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Geo-Spatial Modeling in the Assessment of Environmental Resources for Sustainable Water Resource Management in a Semi- Arid Region : A Case Study of Bhandara District, India

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ABSTRACT

The present study is geospatial modeling in the assessment of environmental resources for sustainable water resource management in a Bhandara district, India, using by geographical information system (GIS) and remote sensing (RS) techniques. The study will be based on secondary data. Secondary data was collected during the time period between are 1971 to 2013. After data collection the data were edited and coded. Then all the collected data were scrutinized carefully and recorded in master sheets. The monsoon rains in district are concentrated in the four months from June to September and receive 90.81% rainfall, post-monsoon 1.86% pre-monsoon 4.83% and winter 2.48%. Sandy red soil has covered 31% area; median black soil has covered 47% and Lomi red soil 22% covered the area of district. There are 580 large and 13,758 small and medium sized lakes in the district. The percentage of total area under forest 12.25%, especially during 2001 to 2011 periods it was in Bhandara (12.33%), Mohadi (19.89%), Tumsar (13.27%), Lakhani (11.13%) and Lakhandur (16.24%) decreased on large scale. There is a tremendous increase in the forest area in Sakoli (9.31%). Well irrigation is very important, in 1981; the total irrigated area was 66009 hect. of these 7.67% area is under well irrigation in 2011, the total irrigated area was 128165 hect; of these, 19605 hect. (15.30%) area was under well irrigation in the district. The aim of this present study was to evaluate environmental resource units that have been delineated based on the geospatial modeling of environment parameters with appropriate weights in GIS and RS techniques. The data can be used for area management, utilized in restoration and conservation of natural resources studies in the future.

Keywords:- Geo-spatial Modeling, Environmental Resources, Sustainable Water Resource Management

I. INTRODUCTION

Even though the water content of the earth is 71%, it is not drinkable. Sea water is about 96.5%. The Antarctic Glacier, which contains 61% of all freshwater on Earth, is not available for regular use. The amount of potable water on earth is only 3%. Therefore, water should be used as much as required. Water should not be wasted [1]. Water is the most important gift given by nature. So water is a natural resource. Water is extremely useful for all living things and nature. This has made it an integral part of human life [2, 3]. Water is used in a variety of ways in our daily lives. Water is used not only for drinking but also for washing clothes, washing dishes, cleaning and other activities. Similarly water is also used in industrial areas. Not only this, energy is also generated from water [4, 5, 6].

The biggest need for water seems to be for farming. Because human beings cannot grow any crop without water and if they grow crops, they cannot get food, so water has a very important place in human life. Not only has that, our nature and plants needed a lot of water [7, 8, 9, 10]. There are many factories running business around you. And with the financial help that comes from it, people are making a living. But some of these industries are in dire need of water [11, 12, 13, 14, 15]. If such industries do not have water, they may come to a standstill, so water also plays an important role in industrial causes [16, 17, 18, 19].

What exactly is groundwater management? So, use the available groundwater to meet your needs of drinking water, irrigation in such a way that it can be used for a long period of time without affecting the natural availability of groundwater. Groundwater management requires attention to availability planning and demand control i.e. 'demand-supply chain'. 'Ensuring demands planning' is the core of groundwater management. Groundwater balance is first presented in any watershed area for groundwater management. Groundwater balance helps in measuring the availability and demand of groundwater in our catchment area [20, 21, 22, 23, 24, 25]. Water is a community asset. Given that it cannot be created artificially, it is imperative that people participate in groundwater management [26, 27].

In the study, an attempt has been made to delineate distinct physiography, soil types, geology, slope, relief, climate and rainfall, water quality analysis, demographics, water resource management, resource units, inventory of existing medium/minor/lift irrigation schemes constructed the areas through geospatial modeling for sustainable development in Bhandara District, central India.

II. Study Area

The Bhandara district (Fig. 1) is located on 20˚30' N to 21˚38'N and 79˚27' E to 80˚07'E. Spread over an area of 4087 sq. km. covered 1.3% area of the District. It covers an area of 3,716 sq km and is bounded by Gadchiroli and Chandrapur in the south, Nagpur in the west, Balaghat in the north and Durg in the north. Bhandara, Gondia and Sakoli are the three talukas of the district. To the north is the natural boundary of the rivers Bawanthari, Wainganga and Wagh between Balaghat and Bhandara districts. The Wainganga River forms the boundary between Nagpur-Bhandara in the southwest and Chandrapur-Bhandara in the south. Bhandara district in Maharashtra falls entirely in the

Wainganga river basin. Wainganga is the main river in the district. Its flow does not dry out even in summer. The terrain of the district is generally flat. Occasionally there are loose mountain ranges. There are 7 talukas in Bhandara district, as follows. Bhandara, Sakoli, Tumsar, Pawani, Mohadi, Lakhni, Lakhandur.

