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## Remote sensing and GIS based analysis of land use land cover and soil fertility status at inter-block level in Banda District of Uttar Pradesh

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### Abstract

The present study is based on three dimensions of the land, human resource pressure, land cover and land utilization on different categories of land. To identify the level of agriculture, especially crop diversity that can determine by the fertility status of the soil. Banda District is the part of Bundelkhand plateau which is composed of older alluvial deposits and erosional terraces of flood plains of Yamuna, Ken and Baghain rivers. The study area lies between 24°58'29" N to 25°54'43" N latitude and 80°06'38" E to 81°02'06" E longitude. The geographical area of Banda district is 4456.802 km<sup>2</sup> and the altitude varies between 3 to 427 m. This study was carried out to analyze and mapping with the help of remote sensing and GIS techniques. The land surface gradient leaning from the southwest to northeast directions that also affects the flow direction of drainage system of the district. In the southern and western part of the Naraini & Badokhar Khurd blocks of Banda District, bare parental rocks such as silica (SiO<sub>2</sub>), shale, sandstone and granite are predominant. To assess the land carrying capacity, the inter-block physiological population density reveals the dependency of human population on land, which is found higher than the national level physiological density ranging from 306 – 551 person/km<sup>2</sup>. On an average the results of soil fertility status in terms of nutrient index (NI) value of Banda District (mean of all the 08 blocks, namely Jaspura, Tindwari, Badokhar Khurd, Baberu, Kamasin, Bisanda, Mahua and Naraini) soils, indicate that nutrient index value regarding organic carbon content/ available nitrogen (1.53) and for available phosphorus (1.54), which fall under very low category of NI, and nutrient index value for available potash (2.70), available sulphur (2.21), which belong to medium category of nutrient index. In case of available essential micronutrients such as zinc (2.18), which also fall under medium category of NI. However the status of other available essential micronutrients such as iron (2.94), copper (2.92) and manganese (2.96) are fall under high category in terms of nutrient index value.

**Keywords:** Remote sensing & GIS; Physiological density; Soil fertility; Nutrient index

### Introduction

The present study deals with the land and human resources with Remote Sensing and GIS integrations at block level in Banda district. Here the components which are taken in to account to arrive at level of development of these resources land use and land cover, soils and human resource pressure. These resources play a significant role to sustain the livelihood. Crop production broadly depends on the fertility status of the soil where a crop is raised. Adequate level of soil fertility and sufficiency level of nutrient leads to better quality and quantity of crop productivity and other agricultural produces besides maintaining soil health. For appropriate advisory work, soil fertility maps (SFM) or soil test value (STV) report should be accompanied by appropriate fertilizers use recommendations for each fertility class (Sanchez, *et.al.*, 1982) [11]. The physico-chemical and biological properties of soil largely influenced by various factors such as climate, biosphere ( soil flora and fauna), relief or topography, parent material from which soil being formed through weathering and different pedogenic process, time or age of the soil, and in some extent drainage pattern, land use land cover, etc. Soil nutrients play a vital role for increasing the capability of soils for crop production. Managerial activities of human resource associated with natural resource to also enhance their potential. Though Banda district is a part of doab region in Yamuna, Ken and Baghain rivers indicates the availability of water for primary economic activities mainly agriculture. Pressure of Human resources over the land resources compel to use of the resources haphazardly that leads to deterioration of the resources. Zonal analysis is one of the important tools in ArcGIS under its spatial extraction. It is used in tabulate area zone and fill, zonal geometry, zonal statistics as a table (Muryama, y., *et.al.* 2011) [8].

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The study carried out only block level to evaluate human and land resources. Regional planners required nearly continuous acquisition of data to formulate governmental policies and programme. These policies and programme might range from social economic and cultural dominant to context of environmental and natural resource planning (Lillisand, *et.al.*, 2004) [7]. GIS and Remote Sensing is used effectively to analyse various components of natural and cultural aspects of earth surface (Chauniyal, D.D., 2012) [1]. Block boundary is being consider as a zone to analyse resources spatially. Through the statistical and diagrammatical method make easy to represents the various variables in visual and graphical form that may be related to time and space and both (Yadav, H., 2002) [13]. Soils adversely affect the growth and yield of crop plants due to adverse physico-chemical properties (Parihar, A.K.S., *et.al.*, 2013) [9]. The present study aims to spatially asses the fertility status and of soils thorough nutritive index at inter block level of Banda district.

### Study Area

Banda district is a part of Bundelkhand plateau at which most of the area covered Precambrian granites and older alluvial deposits. It show the erosional terraces of the study area is the main role of Yamuna, Ken and Baghen Rivers which are part of Yamuna drainage system. Banda district lies between 24°58'29" N to 25°54'43" N latitude and 80°06'38" E to 81°02'06" E longitude. The total geographical area is 4456.802 km<sup>2</sup> and the altitude varies between 3 to 427 m. It is extending from north to south is about 104.60 km and west to east is about 94.50 km. It is situated in Fatehpur District (U.P.) northeast, Hamirpur District (U.P.) northwest, Mahoba District (U.P.) west, Chitrakoot District (U.P.) southwest and Madhya Pradesh (State) south and southwest. Banda District is divided into 8 blocks which includes Jaspura, Tindwari, Badokhar Khurd, Baberu, Kamasin, Bisanda, Mahuva and Naraini respectively. The Yamuna River departed from Fatehpur District and Banda District and its flow direction from west to east entire district border of Banda. River Ken confluences Yamuna River at Chilla in north direction. River Baghain also departs Banda district from Chitrakoot district in southeast.

