area. It also plays significant role in income and employment generation for women. Going by the Table 2, it may be noticed that on an average per household annual collection of fish is around 235 kg. During a year, average daily time spent is 2.2 hours per female per household. Average contribution to income rests at Rs.7002 for poor households and Rs.7071 for other households. Moreover, it also provides nutrition to the village

people who possess very few options to consume nutritious food.

On the whole, CPR product collection provides approximately 278 female days of employment per household per year. This shows greater importance of CPRs for female members mainly due to gendered division of responsibilities.

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**Table 3: Employment generation for males and females**

Activities	Annual employment generation(per hh)	Annual income generation (per hh )
Fuel wood collection+Fishing	178+100= 278 days approx	7531+7036= 14567

Source: Based on personal fieldwork data, 2014-2015

**Other Activities**

It is not possible to translate all the supplies and services provided by CPRs into income flows but this by no means diminish the role played by the CPRs in the lives of average rural poor and particularly in the lives of rural women. Women also collect fodder from CPRs but the area concerned is rich in biomass availability and grazing time is also higher. That is why frequency to visit CPRs for fodder collection has been reported low. Apart from the above activities, women and children dug out clay from ponds is used for plastering the huts, washing hair, making clay vessels, etc. We can see extensive use of clay made objects in their day to day lives. Moreover, women also collect seasonal fruits, roots, tuber etc. from nearby forests and ponds. These items not only diversify their food options but also provide them with extra nutrition. Since long villagers are living in proximity to the forests. Thus, they have great knowledge of plants and herbs found there and they use them for various purposes. Old *Tharu* women have a good knowledge of local ethno-medicine practices to cure minor ailments for which they use several local plants and herbs. CPRs also provide them (public) space to perform several religious functions. As a matter of fact each *Tharu* village is located near a grove to hold most of the social and religious functions.

Thus, it is evident that CPRs help in income and employment generation to the rural women, and, the rural women of *Tarai* utilize number of products collected from CPRs in their daily lives.

**CPR Management and Women**

As mentioned earlier, the sample villages are located in buffer areas of Dudhwa National Park and inhabited by the Thrau people. This tribal community has lived in harmony with forest since more than a century. They have a strong cohesive society, a rich culture, a vibrant and colourful dressing style and rice and fish are their favourite food. They have special knowledge of medicinal herbs and barks. They form an inseparable part of these jungles of Awadh Tarai. Their simple and serene lifestyle set a perfect example of harmonious co-existence between man and nature. According to Nesfield, “the Tharus are, for the most part, a peaceful and good natured race, following without question, as if law of nature, the customs and maxims of their ancestors”, while Charles Williams described them in Oudh census report in 1869 as ‘courageous and good-natured, peaceful, and hardworking. . . mutually helping each other’ (cf. William, 1869).

Although agriculture remains to be their main occupation, they still perceive forest as their home. However, the people residing in the study area do not follow any grand design to

manage the CPRs. Their socio-cultural setting in which group action, co-operation and respect for natural environment are in-built in their way of living, promotes management of CPRs. Conservation efforts in this human dominated landscape requires the basic support of local residents. This will require sustained efforts to expand the conservation benefits to locals, improve compensation for losses to wildlife, and improved relationship with forest officials and to create alternative opportunities to reduce dependence on natural resources. Reducing dependence on fuel-wood for cooking must be the foremost priority of policy makers as it has been mentioned earlier that around 98 percent people depend on it.

The diagnosis of the existing systems of CPR use and management in the sample villages reveals that no effective formal or informal institutional arrangement functions have been devised and implemented for the CPRM. The elected village *Panchayats*, a formal institution responsible for the development and management of CPRs, have miserably failed to establish any effective mechanism for the said purpose. The traditional socio-cultural and religious ethos, of self-restrained use of CPRs, is still pertinent in the region. Thus, the use of common property has been according to need and it is not driven by greed. More precisely, the prevailing CPRM has been highly unsustainable, inefficient, and highly bureaucratic and authoritarian. It has been leading to very negative outcomes with respect to both CPRs and rural society. Although both rural men and women play a significant role in natural resource management, women's use, conservation and knowledge of

resource play a key role in shaping local biodiversity. Despite of this fact, participation of rural women has totally been ignored.

At the local level, natural resource projects and interventions emphasize community-level participation. Careful and thoughtful planning in relation to gender must be exercised in the design of participatory projects. Even community-level participation often leaves women's voices and concerns unacknowledged. When women attend meetings or events, they may not feel free to voice their opinions, or their opinions and needs may not be taken seriously (cf. Agarwal, 2003).

### **Conclusion**

Women in rural India, due to social roles assigned to them, remain closer to CPRs than men without harming its existence. CPRs being out of market value can be a very good option to reduce gender vulnerability as women of the study area extensively use CPRs to fulfil their household responsibilities. Considering their role in income and employment generation for rural women, it is important to recognize the role of CPRs to promote preservation of these local natural resources rather than conserving them. Involvement of rural women in managing these resources is indispensable. Thus, it would be better for policymakers to actively involve women in the management of CPRs in general and forests of Awadh Tarai in particular. It would certainly be beneficial for the villagers as well as to the environment if the intuitive knowledge and practical experiences of rural women are given importance in framing the policies related to conservation and preservation of the CPRs. This will lead to the empowerment of *Tharu* women and will also

lead to sustainable development. Thus, it can be said that women should be given a voice when it comes to the CPRs to benefit both.

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# **Growth and Distribution of Population in Basti City (1901-2011)**

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Population is the basic resource and its impact on overall development becomes the key factor in the local level planning. Population characteristics and socio-economic factors determine the direction and destiny of urban development. The socio-economic conditions are very much influenced and governed by the different demographic characteristics like growth of population, their distribution and density pattern, sex composition, literacy etc. These demographic characteristics are conditioned by the attractive and restrictive factors like physico-cultural, infrastructural development like urban water supply and sewerage facilities and transportation etc. This paper intends to examine the aspects of population of a class I city i.e. Basti in spatio- temporal context.

**Keywords :** Matrix, Growth, Spatial distribution, Size class jump, Concentration index, Density, Scheduled caste, Scheduled tribe, Non-notified slums.

## **Introduction**

Population plays dual role of producer and consumer which is in turn influenced by the quality of population. Demographic dimensions will include the growth, distribution, and density of population as well as the occupied by scheduled caste and scheduled tribe population and their social characteristics in the municipality of Basti city. Recent trend in the population growth have been examined in the long term of perspective of ten decades of the city and the spatio- temporal distribution and density of population have been analyzed for two decades (1991 and 2011). The analysis of population distribution, density and growth is one of the most significant aspects for the geographers since it squarely presents the demographic characteristics of an area.

The increasing population and its uneven

distribution have attracted the scholars to measure various population facts. Population distribution is important in understanding the spatial spread of population and its concentration as sparse, dense, agglomerated distribution etc., while the density of population demonstrates the man- land ratio by relating the size of population with the area. The different physical, social, and economic set up of an area produce the varying pattern of population distribution and density. It is, however, not to suggest that population distribution, density and its growth on the earth surface is determined only by physical factors rather socio- cultural and economic factors strongly influence the pattern human beings is distributed over the earth. These factors do not operate in isolation but in combination with each other. One cannot, therefore, isolate the

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influence of any one factor on population distribution and density. The interplay between these determinants is generally very complex. Spatial distribution of population in an area is the product of interplay between the physical milieu and the society through the matrix of time. Since the understanding of the contemporary population pattern requires a peep through the past, the dimension of time gets appended (Chandna, 2012). The entire matrix of determinants have rightly been summarized by Zelinsky (1966, p.53) in the following words “in order to understand the meanings lying behind the contemporary pattern of population, one must wield encyclopedic knowledge of the area’s physical setting, economic behavior, the broader lineaments of its cultural and social structure and virtually all aspects of its human geography.”

Physical conditions, such as climate (temperature and rainfall), landforms in terms of altitudes, and the quality of the soil and the availability of energy and mineral resources are the important geographical determinants of population distribution. These above geographical factors affecting population distribution clearly indicates that, generally, no factor by itself is responsible for the concentration of population or lack of it. All these factors are interrelated. Geographers are not unanimous in their opinion that the distribution of population is determined mainly by physical factors. Social and economic factors are more important than physical factors, and that, as society becomes more complex, these physical factors become less important in determining population distribution. Though the three demographic variables fertility, mortality and migration are themselves determined by social, economic and geographic

factors, it is possible to consider them in the light of their influence on population distribution. Differential fertility and mortality rates lead to differential growth rates which, in turn, lead to changes in the population of a region over a long period of time.

### **Objectives and Methodology**

Within this introductory note and contextual background this paper aims to examine

1. The trend and pattern of population growth in one of the class I cities of eastern Uttar Pradesh i.e. Basti since the beginning of 20<sup>th</sup> century (1901- 2011).
2. The spatial pattern of population distribution and density and its relationship with existing urban land use.

This work is primarily based on secondary data sources including published and unpublished records available in different institutions/ offices at the state, district and municipal authority level. Some of the relevant grass root level information has also been collected through FGD, PRA and informal discussion with the city dwellers. The information about the reconstruction of the townscape during various historical periods is obtained from the Gazetteer of Basti district (1907 & 1988). All the maps have been prepared on Arc- GIS 9.3 with the help of the city map of 1991 and 2011, collected from Basti Municipal Board and Google earth images (2013) and also the Toposheets (No.63 J/9 & 63 J/13) of the Basti district (1907 and 1975) . Population projection for the city has been calculated by using the formula-

$$A = P (1+r/100)^n$$

where, A is the projected population, P is the present population, r is the annual growth

**Table 1: Ward Wise Area and Population of Basti City**

Ward No.	Ward Name	Area (Km <sup>2</sup> )	Poulation (2011)
1	Mishrauliya	0.9	6019
2	Narhariya	0.9	5367
3	Purana Dakkhana	.75	6323
4	Murlijot	.7	5737
5	Pandey bazaar	.85	5127
6	Turkahiya	.95	4955
7	Pikaura Shivgulam	.8	3484
8	Surtihatta	.93	3392
9	Pikaura datturai	.81	4751
10	Chikwatola	.95	5487
11	Rautapar	.65	4973
12	Malitola	.71	3281
13	Pathantola	.65	5921
14	Company Bagh	.6	2391
15	Gargoriya	.7	4169
16	Barihawa	.65	4294
17	Rameshwerpuri	.82	4079
18	Italiya	.93	4353
19	Belwadandi	.65	4564
20	Pikaura Bux	.95	4502
21	Vishunpurva	.63	4210
22	Awas Vikas Colony	.7	5479

rate, and n is the number of years. Taking year 2011 as base year, population has been estimated for the next four decades, i.e. 2021, 2031, 2041 and 2051 AD.

### The Study Area

Basti city, headquarter of the district Basti is situated on the bank of river Kuwano, and is located at the coordinates of 26° 47'N latitude- 82° 43' E longitude at a distance of 80km west-north-west of Gorakhpur and 82km east of Faizabad. Located in the eastern Uttar Pradesh

in the Middle Gangetic Plain, it is the largest town of the district with 114657 populations (2011) distributed in 25 wards of Basti Municipal Board. Average rainfall of the city is 1044.70 mm. and average mean temperature is 33° C. The area (19.43 km<sup>2</sup>) of the city has been constant since 1961 when the city boundary was demarcated. Population density of the city is 5901 persons /sq.km. About three fourth (74 per cent) of the population is literate which is more than the state average (67.7 per cent). Female literacy rate is 68 per cent and male literacy rate is 78 per cent. Sex ratio of the city is 908 females/ thousand male which is slightly less than the state sex ratio (912 females/000 males). Basti city is at present governed by the Uttar Pradesh Municipal Act (1916/1959) as amended from time to time and in the light of provision of Nagar Palika Act (1994).

## Results and Discussion

### Population Growth

The concept of growth of population is often used to connote the change in the number of inhabitants of a territory during a specific period of time, irrespective of the fact whether change is negative or positive (Chandna, 2008). It is controlled by the relative balance of fertility, mortality and migration which are generally influenced by six groups of factors: biological, environmental, economic, social, political and technological (Sauvy, 1969). Population growth rate calculated with the help of actual population counts is known as natural increase of population growth. This natural rate of growth of population is obtained by dividing the difference between the births and deaths of population at the beginning of the period and multiplying it with hundred. It implies that while in case of natural growth rate only the births

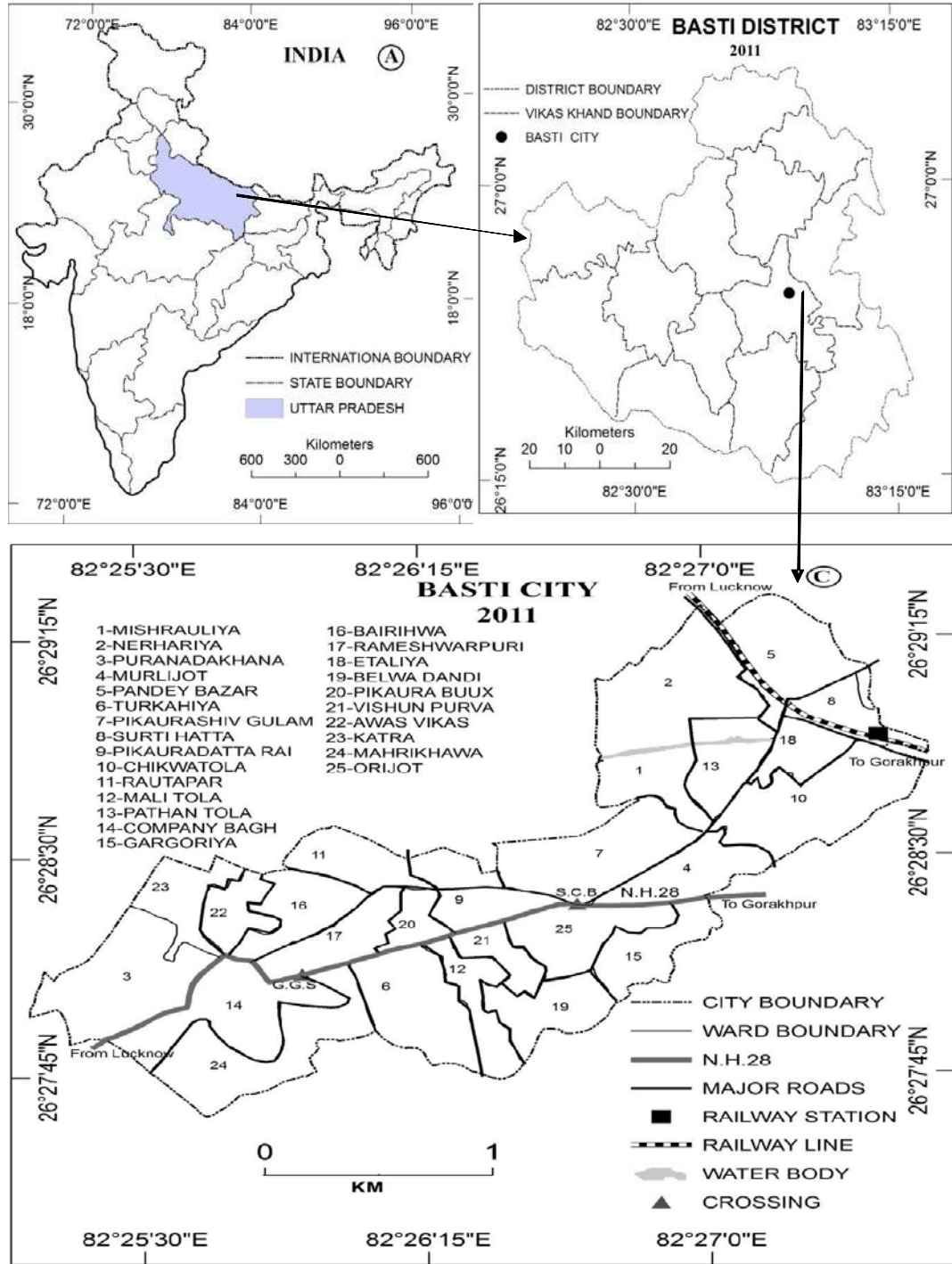


Fig.1

and deaths are taken into account, in case of actual growth rate, the factor of migration is also taken into consideration. Both actual and natural rates of population growth have been subjected to spatial portrayal and interpretation. The factors which are responsible for population growth, consists of progressive character of population, greater transport and communication facilities, urbanization, development in agriculture and infrastructure as well as deterioration in death rate. These factors transform the traditional rural settlement i.e. village into a town/city.

Population growth of Basti city can be analyzed conveniently with the help of census data available from 1901 onwards. As it is well known that India's population remained stationary around 100-200 million through most part of its demographic history as both fertility and mortality remained high and cancelled out each other leaving very little scope for its population to grow in numbers. In 1901-1911, the population of Basti city decreased from 14761 persons to 11477 persons, which gave the growth rate of population to -22.45 per cent and the city was class IV town and maintained its demographic status in the next decade also. In this decade the decline in population was recorded at national level because of famine and epidemics and Basti was not an exception. So population growth rate declined at large level. During 1911-1921, the population increased to 17691 persons recording rate of 54.55 per cent. Till 1921 the city was class IV town and 1931 witnessed a change in the class status of Basti city from class IV to class III town and this status continued for the next four decades. Total population of the city in 1931 was 22526 recording an increase of 27.33 per cent. This increase was the result of

improvement in general conditions of health and sanitation and improvement in the distribution system together helped the nation in initiating a decline in its mortality. In 1941, the population increased to 23893 persons, which was 6.07 per cent of growth in the city. By the time, in 1951, population of the city grew to 33203 persons, which was 38.97 per cent, more than the previous decades. In 1947, India got independence and her social and economic development initiatives got impetus through five year plans. Age old feudal system got its grip weakened and the democratic setup found its base strengthened. A considerable portion of Sikh population immigrated to India from Pakistan during 1951-61. In Basti city, a large number of Sikh refugees came and settled in ward no.14 (Company Bagh) and the adjoining wards. So this period registered drastic population growth. After independence, the rural people migrated into the city which was strictly regulated during British rule. The situation continued to occur by 60's. In 1961, the population was 38403 persons, which gave the growth rate of population to 15.66 per cent. In the next decade (1971), it increased to 49635 persons, with the growth rate of 29.25 per cent. Till this period the city was class III town.

In 1981, there was size class jump of the city when it got class II status with a total population of 69465. The period from 1950 to 1980 was the time of population explosion at national level. Fertility continued to remain high; the country experienced a widening gap between mortality and fertility. The scenario was almost same in Basti city too. In 1991, the growth rate of population increased 25.78 per cent with 87371 persons. The city became class one town in 2001 with the population of 107601 persons with 23.15 per cent growth rate. In

**Table 2: Population and Decadal Growth Rate (1901-2011)**

Year	Population (Persons)	Decadal Variation (Persons)	Decadal Growth Rate (per cent)	Class of Town
1901	14761			
1911	11477	-3284	-22.45	IV
1921	17691	6214	54.55	IV
1931	22526	4835	27.33	III
1941	23893	1367	6.07	III
1951	33203	9310	38.97	III
1961	38403	5200	15.66	III
1971	49635	11232	29.25	III
1981	69465	19830	39.95	II
1991	87371	17906	25.78	II
2001	107601	20230	23.15	I
2011	114657	7056	6.55	I

Source: Primary Census Abstract 1901-2011, Census of India, 2011

2011, the population became 114657 persons, which shows the slow growth rate in population increase. For the first time during the post-independence period there is a fall in the city's population to the tune of 6.55 per cent. The overall analysis of the growth rate shows the continuous decline since 1981 which could be attributed to various possible factors such as declining fertility, less movement of rural people towards this city and a preferred choice for Gorakhpur, Lucknow and Delhi. However, this needs to be researched and examined before coming to any conclusion.

A temporal analysis of demographic change reveals that during 1901-1921, population of the city increased by 20 per cent recording almost stagnant population growth. The next thirty years (1921-1951) population of the city increased by 88 per cent witnessing significant changes because of control over abnormal deaths. In the next sixty years (1951-

2011) population of the city has increased by 2.45 times. However the decadal growth rate has recorded declining trend since 1981.

### Population Projection

Growth in urban population will continue at a faster rate as it can be guessed from the trend of migration from rural areas (Bhardwaj, 1974). To predict and project the future trends of population growth is known as population projection. It serves to illustrate the growth patterns that would ensue if a set of assumptions concerning fertility, mortality and migration operated in the assumed patterns. The assumptions take due regard of the past trends and make allowances for possible demographic attractions that could affect the population growth and structure. However, population projection is an essential part of development planning. The population projection for Basti city has been calculated by the arithmetic

**Table 3: Projected Population of Basti City (2021-2051)**

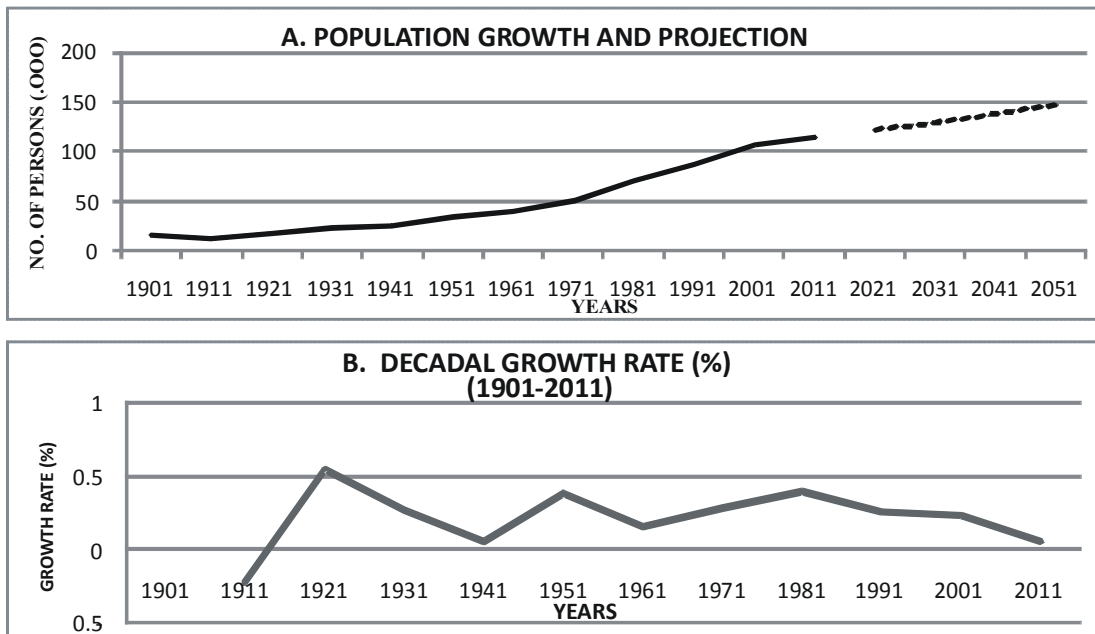
Year	Projected Population
2021	122089
2031	130002
2041	138428
2051	147401

Source: Calculated by the Researcher

method implying the formula of compound interest. Taking year 2011 as base year, the population has been projected for the next four decades, i.e., 2021, 2031, 2041, and 2051 A.D.

The projected population of Basti city shows the decreasing growth for upcoming decades. The population projection from 2021 to 2051 show that the city will register a constant urban population growth without

undertaking the socio- economic factors. In 2021, the urban growth rate of Basti city will be lower than the previous census year. The city is facing drastic decline in urban population growth from 2001 and it will witness the decline in coming decades too. The constant urban population from 2021 to 2051 implies that the dynamics of population growth will be constant which may lead to stagnation of spatial expansion of city but increasing concentration of population in existing boundary of city. It also shows that if population grows without increase in availability of urban amenities will lead to lack of basic urban amenities and deterioration of urban environment. The constant increase will have its own adverse impact like slow growth of secondary and tertiary economic activities, migration of population, and sex ratio etc.