III. DATABASE & METHODOLOGY

The analysis includes relief, forest, soil, drainage, rainfall and water analysis, Collection of rainfall and long term rainfall data for the entire Wainganga basin as well as small tributaries, particularly for district area have been collected from Indian Meteorological Department (IMD). Water sample has been collected from the tehsil area and also at river Wainganga and physio-chemical water has been analyzed, Satellite data products Multispectral imageries have been acquired for time series analysis of various hydrological as well geomorphological features of in study area. The following steps have opted for the study environmental network of the tehsil was analyzed. Using SOI topographic maps and Universal Transverse Mercator (UTM) zone 44N projection was georeferenced using WGS 84 datum, in ArcGIS desktop 9.3. The study will be based on secondary data. Secondary data was collected during the time period between are 1971 to 2013. After data collection the data were edited and coded. Then all the collected data were scrutinized carefully and recorded in master sheets (28, 29). Present study deals with 20 years changes in rice production in the Bhandara district. This study contains how decrease of rice production affects rice mills. Information regarding area, production and productivity collected from different sources.

IV. RESULT ANALYSIS

The state of Maharashtra is intertwined. There are a total of 36 districts in Maharashtra. Each district in Maharashtra has a different identity. Each district has some history, some tourist destinations and some differences. One of them is the district with the highest number of lakes. The district is known as the district of lakes. There are about three thousand 648 small lakes in this city. There are no such lakes in any city in Maharashtra. The district is a major producer of rice. The district is known for the production of fragrant rice and copper. Bhandara is a district known as the "Rice Warehouse" of Maharashtra. Bhandara is known as the largest rice growing district in Maharashtra. Agriculture is the main occupation of the people of the district. The economy of the district depends on this income. The population of the district is 11 lakh 35 thousand 835. Due to the unfavorable climate of the district, it receives relatively good rainfall.

4.1 Climate of the district

The weather in Bhandara district is warm and dry in summer, cold and dry in winter and humid in the rainy season. The average maximum temperature in month of May is 47.5^{0}C. The average daily temperature is 25.9^{0}c. Running into months of November to February the average maximum temperature is 31.8^{0}c and minimum temperature is 9.7^{0}c. Bhandara, Pawani and Sakoli are the places cleared from the 35 years rainfall data from 1987 to 2001 that more than 90% of annual rainfall falls during monsoon period. In monsoon period 100% of the total rainfall in some years has been recorded and 7% to 75% of the total rainfall in some years has been also recorded. During the monsoon period, the uncertainly of rainfall is evident (Kudnar et al, 2022). The annual rainfall of Bhandara place is 1246 mm. The median value is 1250 mm. That's it, from this it is clear that they are not very different from the average, the same view seems to apply in the place of Pawani & Sakoli, with a slight curvature. The standard deviation of annual average rainfall is 296.63 in Bhandara district. The 'V' value of this place's rainfall is 23.80 and quartile deviation is 198.90. It looks like the rainfall is very reliable compared to the annual average of the monsoon rainfall. In comparison, standard deviation of rainfall of monsoon period is more than annual average rainfall. With this 'V' value

also more, so it is evident that the rainfall in the monsoon is more reliable than annual average rainfall. It is clear that annual rainfall is low than median value in the dispersion of rainfall. This situation is generally found in Sakoli and Pawani and this is a main cause of agricultural hazard. As Bhandara district is far from the coast, the climate here is uneven. Generally January is the coldest month and May is the hottest month. The climate of Bhandara district is temperate and will be as severe as summer and winter. Mostly rainy.The actual amount is between July and August. It started raining from the second week of June and ended in October. It rains for weeks. About 90% of the annual rainfall falls during this period. By the end of 2020 in Bhandara district 1394.3 mm (**Figure 2**) It is raining (Pithnya). This is 11.5% more than the average Pithna. The year 2013 as well Compared to the average Pithna, Pithna has been declining significantly since 2014. 2020 compared to 2019. The average rainfall in India fell by 3 per cent and today the average Pithinya days have increased by 7 days. The temperature changes according to the season. The maximum temperature of the year is 450C. This summer, the minimum temperature is 80 To It lives in Jahwala [30, 31, 32, 33].