### Soil and Climatic conditions

Broadly, the soils of Banda district fall into two categories namely red and black soils with three distinct soil associations (a) coarse grained reddish brown soil (b) coarse grained grey to greyish brown soils and (c) two types of clay loam black soils. In local parlance these soils are termed as, *Rakar* (belongs to Alfisol soil order), *Parua* (belongs to Inceptisol soil order), and *Kabar* (belongs to Vertisol soil order), *Mar* (belongs to Vertisol soil order) respectively. Horizon differentiation is almost absent, soils are slightly acidic to neutral in nature with presence of CaCO<sub>3</sub>/Mg CO<sub>3</sub> granules in lower depth. Most of the soils of Banda district are low in organic matter/ carbon content, available N, and P, and medium in available K and S. The status of available micronutrients contents such as zinc, iron, copper and manganese are ranged from medium to high value. *Mar* is Bundelkhand most prized soil, and wheat, gram, lentil, pea, flax, mustard etc. are successfully cropped on it under rainfed conditions. The soil has relatively high organic matter content, very good water holding capacity (WHC) and hence can be cropped without use of fertilizers. It has high clay content and is prone to water logging. Therefore, time for ploughing has to be selected carefully, as the soil can be either too dry or it too wet for tilling.

The climate of Bundelkhand region including Banda district is semi-arid in characteristics. It is typically monsonic with the year divisible three season namely rainy/ kharif (mid June to end of October), winter/rabi (mid October to mid February) and summer/zaid (mid February to mid June). On an average rainfall of the site is 900mm of which more than 80% occur during July to September. The distribution of rainfall is also erratic. The annual temperature is uniformly high. The summer, rainy and winter temperature vary 30-44 °C, 20-24 °C and 14-21°C respectively. The May and June are the hottest months and some time temperature goes up to 48-50°C and minimum temperature falls to 2 °C during December – January. Hot breezes locally known as loo are common during summer season. The predominant soil temperature regime (STR) is hyperthermic and soil moisture regime (SMR) is Ustic.

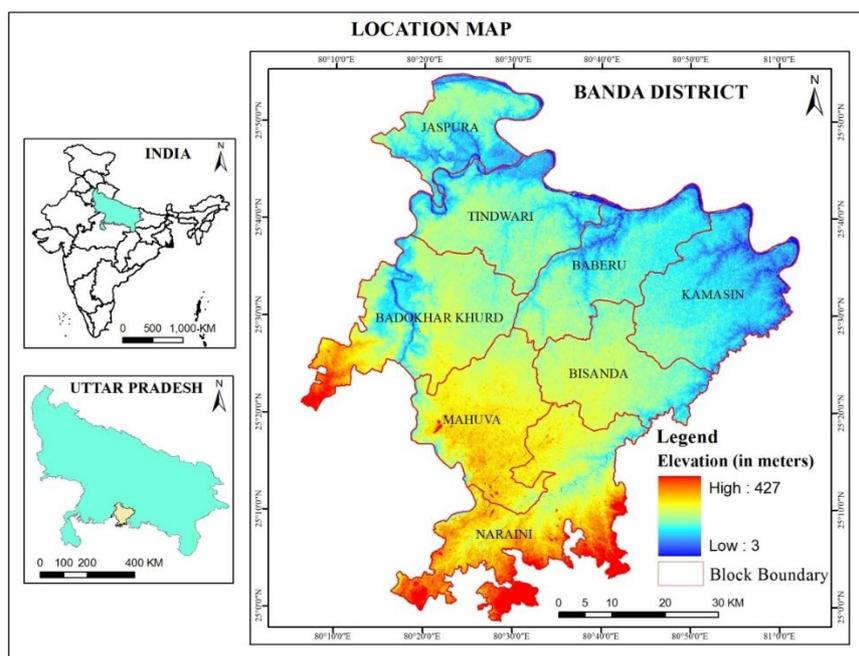


Fig 1

## Material and Methodology

The study area includes three major type analysis like various type of density of population (population density, physiological density and agricultural density), nutritive index of soil fertility index and land use land cover map preparation and interpretation such as map preparation for base map, various density map, nutritive index map and land use land cover map and interrelationship distribution at block wise in Banda District. The base map prepared for the Survey of India toposheet map (63C/01, 63C/02, 63C/03, 63C/05, 63C/06, 63C/07, 63C/08, 63C/09, 63C/10, 63C/11, 63C/12, 63C/13, 63C/14, 63C/15, 63D/05, 63G/02, 63G/03) on 1:50000 scale in Banda district and variation of altitude identification by DEM. The delineation of district boundary and block boundary prepared by toposheet map using with the help of GIS Software such as ArcGIS 9.3, Erdas 9.2. Soil fertility level and nutrient index are based on total 38320 georeferenced soil sample collected from all the eight blocks (such as Jaspura- 908, Tindwari- 3157, Badokhar Khurd- 14339, Baberu-3291, Kamasin-2495, Bisanda-1423, Mahua- 8312 and Naraini- 4295 soil samples) of Banda district. Data related to soil fertility and nutrient index, generated by Zonal Soil Testing Laboratory, Chitrakoot Dham Mandal Banda and District Agriculture Department, Banda Govt. of Uttar Pradesh,