**Fig.2**

Source: Primary Census Abstract 1901-2011, Census of India, New Delhi

### Spatial Distribution of Population of Basti City

The study of population distribution is mainly based on aggregate of investigation about the people and the space they occupy in a region as a whole in its smallest aerial units (Trewartha, 1969). The distribution of population implies the level of concentration of population in a particular area. It also gives the picture of socio-economic characteristics of the area. The distributional patterns of urban and rural areas are opposite to each other, urban area is characterized by high concentration of population while rural area has low concentration of population. In urban area, the distribution of population is influenced by both social and economic factors like residential, commercial area has high population density while open areas, administration areas, public places has low population density. Indian cities, particularly small cities are also influenced by social factors like caste and religion. The

distribution of population is locational, i.e. spatial pattern in which the population finds its location such as linear, dispersed, nucleated, agglomerated etc. Two common methods to show the spatial pattern of population is dot method and concentration index method. Population of Basti city is shown by using these two cartographic methods.

Dot method is employed to show the absolute total distribution of population. It is the most commonly used method for showing population distribution on the map. This method is particularly useful for showing absolute figures. Dot maps are used primarily to express distribution of discrete quantitative characteristics, especially point phenomena. The distribution of points on a map represents the given phenomena in reality and also shows the change in the intensity or dispersion. In the following maps, population distribution of Basti city has been shown for the two time periods (1991, 2011).

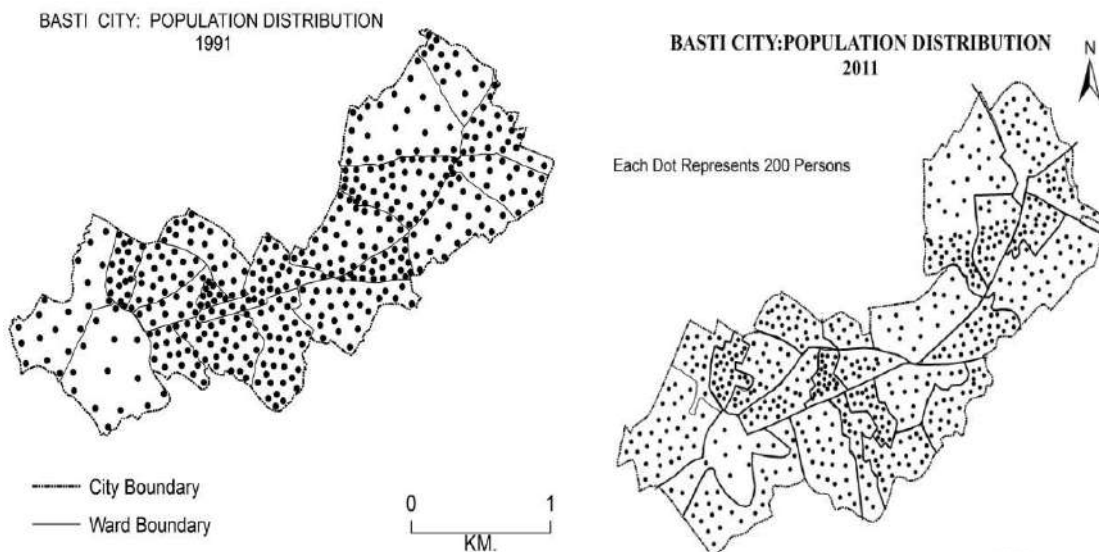


Fig. 3

Concentration index (CI) is applied to show the spatial distribution of population. It is calculated by dividing actual population of the municipal ward by the average population of the wards for 1991 and 2011. The average population of the municipal ward of the city is 4369 and 4586 persons respectively for the two points of time. By applying this method we find that the distribution of population is very uneven in the city. The wards Mishrauliya, Pathantola, Surtihatta and Italiya, which is also called as Old Basti, have very high concentration index in both the decades. The reason could be attributed to the oldest settlement of the city and its location near the railway station. The major characteristics of this area are poor sanitation and health facilities, lack of space, congestion, poor water supply, and dilapidated condition of houses with improper drains. The number of wards with high concentration index was two in 1991 and eight in 2011. They are scattered in different parts of the city and along

the N.H. 28. Concentration index is high in the middle part of the city along the N.H. 28, in wards Pikaura Baksh, Malitola, Vishunpurva. This middle part of the city is the central business district and the settlement found here is residential cum commercial type. The factors of high population are easier accessibility to bus stand and main market, and dominance of poor and lower middle class families, who could not be able to shift their residences in outer parts of the city or to another city. Another pocket of high population is found in the south-west part of the study area in which Purana Dakkhana, Katra, Awas Vikas Colony, Rautapar, Barihawa and Rameshwepuri wards are located. These wards are basically the residential type. The outer parts of the city are less populated. Pikaura Shivgulam, Chikwatola, Belwadandi and Company Bagh are low populated areas in the city. Some of these wards are big in size wherein settlements are interspersed by agricultural lands, vacant

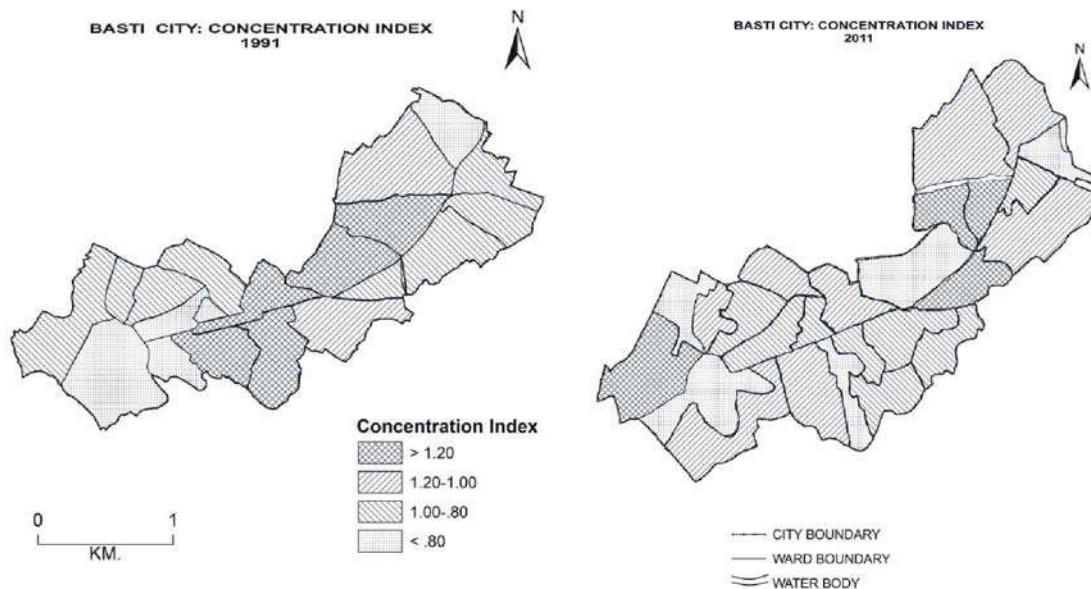


Fig. 4

**Table 4: Concentration Index of Population of Basti City (1991, 2011)**

Category	Concentration Index	No. of Wards(1991)	No. of Wards (2011)
Very High	Above 1.20	05	04
High	1.20- 1.00	02	08
Medium	1.00-0.80	08	08
Low	Below 0.80	05	05

Source: Based on Primary Census Abstract 2011, Census of India, New Delhi.

plots, and open space. In these areas density is high along the major roads. In the wards, Chikwatola and Pikaura Shivgulam, population is low due to residences of high class society who prefer nucleus families and even in that some family members have migrated out either to pursue education or to run business.

#### **Scheduled Castes and Scheduled Tribes Population**

Indian constitution identifies Scheduled caste as such castes, races or tribes as parts of or groups within such castes, races or tribes as are deemed under article 341 to be Scheduled castes for the purpose of this constitution. According to 2011, the total population of scheduled castes in India is roughly 16.6 per cent of the total population whereas in urban India it is 12.6 per cent of the total urban population.

**Table 5: SC Population of Basti City (1991-2011)**

Decade	S.C. Population	Per cent of S.C. Pop. To Total Pop.
1991	13359	15.28per cent
2001	15792	14.67per cent
2011	17036	14.85per cent

Source: Primary Census Abstract 1991-2011, Census of India, New Delhi.

Scheduled castes in Basti city (14.85 per cent) is less than the national average but more than the urban average. Spatial distribution of this vulnerable social group is shown in table-6. There are eleven wards in the city where majority of the population is under this category and they are residing in non notified slums. The slum population concentrated in old parts of the city around railway line, and the highway connecting Lucknow and Gorakhpur. It is mainly concentrated in wards like Mishrauliya, Narhariya, Purana Dakkhana, Murlijot, and Pandey Bazaar. There are seven out of eleven wards where more than 60 per cent of scheduled castes, tribes and minorities living in the non- notified slum areas. There are three wards (Pikaura Datturai, Purana Dakkhana and Malitola) where more than 80 per cent of the SC/ST and minorities are living in non-notified slum areas. Wards like Turkahiya, Mahrikhawa and Murlijot have large number of Muslim population. Except few families, most of them are associated with primary and secondary economic activities. After informal interactions with these people, it is found that most of these people are working as daily wagers in informal sector. They have large families and the condition of women and children is miserable. The houses are age old and in very poor and dilapidated condition. Basic infrastructure and public amenities have been ignored because of

**Table 6: Proportion of S.C., S.T. & Minorities in the Slums of Basti City**

Serial N o.	Wards having Slum area (Non-notified)	Total Number of S.C. S.T. & Minorities of the Ward (in persons)	Proportion of S.C. S.T. & Minorities living in Slums (in persons)	per cent of S.C. S.T. & Minority living in Slum Area
1	Mishrauliya	3106	1962	63
2	Narhariya	2412	1405	58
3	Pandey Bazaar	1390	538	39
4	Murlijot	1265	765	60
5	Purana Dakkhana	1112	945	85
6	Turkahiya	576	388	67
7	Rautapar	511	347	68
8	Malitola	484	431	89
9	Pikaura datturai	431	402	93
10	Mahrikhawa	370	289	78
11	Katra	161	96	60

their non notification.

Correlation between the two variables i.e. total number of SC/ST and minorities in the wards and their proportion living in slums show a strong positive relationship ( $r=+0.89$ ) and seems to be statistically significant at 0.01 and 0.05 confidence level. Inclusion of these wards under notified slums by the municipal authorities will attract government machinery for various development schemes and the situation is likely to improve. The main Schedule tribes in the city are Gond and Tharu population of only 275 (2011) and found in 10 wards of the city. The highest S.T. population is found in ward no. 14 (Company Bagh) that is 179 persons and the lowest S.T. population is found in ward no. 10 (Chikwatola) with only 1 person. Both S.C. and S.T. reside besides the roads and old dilapidated houses. It is important to have a reformed social approach towards the upliftment of their living conditions and status.

In the cities, citizen finds their identification by their work, not by their caste or community. This provides the reason to believe that in spite of having the status of an urban place, Basti city lacks urban in quality and social biasness.

### Population Density

Geographers have devised various types of population densities having a varying degree of utility in different situations. The objective, of course, has been to arrive at a better understanding of the population- resource relationship. These ratios have been called as arithmetic density, physiological density, agricultural density; economic density etc. (Chandna, 2008). However each of these suffer from one or the other types of handicaps like availability of data at specific areal unit and their comparatively. Clark (1972) observes that despite all these handicaps, the concept of density of population is a useful tool in analyzing the distribution of humans over the space. The

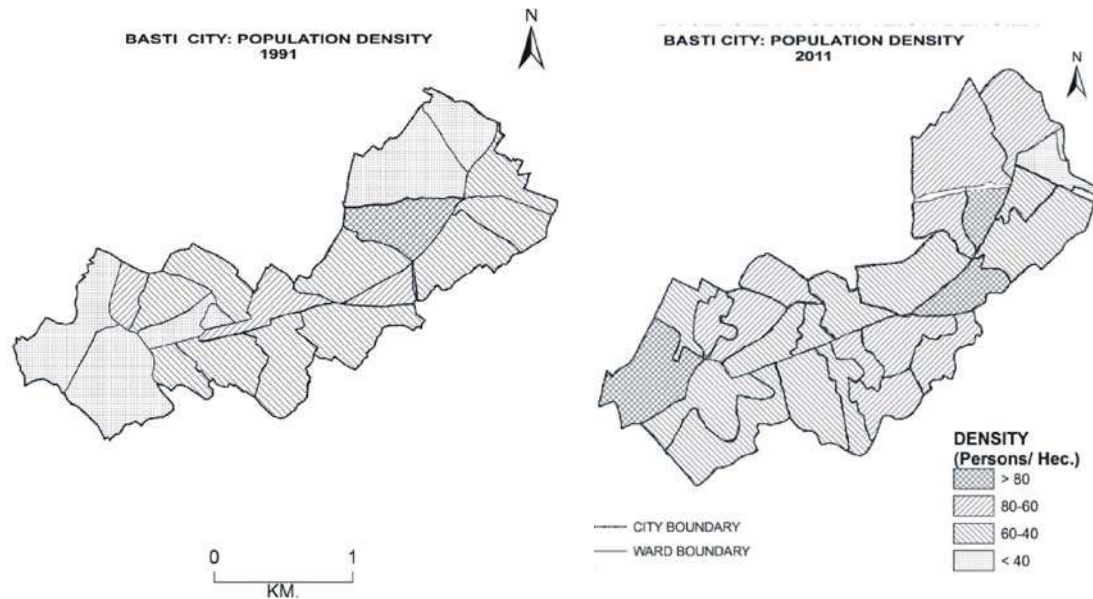


Fig.5

present paper dealing with population aspects of Basti city has taken into account to depict the spatial pattern of city for the year 2011. Arithmetic density is expressed in terms of persons per square unit of land area. The density of population affects the socio-economic conditions, urban environment as well as the facilities like health, education, employment, recreation etc. it is considered as an important factor in understanding how cities function. In addition, high urban density has potential costs in the form of congestion, noise and localized pollution, but at the same time low density of population can also be costly, the higher economic and environmental costs of mobility. Density of population has changed from time to time with increasing population of city. Density of population in Basti city has increased from 45 persons per ha in 1991 to 59 persons per ha in 2011 recording an increase of 14 persons per ha. At ward level in 1991

there were four wards where population density was more than 60 persons/ha and six wards where the figure was less than 40 persons/ha. In 2011 the number of wards increased to 3 with the density of more than 80 persons/ha while in the category of less than 40 persons/ha the number of wards remained only one. This shows how the city is facing the problem of congestion with the passage of time.

In 2011, highest population density is found in ward no. 13 (Pathantola), with 91 persons/ha and lowest is in ward no.8 (Surtihatta) with 36 persons/ha only. The population density is above 60 persons/ha in wards Pathantola, Barihawa, Vishunpurva, and Belwadandi. Pathantola and Vishunpurva wards fall under the oldest residential cum commercial area. Most of the educational institutions, offices, hospitals and market are situated here, that have attracted people to live here. Low population density is found in the peripheral zone of the

**Table 7: Ward wise Variation in Population Density (1991- 2011)**

Category (persons/ha)	No. of Wards (1991)	No. of Wards (2011)	Variation (1991-2011)
Above 80	01	03	02
80- 60	03	10	07
60-40	10	11	01
Below 40	06	01	-5

Source: based on primary census abstract, 2011, New Delhi, India.

city, where there it is below 40 persons/ha. Company Bagh, Surtihatta, Murlijot and Rautapar are the areas of low density of population. The basic reason is that these areas are occupied with vacant plots and open spaces. These wards are not properly connected to the major roads of the city. There are little agglomerations of houses. Now a time, this region has attracted people because of construction of new buildings along the roads, installation of several projects, industries, expansion of several colonization, establishment of new offices of the government, and government hospitals.

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Figure .4 has been shown here to explain the spatial- temporal variation of arithmetic density and the table. 5 show the ward wise variation in population density between 1991-2011.

## Conclusion

The present paper aims to highlight some of the realities related to urban demography of Basti city a class I city in eastern Uttar Pradesh and an attempt has been made to examine, analyze and interpret the demographic characteristics in spatio-temporal perspective. The city has witnessed a fluctuating growth of urban population and there are spatial biases for population concentration in favour of physical and socio-cultural and economic factors both. Formalizing of slums and providing them with basic amenities is likely to improve the living condition of vulnerable groups. The population growth and its change is the major aspect of population affecting region positively or negatively. Such study has potential to attract experts from the field of planning, agriculture, economics and administration in order to propose a strategy for all around development of the city.

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# Voting Behaviour of Uttar Pradesh Assembly Election, 2012: A Spatial Study

Seema Sahdev and Haseena Hashia

Mapping the voting behaviour and voting turn out pattern of an area is of great significance for an Electoral Geographers as it depicts the level of political consciousness and development of that area. The present paper attempts to analyse spatial pattern of voting behaviour in Uttar Pradesh in 2012 assembly elections with a view to bringing out the electoral consciousness and party performance in different Constituencies and examine voting behaviour in the context of Environmental issues. The finding of the paper reveals that there is variation in voting turnout across the region. It was highest in Rohilkhand Plains at 65 percent and lowest in the Region at 56 percent. The spatial spread of the SP's (Samajawadi Party) votes become more even with the increase in overall party vote share. The SP performed well in Awadh Plains, Ganga-Yamuna Doab and Purvanchal Region both in term of seats and votes where as the second largest party, the BSP did not formed any continuous region of high support. The national parties – the BSP and the Congress form a region of low support. In this election, young, well educated and relatively well of urban were important and influencing voting segment and voters have favoured parties on the basis of better governance and class was the main determinant of voter support.

**Keywords:** Voting Behaviour, Assembly Election, Uttar Pradesh, Constituencies, Electoral Pattern

## Introduction

Uttar Pradesh, one of the politically important state in India has shown many ups and down since independence in India with three different phases such as Congress regime, coalition politics regime and regional party regime. The Congress party ruled almost four decade and represented by all caste and classes under its umbrella network. During Congress regime Ch. Charan Singh, a Jat peasant leader from western Uttar Pradesh

resigned from the Congress in 1967 and formed Bhartiya Kranti Dal (BKD) in 1967. This phase continued until 1990s and 1989 election brought about a radical change in U.P politics. However, this election brought the Janta Dal into power, but disintegration of Janta Party and formation of BJP government in 1991 election was another distinctive mark of this period in U.P. politics. Since the 1990s the cohesion and political strength of the landed middle and backward caste, coalition within party politics

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in U.P. have eroded (Duncan, 1997). Given its narrow social base, the mobilisation of the rich farmers under BK D/u also saw a sharp decline during this period (Madsen, 1998). The loss of political Coalition amongst rural landowners since the late 1990s is connected to a process of greater democratisation in U.P politics associated with the rise of Samajwadi Party, Bahujan Samaj Party, Bhartiya Janta Party as a major political force. All three have been in power during 1990s through a variety of Coalition, but could not prove stable. The Coalition between SP and BSP also end with disruptive views. All these political consequences was accounted as genesis of regional parties and Babri Masjid - Ayodhya Mandir issue and Mandal issue provided impetus to the regional parties to spread their political space in the state. In the 1993 and 1996 assembly elections, no party was able to gain majority leading to short lived Coalition government. In 2002 Assembly elections again hung assembly has emerged. The electoral trend in U.P. for nearly fifteen years (from 1993 until 2007 assembly election results has been marked by a pattern of triangular contestation, represented by the BJP, the SP and the BSP.

The 2007 and 2012 election brought about a change in U.P. party system. A sort of secular trend has come to operate in U.P. politics which indicates the gradual decline of BJP as the third force in U.P. politics. From the mid 1990s the seat and vote share of BJP has been on decline due to demolition of Babri Masjid and this issue could not affect electorates. Its seats in parliament reduced from 57 in the 1996 to 29 in 1999 and 10 in 2009 in the Lok Sabha elections. In the 2012 Assembly elections the party had won only 47 seats as compared to 88 and 51 seats in 2002 and 2007 respectively.

The Congress party which had obtained 404 seats in 1985 Lok Sabha elections, reached very low in 1989 winning only 15 seats since then its vote and seat share declined till 2004 election when it got only 9 seats. However in 2009 elections it revived and obtained 21 seats. In the Assembly elections also its seats and vote share is declining since 1985. In 2002 elections, the party had won 25 seats as compared to 22 seats in 2007 and 28 in 2012 elections. With the decline of both the Congress and BJP in the 1990s, it was SP and BSP that dominated U.P politics in the 2000s. Since then till 2012 Assembly elections, people had showed faith in the larger backward class leadership and had rejected the manifestations of both the national parties. It seems that the state is moving towards a bipolar system represented by the BSP and SP.

The BSP founded in 1984 and first appeared in western U.P. during the assembly elections of 1984. Since then till 2007 it could hold power with the support of SP and BJP formed a full fledge government (2007-2012) in the state. The political wheel again turned then the BSP supremo Mayawati diverted her political policy from "Bahujan Samaj to Sarva Samaj" and opened the door for people belonging to every caste to join BSP. Thus she played the politics of inclusion in the form of social engineering and secured 206 assembly seats in 2007 assembly elections wherein Brahmin and dalits voted together for BSP but this experiment of social engineering did not work during 2012 election and BSP lost 126 assembly seats whereas SP won the election in 2012 with a huge majority and also receive the overwhelming support of dalits.

The SP was formed in 1992 by Mulayam Singh Yadav out of a series of defections from

the erstwhile Janta Dal and sought to cater to the economic and political interests of the relatively wealthier OBCs, Such as Yadavs and Gujjars and broader groups of Muslims. From December 1993 SP leads the SP-BSP Coalition government till June 1995. Since 1996, the seat and vote share of SP have shown increasing trend in both Parliamentary and Assembly elections. Its seats in parliament increased from 16 in 1996 to 20 in 1998, 26 in 1999 and 35 in 2004 Lok Sabha elections but reduced to 23 in 2009 election. In 2002 assembly elections the party won 143 seats and after brief interval of Presidents rule and a BSP-BJP Coalition government, SP formed the government from August 2003 till May 2007. For the first time, the party by winning 224 seats in 2012 assembly election defeated the BSP and formed the government on its own.

Thus transformation of party system may be attributed to many factors. First, caste is becoming narrower and more localized in terms of electoral behaviour. Second religion is also not playing a somewhat different role, in the past Babri- Masjid demolition Era. Earlier Hindus voted to BJP But soon afterwards, the people were disillusioned and religion alone could not attract them to vote for any party. Thus Hindutva wave came down. Therefore, BJP and to a certain extent all political parties have started emphasizing other socio-economic factors. Third, regional politics is narrowing down to sub regions and therefore local issues are becoming more important. As a result of this, local politics is fast emerging in U.P. which is consequent upon changing voting behaviour of people which not only varies from one election to another. But choice of voter also varies from one region to another. These

changing patterns of voting behaviour are observed in 2012 assembly elections.

### **Aims and Objectives**

1. To analyse the spatial pattern of voting turnout.
2. To analyse the electoral performance of major parties in the 2012 assembly elections.
3. To analyse the spatial patterns of support for the parties and the nature and degree of its spatial concentration.
4. To examine how the environmental issues shape voting behaviour and voting pattern.

### **Methodology and Techniques**

The main objective of the present study is to aggregate voting behaviour of the people of Uttar Pradesh. For the purpose of analysis, aggregate data analysis approach has been taken. For the identification of voting pattern, two indicators have been taken, i.e. electoral participation and party performance. In the electoral participations, percentage of votes polled have been taken. Whereas, spatial distribution of party victories, numbers of seats won by political parties, discrepancy in the seat vote share and percentage of votes polled by political parties have been included to analyse the party performance. The level and spatial variations of turnout are examined in terms of average turnout, standard deviation and coefficient of variation. Cartographic techniques, most commonly the choropleth method are applied to portray the spatial distribution of various election phenomenon.