4.2 Relief Structure

Naturally, Bhandara district is considered as a part of the Wainganga basin on the plateau of the Deccan which is considered as a plain of this area is called “Plains of Wainganga”. It is an average altitude of 270 meters (Figure 3) above from sea level, with Chandpur hills (465 m.), Ambagad hills (533 m.), Gaimukh hills (394 m.) on the north side of this vast plain. Gaikhuri hills (520 m.) and Koka hills (418 m) are on east side of plains and Bhimsen hills (452 m.) and Pawani hills (365 m.) are scattered in the central and southern parts of Bhandara district. In Bhandara district 84% area is plains and 16% is hilly. Bhandara district in Maharashtra falls entirely in the Wainganga river basin. Wainganga is the main river in the district. Its flow does not dry out even in summer. The terrain of the district is generally flat. Occasionally there are loose mountain ranges. The northwestern and eastern parts of the district are hilly. Ambagad mountain range in the northwestern part of the district is an extension of Satpuda mountain range. There are Gaimukh, Ambagad and Chandpur hills and Ambagad built in 1700. The soils of Bhandara district are mainly Kalikanar, Jashar, Morand, Kharadi and Bardi. Kanhar Min is low. The truth is worth it. On the banks of the Wainganga River, there is a moraine mine of Kali Kanhar and Prem Di. She digs deep, Sand deposits in Waingange valley Is found. It retains deep moisture and moisture and is suitable for rice cultivation. In the case of Morand type minis, especially: Sorghum, wheat and sorghum are also grown. In Kharadi and Bardi soils, light variety of paddy is cultivated. Due to the formation of many hilly areas due to Satpuda Pavatha, precious metals like Magnesium, Kainite, Jaslijamnite An underground structure with a treasure trove is found [34, 35, 36, 37]. It retains moisture and moisture and is taken twice a year. Bhandara district is known as the district of lakes. These lakes have contributed to the increase in irrigation. The area of the district has also become scenic. The rich forests of the district, abundant minerals, wealth, habitat of various ancient castes and tribes and the manufacture of metal utensils and the traditional handicrafts on them are the main features of the district.

4.3 Drainage

Wainganga river is the largest and most important river in Bhandara district and it enters the north-eastern part of the district. She continued. It flows through the southern district of Chandrapur [38, 39, 40]. Tigers, Pangodi, Sur, Gadhvi, Chandan Ajan Bavanidi are tributaries of Wainganga river. The length of the river in Bhandara district is 200 km. is. The main river flowing from Bhandara district is the Wainganga river and due to the special order of flowing the tributaries such as Bawanthadi, Sur, Kanhan, Chulband and Maru etc. the tree lined river system has been created (Figure 4).

4.4 Soil

Soil in Bhandara district has been created from fire and metamorphic rocks. Sandy Red soil has covered 31%

area in total geographical area of Bhandara district. Median Black soil has covered 47% and Lomi Red soil 22% covered the area of district (Figure 5).

4.5 Forest

Bhandara region was known as a "Gondwan" and according to Mahanubhaw literature the term "Zadipatti" is referred to here as the terrain in ancient and medieval time, the region was rich with dense forests, but in last century, the proportion of the world here is very low. There are 20 to 30 feet high mixed plant and low-highly shrubs inhabitant here. For Example, High quality Sagwan, Bija, Halhad, Tiwas, Yen, Khair, Mohagni, Garadi, Dhawda, Tendu, Behada, Kalamb, Bambu, etc. There are 41499 hector. Area are under forest (year 2011), this is 8.96% in total geographical area of district.

4.6 Projects in Bhandara district

Indirasagar Project, Karhada Lake Project, Khamb Lake Project, Chandpur Lake Project, Bahula Dam Project, Balasamudra Project, Itiyadoh Project, Bagh Shirpur Project, Bagh Pujaritola Project, Bagh Kazisarar Project, Gosiakhurd Project. The major projects are the Wagh River Project and the Etidaho Project. Wagheda Project, Sorana Lake, Bodalaksa Lake, Chandpur Lake, Chorakhmara Lake, Khairbanda Lake, Mangad Lake, Sangrampur, Chulband Lake, Belekar Bothali Lake, Kalisarar are the medium scale projects in the district.There are four major divisions of the district in terms of topography Gaimukh and Ambagad mountain ranges Gaikhuri and Pratapgad mountain range Wainganga river basin and Wagh and Pangoli river valleys.