## Result and Discussions

### Analysis of Land use Land cover

Land surface resources display the scenario of the resources of an area. Banda district which is located at Bundelkhand plateau. The land resource is mainly governing by the agricultural land because of availability of water and compatibility of soil to grow the crops. It has been observe throw the satellite image interpretation that agricultural land is major land use category which occupied about 83.37% of district. The land use land cover scenario changes one block to another block in the district due to the terrain characteristics and drainage system. It is experienced that Banda district has more agricultural land (83.37%) in percentage in comparison to state average (79.23%), (Bhuvan, 2011-12).

Banda district has 8 block viz. Jaspura, Tindwari, Badokhar Khurd, Baberu, Kamasin, Bisanda, Mahuva and Naraini have area 7.08, 10.62, 9.89, 8.74, 13.04, 11.74, 14.93 and 10.38 percentage of area respectively. Jaspura and Mahuva are the smallest and biggest blocks in respect to area of the district.

### Inter-block level LULC description

#### Agricultural Land

Banda is rural population concentrated district where 84.68% population inhabited in rural areas, which is greater than the national and state average (Census of India, 2011). Only 15.32% population lived in urban areas. All the rural population depends upon the agricultural land which occupies about 88.77% area of the total land of the district. Kamasin,

Bisanda, Mahuva and Naraini blocks is more than 85% area included in agriculture. While Tindwari, Badokhar khurd and Baberu blocks are about 75% to 85% area implies in agricultural land. Jaspura is the only block, where about 62.52% area falls under this category of land.

#### Barren Land

This area is mostly associated with stream courses and its proximity areas of the district. In these areas riverine sent can be seen that accumulate during the flooding time. Those blocks in the proximity of rivers have large area of this type of land viz. Jaspura, Tindwari, Badokhar Khurd, Baberu, Mahuva and Naraini are the blocks have more than 5% barren land. Jaspura and Badokhar Khurd is largely suffering with growing this type of land due to flooding and water logging during the rainy season.

#### Forest

In Banda district forest is found only 1.9% area which varies from one block to another blocks Tindwari, Mahuva and Naraini are the blocks where 2.48%, 2.58% and 6.61% area is found under forest covered besides this all the block have less than 1% forest cover land. Mainly in southern part of the district where some ranges of Vindhyan mountain range passes that is why some patches of forest found there.

#### Waste Land

The land resultant of the terrain deformation due to water erosion which occurs widely in the areas associated with stream courses. Gullies are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. After some time this land convert into degraded land. In Banda district about 1.75% area found in this type of land, which is mostly found in the blocks associated with river courses in Baberu where about 12.07% area found independently in this land. Jaspura, Tindwari, Badokhar Khurd and Kamasin blocks are falls 0.75, 0.92, 0.38, 0.40 percentage areas in these categories respectively.

#### River Bodies

The district encompassed by the rivers from the three sides of the district, occupy about 2.67% area of the district inclusively. The district is about quadri-lateral in shape. Yamuna River flows from west to east in the northern direction. Baghain and Ken Rivers, sub-tributaries flow from southwest to northeast direction in the district.

#### Settlement & Built-up Area

Banda district is rural population dominant district where about 77.7% rural and 22.3% urban population inhabited subsequently. In the district about 1.11% area included in built-up area which is varies from block to block. All the block except Mahuva and Naraini have more than 1% area of built-up land which less than state average (1.73%).