The Electoral support for the party is measured in terms of percentage of votes polled in favour of party in relation to the total valid votes in each assembly constituencies which

is divided into five categories. The number of constituencies where the party is very weak falls below 20 per cent of votes category. The next category 20.01 to 30 per cent shows that the party is weak. The third category 30.01 to 40 per cent shows that party is moderately strong. The fourth category is of 40.01 to 50 per cent shows that the party is very strong and above 50 per cent category shows those areas where the party is overwhelmingly strong.

#### **Data Source**

This study is based on secondary data which has been collected from various Government sources. The Secondary sources of voting data are Election Commission published by Election Commission of India. The secondary sources of socio-economic data are various publications of Census of India, Directorate of Economics and Statistics. District and state level Gazetteers are consulted for historical background. It also consists of books and articles on U.P. politics. The centre for the study of developing society conducted a survey in U.P. during 2012 Assembly elections and that data we have used for identifying the social bases of voting.

#### **Unit of Analysis**

In the present study, Electoral participation and party performance is analysed region wise (Geographical Regions, Census of India, 2001) and district wise. A Comparative study of different region gives a clear picture of the support base of parties and on the basis of such analysis, comprehensive picture on the social base of parties in the entire state is drawn. In India, political arenas are often determined by administrative boundaries and when such boundaries have enjoyed

undisturbed continuity over a long period of time. They leave their political and cultural mark. Districts therefore frequently have distinct identities despite internal variety. Further a large part of continuous political activity is organised on a district basis. Parties are typically organised on a district committees as key units in the structure and the whole apparatus of local self government with its own set of election is arranged within the district framework (Dasgupta and Jones, 1975).

#### **Geographical Profile of the Study Area**

Uttar Pradesh is situated between 23° 52' N and 31° 28' N latitudes and 77° 3' E and 84° 39' E longitudes. The landscape of U.P. is flat and comprises fertile plain known as Gangetic plain, in the centre is watered by Yamuna, the Ganga and major tributaries, the Ramganga, Gomati, the Ghaghra and the Gandak. On 9<sup>th</sup> November 2000, state of Uttaranchal was carved out of Uttar Pradesh and state is now divided into 71 District under eighteen divisions, 312 Tehsils, 1.06 lakh villages. Administratively, 81 parliamentary and 403 assembly constituencies are found in U.P. (Fig. 1). According to Census, 2001 U.P. is divided into 5 distinct geographical regions (Fig. 2).

In terms of economy, Uttar Pradesh has agricultural based economy. Around 80 percent of the total population of the state is involved in agriculture and about two third of the total area of the state is under cultivation. In terms of demography, Uttar Pradesh is fifth largest and most populous state with a population density of 828 persons per sq. Km and population of 199,581,977 contributing 16.16 percent of India's population. About 22.8 percent population lives in urban area and literacy rate is 69.72 percent. About 80 percent of Uttar

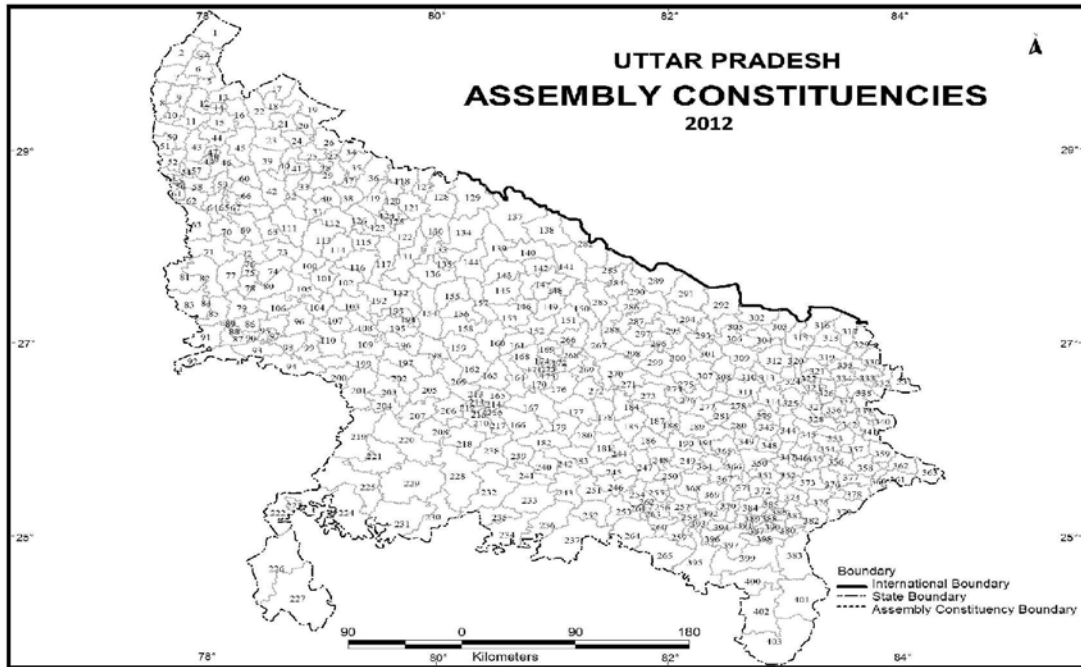


Fig. 1

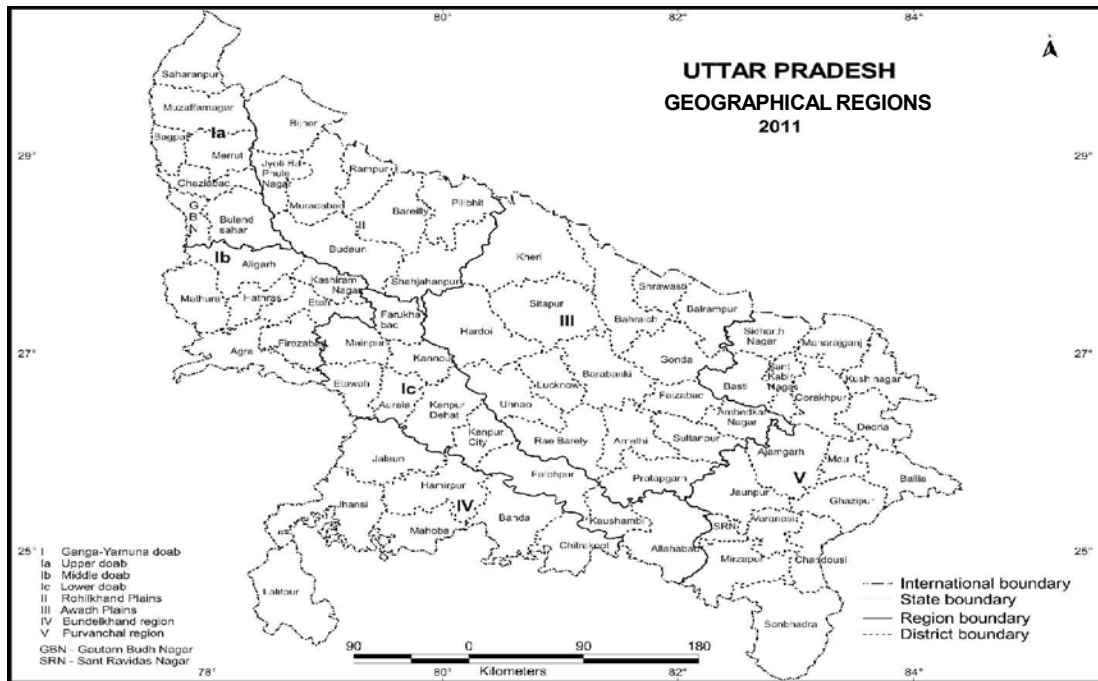


Fig. 2

Pradesh population is Hindu, while Muslim makes up around 18 percent of population. It has a very complex population structure especially in case of caste composition. The Brahmins, Kshatriyas and Vaishyas -the upper caste people of the state constitute 20 percent population. A major group comprises of the backward classes, scheduled castes and tribes. About 21 percent of the total population of the state consist of scheduled castes. The literacy rate of scheduled caste is 46.27 percent, and the scheduled castes are predominantly rural as 87.7 percent of them live in villages. The Backward and Other Back ward class (OBC) account 35 to 40 percent of population. On the basis of economic development, middle castes or OBCs like Yadav, Kurmis, Gujjars, Lodh, Jat are usually economically well off, while most backward classes like Dhiwars, Jogis, Kumahars, Nais, Sainis form the poorer section.

### **Voter Turnout**

Electoral participation is a process in which the electorate participates in choosing the government and gives credibility to the political system. Voting turnout has been measured as the percentage of registered voters in each constituency who had actively exercised their voting right. In 2012 elections for the first time in U.P. voting turnout was recorded about 60 percent. This time voting turn out had shown an improvement of 9.6 percent over the voting turnout for 2007.

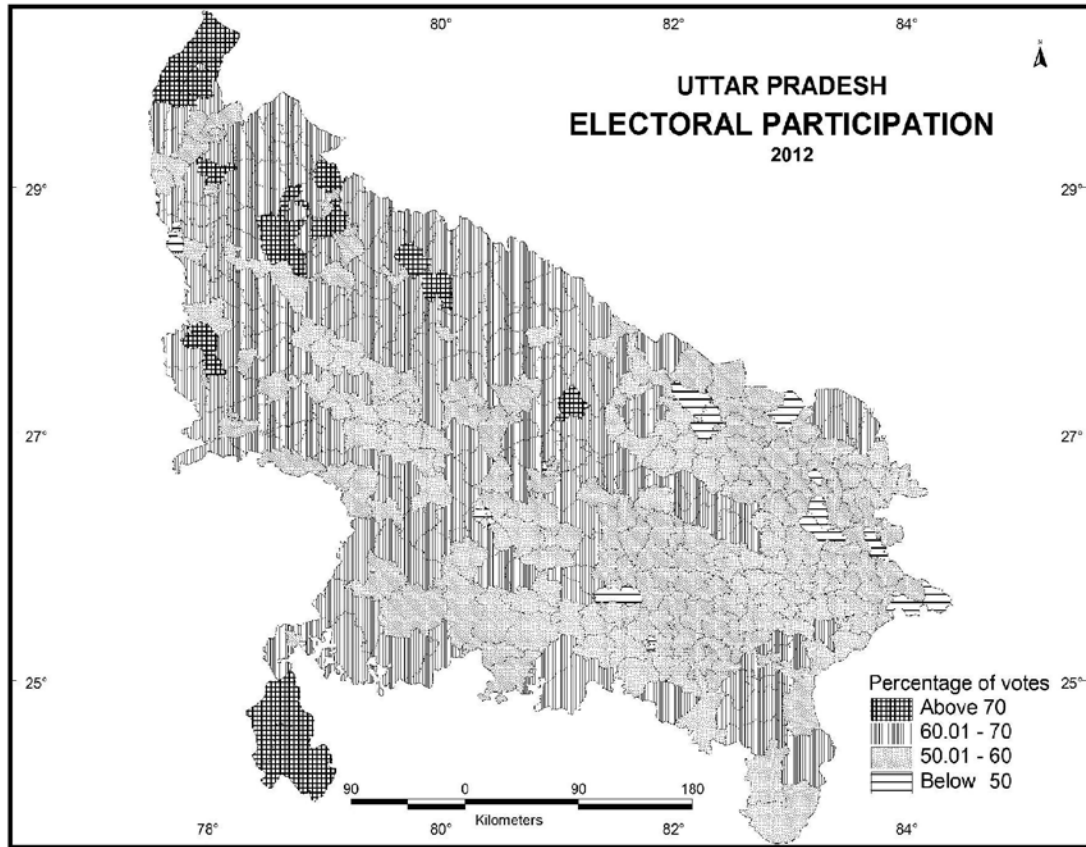
### **Spatial patterns of Voter Turnout**

This election recorded variation in voting turnout across the regions. It was highest in Rohilkhand plains at 65 percent and lowest in Purvanchal region at 56 percent. Voting turnout has been divided into five categories. These

categories include very high voter turnout where 70 percent of the electorates turned out for voting and there were 16 Constituencies in the state where such a high electoral participation took place in 2012. Their regional distribution (Fig 3) shows that the highest number of very high turnout Constituencies were in Saharanpur, Lalitpur, Jyotibhaphule Nagar and Moradabad districts. High voter turnout was recorded in 177 constituencies, where 60 to 70 percent of the electorates voted. In Bijnor, all constituencies recorded high voter turnout. In Barabanki 6 of 7, 5 of 9 in Bulandshahar, 6 of 7 in Meerut, 5 of 7 in Muzaffarnagar recorded high voter turnout. In the category of moderate voter turnout (50 to 60 percent), 109 constituencies were found. These constituencies were in large number in Allahabad (9), Ballia (5), Deoria (7). There were 19 constituencies, where participation of the electorates in the election process was low (40 to 50 percent). Kanpur district had largest numbers of constituencies (4) followed by Gorakhpur (3), Allahabad (2), Ballia (2), Balrampur (2), Deoria(1), Gautam Budha Nagar (1) and Pratapgarh, (1). In this election no constituencies registered less than 40 percent of the votes polled.

### **Party Performance- The seat share and Degree of Success**

The seat share of the political parties denotes their respective strength in the legislature and determines which party will form the government. The degrees of success of political party are taken as the proportion of seats won to total seats contested. The assembly seats whereas BSP could secure only 19.8 percent of the assembly seats as compared to 51 percent in 2007. BJP could get



**Fig. 3**

11.6 percent of assembly seats and INC got only 6.9 percent of assembly seats whereas RLD secured 19.5 percent of assembly seats. To know how successful has been the political panels, the degree of success of political parties is identified. SP recorded a high degree of success of 55.86 percent as compared to 24.68 percent in 2007 election. But the degree of success of BSP was poor this time i.e. only 19.85 percent as compared to 51.1 percent in 2007. The degree of success of BJP has declined to 11.8 percent as compared to 14.5 percent in 2007 and 27.5 in 2002. The degree of success of INC was very low, 7.8 percent

only. The degree of success of independent candidates was only 0.35 percent (Table 1).

**Gains and losses of seats by political parties**

Whereas the number of seats won by political parties reflected its strength in the legislature at a particular time, the gains and losses of seats by political parties over elections reflect the direction in which a political party is moving i.e. whether the party is consolidating its position, losing its position or is maintaining it. Table 2 depicts gains and losses of political parties since 2002. SP with this gain of seats, regained its legislative strength of 2002 in 2012

**Table 1: Degree of Success of Different Parties, U.P. Assembly Elections, 2012**

Party	Seats Contested	Seats Won	Percentage of Success
<b>National Parties</b>			
BJP	398	47	11.8
BSP	403	80	19.85
INC	355	28	7.88
NCP	127	1	0.78
CPI	51	0	0
CPM	17	0	0
<b>State Parties</b>			
SP	401	224	55.86
RLD	46	9	19.56
<b>Registered Parties</b>			
QED	43	2	4.65
PECP	208	4	1.92
AD	76	1	1.31

election whereas BSP lost its position of 2007 in 2012 election with the loss of 126 seats. National parties, BJP lost 4 seats over 2007 election. But, INC gained only 6 seats in 2012 over 2007 elections.

### Areal Representation of Winning Parties

UP is a large state, hence region wise analysis of the election results provides us pattern whether a party represents the whole state or is limited to a part of the state as a whole but their representation is regional. The performance of political parties varied in different region of U.P (Table 3).

The spatial extent of party victories is in Figure 4 shows that in 2012, SP was the only party had representation from all the districts of the state. SP performed well in Awadh Plains, Ganga-Yamuna doab and Purvanchal regions both in terms of seats and votes. Out of these three regions, the party registered its best performances in the region of Awadh, winning

**Table 2: Gains and Losses of Different Parties since 2002, U.P. Assembly Elections**

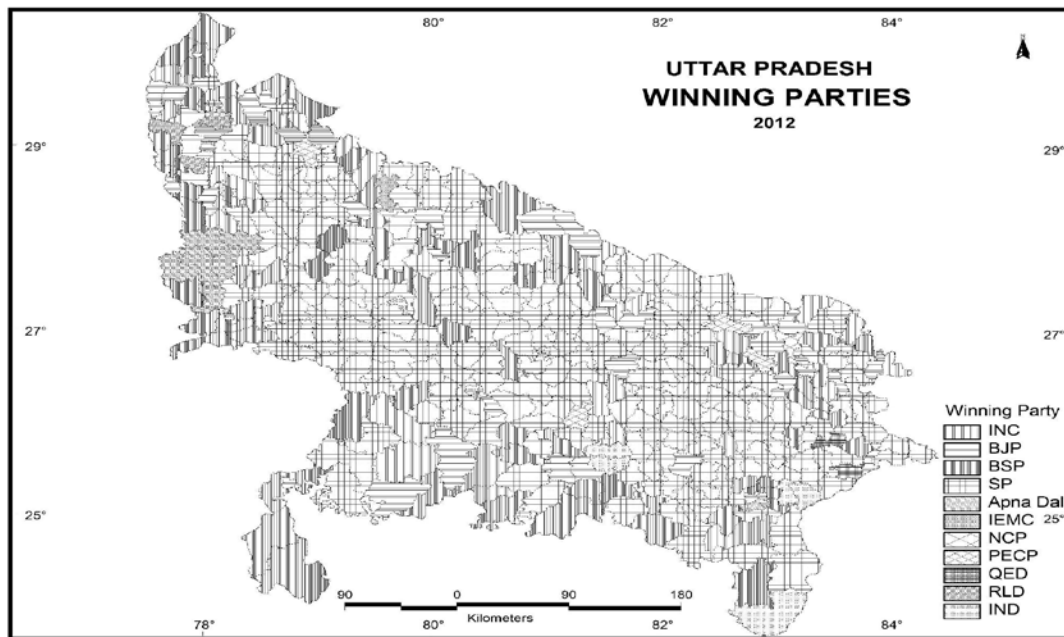
Party	Seats won 2012	Seats won 2007	Seats won 2002	Gain/Loss of Seats 2007-12	Gain/Loss of Seats 2002-07
<b>National Parties</b>					
BJP	47	51	88	-4	-37
BSP	80	206	98	-126	+108
INC	28	22	25	+6	-3
NCP	1	0	0	+1	0
CPI	0	0	0	0	0
CPM	0	0	2	0	-2
<b>State parties</b>	227	97	143	+127	-46
SP					
RLD	9	10	14	-1	-4
Independents	6	9	16	-3	-7

Source: Data Tabulated from the Reports of Election Commission of India, 2002, 2007 and 2015

**Table 3: Region Wise Electoral Performance of Parties in U.P. Assembly Elections, 2012**

Region	Seats Turn		SP		BSP		BJP		INC+RLD		Others	
	Out	Out	Seats	Votes	Seats	Votes	Seats	Votes	Seats	Votes	Seats	Votes
			Won	Percent	Won	Percent	Won	Percent	Won	Percent	Won	Percent
Ganga Yamuna Doab	132	60.20	59	26.13	37	27.77	18	16.06	17	11.23	1	18.78
Awadh Plains	98	59.62	74	32.98	9	25.41	6	11.91	6	13.73	3	15.95
Rohilkhand Plains	52	64.3	29	28.91	11	22.73	8	18.82	2	18.82	2	18.92
Purvanchal Region	102	55.73	57	31.19	16	25.39	12	13.54	8	9.35	9	21.51
Bundelkhand Region	19	61.92	5	25.29	7	26.20	3	18.89	4	18.57	-	11.02
<b>Total</b>			<b>224</b>		<b>80</b>		<b>47</b>		<b>28</b>		<b>24</b>	

Source: Data Tabulated from the Reports of Election Commission of India, 2012



**Fig. 4**

(INC: Indian National Congress, BJP: Bhartiya Janta Party, BSP: Bahujan Samaj Party, NCP: National Congress Party, RLD: Rastriya Lok Dal, SP: Samajvadi Party, IEMC: Ittehad – e – Millat Council, PECP: Peace Party, QED: Quami Ekta Dal, IND: Independents )

74 out of 98 seats. Within Awadh plain, the party did particularly well in Faizabad and Ambedkar Nagar winning all seats in the district. In Sitapur, Lucknow, Raebareilly and Sultanpur district also the party won majority of seats. In Rohilkhand plains of 52 constituencies, covering 8 districts, it won 29 seats giving its best performance in the districts of Moradabad, Jyotibaphule Nagar and Badaun. In Purvanchal region, out of 102 constituencies covering 17 districts, the SP won 57 seats and performed well in the districts of Deoria, Azamgarh, Balia, Jaunpur, Ghazipur and Mirzapur. The Ganga Yamuna Doab region, with 132 seats covering 25 districts, the party won 59 seats. Within this region, the SP swept the districts of Meerut, Etah, Mainpuri, Farukhabad, Kannauj, Etawah, Auriaya, Kanpur Dehat, Kanpur Nagar and Allahabad. In Bundelkhand region, the party fared badly by winning 5 of 19 seats in Jhansi, Jalaun, Bada and Chitrakoot districts.

The BSP was the most successful of opposition parties with total of 80 seats but it could not form a continuous region. In Ganga Yamuna Doab region with 132 seats, BSP won 37 seats giving its best performance in the districts of Saharanpur, Muzaffar Nagar, Bijnor, Ghaziabad and Agra. In Purvanchal region, the BSP won 16 of 102 seats in Basti, Gorakhpur, Maharajganj, Khushinagar, Azamgarh and Varanasi districts. In Rohilkhand region, out of a total 52 constituencies, it won only 11 seats in Kheri, Sitapur, Hardoi and Unnao districts. In Bundelkhand region, the party won only 7 of 19 seats in Lalitpur, Jalaun, Jhansi, Mahoba and Chitrakoot district. In Awadh plain the BSP won 9 of 98 seats in Kheri, Silapur, Hardoi and Unnao districts.

The BJP was the third largest party and

**Table 4: Vote Share of Parties, U.P. Assembly Elections 2012**

Party	Voters Polled (%)
<b>National Parties</b>	
BJP	15.21
BSP	25.91
INC	11.65
CPI	0.13
CPM	0.09
<b>State Parties</b>	
SP	29.15
RLD	2.33
State Party - Other States	1.05
Registered Unrecognized Parties	10.26
Independents	4.13

Source: Data Tabulated from the Reports of Election Commission of India

did well in the district of Meerut by winning 4 of 7 seats and in Kanpur by winning 4 of 10 seats. The party did best in Ganga Yamuna Doab where it captured 18 seats. It fared better in Purvanchal Region by getting 12 seats but did worst in other regions.

The Congress and RLD alliance got very few seats. The only region where Congress seems to have good performance is Bundelkhand, where the party won 5 of the 19 seats and in Mathura district party won 4 out of 5 seats.

#### **Party Performance- Vote Share**

Whereas the seats won by various political parties shows their relative strength in the legislature, the vote share of various parties denotes their respective strength among the electorate. The vote share of different parties has been given in the table 4. In 2012 elections,

**Table 5: Frequency Distribution of Assembly Constituencies in Various Categories of Votes Polled to major parties, U.P. Assembly Elections 2012**

Percent of Votes Polled	SP	BSP	INC	BJP
Below 20-00	74	105	272	272
20.01-30.00	135	201	61	84
30.01-40.00	126	91	17	37
40.01-50.00	51	6	5	5
Above 50.00	15	0	0	0
Seats Contested	401	403	355	398

Source: Data Tabulated from the Reports of Election Commission of India.

the incumbent Bahujan Samaj Party lost to 4.5 percentage points in votes whereas SP recorded its best ever performance by securing 29.15 percent of the votes, a gain of nearly 4 percent since 2007. The BJP could get only 15 percent and Congress could get only 12 percent of the votes.

### **Spatial Patterns of Party Support**

The present section examines the spatial patterns of support for political parties in 2012 election which address that how the strength of individual parties was distributed throughout the state in 2012 elections. In the assembly election of 2012, the main parties in the fray were BSP, SP, BJP and INC. Table 5 gives frequency distribution of constituencies in various categories of party support.