4.7 Pond

There are 580 large and 13,758 small and medium sized lakes in the district. That is why Bhandara district is known as the 'Lake District of Maharashtra'. There are two types of lakes. The first type is the crescent-shaped lakes in the hilly region, especially in the Gaikhuri, Navegaon and Palasgaon mountain ranges. Although these lakes are large in size, their expansion is irregular and the banks of these lakes are made up of dense, rugged hills that collect water on them. The lake has been constructed by the tribals of Kohli tribe and no planned technique or engineering knowledge has been used in the construction.

4.8 Land use

In 2011, "Medium land holder" (2 to 5 hect.) reached at 22.37% and "Large land holder" (5 to 10 hect.) reached at 9.25%, respectively "Very low land holder" "low land holder" and "Very large land holder" had decried on large scale, in the district. In 1981, 97% of the farmers in the district were forced to cultivate their land by self and in 2001, 99.84% land holder cultivate their agricultural land by self.

In the year 1981, 192400 hect. area was under cultivation, the ratio is 49.94% with geographical area. In 2001 it increased to 54.22 and again in 2011 it increase and reached on 55.13%. Probably the pasture is provided for grazing land for animals by the government in every village. In 1981, the district had 40700 hect. (10.56%) area was under grass. In 2011 it decreased bond come up 4.97%. The area under grazing land decreased by 5.60% from 1981 to 2011. The geographical area (without Gondia district) of Bhandara district was 38530 hect., but in the year of 2001 was 3753500 hect.. Means 7375 hect. Geographical area has become less. During the period 1981 to 2011, there was a significant decline in the forest area, as a result, the net shown area; appears to have increased during the period of last 30 years from 1981 to 2011. The percentage of total area under forest in the district has decreased by 12.25%, especially during 2001 to 2011 periods it was in Bhandara (12.33%), Mohadi (19.89%), Tumsar (13.27%), Lakhani (11.13%) and Lakhandur (16.24%) decreased on large scale. There is a tremendous increase in the forest area in Sakoli taluka (9.31%). Now the implementation of government policy is increasing the forest area. Areas not available for agriculture includes land that is not available to agriculture, there is no such land available for a agriculture such as reservoirs, roads, grasslands village area and other colonies. The area of non cultivable land increased by 2.40% during 1981 to 2011 (Figure 5). In total follow land have included

permanent and current follow land. In the year of 1981, there was 3.17% area under total follow land however; it is 3.52% in 2011 has come up. Net area under cultivation i.e. land under cultivation is meant only during the year, the part of land that was once in use is the net under the crops. Generally the agricultural land using the capacity of Bhandara district has been devided into five parts, i.e. very high (over 90), high (85 to 90), medium (80 to 85), Low (75 to 80) and very low (below 70). In "Medium agricultural land use capacity group" have included Bhandara and Lakhandur taluka in the year of 1981 and only Sakoli taluka in the year of 2011. Other area includes such as the land under various uses but that is not available for agriculture [41, 42, 43, 44]. In 1981 14500 hect. area include in this type of land. In the district during period 1981 to 2011, it increased by 11.23%6 (Figure 5).

Agribusiness is mainly affected by topography, river, air and weather, fertile land and water resources factor in the region. Agriculture land use is very important, however it use for various causes. In "Low agricultural land using the capacity group" has included Mohadi and Pawani in 1981 and Mohadi and Sakoli taluka in 2011. In "Very low agricultural land using the capacity group" has included Tumsar and Sakoli talukas in 1981 and there are not obtained this type of capacity in 1991, 2001 and 2011 year also. In 1981, there are 197844 total farmers in the Bhandara district, most of them are in "Very low land holder group" (Below 01 hect.) and amount of them is 90944. The maximum number of land holder is in "Small land holder group" (less than 1 hect.) that is 90944 Land holder and ratio is 1.88%.