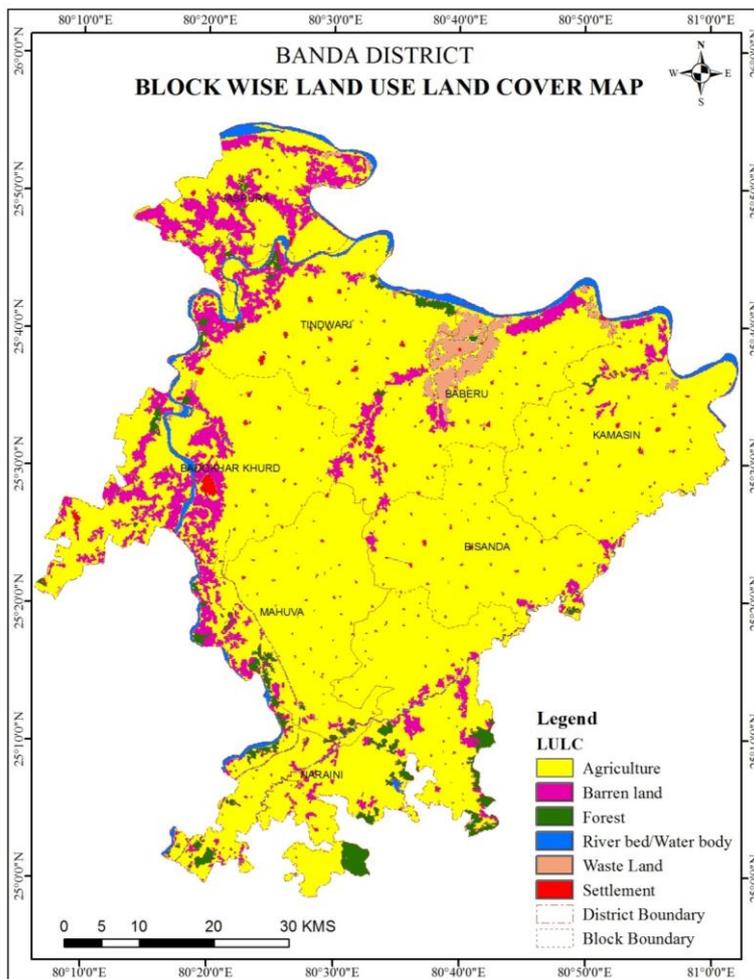


Fig 2

Table 1: Block wise land use land cover of Banda District

LULC	Jaspura	Tindwari	Badokhar Khurd	Baberu	Kamasin	Bisanda	Mahuva	Naraini
Agriculture	62.54	81.10	78.35	75.58	93.23	95.85	88.77	85.59
Barren land	29.01	8.99	16.33	8.38	2.80	2.58	6.29	5.29
Forest	0.61	2.48	0.73	0.22	0.24	0.24	2.58	6.61
Waste Land	0.75	0.92	0.38	12.07	0.40	0.00	0.00	0.07
Settlement	1.22	1.35	1.71	1.35	1.05	1.03	0.77	0.51
River bed/Water bodies	5.86	5.16	2.50	2.40	2.28	0.31	1.59	1.93
Total	100	100	100	100	100	100	100	100

Source: Biodiversity Information System

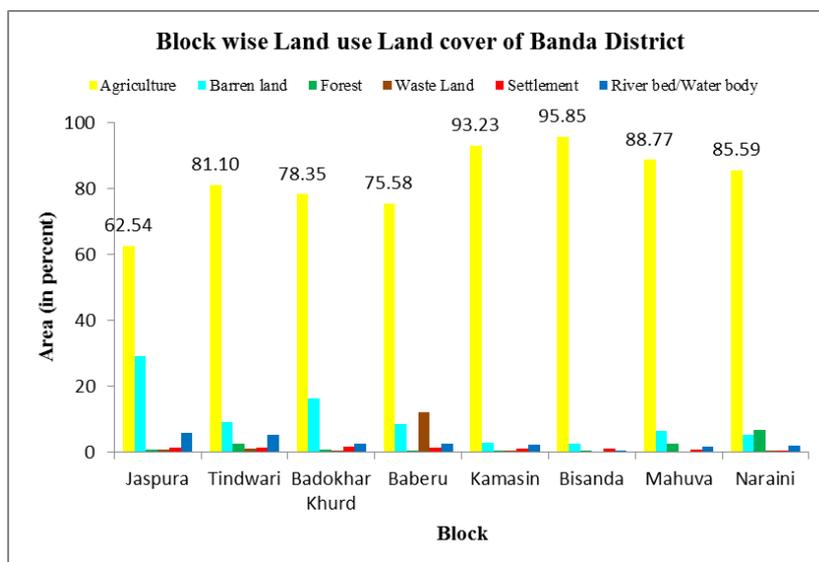


Fig 3

**Analysis of different type of Density**

**Population Density**

Population density is defined as the ratio between total population and total area of the particular region. It is known as arithmetical density. It understands between man and land relationship which describes population pressure on land surface. The population of Banda district is depends on agricultural land. The population density of Banda district is 346 which show low population density. The highest population density is concentrated in blocks Babaeru (416) and Bisanda (410) which is greater than 400 person/km<sup>2</sup>. While, the lowest population density concentrated in blocks Jaspura (288) and Kamasin (286) which is less than 300 person/km<sup>2</sup>. The other 4 blocks (Tindwari, Badokhar Khurd, Mahuva and Naraini) population density is found low and medium category which ranged from 306 - 398 (table 2).