**Performance of Samajwadi Party:** Samajwadi party fielded candidates in 401 seats. During this election SP recorded its best ever performance winning a total of 224 seats, 127 more than the 2007 assembly elections and secured 29.15 per cent of the vote, a gain of nearly 4 per cent points since 2007. Out of 401 seats contested, the SP got high support (40 to 50 per cent) from 51 Constituencies. The party got high support from 4 constituencies in

Ambedkar Nagar. Other districts are Azamgarh, Basti, Ghazipur, Hardoi, Jaunpur, Kannauj, Kanpur Nagar, Mainpuri and Mirzapur. There were only 15 constituencies where the party was so strong. It includes 2 constituencies of Firozabad, and 2 constituencies of Azamgarh and 1 constituency in each of Agra and Ambedkar Nagar.

### **Performance of Bahujan Samaj Party:**

In 2012 elections, BSP had contested all 403 seats but recorded a significant decrease in its seats and vote share. BSP secured only 80 seats and lost 4.05 percentage points in its votes and lost 126 assembly seats. Figure 4 gives the patterns of strength of the BSP in 2012, Out of 403 seats it contested, the party got low to very low support throughout the state and from 91 constituencies. It includes 7 constituencies of Agra, 5 each of Ambedkar Nagar and Saharanpur, 4 each of Azamgarh and Muzaffar Nagar, 3 each of Basti, Gaziabad and Sultanpur district. BJP could get high support from only 6 constituencies. These constituencies are Dadri, Loni, Rasara, Sikandararao, Manjahanpur, and Allahabad west. There was no constituency where BSP vote crossed 50 per cent mark.

### **Performance of Bhartiya Janta Party:**

In this election the BJP got 47 seats and 15 per

cent of the votes, a decline of four seats and 2 per cent votes respectively since 2007. The party contested 398 seats and could not get very strong support from even a single constituency. Even the party got high support from only 5 constituencies. It includes 1 constituencies in each of Gorakhpur, Kanpur Nagar, Muzaffar Nagar, Pilibhit, Shahjahanpur and Deoria district. The party got moderate to low support throughout the state.

**Performance of Indian National Congress:** In this election the Indian National Congress however contested in an alliance with the Rashtiyi Lok Dal while the Congress fielded candidates in 355 seats and RLD contested 46 seats. The Congress managed to win 28 seats, a marginal increase of six seats since 2007 and gathered nearly 12 per cent of the vote up, 3 percentage points. Its alliance partner the RLD won nine seats with 2 per cent of the total vote, a drop of one seat and one per cent vote respectively. The party formed a continuous region of low to very low support. It could get high support from only 5 constituencies. It includes one constituencies each in Bulandshahar, Ghaziabad, Hamirpur, Maharajganj and Pratapgarh districts.

### **Voting Turnout in Reserved Constituencies**

In reserved constituencies, the proportion of Scheduled Caste population is slightly higher in comparison to the other constituencies and only Scheduled Caste candidates can contest for these seats. In 2012 election the reserved constituencies have recorded slightly lower rates of turn out in comparison to the general constituencies. The average voting turn out rate in the reserved constituencies was 58.86 per cent as compared to 59.70 per cent in General

Constituencies.

Out of total of 85 reserved constituencies, there were only two constituencies in the category of very high voting turn out, where as thirty constituencies recorded high voter turnout, 48 constituencies recorded moderate voting turn out and only 5 constituencies recorded low voter turnout. This indicates that the electorates of these reserved constituencies were also very conscious about their voting right.

Spatial patterns of party support in reserved constituencies shows that this time BSP won only 15 of 85 seats reserved for dalits which corresponds to just 18 per cent where as the electoral trend in favour of SP was quiet strong in reserved constituencies and won 58 of 85 seats, BJP and Congress won only 3 and 4 seats respectively. Out of 85 SP got very high support (above 50%) from only Mainpuri, Sultanpur and Gonda constituencies and where as from 17 constituencies S.P got high support. But from rest of constituencies it got moderate to low support. BSP got high support from only one constituencies and rest of constituencies it got moderate to low support.

### **Environmental Issues and voting Behaviour**

In a voting behaviour study, why, how and whom voter votes for are the three most important questions for investigation. In order to analyse the voters intentions and actions, it is necessary to consider all the factors that affect voters choice. The voting behaviour study makes use of background variables like age, sex, caste, income, occupation, education etc to understand the social variation of voters located in different regions. They are treated as explanatory variables for explaining variation

among voters on some chosen dimensions pertaining mainly to political attitude and voting pattern (Ray, 1973). Since, the present paper attempts to examine voting behaviour in the specific context of environmental issues. Therefore, the spatial variation of electoral participation and different results for political parties, and the emergence of regions of different degree of involvement of the citizens in the electoral process lead us to search for the factors that may be responsible for spatial variation in strength of political parties. In the absence of ecological and development data at constituency level, inferences from the levels of development and cartographic correlation of the different variables has been attempted here. The SP performed well in terms of economically well off voters, and in the region of high rural and high urban literacy. In this election youth was an important and influential voting segment. The Samajwadi Party had addressed the new constituency of the youth in a very systematic manner. The excessive rush in the later phase of the election is the employment exchanges in many cities were pointer that the unemployed youth had shifted towards the Samajwadi Party. The main reason for Samajwadi Party remarkable victory was the loss in support for the incumbent Bahujan Samaj Party from the upper caste, and dalits who were least likely to vote for the BSP formed a relatively distinctive group of young, the well educated, the relatively well off and the urban. The result of the 2012 assembly elections indicate that the incumbent Bahujan Samaj Party is losing to the Samajwadi party. The BSP could not perform well in places, where it had traditionally done well.

“In 2007 the BSP secured the overall majority, winning 206 seats and 30 % of votes. During 2012 assembly elections the BSP lost

4.5 percentage points and lost 146 assembly seats. Though the decline of 4.5 percentage vote may not look like a big loss; in a four cornered context even a modest change in votes can have a big impact on seats. Moreover, of potentially great concern to the BSP, the party’s popularity declined most amongst its core supporters. The BSP feared particularly badly in places where it had traditionally done well, such as in the assembly constituencies reserved for dalits. In the 2007 assembly election the BSP won 61 of the 89 seats reserved for dalits, which corresponds to the 68 % of the reserved seats. This time, in 2012 the BSP won only 15 of the 85 seats reserved for dalits, which corresponds to just 18 percent” (Heath and Kumar, 2012). CSDS survey based estimates of vote by social background reveal that both the SP and the BSP continue to get and overwhelming proportion of their total votes from Yadavs and Jatavs, respectively. They were unable to retain their 2007 dominance among these sections. During the assembly elections held five year back in 2007, 86 % of Jatavs voted for the BSP, where as in the recently concluded assembly election of 2012 only 62 % of Jatavs did so (Table 6). CSDS survey also indicates that less educated dalits were much more likely to vote for the BSP than well educated. Poor dalits were also much more likely to vote for the BSP than richer dalits. Dalits living in urban areas were much less likely to vote for the BSP than dalits living in rural areas, and there are also some differences in support for the BSP by occupation. Dalits involved in small and petty business (81%) were the most likely occupational group to vote for the BSP, followed by skilled (71%) and unskilled workers (71%), where as farmers (21%) and low graded professionals (50%)

were the least likely occupational group to vote for the BSP. The BSP loss of votes among dalits seems to have benefited SP the most. In fact SP gains were more impressive among the communities that are not considered as its core supporters. Among Brahmins, the SP secured 19 percent of the votes up 9 percentage points since 2007. Among Rajputs its vote share went up by 6 percent and among Kurmi and Koeris its votes more than double. The SP gained across categories of age, education, gender, class and locality. Among them, women, poor, rich, rural and urban voters, SPs gains were in the range of 3 to 5 percentage points since 2007. Whereas BSP lost across these categories, however among lower OBCs who had also given BSP an advantage in 2007, the party lost 11 percent votes. BJP also lost its traditional voters, namely the Brahmins, Rajputs and other upper castes. Economically well of voters and college educated voters, core supports of the BJP for a long time, also seem to have move away from the party. However the performance of Congress was very good, it did improve its performance among some sections. The party made gains among dalits, kurmis, koeris and muslims poor young (18-25 yrs) and the college educated compared to the 2007. In terms of locality, most of the BSPs losses came among rural voters. The SP on the other hand, gains among both rural and urban voters.

In trying to explain why so many dalits failed to vote for the Bahujan Samaj Party. It is found that there are strong “performance effects” that determined voter choice in the 2012 assembly election in Uttar Pradesh. In the eyes of many dalits, particularly the young and the well off, the BSP did not perform well enough on key issues of governance. We find

strongest effects for performance issues relating to corruption and development during the BSPs rule (Heath and Kumar, 2012). Thus, the results from 2012 election illustrate that caste politics have not affected the voting behaviour. This time voters were more concerned on the issue of development.

### **Conclusion**

The political landscape has been driven from national to regional politics over time and in between, 4 political parties have ruled the state. Amongst them, the congress party has ruled for the maximum period and other political parties have ruled either through coalition or for short period. Then political landscape of the state has not been the same after 1989 or post Babri- Masjid- Ram Mandir movement when BJP polarised the society. The presence of BJP in state politics is noted during 1991 and 1997-2002 when BJP formed the government in the state. The BSP ruled 2007 and SP has been ruling the state since 2012 independently. SP emerged as a strong political party marked by the decay of Congress BSP and BJP in Uttar Pradesh and BSP also have lost seats and votes in every sub region of UP except for the western where as SP won by a margin than any other party had since 1985. The major factor of election was a massive shift of votes from the Congress, BJP and BSP to SP. Thus, this election marks a few trends in U.P. politics. One, the end of political instability in the state that was prevailing since 1989 and second, the formation of government with clear majorities shows that state is moving towards stable party systems. Third, this election highlighted a shift from narrow caste and religion based politics to more progressive and secular development and governance based politics. So, we hope

**Table 6: Social Bases of Voting for Major Parties in Assembly Elections (2007 and 2012)**

	Congress		BJP		BSP		SP		RLD		Others	
	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012
Age groups	10	15	19	15	28	23	27	30	4	1	13	16
Up to 25 years												
26-35 years	8	11	19	16	30	26	26	29	4	3	13	14
36-45 years	8	11	18	13	32	29	24	27	3	2	14	18
46-55 years	8	11	18	16	31	24	25	30	5	2	13	17
56 years & above	9	11	18	15	30	26	24	31	3	3	15	15
GenderMale	9	11	19	16	30	27	25	28	4	3	13	16
Women	8	12	18	14	32	25	26	31	3	2	13	16
Level of EducationNon-Literate	7	10	13	10	37	33	25	30	4	2	15	16
Up to Primary	9	10	17	15	30	26	27	34	4	2	13	13
Up to Metric	9	10	20	16	28	26	27	28	4	3	12	18
College & above	11	17	27	21	22	17	23	27	4	3	12	15
LocalityRural	8	10	18	14	32	27	26	29	4	3	13	16
Urban	16	18	21	18	21	20	23	29	2	1	18	14
ClassUpper	12	16	30	17	14	21	25	27	6	5	14	15
Middle	10	9	24	15	24	26	28	33	5	1	10	16
Lower	10	12	15	15	33	26	25	28	2	2	15	18
Poor	5	10	12	12	41	33	23	28	4	2	15	15
Caste communityBrahmin	19	13	44	38	16	19	10	19	3	1	8	11
Rajput	9	13	46	29	12	14	20	26	5	2	9	16
Vaishya	10	21	52	42	14	15	12	12	0	0	12	10
Other Upper Caste	12	13	41	17	15	17	17	15	1	4	14	34
Jats	2	11	18	7	10	16	8	7	61	45	2	15
Yadav	4	4	5	9	7	11	72	66	1	1	10	10
Kurmi/ Koeri	6	13	42	20	16	19	17	35	4	1	16	12
OBC	9	12	17	17	30	19	20	26	6	3	19	23
Jatav	2	5	3	5	86	62	4	15	1	2	4	12
Balmiki	4	12	11	3	71	42	2	9	4	0	9	34
Pasi/ Pano	7	7	12	4	53	57	16	24	0	0	11	9
Other SC	4	17	9	11	58	45	16	18	1	1	13	8
Muslim	14	18	3	7	17	20	45	39	8	1	13	15
Others	12	9	14	16	30	23	23	31	3	0	18	21

All figures are in percentage

Source: CSDS DATA, EPW. APRIL 7, 2012. VOL. XLVII. No. 14

that in future SP will retain its popular support. But 2014 Parliamentary elections brought a change in the state party system in which BJP defeated both state parties by securing 71 seats with 42.3 percent votes and its ally Apna Dal won 2 seats where as SP could get 5 seats of family members including Mulayam Singh Yadav (Mainpuri and Azamgarh seats) and BSP was unable to secure any seat. How successfully BJP will dominate over state

politics or SP will retain its popular support of 2012 elections, it will be seen in 2017 assembly elections. It is concluded that the mapping of spatial variation of voting turn out and party support reveals changes in voting behaviour. The Significance of the study lies in the fact that it would contribute to evaluate and examine the changing trends and patterns of voting behaviour as well as electoral participation of the area under study.

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# Dynamics of Coral Community and Ecosystems of Andaman and Nicobar Islands

S.C. Chaturvedi

The Andaman & Nicobar Islands form a long / narrow broken chain of Islands spread over in length of more than 700 kilometers from north to south, occupying an area of 8249 square kilometers. These Islands are famous for nature's beauty and underwater paradise. Corals are tiny organism belonging to group Anthozoa of phylum Cnidaria. The coral is formed by creatures which are very like the sea anemones. These coral polyps are of many colours- red, yellow, green, pink purple and white and are many shapes. These Islands richest of the Indian in coral diversity with as many as 179 species belonging to 69 genera, coral colonies are near Ross Island, North Bay, Back side of G.B. Pant Hospital, Wandoor Mahatma Gandhi National Park, Rangachang, Chidiyatapu, Kamorta, Nancowry, Campbell Bay and North Andaman.

The Coral reef inhabitant fauna and flora of these Islands include -750 species of fishes, 1422 species of Mulluses, 430 species of echinoderm, 112 species of sponges, 235 species of hard corals and 41 species of soft corals, 44 species of crustaceans , 64 species of algae and few species of reptiles and mammals. The coral named *Elentherobia* a rare species of soft coral is a potential drug for breast and ovarian cancer. The corals of these Islands are facing two types of threats – Natural threats and Anthropogenic threats. So all of us should save and protect the corals and ecosystem of marine life of these Islands, which are rare in the country and the world. So, future generation can also enjoy underwater paradise of these Islands.

**Keywords :** Anthozoa, anemones, fringing reef, Nanoplankton, echinoderms, silicoflagellates foraminifera, Tsunami.

## Introduction

The Andaman and Nicobar Archipelago is divided into two groups of islands namely the Andaman and the Nicobar, which is an integral part of India, far away 1200 kilometers from the mainland. The total geographical area of these Islands is 8249 square kilometers comprising 572 Islands islets and rocks. These Islands are famous in the world for their natural

beauty and underwater paradise of corals & ecosystems.

Corals belonging to the genera *Fungia*, *Flabellum*, *Caryophyllia*, *Balanophyllia* are solitary, having disc up or mushroom shaped corallites, 5 millimeter to 250 millimeters. They reproduce by longitudinal fission or by budding from almost any part of the surface. Corals are tiny organisms belonging to group Anthozoa

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of phylum Cnidaria. Most of the Islands are surrounded by fringing reefs on their eastern side and barrier reefs on their western side. The area covered by the reefs is about 2000 square kilometers. The variety of corals and other animals in a reef make it a fascinating and unique marine ecosystem. Corals are most important to the progressive world due to its high productivity as well as nutrient recycling capability (Mann, 1982). The existence of coral reef biodiversity is the ecological tutor for the maintenance of entire biogenic habitat of marine world through the support of a great deal of associated faunal communities (Smith 1978). The group of animals and plants found in a reef is known as the reef community. The present paper describes corals communities and ecosystems of the Andaman & Nicobar sea.

#### **Database & Methodology**

The present research study is based on primary and secondary data collected from various sources on the basis of information and field survey. This research paper highlights about the coral community and its impact on ecosystems of Andaman & Nicobar Islands, high degree of endemic flora and fauna is an asset of the tract, besides it has several species of fishes reptiles mammals and plants which are rare in the world. They make different types of environment underwater of Andaman & Nicobar sea.

#### **Aims & Objective**

This research paper attempts to identify varieties of corals, location, site and ecosystems of surroundings coral reefs, importance of coral reef and types of threats looms these coral reefs and how can we save, or protect the coral reefs and associated marine diversity of Andaman & Nicobar Islands.

#### **Study area**

The marine ecosystems of these Islands are unique in having very high degree of ecosystem and endemism in fauna and flora.

All the islands of Andaman & Nicobar are the exposed peaks of long ranges of submerged mountains which extend from Myanmar to Sumatra. Most of these islands are surrounded by fringing reefs on their eastern side and barrier reef on their western side. They harbor a rich population of corals and molluscs, and most of them have a luxuriant mangrove vegetation around them. The Andaman & Nicobar sea occupies an area of  $6.02 \times 10^5$  square kilometers and has a volume of  $6.6 \times 10^5$  km<sup>3</sup> with an average depth of 1096 meters. The Andaman sea extends to about 650 kilometers east from the Malaysian Peninsula to about 1200 kilometers southwards from Irrawaddy delta in Myanmar. The former is a coral sea with an archipelago of 24 atolls and many submerged banks of coral origin scattered in between Andaman sea. On the other hand it has 15 Islands of volcanic origin with luxuriant fringing coral reefs around many of these islands.

In an exploratory survey conducted by R.V. Goveshane during 1979 he discovered very hard live coral colonies in the north & south east of little Andaman between latitude 10° - 42' to 10° 48' north and longitude 92° - 21' to 92°-41' East in the shallow bay at a depth of 33 to 40 meters. The massive coral colonies with a diameter over 2.5 meters indicate that these reefs must have continued to grow over 200 years. In the south west side of the island between the depth contour of 70 to 90 meters remnants of coral colonies exit, which is further extended to 600 to 710 meters contour line.

Luxuriant growth of coral colonies are

Ross Island, North Bay behind of the G.B.Pant Hospital, Panighat, Dundas Point, Minnie Bay at a depth of 30 to 40 meters and in the Wandoor, Mahatma Gandhi National Park, Rangachang and Chidiyatapu. These are small and large islands where corals are found upto a depth of 50 meters between latitude 11° and 12° north and longitude 93° to 94° East.

In the Nicobar group of islands at Kamorta, Nancowry, Campbell Bay between latitude 7°-40' to 8°20' North and longitude 93° to 94° East, coral colonies have been located at a depth of 80 to 200 meters.

The Geographical Distribution of coral fauna of the Andaman & Nicobar Islands (List of corals family wise)

**Family Acroporidae**

1. *Acropora nasuta* (Dana)
2. *Acropora graundes* (Brook)
3. *Acropora humilis* (Dana)
4. *Acropora palifera* (Lamarck)
5. *Acropora rectina* (Nomenzo)
6. *Acropora pacifica* (Brook)
7. *Acropora digitifera* (Dana)
8. *Acropora Canalis* (Quelch)
9. *Acropora Calviger* (Brook)
10. *Acropora Calamaria* (Brook)
11. *Acropora Hyacinthus* (Dana)
12. *Acropora Polymorpha* (Brook)
13. *Acropora corymbosa* (Lamarck)
14. *Acropora echinata* (Dana)
15. *Acropora rabusta* (Dana)
16. *Acropora clathrata* (Brook)
17. *Acropora squarrosa* (Ehrenberg)
18. *Acropora Concellata* (Brook)
19. *Acropora botryoides* (Brook)
20. *Acropora Formosa* (Dana)
21. *Acropora Variabilis* (Klunzinger)
22. *Acropora Palmeri* (Wells)

23. *Acropora monticulosa* (Bruggemann)
24. *Acropora diversa* (Brook)
25. *Acropora intermedia* (Brook)
26. *Acropora armate* (Brook)
27. *Acropora pulchra* (Brook)
28. *Acropora brueggemanni* (Brook)
29. *Acropora surculosa* (Dana)
30. *Acropora conigera* (Dana)
31. *Acropora irregularis* (Brook)
32. *Acropora Montipora fruticosa* (Bermerd)
33. *Acropora Montipora hispida* (Dana)
34. *Acropora Montipora composite* (Cross land)
35. *Acropora foliosa* (Pallas)
36. *Acropora Montiporo florida* (Nomenzo)

**Family Pocilloporidae**

37. *Pocillopora elegans* (dana)
38. *Pocillopora damicornis* (Linneaus)
39. *Pocillopora stylophora mordex* (Dana)
40. *Pachyseris gemmae*
41. *Pocillopora Pavona (Polyastra) obtusta* (Quelash)
42. *Pocillopora Leptoseris papyracea* (Dana)

**Family Mussidae**

43. *Mussa Lobophyllia hemprichii* (Ehenberg)
44. *Mussa angulosa* (Pallas)
45. *Euphyllia glabrescens* (Chamisso & Eysehardt)
46. *Euphyllia SP*
47. *Symphyllia recta* (Dana)

**Family Merulinidae**

48. *Merulina ampliata* (Ellis and solander)
49. *Merulinidae lexa* (Dana)

**Family Fossidal**

50. *Favia abodita* (Ellis and Solander)
51. *Favia halicora* (Ehrenberg)
52. *Favia speciosa* (dana)
53. *Favia pallida* (Dana)
54. *Diploastrea heliopoia* (lommarrck)
55. *Platygyra daedalea* (Ellis & solander)

56. *Platygyra sinensis* (Milne Edwards & Haime)
57. *Goniastrea pectinata* (Ehrenberg)
58. *Goniastrea plamalata* (Milne, Edwards & haime)
59. *Goniastrea benhami* (Vaughan)
60. *Goniastrea retiformis* (Lamarck)
61. *Coniastrea* sp
62. *Coelaseris magiri* (Vaughan)

**Family Oculinidae**

63. *Galazea fascicularis* (Lunneaus)

**Family Tamnasteridae**

64. *Psammocora contingua*
65. *Psammocora* sp

**Family portidae**

66. *Alveopora* sp
67. *Porites porites* (Pollas)
68. *Porites tenuis* (verill)
69. *Porites nigrescens* (Dana)
70. *Goniopora columna* (Dana)
71. *Goniopora tenaidens* (Quelch)
72. *Goniopora stokesi* (Milne, Edwards & Haime)
73. *Goniopora peteolata* (Bernard)

**Family Pentinidae**

74. *Echinophyllia aspersa* (Ellis & solander)

**Family Fungiidae**

75. *Fungia echinata* (Pallas)
76. *Fungia fugnites* (Linneous)
77. *Fungia horrid* (Dana)
78. *Herpolitha limax* (Fesper)

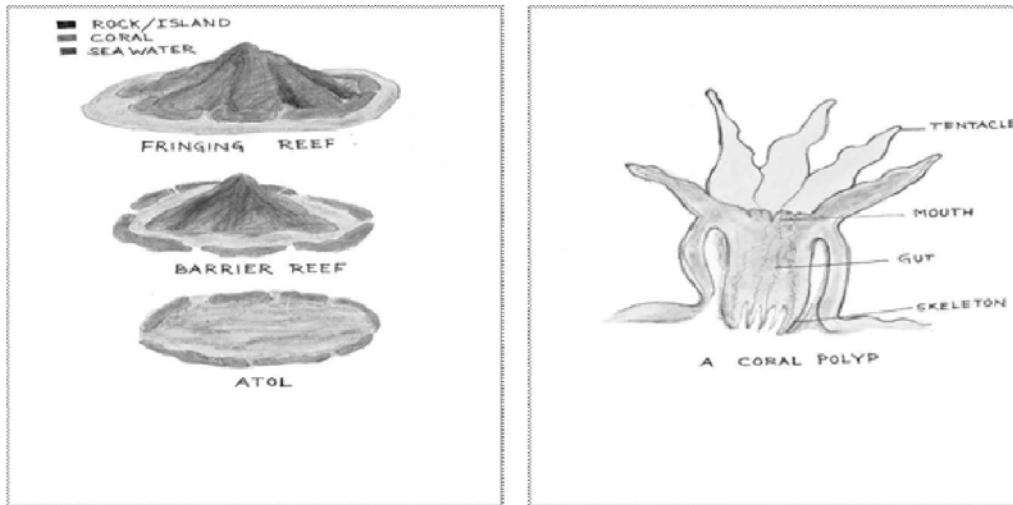
A total no. of 78 species of coral under 25 genera and 10 families have been recorded in Andaman & Nicobar sea, but the latest investigation report of Ramakrishna et al (2010) says that nearly 82 species are found in the Andaman & Nicobar reefs. In 2011, Mondal et al, (2011 a, b, c, d, e, f & g) contributed 44 new records from Rut land, Rani Jhansi Marine National park.

In 1983 fifteen Islands (Alexandra, Red skin, Boat Hobday, Tarmugli, Grub, Chester, Snob, Bell, Pluto Malay, Jolly Buoy, Riflemen, Twins and part of Rut land Island) and some islets in Wandoor declared as Mahatma Gandhi Marine National Park under the wildlife Protection Act of 1972 for the protection of Marine biodiversity covering a total area of 281.5 square kilometers. In 1996 three Islands in Ritchie's archipelago declared as Rani Jhansi Marine National Park (RJMNP) also known as John Lawrence Island, Henry Lawrence island and Outram Island cover a total area of 256.14 square kilometers. North Reef Island sanctuary, Smith Island, Ross Island, Avis Island, Lamia Bay, Harminder Bay, Cinque Island, Campbell Bay, Nancowrie group of Islands etc. total area of this Marine National Park is 281.5 square kilometers which includes 220 square meters of territorial sea water.

**Ecosystem of Andaman & Nicobar Sea**

Under the sea water around the Andaman & Nicobar Islands is reported to have as many as 1200 species of fish and of this 571 species are reef fishes, common reef fishes found here include – butterfly fish, clown fish, parrot fish, cardinal fish, golden fish, wrasses, surgeon fish moorish fish, stone fish, scorpion fish, eels fish, trigger fish etc other important vertebrate dwellers are sea turtles and sea snakes and somewhere salt water crocodile. 1422 species of molluscs, 430 species echinoderms, 112 species of sponges, 235 species of hard corals and 41 species of soft corals, 44 species of crustaceans, 64 species of algae are common and sea shore are surrounded by different types of mangrove and rainforest tree.

Majority of the Andaman & Nicobar Island coral reefs are fringing type occurring

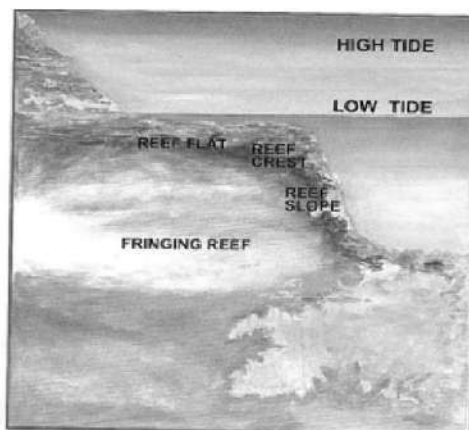


close to the shore which covers an area of 98.8 square kilometers, coral reefs provide habitats for a large variety of organisms. These organisms relying on corals through mutualism, commensalism and parasitism are within the taxonomic groups porifera, polychaeta, Gastropoda crustacean, echinodermata and spices.

### Types of Coral reef

Three types of coral reefs are found in the Andaman & Nicobar Islands such as

#### 1. Fringing reef : Coral reefs developed



Profile of a Fringing Reef

along the continental margins or along the Islands are called fringing reef. This types of reef is found in 15 Islands of volcanic origin with luxuriant fringing reef. It mainly includes Mahatma Gandhi Marine National Park and North Bay, Smith and Ross Islands and Cinque Island. It is found along eastern side of these Islands.

**2. Barrier reef :** The largest coral reefs off the coastal platforms but parallel to them are called barriers reefs. Barrier reefs are the largest most extensive and widest reefs of all types of coral reefs. The base of barrier reef exceeds the required depth for the development of coral polyps near about 90 meters to 300 meters around Kamorta, Group of Nancowry Island. This reef is found on western side of these Islands.

**3. Atoll :** A ring of narrow growing corals of horse shoe shape and crowned with palm trees is called atoll. It is generally found around an island or in elliptical form on a submarine platform. The former is a coral sea with an archipelago of 24 atolls and many submerged banks of coral origin are scattered in between



Andaman sea Rani Jhansi Marine National Park, Mahatma Gandhi Marine National Park.

### Importance of corals reefs of Andaman & Nicobar Islands.

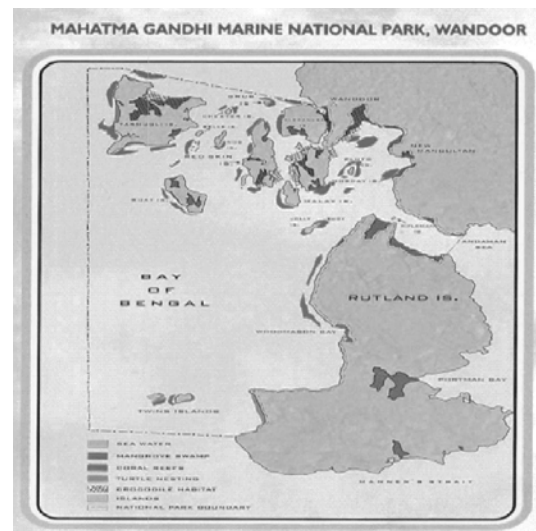
Coral reefs are the most diverse marine ecosystem in our Andaman & Nicobar sea. Coral reefs play a very important role providing sea food to us like groupers, lobsters, crabs. Coral reef protect sea shore from storm. They are beautiful place for swimming and enjoyment. Corals, shells and other animals use calcium carbonate in their skeleton which eventually gets worn-down to leave beautiful white sand, when sea become rough, reef becomes a protected area for boatmen to move their boats. The area behind the reef known as the lagoon, is often used by fishermen to anchor their boats. Diving and snorkeling is becoming more and more popular in these Islands and they are attracting tourists from other countries. The coral reef creates jobs and provides money for islanders, hotel owners, boatmen, diving instructors and fishermen. The reef of these islands attract tourist which provide income to Andaman & Nicobar Administration and

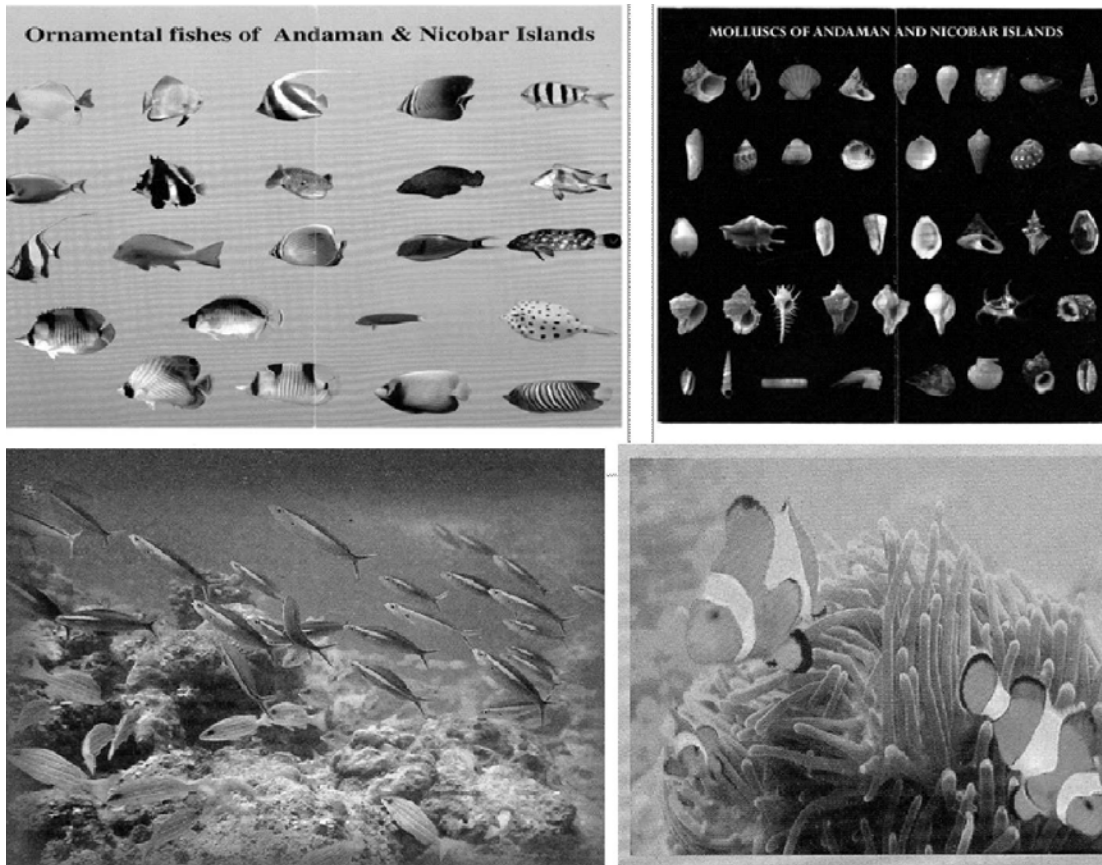
environment forest department. Corals are useful for cancer disease and other serious diseases, sponges produce chemicals which prevent other animals over growing. Reef is birth place and livelihood place for different types of animals sea grass and sea weeds, these animals and grass are very useful for human beings as a sea food and medicine. They control sea water temperature. The reef purifies sea water and controls harmful effect of environment.

### Threats for coral reef of Andaman & Nicobar Islands

There are two types of threats for coral reef in these Islands –(a) Natural threats (2) Anthropogenic threats.

**(a) Natural threats :** These islands are scattered in the Bay of Bengal from North South direction. They are situated in the open sea. So most of the time depressions occur in the Bay of Bengal and coral reefs experience hurricanes, cyclones, strong that damage corals and their ecosystem. White band disease is very harmful for coral reef. Predation by ‘crown of





Coral Reef Ecosystem

thorn' starfish (A canthaster planci and corilivorous fish eat corals and stops their growth. Climatic changes like change in sea – surface temperature may lead to coral bleaching. A planci plague constitutes a serious threat for coral reef.

**(b) Anthropogenic threats:** Over fishing, collection of shells and sea cucumbers for commercial purposes damage coral reef and marine ecosystem. Most of these islands are connected by sea route from mainland through ship and inter islands ship and boats, these ships and boats discharge a lot of oil and smoke that is very harmful for coral reef and marine life.

Fishermen coming mostly from Myanmar, Thailand, Indonesia, Bangladesh, Sri Lanka and other countries for fishing in Andaman sea are damaging coral reef and ecosystem of Andaman & Nicobar Islands. Deforestation and faulty agriculture practices are damaging coral reef and marine life. Faulty anchorage of boats is harmful for coral reef. Tourists stepping on the corals also cause damage to the coral reef around the main corals area of North Bay, Chidiyatapu, Jolly Buoy, Red Skin Island and Elephant beach of Havelock and other places.

Scuba divers also damage corals by touching corals through hands feet and

sometimes by down on it. Increasing human activities and construction of buildings, roads and other development increase sedimentation and siltation in coastal water damaging coral reefs and marine life. Local people know about the medicinal value of corals and sometimes they also deplete coral from coral reef. Some government officers also deplete the corals from reef for their house beautification.

### **Preservation and conservation management for coral reef and ecosystem**

Preservation and conservation are often used as synonymous terms but both are different in meaning. In ecological content preservation means upkeep of rare and endangered species of plants and animals in specially protected area so as to increase their population to optimum level. Conservation, on the other hand is a process which aims at proper use. Preservation and management of resources in such way that are always available for judicial use by man. The aim of coral reefs management of Andaman & Nicobar Islands is to sustain the ability of tropical reefs to provide the ecosystem goods and services (fisheries, tourism, aesthetic and cultural values) upon which human welfare depends. The department of Environment and Forest, Andaman & Nicobar Administration look after the conservation & management of coral reefs. All reef building corals (all scleractinious, black coral all antipatharians) organ pipe coral (*Tubipara musfca* and Fire corals (all millipora species) are included in schedule -1 of wildlife (protection) Act 1972 thus giving maximum protection.

Collection of corals or damage to reef is

an offense under the wild life (Protection) Act, 1972 and is punishable with an imprisonment of minimum three years ( upto seven years) and a minimum fine of ten thousand rupees.

But there should be taken more steps for preservations & conservation of coral reefs & marine ecosystem. Poaching should be strictly stopped in these islands. They are damaging coral reef and ecosystem by depleting marine resources. To establish more research sub-centres on the other islands which can study about the coral & ecosystem. The conservation of ecological resources of marine life & coral reefs should be approached in three ways (i) through species preservation (ii) through assemblage protection and (iii) through habitat protection. There should be a provision of elementary environmental education regarding coral reef and marine ecosystem for local people, divers, boatmen and tourists. Andaman sea receives huge amounts of sewage garbage, agricultural discharge, heavy metals and biocides etc as these are discharged by islanders shipping service, farmers and tourists. These should be totally stopped, and heavy fine should be imposed on these people. Anchoring of boats should be banned near the coral reefs. The pollutants in Andaman sea may become dispersed by turbulence and sea currents or concentrated in the food chain of marine species. These pollutants may be accumulated at the coral reef. Bio-accumulation in food chain may result into loss of species diversity.

Regular awareness generation programmes should be carried out to sensitize people particularly the youth about the importance of preservation & conservation of

coral reefs.

### **Conclusion**

Andaman & Nicobar Islands are known for their natural beauty sand beaches and rich marine ecosystem. The coral reefs & ecosystem of Andaman & Nicobar sea is heritage for our country. They harbor a rich population of corals, molluses, fishes and other sea animals etc and most of them have luxuriant mangrove vegetation closely

associated with them. Near about 179 species are found in these coral reef in different colours. The coral reef protect these Islands from Natural disasters and harmful environmental effects. The reefs attracts tourists from all over world and provide livelihood to the islands. So this is our responsibility to protect, preserve and conserve the coral reefs & marine ecosystem of these Islands.

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# The Study of the Drainage Basin Morphometry of Papagni River Basin, Andhra Pradesh

Narender Verma

The present paper attempts to study the morphometric characteristics of Papagni River Basin, a tributary of Pennar River in south India using ASTER DEM. Morphometric analysis of a river basin provides a quantitative description of the drainage system, which is an important aspect of the characterization of basins. Morphometric analysis using GIS techniques coupled with remote sensing data is more suitable to analyze the drainage basin characteristics as it provides the real time and accurate information related to distinct geological formations, landforms and help to identify the drainage channels which are altered by natural forces or human induced activities. From the relief distribution of the basin it is inferred that major part of the basin has low relief and is in the old stage of geomorphic cycle. This is clearly indicated from the low values of dissection index as well as ruggedness index which are less than 0.15 for three fourth of the basin area. The sigmoid shaped hypsometric curve also indicates towards the old stage of the basin with majority of the sub-basins having integral value between 0.20 and 0.45. The linear and areal aspect of the basin reveals that the basin is normal, near-elongated and geologically less disturbed.

**Key Words:** Bifurcation Ratio, Drainage Density, Relief Ratio.

## Introduction

Morphometric analysis of a river basin provides a quantitative description of the drainage system, which is an important aspect of the characterization of basins (Strahler, 1964). The relational analyses between various morphometric parameters give us clue about stages of landscape development (Tucker and Bras 1998; Reddy et al. 2004; Lin and Oguchi 2004). River characteristics are reasonably understood by the morphometric analysis of that particular river basin. It can be performed through the measurement of linear, aerial, relief, and gradient of channel network and

contributing ground slope of the basin (Nautiyal 1994; Nag and Chakraborty 2003; Magesh et al. 2012b). Morphometric assessment helps to elaborate a primary hydrological diagnosis in order to predict approximate behavior of a watershed directly coupled with geomorphology and ecology. Morphometric analysis of drainage basin, thus, provides not only an elegant description of the landscape, but also serves as a powerful means of comparing the form and process of drainage basin that may be widely separated in space and time (Esthenbrook, 1993). It provides quantitative specifications of basin geometry to understand

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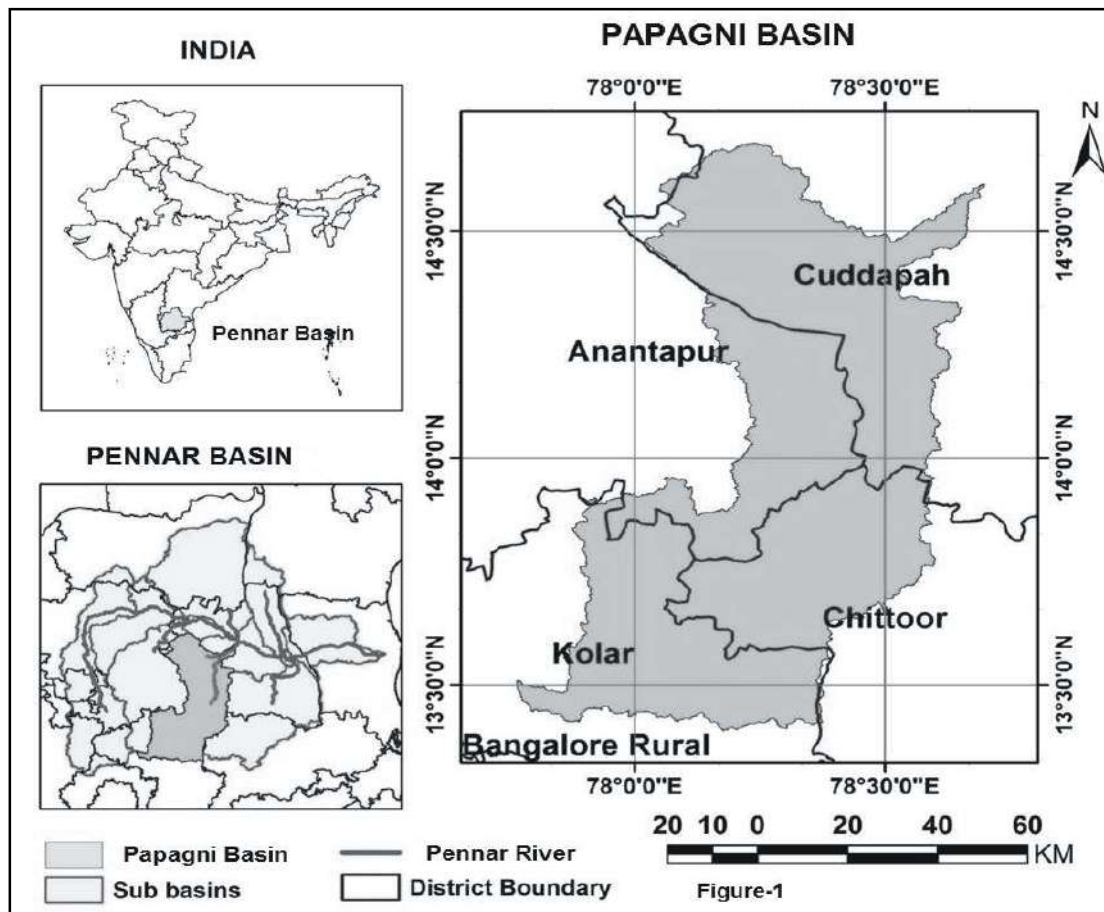


Fig.1

initial slope or inconsistencies in rock hardness, structural controls, recent diastrophism, geological and geomorphic history of drainage basin (Strahler, 1964).

Morphometric analysis using conventional methods is laborious, cumbersome and time consuming. But, adoption of GIS techniques coupled with remote sensing data is more suitable to analyze the drainage basin characteristics. It provides the real time and accurate information related to distinct geological formations, landforms and helps to identify the drainage channels which are altered by natural forces or human induced activities.

Multispectral satellite sensor data provides a convenient means to analyze drainage and distinct landform characteristics at various scales. GIS is an effective tool to analyze spatial as well as non spatial data on drainage, geology, landforms and soil parameters to understand their inter-relationships. Geo-coded resource database generated on drainage, landforms and soil parameters in the core of GIS provides an excellent means of storing, retrieving and analyzing at river basin level to find out their association. It also provides a powerful mechanism not only to upgrade and monitor morphometric parameters but also to

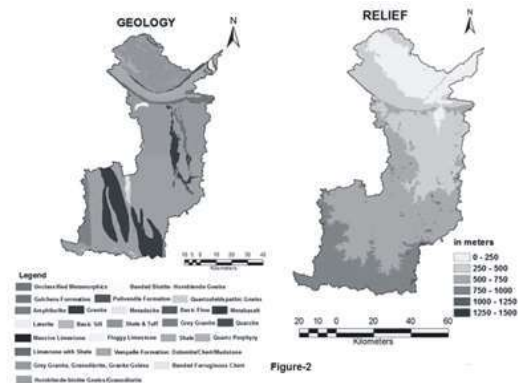
provide the spatial analysis of other associated resource database (Jain et.al.1995). In the present study an attempt is made to understand the morphometric characteristics of Papagni River Basin a tributary of Pennar river flowing through the two southern states of Karnataka and Andhra Pradesh using Aster DEM.

### Materials and Methods

The present study is based on Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital elevation Model (ASTER GDEM) of 1 arc-second resolution. Also toposheet no 57J, 57K and 57G obtained from Geological Survey of India is used to prepare geological map of the study basin. At the outset the DEM was processed to fill sinks and obtain flow direction and flow accumulation using hydrological tool in ArcGIS 10.2. Drainage network was extracted by considering pixels greater than a threshold of 100 by 'trial and error' approach and basin boundary was delineated by giving pour point. Sub basins were delineated by taking 4th order stream as threshold using SWAT. In all 17 sub-basins were delineated. The basin was divided into 7525 numbers of 1x1 km square grids to extract areal and relief parameters viz. drainage density, stream frequency, relative relief, dissection index and average slope for each grid. Various morphometric parameters of whole basin and all sub basins were calculated based on literatures (Horton, 1932, 1945; Strahler, 1952a,b, 1964; Schumm, 1956; Miller, 1953). Inverse-distance-weighted (IDW) method was applied for interpolation of grids value to prepare all corresponding maps.

### Study Area

Papagni drainage basin, a sub basin of Pennar river, Andhra Pradesh, situated between



13°20' to 14°40' north latitudes and 77°50' to 78°40' east latitudes and covers an area of about 7129 km<sup>2</sup> (Figure-1). It covers parts of Andhra Pradesh and Karnataka but major part is flowing in Andhra Pradesh only. It is located in the parts of Anantapur, Kadapa and Chittoor of Rayalseema region in Andhra Pradesh and Kolar district of Karnataka state. Twenty five mandals in Andhra Pradesh and five taluks in Karnataka state lie within the study basin. It is the principal right side tributary of Pennar River, one of the major east flowing rivers in Southern India.