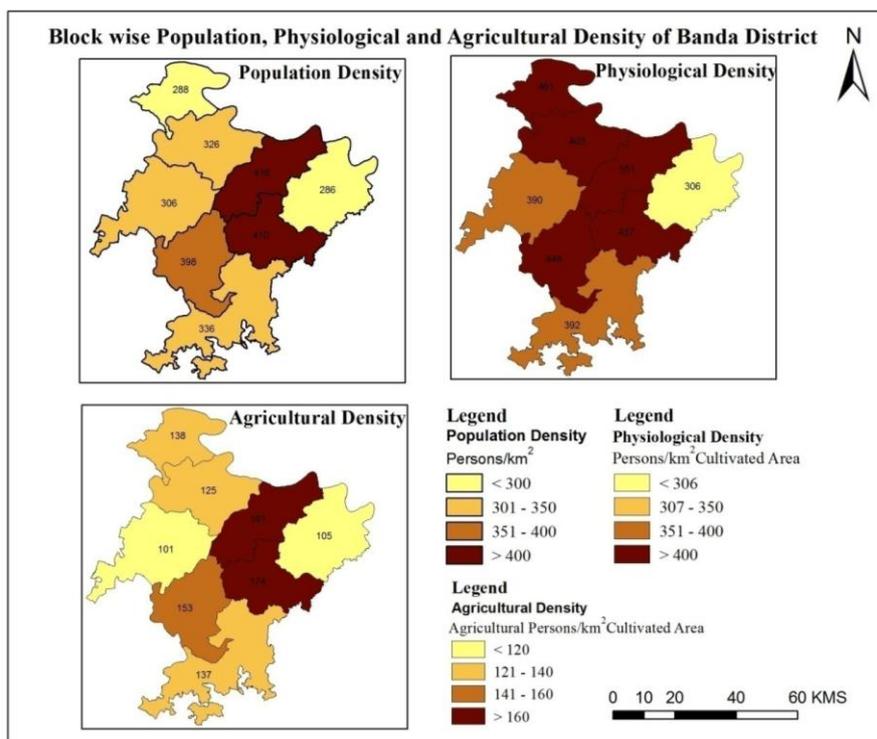
**Physiological Density**

Physiological density is defined as the ratio between total population and the cultivated land. It is known as nutritional density of population. It describes that the pressure of human on cultivated land. The physiological density of Banda district is 422, at which the five blocks of Banda district belongs to high physiological density such as Jaspura, Tindwari, Baberu, Bisanda and Mahuva ranged from 403 – 551 which more than

400. The lowest physiological density is found in Kamasin (306) and moderate density in Badokhar Khurd (390) and Naraini (392) respectively (table 2).

**Agricultural Density**

Agricultural density is the ratio between agricultural population and cultivated land that deals with the population pressure over the agricultural land (Tiwari, 2015). The agricultural density of Banda district is 139, at which Bisanda (174) and Baberu (181) are found high density where as more than 160. The lowest agricultural density is found Badokhar Khurd (101) and Kamasin (105) respectively where as less than 120. The rest four blocks of Banda district such as Jaspura, Tindwari, Mahuva and Naraini is found with moderate category which ranged from 125 – 153 (table 2). Participation of high agricultural population over agricultural land pertains to low per capita income and low level of human resource development in the area. Involvement of the population in other economic activities releases the pressure and dependency over the agricultural land and increase the per capita income. It is the better expression of the population pressure on land then the arithmetic method. It is also depicts the requirement of food grains of the total population inhabited in that particular area.



**Fig. 4**

**Table 2:** Block wise Population, Physiological and Agricultural Density of Banda District

Block	Population Density	Physiological Density	Agricultural Density
Jaspura	288	461	138
Tindwari	326	403	125
Badokhar Khurd	306	390	101
Baberu	416	551	181
Kamasin	286	306	105
Bisanda	410	427	174
Mahuva	398	448	153
Naraini	336	392	137
Banda District	346	422	139

Source: Census of India, 2011

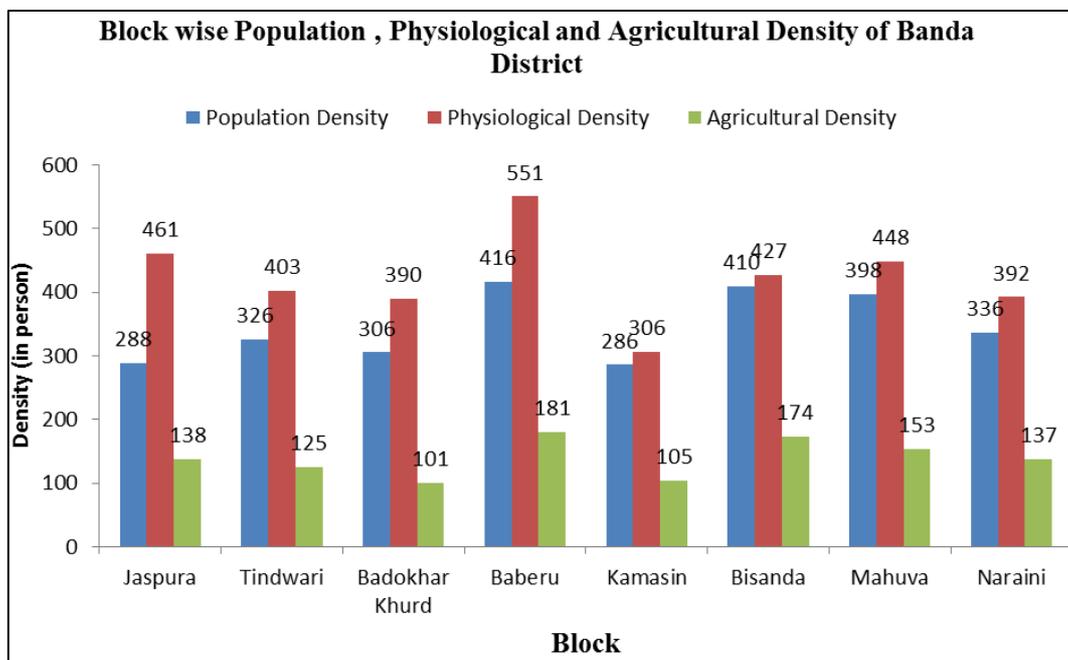


Fig 5

### Status of Soil Fertility and Nutrient Index (NI)

Table-3 indicates the soil nutritive index classes, categorized in ranged from very low, low, medium and high for primary essential nutrients (such as organic Carbon/Nitrogen, Phosphorus and Potash) and for secondary (Sulphur) and micro-nutrients (namely Zinc, Iron, Copper and Manganese) which is categorized in ranged from low, medium and high. The spatial distribution of available primary soil nutrients such as (organic carbon/Nitrogen, Phosphorus and Potash), secondary (Sulphur) and micro-nutrient (Zinc, Iron, Copper and Manganese) in terms of soil fertility status and levels of nutrient index of all the 8 blocks (namely Jaspura, Tindwari, Badokhar Khurd, Baberu, Kamasin, Bisanda, Mahua and Naraini) of Banda district are depicted in Table- 4.

According to Table 4 it is clear that organic carbon content in terms of available nitrogen nutrient index of Banda district soil (mean of all the 8 blocks) is 1.53, which falls into very low category of NI, at inter block levels, only soils of Bisanda block show NI value 1.76 (low) and rest of the 7 blocks soil (namely Jaspura, Tindwari, Badokhar Khurd, Baberu, Kamasin, Mahua and Naraini) are found very low category of NI, which is ranged from 1.39 to 1.67. Nutrient index value regarding available Phosphorus of Banda district soil (mean of all the 8 blocks) is 1.54, which is also belongs to very low category of NI, at inter block levels, only soils of Kamasin (1.82) and Bisanda (1.84) blocks belong to low category of NI, and rest of other six blocks (namely Jaspura, Tindwari, Badokhar Khurd, Baberu, Mahua and Naraini) soils are belong to very low category of NI, that is ranged from 1.38–1.71. Nutrient index value regarding available potash, in soils of Banda district (mean of all the 8 blocks) is 2.7, belong to medium category of NI, at inter block levels, only soils of Jaspura (2.11) and Baberu blocks (2.41) belong to low category of NI, however, rest of other six blocks (namely Tindwari, Badokhar Khurd, Kamasin, Bisanda, Mahua and Naraini) soils are belong to medium category of NI, which is ranged from 2.54 – 2.93. Nitrogen, Phosphorus and Potash are regarded as primary essential plant nutrients because of their larger requirement by the growing plants and correction of their wide-spread deficiencies is often necessary through

application of commercial fertilizers of which these are the major constituents (Rattan *et. al.*, 2009)<sup>[10]</sup>.

Calcium, Magnesium and Sulphur are termed as secondary essential plant nutrients because of their moderate requirements by growing plants (Rattan *et. al.*, 2009)<sup>[10]</sup>. Nutrient index value regarding available sulphur in soils of Banda district (mean of all the 8 blocks) is 2.21, which belong to medium category of NI, at inter block levels, only soils of Mahua block belong to low (1.56) category of NI, however soils of Badokhar Khurd (2.00) and Bisanda (2.04) blocks are fall into medium category of NI, and rest of other five blocks (namely Jaspura, Tindwari, Baberu, Kamasin, and Naraini) are fall into high category of NI, which ranged from (2.38 – 2.53).

Nutrients that are required in relatively smaller quantities (even in ppm) but are as essential as macronutrients are termed micronutrients. These include iron, copper, manganese, zinc, molybdenum, boron, chlorine and nickel. Their importance can be judged from the fact that in the absence of one atom of molybdenum (Mo), 60,000,000 atoms of hydrogen (H), 30,000,000 atoms of carbon (C), 30,000,000 atoms of oxygen (O) and 1,000,000 atoms of nitrogen (N), may become ineffective from the point view of plant nutrition (Rattan *et. al.*, 2009)<sup>[10]</sup>.

Nutrient index value regarding available zinc, iron, copper and manganese (Table-4) in soils of all blocks of Banda district are around the high and medium category of NI. The NI value of available zinc in soils of Banda district (mean of all the 8 blocks) is 2.18, that belong to medium category of NI, and soils of Baberu block NI is 2.62 (high) and rest of other seven blocks (namely Jaspura, Tindwari, Badokhar Khurd, Kamasin, Bisanda, Mahua and Naraini) soils NI are fall into medium category of NI, which is ranged from 1.82 – 2.14 value of NI. Nutrient index value regarding available iron, copper and manganese in soils of all the 8 blocks of Banda district are belong to high category of NI, where iron ranged from 2.92 – 2.98, copper ranged from 2.82 – 2.98, manganese ranged from 2.94 – 2.99. The NI mean value of soils of all the 8 blocks of Banda district for available iron, copper and manganese are 2.94 (high), 2.92 (high) and 2.96 (high) respectively.