Geologically (Figure-2) the major part of Papagni basin is located in granitic terrain in the southern part and Proterozoic formations consisting of Vempalle dolomites and Shales with basic intrusives and lava flows in northern part of the basin. The major geomorphic units in the study basin include black soil plains, fluvial plains, wash plains, creep built plains, valley fills, shallow weathered pediplains, piedmont plains, pediplains, pediment inselburg complex area, Velikonda hills, Palaknanda hills and isolated hills (Krishnaiah, 2011). Elevation wise major part of the basin (38.85%) lies between 500 – 750 m height and only 0.004% of the total area lies above 1250 m. 13.90%,

**Table 1 : Papagni Basin elevation**

Elevation (meters)	Area (km <sup>2</sup> )	Percentage Area
0 – 250	991.49	13.90
250– 500	1978.81	25.76
500– 750	2770.04	38.86
750– 1000	1363.04	19.12
1000– 1250	25.15	0.35
1250 – 1500	0.33	0.004

27.75%, 19.12% and 0.35% of the total basin area lies in very low (<250 m), moderately low (250 – 500 m), moderately high (750 – 1000 m) and high zones (1000 – 1250 m) (Table-1)

## Results and Discussion

### Relief Aspects

#### Relative Relief

Relative relief (Rr) is the difference of elevation between highest and lowest point in a basin. It is an important factor in understanding the denudational characteristics of the basin and plays a significant role in landform development, drainage development, surface and subsurface water flow, permeability and erosional properties of the terrain (Magesh et al. 2013). It is also termed as amplitude of local relief and is used for overall assessment of morphological characteristics of terrain and degree of dissection. More the degree of dissection, greater is the relative relief. High value of basin indicates the gravity of water flow, low infiltration and high runoff condition. In the study basin Rr ranges from 0.08 to 455 m. Figure-3 shows that 80.17% of the basin area lies in low Rr zone. Moderately low, moderately high, high and very high zones cover 16.50%, 3.02%, 0.29%, and 0.01% of the total basin

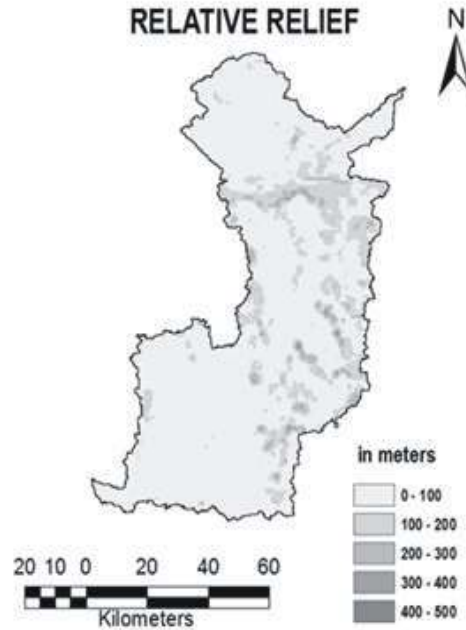


Figure-3

area respectively. Almost all sub basins lie in low Rr zone but some part of sub basin 2, 4, 5, 6, 7, 8, 9, 10, 12, 13 and 14 cover moderately low and moderately high zones. High zone covers some of the part of sub basins 7, 11, 13 and 14.

#### Relief Ratio

Overall steepness of the drainage basin was measured using relief ratio (Rh), a ratio between maximum basin relief and basin length (Schumm 1956). It is also an indicator of intensity of erosion processes and sediment delivery rate of the basin (Strahler 1964; Schumm 1956; Hadley and Schumm 1961). In the Papagni drainage basin, among sub basins Rh ranges from 0.007 to 0.02. Sub basins 1, 2, 3 and 15 have very low relief ratio whereas sub basins 4, 5, 6, 7, 8, 9, 10, 11, 13, 16 and 17 have low relief ratio which indicates low relief and gentle slope. Except these sub basins others

**Table 2 : Sub Basin wise relief aspects of Papagni Basin**

Sub Basin Id	Area (km <sup>2</sup> )	Max. Height (m)	Min Height (m)	Basin Relief (m)	Dissection Index	Relief Ratio (Rh)	Hypsometric Integral (%)	Average Slope (degree)
1	508.77	554	198	356	0.64	0.007	0.32	1.71
2	930.89	851	137	712	0.84	0.007	0.31	5.46
3	214.71	606	198	408	0.67	0.009	0.35	2.60
4	472.69	726	168	558	0.77	0.01	0.22	2.43
5	230.77	893	193	700	0.78	0.012	0.41	5.26
6	453.43	913	234	679	0.74	0.017	0.3	5.25
7	289.80	928	278	650	0.70	0.016	0.41	4.41
8	349.98	1088	367	721	0.66	0.014	0.31	4.99
9	484.87	1156	583	573	0.49	0.014	0.33	4.15
10	921.03	1067	415	652	0.61	0.018	0.37	3.47
11	324.76	1094	417	677	0.62	0.013	0.21	4.06
12	273.59	1291	480	811	0.63	0.021	0.27	5.93
13	220.38	1292	565	727	0.56	0.012	0.26	4.93
14	284.69	1332	591	741	0.56	0.02	0.29	3.39
15	351.65	1043	697	346	0.33	0.007	0.45	2.14
16	205.29	1138	697	441	0.39	0.012	0.34	2.04
17	462.81	1151	590	561	0.49	0.011	0.38	2.19

have comparatively high relief ratio.

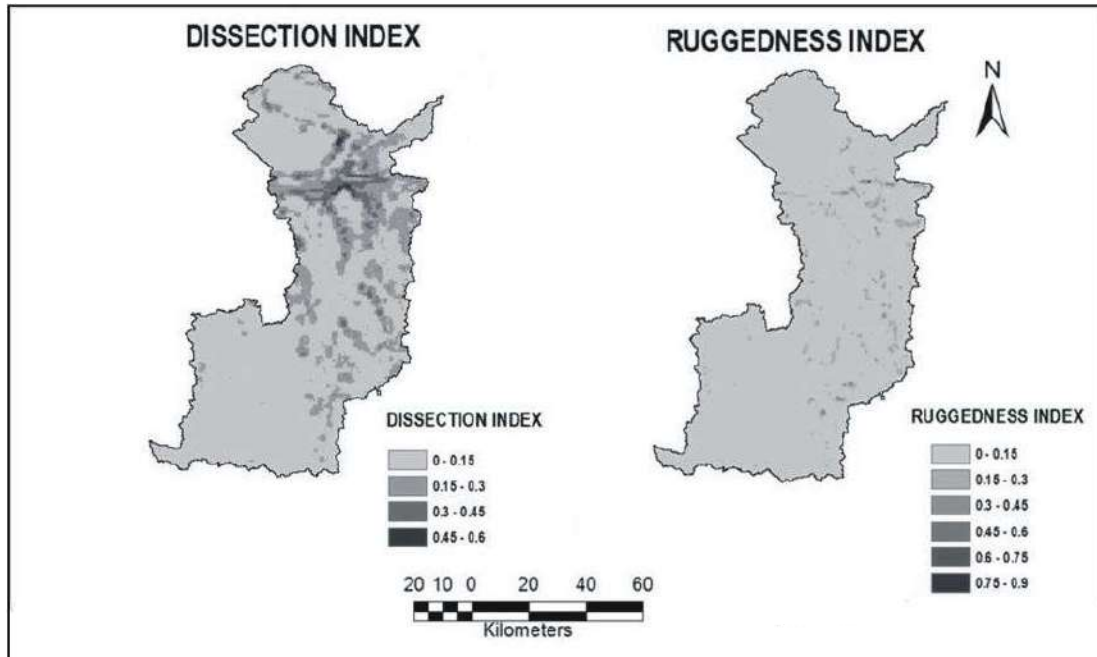
#### Dissection Index

Dissection index (DI) is the ratio between relative relief and absolute relief of an area. It is an important relief parameter that indicates the nature and magnitude of dissection of a terrain (Singh, 1998). On an average, the values of dissection index vary between 0 (complete absence of vertical dissection/ erosion and hence dominance of flat surface) and 1 (in exceptional cases, vertical cliffs, it may be at vertical escarpment of hill slope or at seashore). High value of DI shows young stage and low value shows old stage. In the Papagni Basin, DI varies between 0.33 and 0.84.(Table-2) Most part of the basin area(75.64%) comes

under the low DI zone (<0.15) which shows that the basin is in the old stage whereas 0.29 % of the total basin area lies in high DI zone. 20.09 % and 3.96 % of total basin area lies in moderately low and moderately high zones respectively(Figure-4). High DI zone in eastern and south eastern part of the basin indicate highly fragmented relief. In the sub basins 2, 4, 5, 6, 8 and 11 most of the part lies in moderately low and moderately high zones. Sub basins 3, 15, 16 and 17 come under low DI zone which indicates flat surface and old stage. Except these sub basins others lie in moderately low and low DI zone.

#### Ruggedness Index

Ruggedness index (RI) is used to



**Fig. 4**

measure surface roughness or unevenness. RI is measured by dividing the product of drainage density and relative relief by thousand. It indicates the structural complexity of the terrain and is a measure of surface unevenness. An extremely high value of ruggedness index occurs when both variables are large and slope is not only steep but long as well. High RI values are highly susceptible to erosion and are expected in a mountainous region of tropical climate with higher rainfall. Low value implies that area is less prone to soil erosion and has intrinsic structural complexity in association with relief and drainage density and indicates gentle slope. RI of the Papagni basin ranges from 0 to 0.79

Most part of the basin i.e. 95.72 % area has very low RI (<0.15) which indicates that it has gentle slope and is less prone to soil erosion. Moderate to high values are found in the eastern

and south eastern part of the basin. 3.79 %, 0.43 %, 0.05 %, 0.02 % and 0.002 % of the total area covers low, moderately low, moderately high, high and very high zone respectively. Though most part of all sub basins come under low DI zone but some parts of sub basins 2, 4, 5, 7, 8, 9, 10, 11, 12, 13 and 14 lies in low and moderately low zones.

#### **Average Slope**

Average slope of the study basin varies from 0 to 30 degree. 92.55 % of the total study basin area comes under gentle slope zone (<100) whereas 7.37 %, 0.08 % and 0.002 % lies in moderate, moderately steep and steep zones. Among the sub basins average slope varies from 1.710 to 5.240. Most part of the sub basins come under the gentle slope zone but some parts of sub basins 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 have moderate slope

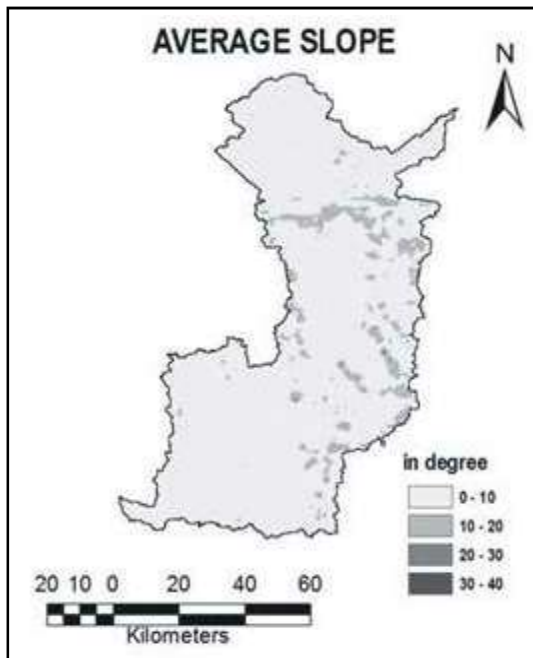


Fig. 5

whereas very small parts of sub basins 2, 8, 11 and 13 are in moderately steep zone (Figure 5).

**Hypsometric Curve**

Hypsometric curve, plot of normalized height against normalized area, was used to show the distribution of surface area with respect to elevations above local relief (datum).

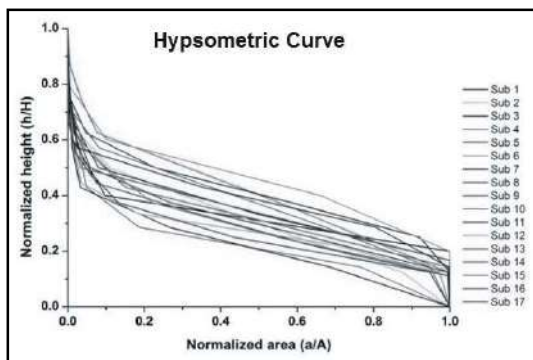


Fig. 6

The hypsometric integral, area below the curve, was calculated to express the stage of landform development (Strahler 1952b). Strahler used hypsometric integral of landform above 0.6 (60%), 0.6 – 0.35 (60 – 35%) and below 0.35 (35%) as proxy of youth, equilibrium (mature) and old stages respectively. Sigmoid shaped hypsometric curve and integrals between 20 and 45 percent shows that most of the study basin and sub basins are either in the mature or old stage of geomorphic evolution (Table-2 & Figure-6).

This is obvious as the river traverses through Deccan plateau region which is one of the oldest land masses in the world.

**Linear Aspects**

**Stream Order**

It is defined as a measure of the position of a stream in the hierarchy of tributaries (Leopold, Wolman and Miller, 1969). It expresses the hierarchical relationship between stream segments, their connectivity and the

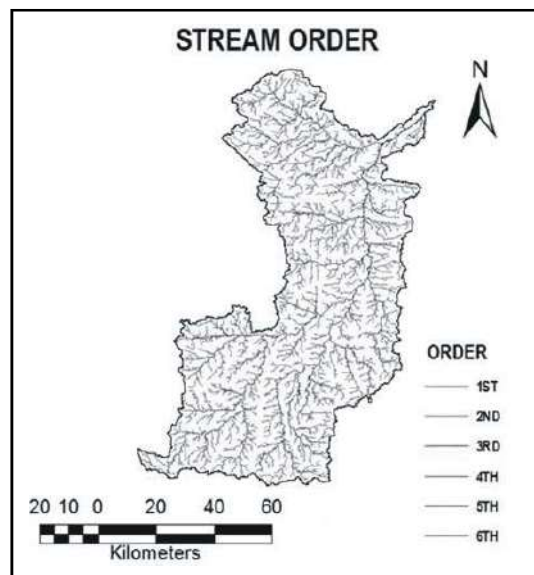


Fig. 7

discharge arising from contributing catchments. Here Strahler's method has been adopted and it is found that the study basin is a 6th order drainage basin (Figure-7). In the case of sub basins, only sub basin 2 has 6th order stream whereas sub basins 2, 4, 10, 11 and 12 have 5th order streams. The number of streams decrease with increase in stream order. In accordance with the Horton's law which states that the number of stream segments of each order form an inverse geometric sequence with stream order.

### **Stream Number**

The number of stream segments in each order is known as stream numbers. In the study basin  $N_u$  of 1st, 2nd, 3rd, 4th, 5th and 6th order streams are 1196, 264, 59, 13, 3, 1 respectively. At sub basin level, stream numbers of each order are presented in Table 3. Among the sub basins maximum stream numbers are found in sub basin 10 (206) and minimum is found in sub basin 3 (46). Not only in the case of basin but in sub basins also stream number decrease with increasing stream order. This observation follows Horton's law of stream numbers which states that the number of stream segments of successively lower orders in a given basin tends to form a geometric series beginning with the single segment of the highest order and increase according to constant bifurcation ratio.

### **Stream Length**

Stream length ( $L_u$ ) is the total length of streams of each order. It is a dimensionless property used in understanding the drainage network components which reflects the hydrological characteristics of the underlying rock surfaces over the areas of connective stream orders. Stream length is indicative of chronological developments of the stream

segments including interlude tectonic disturbances. Streams with relatively short length are representative of areas with steep slopes and fine texture, whereas longer lengths of streams are generally indicative of low gradients (Strahler, 1964). The total length of all drainage networks in Papagni basin is 4279 km (Table-3). The maximum length is observed in 1st order streams (2217 km) that progressively declines with each successive higher order up to 6th order which is 87 km.  $L_u$  of sub basins is proportional with size of sub basins. Among sub basins maximum stream length is observed in sub basin 2 whereas sub basin 6 has minimum stream length. (Table-4) In the basin and sub basins the total length of stream segments is maximum for 1st order and decreases as stream order increases. This is a normal trend and indicates that the terrain is gently sloping, with low relief and homogenous lithology.

### **Mean Stream Length**

It is a dimensionless property and the mean length of all segments in a given order. It is obtained by dividing the total length of streams of order  $u$  by total number of segments in the order  $u$ . The  $L_{sm}$  of the study basin ranges from 1.85 km to 88.60 km (Table-3). It is observed generally  $L_{sm}$  of any given order is greater than the mean length of lower order and less than that of next higher order i.e mean stream length increases with increase of stream order. At sub basin level same pattern has been observed except sub basin 13 and 15 where mean stream length decreases with increasing stream order.

### **Stream Length Ratio**

It is the ratio between mean stream length of a given order and its next higher order. It

**Table-3 Linear aspects of Papagni Basin**

Stream Order	Stream Number (Nu)	Stream Length in km	Mean Stream Length ( $L_{sm}$ ) in km	Cumulative Mean Stream Length in km	Stream Length Ratio ( $R_l$ )	Bifurcation Ratio ( $R_b$ )
1	1196	2217.10	1.85	1.85	—	4.53
2	264	1002.11	3.79	5.65	2.05	4.47
3	59	545.59	9.25	14.89	2.44	4.54
4	13	280.49	21.58	36.47	2.33	4.33
5	3	145.52	48.51	84.98	2.25	3
6	1	88.60	88.60	173.58	1.83	—
Total	1536	4279.41				

has an important relationship with the surface flow discharge and erosional stage of the basin. Variation from one order to another order indicates their late youth stage of geomorphic development (Singh and Singh, 1997). Horton's law of stream length states that mean stream length segments of each of the successive order of a basin tends to approximate a direct geometric series with stream length increasing towards higher order of stream. In the basin  $R_l$  ranges from 1.82 to 2.83. The sub basins 5, 14 and 16, in general, have increasing stream length ratio which indicates that these sub basins have achieved graded condition (Singh and Singh, 1997). On the other hand, other sub basins have decreasing stream length ratio with respect to stream order. (Tables-3 )

#### **Bifurcation Ratio**

Bifurcation ratio defined as the ratio between the total number of stream segments of one order to that of the next higher order in a drainage basin (Schumm, 1950) is a dimensionless property that shows the degree of integration prevailing between streams of various orders in a drainage basin. Lower  $R_b$

values are the characteristics of structurally less disturbed watersheds without any distortions in drainage pattern. In the present study area  $R_b$  ranges from 3 to 4.53, is more or less constant. It signifies that this river basin is normal and structurally less disturbed. All the sub basins except sub basin 14 have decreasing trend of  $R_b$  with increasing stream order whereas sub basin 13 has near constant bifurcation ratio. Here relatively high  $R_b$  of lower stream orders in the sub basins indicates the presence of high relief. Sub basins 1, 2, 6, 7, 10, 12 have high bifurcation ratio in lower stream orders. (Tables-3 )

#### **Areal Aspects**

##### **Drainage Density**

Drainage density ( $D_d$ ) expresses total stream length per unit drainage area. It is depends on climate (mainly rainfall), geology, vegetation cover, erosivity, infiltration capacity and permeability of underlying rock and soil, relief and slope aspect of the basin (Horton 1932; Strahler 1964; Morisawa 1968; Verstappen 1983). Drainage density depends

Table 4 : Sub-basin wise linear aspects of Papagni Basin

Sub Basin Id	Area (km <sup>2</sup> )						Stream Order(N <sub>u</sub> )						Total Stream Number Length (km)(L <sub>u</sub> )	Mean Stream Length	Stream Length Ratio	Bifurcation Ratio (R <sub>b</sub> )
	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>	N <sub>5</sub>	N <sub>6</sub>	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>	N <sub>5</sub>	N <sub>6</sub>				
1	508.77	92	22	6	1	-	-	-	-	-	-	121	327.41	1.89, 4.07, 6.47, 24.40	2.14, 1.59, 3.78	4.18, 3.67, 6
2	930.89	101	31	6	3	3	1	205	795.85	1.93, 4.45, 8.35, 20.83, 48.5, 88.60	2.29, 4.57, 5.41, 22.12	1.99, 1.18, 4.09	2.29, 1.88, 2.49, 2.33, 1.83	5.19, 5.17, 2, 1, 3		
3	214.71	33	9	2	2	-	-	46	171.86	1.86, 3.17, 14.26, 28.13, 26.81	1.71, 4.5, 1.97, 0.95	3.67, 4.5, 1	4.47, 4.75, 1.33, 3			
4	472.69	85	19	4	3	1	-	112	386.19	1.78, 4.13, 4.13, 26.09	1.32, 2.27, 7.53	4.33, 4.5, 2				
5	230.77	39	9	2	1	-	-	51	141.32	2.06, 5.31, 8.73, 12.42	2.57, 1.64, 1.42	5.2, 3.75, 4				
6	453.43	78	15	4	1	-	-	98	287.91	1.81, 2.82, 8.43, 23.96	1.55, 2.99, 2.84	3.81, 5.33, 3				
7	289.80	51	11	3	1	-	-	66	174.82	1.76, 3.81, 11.75, 13.43	2.16, 3.09, 1.14	4.47, 4.75, 4				
8	349.98	61	16	3	1	-	-	81	204.91	1.70, 3.67, 8.85, 16.54, 59.35	2.16, 2.41, 1.87, 3.59	4.84, 4.13, 2.67, 1.5				
9	484.87	85	19	4	1	-	-	109	282.39	1.72, 4.07, 4.37, 20.99, 40.10	2.36, 1.07, 4.79, 1.91	4.58, 6, 0.5, 4				
10	921.03	160	33	8	3	2	-	206	632.42	2.02, 4.27, 15.94, 7.16, 40.10	2.11, 3.74, 0.45, 5.60	5.25, 4, 2, 1				
11	324.76	55	12	2	4	1	-	74	276.47	1.52, 2.28, 12.13, 10.10	1.50, 5.31, 0.83	4.78, 3, 3				
12	273.59	42	8	2	1	1	-	54	198.03	1.69, 3.05, 2.51, 19.15	1.79, 2.46, 3.88	3.54, 3.25, 4				
13	220.38	43	9	3	1	-	-	56	132.27	1.97, 4.21, 17.19, 16.94	2.14, 4.08, 0.99	4.15, 6.5, 2				
14	284.69	46	13	4	1	-	-	64	176.83	1.86, 2.56, 6.45, 19.26	1.38, 2.51, 2.99	4.11, 4.5, 2				
15	351.65	54	13	2	1	-	-	70	212.39	1.92, 4.23, 16.71, 37.56	2.20, 3.95, 2.25	4.44, 8, 2				
16	205.29	37	9	2	1	-	-	49	124.15							
17	462.81	71	10	2	1	-	-	90	275.04							

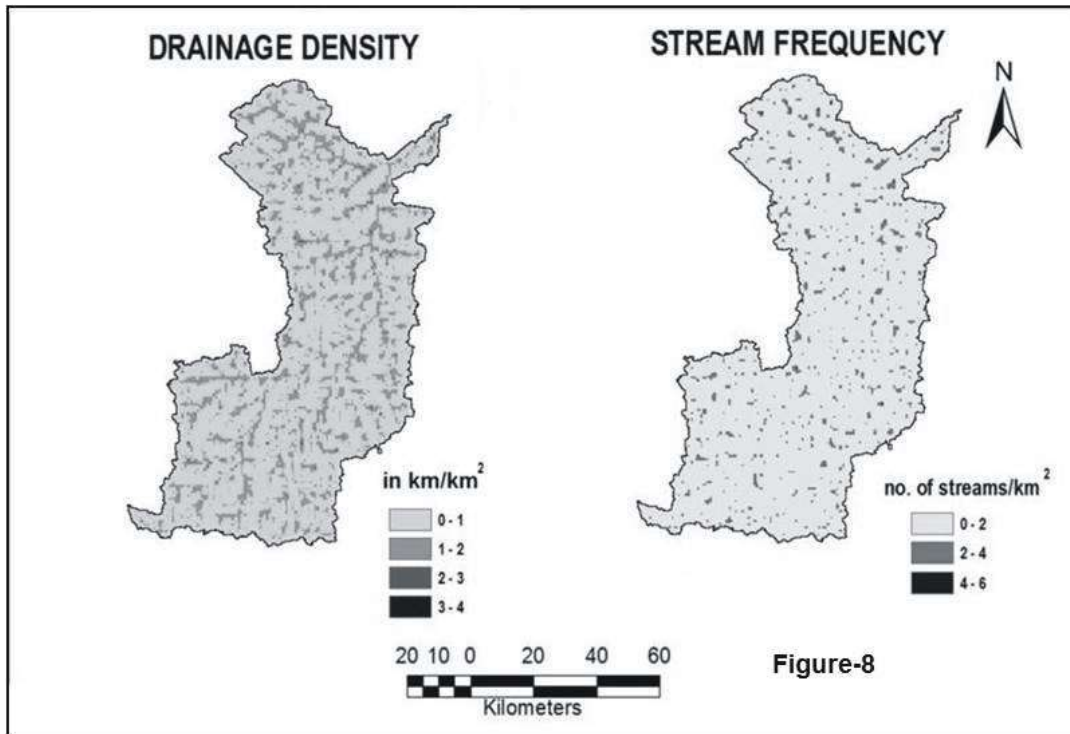


Figure-8

on the stage of evolution. With the progress of youth stage towards maturity, Dd increases rapidly; while towards old stage it decreases. Dd varies between 0 to 3.07 km/km<sup>2</sup> whereas for the whole basin it is 0.60 km/km<sup>2</sup> which indicates low relief and coarse drainage texture. Low, moderate, high and very high zone covers 81.10 %, 18.47 %, 0.41 % and 0.002 % respectively. Figure-7 reveals that maximum part of the study basin comes under low Dd zone which indicates that the basin is in old stage. In the sub basins, Dd varies between 0.58 to 0.85 km/km<sup>2</sup>. Sub basins 7, 8, 9, 13, 15, 16 and 17 have low Dd (<0.60 km/km<sup>2</sup>) and sub basins 1, 2, 3, 4, 5, 6, 10, 11, 12 and 14 have comparatively high Dd (>0.60 km/km<sup>2</sup>). But overall they all have low Dd which indicates that these sub basins are approaching towards old stage.

### Stream Frequency

Stream frequency (F) is defined as number of stream segments of all orders per unit drainage area (Horton 1932). The factors which influence F are rainfall amount, resistance of rock to erosion, permeability, structure of rock, basin shape, tectonic influences etc. The value of F ranges between 0- 5.9 /km<sup>2</sup> but for the whole basin the value is 0.22/km<sup>2</sup>. 94.49 % of the total basin area lies in low stream frequency zone (<2/km<sup>2</sup>). Moderate and high stream frequency zone covers 5.45 % and 0.05 % of the total basin area respectively (Figure-7). Its lower value indicates gentle ground slopes, greater rock permeability and high infiltration. Among the sub basins the values range from 0.19 to 0.25 that indicates gentle slope and high infiltration. Sub basins 12, 15 and 17 have very low

Table 5. Sub-basin wise areal aspects of Papagni Basin

Sub basin Id	Area (km <sup>2</sup> )	Perimeter (km)	Basin Length L <sub>b</sub> (km)	Drainage Density D <sub>d</sub> (km/km <sup>2</sup> )	Stream Frequency F (/km <sup>2</sup> )	Constant of Channel Maintenance C <sub>f</sub>	Form Factor Ratio R <sub>f</sub>	Elongation Ratio R <sub>e</sub>	Circularity Ratio R <sub>c</sub>	Compactness Coefficient C <sub>c</sub>	Texture Ratio R <sub>t</sub>	Drainage Texture D <sub>t</sub>	Infiltration Number If	Length of Overland Flow L <sub>g</sub>
1	508.77	138.6	46.81	0.64	0.24	1.55	0.23	0.54	0.33	1.73	0.66	0.87	0.15	0.78
2	930.89	370.26	101.51	0.85	0.22	1.17	0.09	0.34	0.09	3.42	0.43	0.55	0.19	0.58
3	214.71	129.42	46.62	0.80	0.21	1.25	0.10	0.36	0.16	2.49	0.25	0.36	0.17	0.62
4	472.69	195.48	54.39	0.81	0.24	1.22	0.16	0.46	0.16	2.54	0.43	0.57	0.19	0.61
5	230.77	187.92	57.52	0.61	0.22	1.63	0.07	0.29	0.08	3.49	0.21	0.27	0.14	0.82
6	453.43	147.42	39.81	0.63	0.22	.58	0.29	0.61	0.26	1.95	0.53	0.66	0.14	0.79
7	289.8	128.7	41.97	0.60	0.23	1.66	0.17	0.46	0.22	2.13	0.39	0.51	0.14	0.83
8	349.98	151.2	52.89	0.59	0.23	1.71	0.13	0.40	0.19	2.28	0.40	0.54	0.14	0.85
9	484.87	156.06	41.74	0.58	0.22	1.72	0.28	0.59	0.25	1.99	0.54	0.69	0.13	0.86
10	921.03	306.72	109.26	0.68	0.22	1.46	0.73	0.96	0.12	2.85	0.52	0.67	0.15	0.73
11	234.76	190.8	54.61	0.85	0.23	1.14	0.12	0.39	0.11	2.99	0.29	0.39	0.19	0.59
12	273.59	123.12	39.41	0.72	0.19	1.38	0.18	0.47	0.23	2.09	0.34	0.44	0.14	0.69
13	220.38	100.98	38.45	0.60	0.25	1.67	0.15	0.43	0.27	1.92	0.43	0.55	0.15	0.83
14	284.69	151.02	49.37	0.62	0.22	1.61	0.21	0.52	0.16	2.52	0.30	0.42	0.14	0.81
15	351.65	153.9	50.91	0.60	0.19	1.66	0.14	0.42	0.19	2.31	0.35	0.45	0.12	0.83
16	205.29	105.12	36.46	0.60	0.23	1.65	0.16	0.44	0.23	2.07	0.35	0.47	0.14	0.83
17	462.81	202.86	71.47	0.59	0.19	1.68	0.20	0.51	0.14	2.66	0.35	0.44	0.12	0.84

**Table 6 : Areal aspects of the Papagni Basin**

No	Basin Geometry	Reference	Formula	Result
1	Basin Area (A)			7128.89 km <sup>2</sup>
2	Basin Length (L <sub>b</sub> )	Schumm (1956)		223.86 km
3	Basin Perimeter (P)	Schumm (1956)		907.56 km
4	Relative Perimeter	Schumm (1956)	(A/P)	7.86
5	Drainage Density (D <sub>d</sub> )	Horton (1945)	L <sub>u</sub> /A	0.6 km/km <sup>2</sup>
6	Stream Frequency (F)	Horton (1945)	N <sub>u</sub> /A	0.22/ km <sup>2</sup>
7	Drainage Texture (D <sub>t</sub> )	Horton (1945)	N/P	1.69
8	Texture Ratio (R <sub>t</sub> )	Horton (1945)	N(u-1)/P	1.32
9	Infiltration Number (I <sub>p</sub> )	Faniran (1968)	D <sub>d</sub> *F	0.13
10	Circularity Ratio (R <sub>c</sub> )	Miller (1953)	(4*δ*A)/P <sup>2</sup>	0.11
11	Elongation Ratio (R <sub>e</sub> )	Schumm (1956)	[2(A/δ) <sup>0.5</sup> ]/L <sub>b</sub>	0.43
12	Compactness Coefficient (C <sub>c</sub> )	Gravelius (1914)	P/2(A*δ) <sup>0.5</sup>	3.03
13	Form Factor Ratio (R <sub>f</sub> )	Horton (1932)	A/L <sub>b</sub> <sup>2</sup>	0.14
14	Shape Factor Ratio	Horton (1956)	L <sub>b</sub> <sup>2</sup> /A	7.03

frequency whereas sub basins 1, 4, 13 have moderate frequency.

### Drainage Texture

Drainage texture (Dt) is considered as relative spacing between stream lines. Horton (1945) derived Dt as the number of stream segments of all orders per unit perimeter of the basin. Dt depends upon several factors like rainfall, vegetation, geologic condition, infiltration capacity and permeability. Value of Dt less than 2 indicates very coarse, 2 to 4 as coarse, 4 to 6 as moderate, 6 to 8 as fine and above 8 as very fine texture (Smith, 1950). Dt value of the basin is 1.69 which indicates very coarse texture according to Smith's classification. In the sub basins Dt value ranges between 0.27 to 0.87 which shows that all of the sub basins have very coarse texture.

### Texture Ratio

Horton (1945) used texture ratio (Rt) as the ratio between the total number of first order

streams (N1) and perimeter (P) of the basin (Rt = N1/P). It depends on the underlying lithology, infiltration capacity and relief aspects of the terrain. Texture ratio for the Papagni basin is 1.32 whereas for the sub basins it ranges from 0.21 to 0.66.

### Constant of Channel Maintenance

Schumm (1956) used the inverse of drainage density or the constant of channel maintenance as a property of landform. Generally higher the values higher the permeability of the rocks of the basin and vice versa (Pakhmode, V et al. 2003, Rao, S., 2009). Low value indicates structural complexity and higher dissection of the terrain. The value of C ranges from 1.17 to 1.72 (Table-4). among the various sub basins. Sub basins 2 and 11 have low value which indicates less permeable rocks and hence greater dissection of rocks is seen than the other sub basins.

### **Circularity Ratio**

It is the ratio of the area of the basin to the area of a circle having circumference as the perimeter of the basin (Miller, 1953). It expresses the degree of circularity of the basin and indicates the tendency of small drainage basin in homogenous geologic materials to preserve geometrical similarity. Circularity ratio 0.5 and above indicates that they are more or less circular and are characterized by high to moderate relief and drainage system is structurally controlled. The value of Rc for Papagni basin is 0.10. Among the sub basins values ranges from 0.085 to 0.33. Sub basins 2 and 5 have very low value which is an indication of their highly elongated shape but sub basin 1 and 13 have relatively high value which indicates that these basins are in a near circular shape. Other sub basins i.e 3, 4, 6, 7, 8, 9, 12, 13, 14, 15, 16 and 17 have the moderate value which also indication of elongation shape. .

### **Elongation Ratio**

Schumm defined it as the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. Values close to 1.0 have very low relief with circular shape. These basins are efficient in the discharge of runoff than the elongated basin because concentration time is less in circular basin. Values in the range 0.6 to 0.8 are usually associated with high relief and moderate to steep ground slope. These values can be grouped as Circular ( $>0.9$ ), Oval (0.9-0.8), Less Elongated (0.7-0.8), Elongated (0.5-0.7), More Elongated ( $<0.5$ ). Re value of the Papagni basin is 0.43 which shows that the basin is more elongated. Among the sub basins values range from 0.29 to 0.96. Here sub basin 10 has the value 0.96 which indicates circular

shape. Sub basin 1, 6,9,14 and 17 shows elongated shape but sub basins 2, 3, 4, 5, 7, 8, 11, 12, 13, 15, 16 having value less than 0.5 indicates more elongated shape.

### **Infiltration Number**

It is defined as the product of drainage density and stream frequency and gives an idea about the infiltration characteristics of the watershed. The higher the infiltration number the lower will be the infiltration and the higher runoff. The value for whole basin is 0.13. In the sub basins, value ranges between 0.12 and 0.19 which indicates about high infiltration capacity and low runoff. Sub basin 15 and 17 have very low infiltration number while sub basin 2, 4, 11 have relatively high value ( $>0.19$ ). Sub basin 1, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14 and 16 have moderate value.

### **Conclusions**

Morphometric analysis with the aid of GIS tools makes us easy to understand the nature, geomorphic evolution, drainage network development and geologic control of the basin. Sub basin wise analysis of morphometric parameters was very indicative to explain their stage of development. From the relief distribution of the basin it is inferred that major part of the basin has low relief and is in the old stage of geomorphic cycle. This is clearly indicated from the low values of dissection index as well as ruggedness index which are less than 0.15 for three fourth of the basin area. The sigmoid shaped hypsometric curve also indicates towards the old stage of the basin with majority of the subbasins having integral value between 0.20 and 0.45. The linear and areal aspect of the basin reveals that the basin is normal, near-elongated and geologically less disturbed. Majority of the sub- basins also lie

either in mature or old stage of geomorphic cycle.

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# **Arsenic in Indo- Gangetic Plain of India: A Review**

**Vivek Kumar Sharama and V. K. Rai**

India is a country of different physiographic regions. Indo-Gangetic Plain (IGP), also known as “Great Plains” in one of the main physiographic part of India. IGP is also a great reservoir of fresh ground water. Rapid growth of population, urbanization, industrialisation and over- exploitation of ground water is now creating a critical scenario for human health as increasing Arsenic quantity in groundwater of IGP. West Bengal, Bihar and Uttar Pradesh (Parts of IGP), have maximum Arsenic contamination. There are 79 blocks in 8 districts of West Bengal, 57 blocks in 15 districts of Bihar and 45 blocks in 9 districts of U.P., are affected by the Arsenic contamination. Arsenic contamination can be reduce by using surface water sources, tapping alternate aquifer and rain water harvesting. There is a need to aware the community about Arsenic and its related problems. There is a need of high technology and improved research for knowing the exact sources and mechanism of Arsenic mobility in the aquifers of IGP.

This paper is chiefly an overview of Arsenic contamination in IGP regions of India (West Bengal, Bihar and Uttar Pradesh), based on secondary data, previous surveys and works done on it by several Govt. agencies and scholars.

**Keywords** : Great Plains, Reservoir, Contamination, Alternate aquifer, Rain Water Harvesting.

## **Introduction**

India is a country of different physiographic regions. All types of landscapes are present here as, mountains, hills, plateaus and plains. Indo-Gangetic Plain, one of the main physiographic part of India, lies between Extra-Peninsular region in north and the Peninsular region in south. The period of origin of Indo-Gangetic Plain is assumed as Middle Pleistocene when the tectonic foredeep basin got filled up by alluvial sediments and level plains

were formed ( Saha et al, 2012). The other prediction about its origin is due to collision of the Indian and Chinese plate during the Middle Miocene and its deposits represents the last chapter of earth’s history ( Pal et al, 2009). Indo Gangetic Plain ranks as one of the most fertile fluvial plains of the world. It covers about 13% of the total geographical area of India and produces about 50% of the total food grains ( Pal et al, 2009). Indo-Gangetic Plain is also known as “Great Plains” of India because of

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**Table 1: Distribution of States and Region of Indo-Gangetic Plain (IGP)**

State/UT	Region
Punjab, Haryana, Delhi and Chandigarh	Trans Gangetic Plain
Uttar Pradesh	Upper Gangetic Plain
Uttar Pradesh + Bihar	Middle Gangetic Plain
West Bengal	Lower Gangetic Plain

Source: Korhal, A.K. 2014.

major sedimentation in it. It has a thick lattice of different type of river systems, originated from the Himalaya, the base for various economic activities. Indo-Gangetic Plain has developed mainly by the alluvium of the Indus, Yamuna, Ganga, Ramganga, Ghagra, Rapti, Gandak, Bhagirathi, Silai, Damodar, Ajay and Kosi river (Pal et al, 2009). It is abbreviated as IGP. The Indo-Gangetic Plain is one of the most fertile alluvium plain favourable for multiple cropping. It is also a great reservoir of fresh ground water which fulfill the requirements of industrial and agricultural needs. Due to presence of large amount of ground water and fertile alluvium, IGP is one of the most densely populated areas of the world (Chaturvedi et al, 2010). Trans Ganga Plain, Upper Ganga Plain, Mid Ganga Plain and Lower Ganga Plain are the subdivisions of IGP. Punjab, Haryana, Delhi and Chandigarh are situated in Trans Gangetic Plain, Uttar Pradesh in Upper Gangetic Plain, Bihar and some parts of Uttar Pradesh in Middle Gangetic Plain and West Bengal is situated in Lower Gangetic Plain (Kosal, 2014).

Ground water resources of IGP is divided

as static and dynamic. The static resources are related with the permeable portion of the aquifer below the zone of water level fluctuation while the dynamic groundwater resources belong to zone of water level fluctuation. In developing countries like India ground water is used in various sectors due to its wide spread availability and low capital cost. It plays an important role in economic development of any country. The unplanned and over-exploitation of ground water is now creating a critical scenario for human health as increasing Arsenic quantity in groundwater of all over the world as well as in IGP. This paper is chiefly an overview of Arsenic contamination in IGP regions of India (West Bengal, Bihar and Uttar Pradesh), based on the previous surveys and works done on it. Arsenic (As) contamination of natural origin in groundwater has been envisaged as a worldwide problem (Bhattacharya et al, 2010). Drinking water is one of the most important pathways of exposure to Arsenic in human population and ground water as drinking source is thought to be responsible for the majority of the world's chronic Arsenic related health problems.

#### **Worldwide Occurrence of Arsenic (As)**

Arsenic, the 20<sup>th</sup> most abundant element with 1-2 mg/kg concentration, is found in earth's crust as organic, inorganic and gas form (Chaurasia et al, 2012; Singh, 2006). Arsenic is metalloid in nature which belongs to nitrogen group having atomic number 33 and molecular weight 74.9 g mol/l. 'As' is the abbreviated form of Arsenic. Arsenic (-III) (arsenide), Arsenic (0) (elemental arsenic), Arsenic (III) (arsenite) and Arsenic (V) (arsenate) are the other forms of Arsenic (Neidhardt, 2012). Arsenopyrite

**Table 2 : Country/Region and Environmental Conditions for Arsenic Occurrence**

Country/ region	Environmental conditions
Bangladesh	Natural; alluvial/deltaic sediments with high phosphate, organics
West Bengal, India	Similar to Bangladesh
Vietnam	Natural; alluvial sediments
Thailand	Anthropogenic; mining and dredged Alluvium
Taiwan	Natural; coastal zones, black shales
Inner Mongolia	Natural; alluvial and lake sediments; high alkalinity
Xinjiang, Shanxi	Natural; alluvial sediments
Argentina	Natural; loess and volcanic rocks, thermal springs; high alkalinity
Chile	Natural and anthropogenic; volcanogenic sediments; closed basin lakes, thermal springs, mining
Bolivia	Natural; similar to Chile and parts of Argentina
Brazil	Gold mining
Germany	Natural: mineralized sandstone
Hungary, Romania	Natural; alluvial sediments; organics
Spain	Natural: alluvial sediments
Greece	Natural and anthropogenic; thermal springs and mining
United Kingdom	Mining; southwest England
Ghana	Anthropogenic and natural; gold mining
USA and Canada	Natural and anthropogenic; mining, pesticides, As <sub>2</sub> O <sub>3</sub> stockpiles, thermal springs, alluvial, closed basin lakes

Source: Nordstrom, 2002.

(FeAsS), Realgar (As<sub>4</sub>S<sub>4</sub>) and Orpiment (As<sub>2</sub>S<sub>3</sub>) are commonly found with ores. Insulphides and hydrous iron oxides, Arsenic is found as trace element (Neidhardt, 2012; Nordstrom, 2002). In fresh water its concentration is 1 to 2 µg/l but in groundwater it depends upon parental rocks and geochemical conditions (Neidhardt, 2012). Rapid growth of population, urbanization, industrialisation and need for fresh water has increased the exploitation rate of groundwater resulting in excess Arsenic quantity in groundwater. Naturally occurring Arsenic contamination of groundwater has been

discovered in at least 70 countries to date. In half of these countries, the discovery has taken place within the last 10--15 years (Noorani, 2013). Many more countries can be added in the list and it is continuing to grow (Smith and Steinmaus, 2011). High concentration of Arsenic is reported all over the world. e.g., Argentina, Australia, Bolivia, Cambodia, Chile, Ecuador, El Salvador, Honduras, Hungary, Mexico, Nepal, New Zealand, Nicaragua, Myanmar, Philippines, Taiwan, Thailand, Uruguay and the United States. However affected areas are located in deltaic flood plains (Neidhardt, 2012). Occurrence of Arsenic is depend upon the

environmental condition ( Nordstrom, 2002).

### **Arsenic Contamination in Indo-Gangetic Plain (IGP)**

Rapidly growing population of IGP region of India has sporadically increased the demand for water. This demand cannot be fulfilled by surface water alone therefore dependency on groundwater has been increasing. The excess utilization of groundwater has created new health issues i.e, problematic enrichment of Arsenic ( Nordstrom, 2002). After identifying a number of aquifers with Arsenic concentration, it has become a new problem for groundwater environment and human health all over the world. In IGP region of India it is in critical condition. Although IGP is free from volcanic activity or thermal springs but it has an extensive span of Arsenic affected area (Acharyya et al, 2000). IGP is the feeding bowl of India due to fertile land and surplus production (Chakraborti et al, 2003). For knowing the content of Arsenic contamination, its spatial distribution and to characterize the chemical composition of Arsenic in IGP, various analytical research programmes have been undertaken by several govt. and non-govt. agencies (Kunar et al, 2009). The World Health Organization–recommended standard of Arsenic in drinking water is 10 µg/L, and the Indian standard is 50 µg/L (Chakraborti et al, 2003). It is found that Arsenic contamination is more than the permissible limit (>0.05mg/l) in most states of IGP (U.P., Bihar and West Bengal etc.). In West Bengal, Arsenic concentration is in more severe condition as compared to other states (Kunar et al 2009; Chaturvedi et al, 2010). Recent surveys show that Union Territory of Chandigarh and its surroundings (Chakraborti

et al, 2003) as well as some parts of Chhattisgarh, Jharkhand and North Eastern States are also affected (Kunar et al, 2009). States of IGP like Uttar Pradesh, Bihar etc. have similar geology (Singh, 2006). Arsenic contamination in IGP belong to middle Holocene sediments while early Holocene deposits are free from it (Acharyya et al, 2000). Arsenic toxicity in groundwater in IGPs is an alarming environmental problem for living being (Acharyya et al, 2000).

### **Toxicity of Arsenic**

Inorganic form of As is more harmful than organic form because it stores in body, affecting multiple organ systems (Chaurasia et al, 2012; Neidhardt, 2012). The toxicity of arsenic follows the order- Arsine gas > Inorganic Arsenite (As III) > Organic Arsenic (As III) > Inorganic Arsenate (AsV) > Organic Arsenate (AsV) > Elemental Arsenic (Chaurasia et al, 2012). Arsenic can be absorbed by human beings through ingestion and inhalation. It enters into human body by acute or chronic processes. Acute poisoning is through pesticides and other indirect methods while chronic poisoning is related with oral ingestion (Neidhardt, 2012). Both type of Arsenic ingestion increases its amount in human body resulting in various types of diseases viz, cancers, skin lesion and pigmental problems (Neidhardt, 2012; Gosh et al, 2001; Nordstrom, 2002). Arsenic adversely affects the development of brain and nervous system and causing prematurity, intrauterine growth retardation, malnutrition and infection. It is also responsible for high perinatal and neonatal mortality, spontaneous abortions etc. Arsenic is denoted as a teratogen as well as a reproductive toxin (Chakraborti et al, 2003).

Toxicity of As is depend upon it's sources.