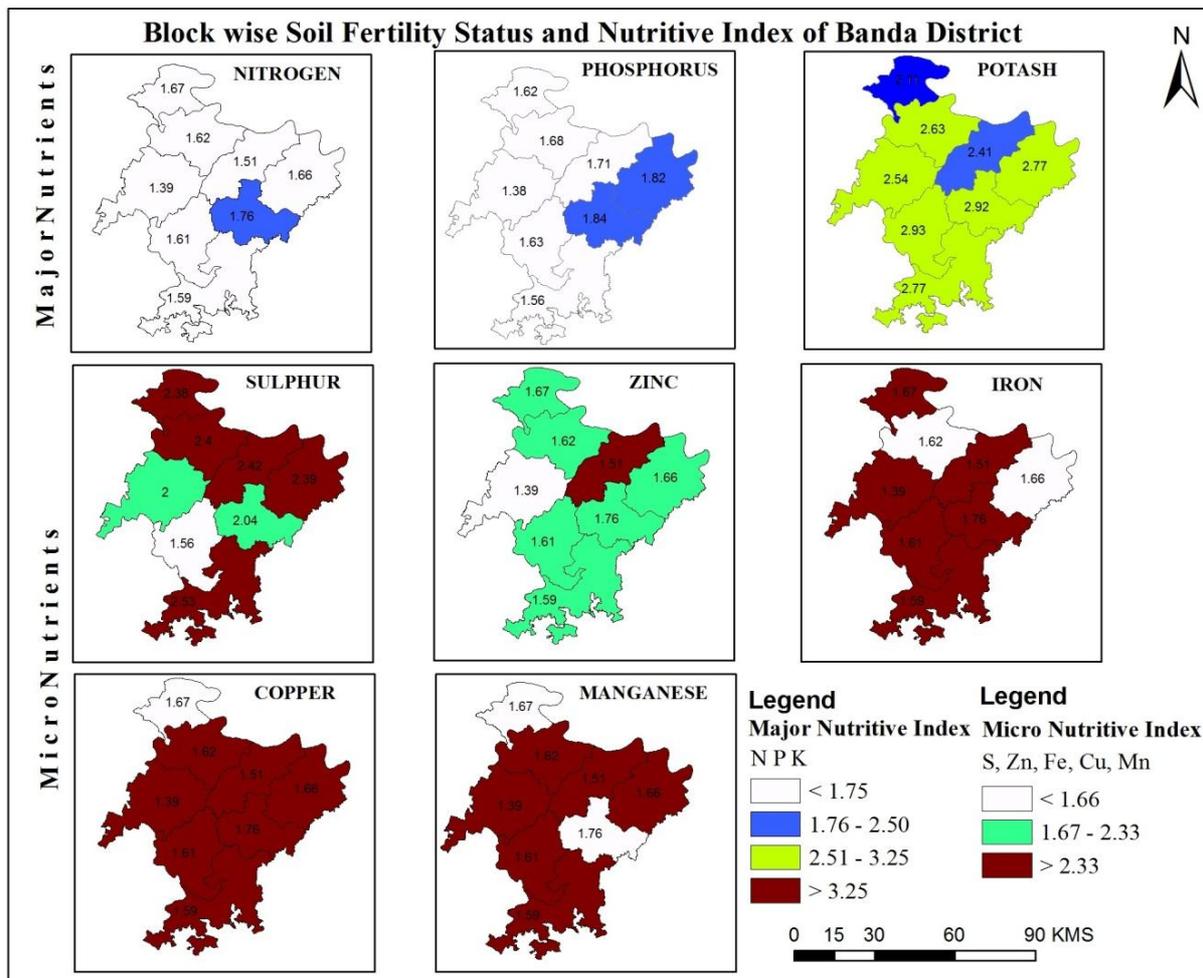


Fig. 6

Table 3: Soil Fertility Index Value

Nutritive Index Class for NPK		Nutritive Index Class for S, Zn, Fe, Cu, Mn	
Class	Remarks	Class	Remarks
< 1.75	Very Low	< 1.66	Low
1.76 – 2.50	Low	1.67 – 2.33	Medium
2.51 – 3.25	Medium	> 2.33	High
> 3.25	High		

Source: Sanchez *et. al.*, (1982) <sup>[11]</sup>

Table 4: Block wise Soil Fertility Status and Nutritive Index

Block	Organic Carbon (N)	Phosphorus (P)	Potash (K)	Sulphur (S)	Zinc (Zn)	Iron (Fe)	Copper (Cu)	Manganese (Mn)
Jaspura	1.67	1.62	2.11	2.38	1.86	2.94	2.82	2.94
Tindwari	1.62	1.68	2.63	2.40	1.98	2.92	2.97	2.97
Badokhar Khurd	1.39	1.38	2.54	2.00	1.82	2.94	2.98	2.98
Baberu	1.51	1.71	2.41	2.42	2.62	2.94	2.95	2.98
Kamasin	1.66	1.82	2.77	2.39	2.08	2.92	2.89	2.97
Bisanda	1.76	1.84	2.92	2.04	1.96	2.98	2.93	2.94
Mahuva	1.61	1.63	2.93	1.56	2.14	2.97	2.94	2.99
Naraini	1.59	1.56	2.77	2.53	2.09	2.95	2.92	2.97
Banda District	1.53	1.54	2.7	2.21	2.18	2.94	2.92	2.96

Source: Zonal Soil Testing Laboratory, Chitrakoot Dham Mandal Banda, E. R. Division-2003

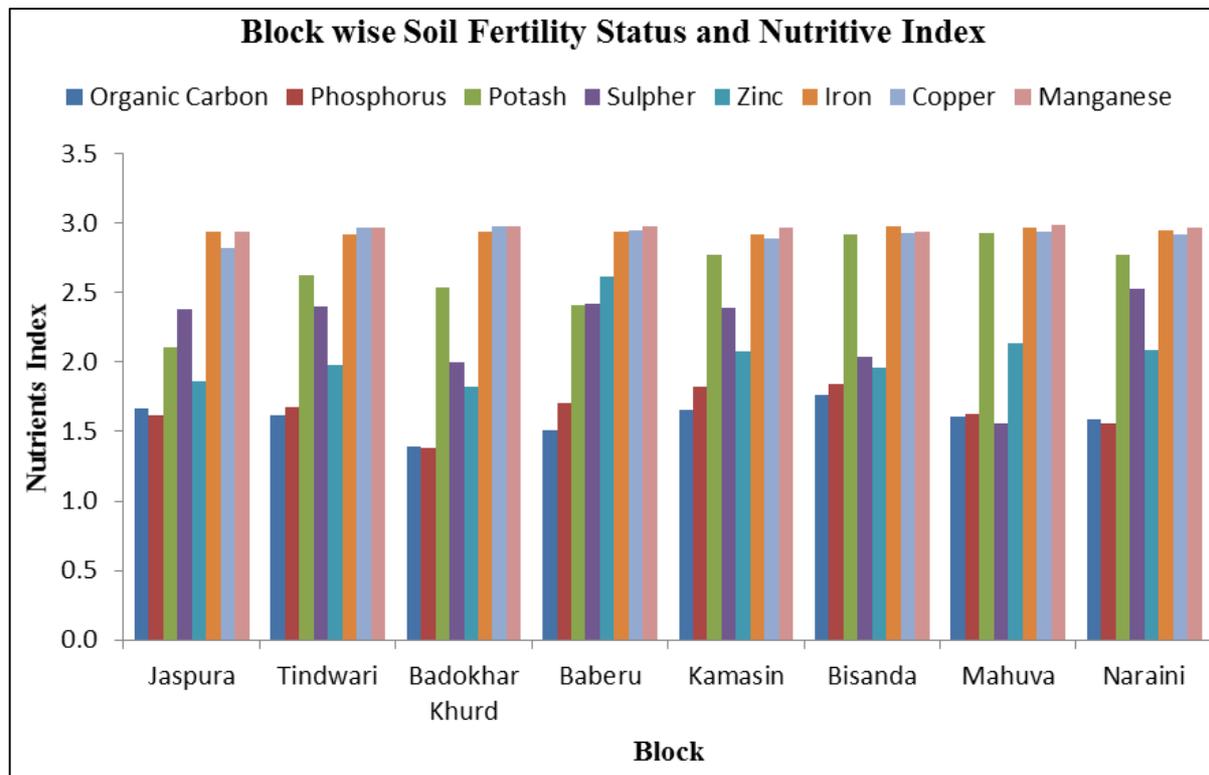


Fig 7

### Conclusion

On the basis of above mentioned parameters of human resource pressure and land resource management, it can be predicted that either the level of human resource or the land resource is very backward in the stage of development in comparison to the other parts of the state. Dependency and requirement of the population for food grains is very high in comparison to inclusion agricultural population. Terrain characteristics of the area are complex due to drainage system and geological formation that also controls the land utilization in the district. In case of soil fertility status and nutrient index (NI) value, it is clear that most of the soils of Banda district are low in organic matter/ carbon content, available N, and P, and medium in available K and S. The status of available micronutrients contents such as zinc, iron, copper and manganese are ranged from medium to high NI value. Therefore external application of nutrients specially nitrogen (N), phosphorus (P), sulphur (S), and zinc (Zn) on the basis of soil test value (STV)/and or soil test crop response (STRC) in balanced and integrated way is required, which will not only sustained the productivity of crops but also improve the soil health. Overall, it is suggested that there is an urgent need to have a separate agriculture development model for the region that is ecologically and environmentally sustainable. Such a model has to be integrated diversified agriculture, animal husbandry and forest regeneration through efficient management of wasteland/problematic siols, and other natural resources by adopting it and developing different agro-forestry models because a major portion of the land is suffering with various kind of degradation. The protection of land in the watershed and planting of various suitable tree species with crops (agro-forestry), not only leads to the benefit to the local people, can increase, water availability, crop productivity, improve soil and environmental health, conserve biodiversity on a sustainable basis as well as reduction in area of waste land and problematic soils.

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