### **Arsenic Sources in IGP**

Geological and chemical characteristics of aquifer materials organicity of sediments and land use pattern play an important role in occurrence of Arsenic in groundwater. There is a strong correlation between the Arsenic affected area and its geomorphology and geology (Acharyya et al, 2000). In India Arsenic origin is mainly geogenic in nature and contaminated aquifers are belonging to post Pleistocene age. Arsenic contamination varies from place to place but there is a similarity that they lie in sediments of Holocenian age (Kunar et al, 2009). It is suggested that Arsenic contamination is entirely natural (leaching of geological materials) (Bhattacharya et al, 2010) or partly anthropogenic (over exploitation of groundwater, use of fertilizer and pesticides) in IGP (Acharyya et al, 2000; Singh, 2006). According to Sumit Saha et al (2012), the older alluvium of IGP is generally Arsenic free but newer alluvium is rich in organic material and has high concentration of Arsenic. There is not much information about natural emission of Arsenic in IGP (Singh, 2006). In IGP region, the sources of Arsenic is predicted as transportation of sediments by rivers and their tributaries from Himalayas (Kunar et al, 2009) and Gondwana coal seams in Rajmahal basin, Mica belt of Bihar, Proterozoic Vindhyan range, the gold belt of the Son Valley are some areas that contain Arsenic rich minerals (lollingite and pyrite) (Acharyya et al, 2000). In 1998 Nickson et al. told that association of aquifer sediment with iron oxyhydroxide is the primary source of Arsenic. (Chakraborti et al, 2003). Arsenic favourably co-precipitates or scavenges by iron oxyhydroxide in the sedimentary environment

which are deposited in deltaic plains under low energy condition (Acharyya et al, 2000). The meandering patterns of the rivers are also responsible for the localized depositions of Arsenic rich sediments in the IGP (Chakraborti et al, 2003). However, it is most accepted theory that the source of Arsenic in West Bengal, Bihar and Uttar Pradesh is the Himalayas. Arsenic-rich sediments derived from the Himalayan mountains are deposited in IGP but the specific source of Arsenic contamination in the Ganges basin is as yet unidentified (Acharyya et al, 2000). Exposure of As contamination in IGP is mainly based on it's mobilizing processes.

### **Mobilization of Arsenic in IGP**

Now a days IGP region of india has become one of the most problematic regions of inorganic Arsenic concentration in groundwater (Neidhardt, 2012). It is documented that the Arsenic mobilization in IGP depends upon a lot of reasons as: rivers origin, weathering of rocks, sedimentation rate, presence of microorganism, rainfall, leaching temperature etc. as well as on geological, geochemical, hydro geological and mineralogical characteristics of late Quaternarian and Holocenean sediments, various redox reactions and their interaction with aqueous environment (Singh, 2006; Bhattacharya et al, 2010). Mobility of As may vary vertically as well as horizontally on small scale (Neidhardt, 2012). There are two processes belonging to releasing of Arsenic into groundwater, either natural or anthropogenic. Naturally Arsenic is generated by parental rocks and sediments while anthropogenic activities include use of herbicides, pesticides and many types of chemicals as well as industrial activities (mining, smelting and fuel

combustion) (Neidhardt, 2012). Most research studies show that high Arsenic contamination in groundwater of IGP is the result of geological rather than artificial or anthropogenic sources. It is assumed that all Arsenic bearing materials have originated from the Himalayan foot hills and transported by streams towards IGP and these are responsible for deterioration of groundwater quality. Hydroxides and sulphide rich Himalayan sediment are carried by various streams and dumped into IGP (Neidhardt, 2012). Arsenate (AsV) and Arsenite (As III) are the major inorganic forms of Arsenic, found in groundwater. There is one another form of Arsenic known as Organoarsenic, generated by biomethylation process (by fungi or bacteria) from inorganic Arsenic (Singh, 2006). As(III) and As(V) preferably bind with Iron-oxyhydroxides. In small quantity it is also found with Magnese and Alluminium oxyhydroxides (Neidhardt, 2012). They change continuously into one another by oxidation of Arsenic-rich pyrite, reduction of iron hydroxides and anion exchange of Arsenic with phosphate (Singh, 2006). Solubilization of Arsenic in groundwater depends on pH, redox condition, temperature and solution composition (Nordstrom, 2002). Previous works of scholars tell that oxidation of sulphide ores produces Arsenic, which is attached to the surface of iron oxyhydroxides in aerobic environment (high pH), a strong affinity point for Arsenic. It leaches through percolation process into groundwater (Singh, 2006).

In groundwater anerobic environment (less pH) is present which triggers the reduction process. Due to this Arsenic becomes free in aqueous phase from iron oxyhydroxides. In anaerobic condition hydrochemical interactions (Neidhardt, 2012) change the molecular

structure of water and sediments. (Singh, 2006). Organic matter-rich sediments of IGP creates strong reducing environment (clayey layers stop the oxygen entry) in which Arsenic converts into Arsenite (As III) which is less strongly absorbed by iron oxide than Arsenate (AsV) and latter reduction produces iron and Arsenic. Iron concentration is less in U.P. and Bihar (1mg/l) as compared to West Bengal (36mg/l). It indicates that in U.P. and Bihar reduction process is not responsible for mobilizing of Arsenic (Acharyya et al, 2000), so land use pattern, microbial activities and use of fertilizers are assumed as another factors for Arsenic mobilization in low iron concentrated areas.

Extreme use of groundwater in some areas of IGP (Bihar, Uttar Pradesh) for irrigation (Multi-crop practices) and drinking water as well as different types of industrial uses (Chakraborti et al, 2003), may be responsible for Arsenic mobilization in ground water because it triggers oxygen entering and the oxidation of Arsenic rich iron sulphide (Singh, 2006) and change of medium, from anaerobic to aerobic, 'As' (III) reacts with atmospheric oxygen and oxidizes within hours to 'As' (V) (Neidhardt et al. 2012) further it mobilizes into groundwater. It is proved by sediment analysis that excessive groundwater extraction is also a promoter for Arsenic mobilization in IGP (Chakraborti et al, 2003; Acharyya et al, 2000).

Microbial activities are also predicted as an important factor for mobilization of Arsenic. Arsenic is a passive element which directly not influence the mechanism of mobilization. Its release in groundwater is an active process with the help of reducing environment and microbial reactions (Neidhardt, 2012). It is predicted that microbial action takes part in reduction process

in iron less areas (Acharyya et al, 2000). Due to huge groundwater exploitation, oxygen entered into aquifer and interact with microorganism which convert the oxidizing medium of aquifer to reducing medium and it increases localized Arsenic mobilization (Singh, 2006; Chakraborti et al, 2003).

Most of the arseniferous groundwater is high in ferrous and phosphate as well. (Bhattacharya et al, 2010). Release of phosphate due to excessive fertilizer use in agriculture and decayed organic material are also cause of Arsenic mobilization (Acharyya et al, 2000) because phosphate is also an affinity point for Arsenic (Singh, 2006) and it promotes desorption of Arsenic from sediments and increases its natural mobility in groundwater (Gosh et al, 2001).

There are many hypotheses and they have their own descriptions but in reality this is a controversial subject due to lack of knowledge about exact process of Arsenic release and its mobilization. Arsenic contamination has evolved suddenly as a major problem for human beings. We need a high technology and improved research for knowing the exact sources and mechanism of Arsenic mobility in the aquifers of IGP (Singh, 2006).

### **Current Scenario of Arsenic Contamination in West Bengal, Bihar and Uttar Pradesh**

#### **West Bengal**

In West Bengal high Arsenic contamination was first reported in 1978. In 1984, only one village in West Bengal was known to be contaminated with Arsenic; the present count is more than 3000 villages (Chakraborti et al, 2003). According to Acharyya et al (2000) the arsenic-affected

aquifers in West Bengal occur beneath the lower-level flood-delta plain of the Ganges River system. Arsenic concentration is beyond the permissible limit (0.05mg/l) in 79 blocks of 8 districts of West Bengal. It is observed that both eastern and western side areas of West Bengal are affected. In eastern side Malda, Murshidabad, Nadia, North 24 Parganas and South 24 Parganas as well as Howrah, Hooghly and Bardhman in western side, are more affected. Only upper aquifers are contaminated while deeper aquifers are free from Arsenic contamination. About 162.6 lakh people live in these risky areas and are facing the problem of Arsenic related diseases. In West Bengal maximum affected districts are Murshidabad and North 24 Parganas (19 blocks in both District). Habra-II block (North 24 Parganas district) is the maximum contaminated area of West Bengal (3.773 mg/l). Sandeshkhali-II block of North 24 Parganas investigated as minimum contaminated area (0.120 mg/l). Bhagwangola- I block of Murshidabad district has maximum concentration of Arsenic (3.0 mg/l) while Raghunathganj-I block has minimum concentration of Arsenic (0.254 mg/l). In Bardhman district 5 blocks are contaminated, in which maximum Arsenic contaminated block is Katwa-II (0.835mg/l) while Katwa-I (0.101mg/l) is minimum contaminated. In Hooghly district only Balagarh block is affected by Arsenic contamination (0.0510 mg/l). Two blocks of Howrah district, Shampur-II (>0.05mg/l) and Uluberia-II (0.155 mg/l) are affected by Arsenic contamination. There are seven blocks in Malda district containing Arsenic beyond the permissible limit in which Kaliachak-III has 1.045 mg/l (maximum) and Ratua-II has 0.333 mg/l (minimum). Out of 17 affected blocks of

**Table 3 : Affected Blocks of High Arsenic (>0.05mg/litre) in Ground Water in West Bengal.**

Sl. No.	District	Name of Blocks Affected With High Arsenic	Max. Value of Arsenic In mg/l
1	Bardhaman	Kalna-II	0.620
2	Bardhaman	Katwa-I	0.101
3	Bardhaman	Katwa-II	0.835
4	Bardhaman	Purbasthali-I	0.618
5	Bardhaman	Purbasthali-II	0.572
6	Hooghly	Balagarh	0.510
7	Howrah	Shampur-II	>0.05
8	Howrah	Uluberia-II	0.155
9	Malda	English Bazar	0.945
10	Malda	Kaliachak-I	0.747
11	Malda	Kaliachak-II	0.917
12	Malda	Kaliachak-III	1.045
13	Malda	Manickchak	0.944
14	Malda	Ratua-I	0.894
15	Malda	Ratua-II	0.333
16	Murshidabad	Lalgola	0.565
17	Murshidabad	Baldanga-I	0.784
18	Murshidabad	Baldanga-II	0.631
19	Murshidabad	Berhampur	2.186
20	Murshidabad	Bhagwangola-I	3.000
21	Murshidabad	Bhagwangola-II	0.840
22	Murshidabad	Domkal	1.605
23	Murshidabad	Farakka	0.508
24	Murshidabad	Hariharpar	1.810
25	Murshidabad	Jalangi	2.037
26	Murshidabad	Murjiaganj	0.890
27	Murshidabad	Nowda	0.727
28	Murshidabad	Raghunathganj-II	0.812
29	Murshidabad	Raghunathganj-I	0.254
30	Murshidabad	Raninagar-I	0.990
31	Murshidabad	Raninagar-II	1.210
32	Murshidabad	Samsherganj	0.301
33	Murshidabad	Suti-I	0.696
34	Murshidabad	Suti-II	0.662
35	Nadia	Chakdah	0.824
36	Nadia	Chapra	0.514
37	Nadia	Hanskhali	0.526
38	Nadia	Haringhata	0.769
39	Nadia	Kaliganj	0.995
40	Nadia	Karimpur-I	1.080
41	Nadia	Karimpur-II	0.926
42	Nadia	Krishnaganj	0.771
43	Nadia	Krishnanagar-I	0.629
44	Nadia	Krishnanagar-II	1.161
45	Nadia	Nabadwip	0.712
46	Nadia	Naksipra	0.586
47	Nadia	Ranaghat-I	1.072
48	Nadia	Ranaghat-II	0.741
49	Nadia	Santipur	0.459
50	Nadia	Tehatta-I	0.544
51	Nadia	Tehatta-II	0.340
52	North 24 Parganas	Amdanga	0.570
53	North 24 Parganas	Baduria	1.331
54	North 24 Parganas	Bagda	0.365
55	North 24 Parganas	Barackpore-II	0.128
56	North 24 Parganas	Barackpore-I	0.967
57	North 24 Parganas	Barasat-I	0.531
58	North 24 Parganas	Barasat-II	0.951
59	North 24 Parganas	Basirhat-I	1.039
60	North 24 Parganas	Basirhat-II	0.634
61	North 24 Parganas	Bongaon	0.539

62	North 24 Parganas	Deganga	0.693	Tehatta-II block has minimum concentration (0.340 mg/l). In South 24 Parganas, Sonarpur block is maximum Arsenic contaminated (2.715 mg/l) and Budge Budge-II block is minimum contaminated (>0.05 mg/l) (Kunar et al., 2009).
63	North 24 Parganas	Gaighata	0.772	
64	North 24 Parganas	Habra-I	0.590	
65	North 24 Parganas	Habra-II	3.773	
66	North 24 Parganas	Haroa	0.730	
67	North 24 Parganas	Hasnabad	0.958	
68	North 24 Parganas	Rajarhat	0.413	
69	North 24 Parganas	Sandeshkhali-II	0.120	
70	North 24 Parganas	Swarupnagar	0.673	
71	South 24 Parganas	Baruipur	2.560	
72	South 24 Parganas	Bhangar-I	0.818	
73	South 24 Parganas	Bhangar-II	0.762	
74	South 24 Parganas	Bishnupur-I	0.237	
75	South 24 Parganas	Bishnupur-II	0.085	
76	South 24 Parganas	Budge Budge-II	>0.05	
77	South 24 Parganas	Joynagar-I	0.611	
78	South 24 Parganas	Mograhat-II	0.217	
79	South 24 Parganas	Sonarpur	2.715	

### Bihar

In Bihar high concentration of Arsenic in ground water is confined in Newer Alluvial belt along the river Ganga affecting both the Active and Older Flood plains. The contaminated water is young in age (<40yrs) (Kunar et al, 2009). According to investigational surveys, about 57 blocks in 15 districts of Bihar, located on both side of the Ganga's bank, are affected by the Arsenic contamination. Maner block of Patana district is the most affected block in Bihar, in which the Arsenic limit is maximum (1.810 mg/l), while Danapur block has minimum contamination (>0.05mg/l). In Bhojpur district Sohapur block has maximum contamination (1.630 mg/l) and Udawant Nagar has minimum contamination (0.051 mg/l). Semaury block of Buxar district is found as 1.40 mg/l Arsenic contamination while Chakki block has minimum contamination (>0.05 mg/l). Only 2 blocks of Kisanganj district, Bahadurgarh (0.085 mg/l) and Kisanganj (0.058 mg/l) have Arsenic contamination. In Lakhisarai district, Lakhisarai block (0.230 mg/l) and Piparia block (0.241 mg/l) are affected by Arsenic. In Purnea district Arsenic contamination is maximum in Purnea East block (0.097 mg/l) and minimum in Kasba block (0.067 mg/l). Out of 4 blocks of Samastipur district, only Mohanpur (0.626 mg/l) and Mohinuddin Nagar (0.370 mg/l) are highly contaminated. It is found that in Saran district, Sonepur block (0.230 mg/l) and Chapra Sadar block (0.205 mg/l), has maximum concentration of Arsenic. Most of the districts

Source: Kunar et al., 2009.

Nadia district, Krishnanagar-II block has maximum concentration (1.161 mg/l) and

**Table 4 : Affected Blocks of High Arsenic (>0.05mg/litre) in Ground Water in Bihar**

Sl. No.	District	Name of Blocks Affected With High Arsenic	Max. Value of Arsenic In mg/l
1	Begusarai	Bachwara	>0.05
2	Begusarai	Balia	>0.05
3	Begusarai	Barauni	>0.05
4	Begusarai	Begusarai	>0.05
5	Begusarai	Matihani	>0.05
6	Begusarai	Sabehpurkamal	>0.05
7	Bhagalpur	Jagdishpur	>0.05
8	Bhagalpur	Nathnagar	>0.05
9	Bhagalpur	Sultanganj	>0.05
10	Bhojpur	Ara	0.426
11	Bhojpur	Barhara	0.420
12	Bhojpur	Behea	0.080
13	Bhojpur	Koilwar	0.306
14	Bhojpur	Shahpur	1.630
15	Bhojpur	Udawan Nagar	0.051
16	Buxar	Brahmpur	1.220
17	Buxar	Buxar	0.940
18	Buxar	Chakki	>0.05
19	Buxar	Semary	1.400
20	Darbhanga	Biraul	>0.05
21	Katihar	Amdabad	>0.05
22	Katihar	Barari	>0.05
23	Katihar	Kursela	>0.05
24	Katihar	Manihari	>0.05
25	Katihar	Mansahi	>0.05
26	Katihar	Sameli	>0.05
27	Khagaria	Gogri	>0.05
28	Khagaria	Khagaria	>0.05
29	Khagaria	Mansi	>0.05
30	Khagaria	Parbatta	>0.05
31	Kisanganj	Bahadurgarh	0.085
32	Kisanganj	Kisanganj	0.058
33	Lakhisarai	Lakhisarai	0.230
34	Lakhisarai	Piparia	0.241
35	Munger	Bariarpur	>0.05
36	Munger	Dharhara	>0.05
37	Munger	Jamalpur	>0.05
38	Munger	Munger	>0.05
39	Patna	Bakhtiarpur	>0.05
40	Patna	Barh	0.584
41	Patna	Danapur	>0.05
42	Patna	Maner	1.810
43	Purnea	Kasba	0.067
44	Purnea	Purnea East	0.097
45	Samastipur	Mohanpur	0.626
46	Samastipur	Mohinuddin Nagar	0.370
47	Samastipur	Patori	>0.05
48	Samastipur	Vidyapati Nagar	>0.05
49	Saran	Chapra Sadar	0.205
50	Saran	Dighwara	>0.05
51	Saran	Revelganj	>0.05
52	Saran	Sonepur	0.230
53	Vaishali	Bidupur	>0.05
54	Vaishali	Desri	>0.05
55	Vaishali	Hajipur	>0.05
56	Vaishali	Raghopur	>0.05
57	Vaishali	Sahdei Bujurg	>0.05

Source:Kunar et al., 2009.

viz, Munger (4 blocks), Vaishali (5 blocks), Begusarai (6 blocks), Bhagalpur(3 blocks), Darbhanga(1block), Katihar (6 blocks) and Khagaria (4 blocks) are minimum contaminated (>0.05 mg/l). (Kunar et al,2009).

### Uttar Pradesh

In Uttar Pradesh, Ballia district was first reported as Arsenic contaminated area in 2003. It was found in further surveys that there are 45 blocks of 9 districts which are affected by Arsenic contamination. Maximum 18 blocks of

**Table 5 : Locations of High Arsenic (>0.05mg/litre) in Ground Water in U.P.**

Sl. No.	District	Block	Location	Arsenic Value (mg/l)
1	Agra	Agra	Agra	0.062
2	Agra	Etmadpur	Samai	0.054
3	Agra	Fatehabad	Gautam Nagar	0.061
4	Agra	Khairagarh	Kakua	0.053
5	Aligarh	JawanSikandarpur	Jawan	0.052
6	Ballia	Bairia	Balihar	0.195
7	Ballia	Belhari	RajpurEkauna	1.31
8	Ballia	MurliChhapra	MurliChhapra	0.053
9	Ballia	Reoti	Gaighat	0.3
10	Ballia	Siar	HaldiRampur	0.35
11	Balrampur	GaindasBujurg	Ajgari	0.093
12	Balrampur	Gainsari	Ratanpur	0.063
13	Balrampur	Harraiyya Bazar	Harraiyya Bazar	0.102
14	Balrampur	Pachperwa	Mansurwa	0.143
15	Balrampur	Sriduttganj	Sriduttganj	0.05
16	Balrampur	Tulsipur	Tulsipur	0.091
17	Gonda	Bhelsar	Digsir	0.06
18	Gonda	Colonelganj	Colonelganj	0.112
19	Gonda	Haldarmau	Simra	0.25
20	Gonda	Katrabazar	Binkatra	0.06
21	Gonda	Nawabganj	Kalyanpur	0.08
22	Gonda	PandariKripal	SubhagPur	0.122
23	Gonda	Tarabganj	Tarabganj	0.07
24	Gonda	Wazirganj	Baleshwar ganj	0.087
25	Gorakhpur	Gorakhpur	Urwa bazar	0.07
26	LakhimpurKheri	Dhaurahra	Amethi	>0.05
27	LakhimpurKheri	Dhaurahra	Laljipurwa	>0.05
28	LakhimpurKheri	Dhaurahra	Pradhanpurwa	>0.05
29	LakhimpurKheri	Ishanagar	Hulaspurwa	>0.05
30	LakhimpurKheri	Ishanagar	Ishanagar	>0.05
31	LakhimpurKheri	Ishanagar	Parasia	>0.05
32	LakhimpurKheri	Ishanagar	RudrapurSalim	>0.05
33	LakhimpurKheri	NigHassan	Dharmapur	>0.05
34	LakhimpurKheri	NigHassan	Khairana	>0.05
35	LakhimpurKheri	NigHassan	Pachpera	>0.05
36	LakhimpurKheri	Palia	Babaura	>0.05

37	LakhimpurKheri	Palia	Kothia	>0.05
38	LakhimpurKheri	Palia	Majhgai	>0.05
39	LakhimpurKheri	Palia	Trilokpur	>0.05
40	LakhimpurKheri	Ramiabehar	Dhanaigaurhi	>0.05
41	LakhimpurKheri	Ramiabehar	Lalapurwa	>0.05
42	LakhimpurKheri	Ramiabehar	Mathurapurwa	>0.05
43	LakhimpurKheri	Ramiabehar	Sujanpur	>0.05
44	Mathura	Mathura	Mathura	0.052
45	Moradabad	Moradabad	Moradabad(Ashiyana)	0.07

Source: Kunar et al., 2009.

Lakhimpur Kheri have Arsenic contamination (>0.05 mg/l). There are 8 blocks of Gonda district have arsenic contamination, in which Haldarmau block has maximum Arsenic contamination (0.25 mg/l) and Katrabazar block has minimum Arsenic contamination (0.06 mg/l). In Balrampur district (6 blocks are affected), Pachperwa block has maximum Arsenic contamination (0.143 mg/l) and Sriduttganj block has minimum Arsenic contamination (0.05 mg/l). Out of 5 Arsenic affected blocks of Ballia district, Belhari block has maximum Arsenic contamination (1.31 mg/l) and MurliChhapra block has minimum Arsenic contamination (0.053 mg/l). In 4 blocks of Agra district, Agra block has maximum (0.062 mg/l) and Khairagarh block has minimum (0.053 mg/l) Arsenic contamination. Only one block of Mathura, Moradabad, Gorakhpur and Aligarh districts has Arsenic contamination. Gazipur and Varanasi districts are minimum affected by Arsenic contamination. (Kunar et al, 2009).

### Conclusion

Safe and fresh water is an essential part of human life. It is not only a need, it is a life line for all living beings. Groundwater is the main

source of fresh water. Arsenic contamination in groundwater is now an emerging environmental issue for world. Although we don't know the exact mechanism of Arsenic contamination in groundwater but it is identified as a major problem through out the world. Its occurrence is reported in drinking water, air and food at many places. Many developed as well as developing countries like India, China and Chile are suffering from Arsenic pollution and it is rapidly spreading. The Indo-Gangetic Plain region as well as eastern part of India is also one of the severe Arsenic polluted regions of the world. This is highly populated and fertile region. This review paper is based on Arsenic contamination, its sources and mechanism of mobility in Indo-Gangetic Plain, chiefly current scenario of West Bengal, Bihar and Uttar Pradesh. Although some regions of IGP are free from Arsenic contamination but where ever it is present, the scenario is dark. This review paper suggests that the Arsenic contamination in IGP region (West Bengal, Uttar Pradesh and Bihar) is chiefly based on geological conditions and affects the major part of it. Arsenic bearing ancient rocks, chemical and biological processes take part in increasing

Arsenic in groundwater as well as human activities also play an important role to increase the amount of Arsenic in and due to low immunity system, environmental degradation and Arsenic related health problems ,it has become a dangerous problem. Arsenicosis, cancers and premature births are some common dangerous feature of Arsenic contamination.In India many poor people are suffering from this type of problem. There is no medicine available for cure. We can only prevent it by using Arsenic removal technologies as:Coagulation/Filtration, Lime

Softening, Activated Alumina, Ion Exchange, Reverse Osmosis, Electrodialysis Reversal and Nanofiltration. We can reduce the Arsenic contamination by using surface water sources, tapping alternate aquifer and rain water harvesting. We need to aware the community about Arsenic and its related problems. Government, NGO's, Research associations and other agencies should organize the awareness programme. This is only the tip of the mountain because a lot of research works need to explore it.

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