4.9 Water Resources and Water Irrigation

Show the table 1 there were 4 large & 4 medium projects of irrigation resources in the district and this irrigation capacity was respectively 33659 hect. And 13071 hect, besides this there were 32 irrigation project on state level and 220 on local level, its irrigation capacity was respectively 16245 hect. and 17835 hect. There were 19 lift irrigation projects in the district. The capacity of irrigation of this 19 project is 57962 hect. and Kolhapur type projects are 310 and its capacity is 9897 hect. Thus, including the different types of irrigation sources, there are 589 total irrigation projects in the district and 148849 hect. area is under irrigation by these different types of sources. In short, 60.30% agricultural area out of 100% is under irrigation in 2010-11 in Bhandara district. Bhandara district is known as a "District of Lakes", but wells and tube wells also are playing important role in irrigation. In the period of 1981 to 2011, total wells reached at 19336 (97.08%) from 9999 (97.63%) total tube wells reached at 182 (0.91%) from 175 (1.71%). After independence, irrigation was given a major place to increase agricultural productivity. Large, medium and small project were started to bring maximum land under irrigation. From the year 1981 to 2011, there is a steady increase in irrigation in Bhandara district. In 1981 there was 66009 hect. area under irrigation. In next ten years, irrigated had area increase by 3829 hect. and reached at 69838 hect. In 2001, it is increased by 53861 hect. and reached at 123669 hect. But in 2011, it increased to a lesser extent by 4496 hect. and reached at 128165 hect. Water supply or irrigation facilities must be available for the growth of agricultural production. On the basis of which the modern seeds, chemical fertilizers, pesticides, etc are strictly used. In pre-planning mans pre-independence period, the large reservoir, Bodalkasa, Chorkhamara, Khairbanda were ready fore the irrigation of agriculture, also "Malgujari" tanks were there in the district, for exam. Nawegaon Bandh, Dhabepawani, Pindkepar, Ekodi, Kosamtondi, Chaprad, Morgaon, Kakodi, Ghatbori, Fulture, Kati, etc. development of wells and tube wells has not been done. Well irrigation is very important, in 1981; the total irrigated area was 66009 hect. of these 7.67% area is under well irrigation in 2011, the total irrigated area was 128165 hect; of these, 19605 hect. (15.30%) area was under well irrigation in the district. The development of tube well irrigation has not been done in the district. In 1981, there was a 6613 hect. (10.02%) area under tube well irrigation and in 2011 it was 25279 hect. (19.72%). Without the irrigation (Table 2)

one can't think the growth of agricultural production, because depending on the rainfall, farming cannot be done on a regular basis for that artificial water supply facilities must be done available. Water supply can only be harvested, if the supply is proper, which lead to crops can use the available water resources to determine the desired amount of water it takes. These water resources are mainly flowing ground water, underground water, atmospheric water and oceans and inland reservoirs are available through this medium. In flowing water through the surface includes rivers, sub-rivers, tanks, lakes, etc. All of this medium water can be supplied to the agriculture, but the proportion of it depends on economical, technical, scientific and other factors. Underground water is the amount water that is poured into the ground surface; the volume of this water depends on internal rocks formation, slope, amount of rainfall, etc. In this region, wells and tub wells have developed and benefitted to agriculture. Ocean and inland reservoirs are huge because of the many rivers that flow through them stocks & sludge come in and store. Therefore, such alkaline water cannot be used for agriculture. In the distribution of water at world level, India is in fifth rank after Brazil, Russia, China and Canada. But in water irrigated area, India is on rank in the world. "An Irrigation is the right amount of artificial water supply, at the right time, for the agricultural crops." Agriculture is such an economic activity which means that the water is the basic factor. Today, irrigation is the soul of green revolution. Generally, the irrigation requirement is uncertain rainfall, needs of different crops, intensive agriculture, increase in productivity, increase in employment, resolving natural imbalance, land for other work, commercialization of agriculture, water transport, fisheries, production of electricity, control water flood, etc. There are three types of irrigation depending on the types of water supply to agricultural farm which is very important for the is flowing irrigation. Store irrigation and lift irrigation. Ground water irrigation is largely developed in the district. During the 1981 to 2011, in this period, there is a steady increase in ground water irrigation. In 1981, 5433 hect area was irrigated by ground water, it reached at 83279 hect. in the year of 2011. During the period of 1981 to 2011, the irrigated area started increasing. Similarly, there is a huge increase in the following area under cultivation in 1981, there was a near about less than 50% area under irrigation, after 30 years, in 2011, it increased regularly and reach at above 60% in comparison of total cropped area. In 1981, the net area shown was 192400 hect., in this comparison 66009 hect. (34.31%) area was under irrigation and in 2011, net area was increased and reached at 208368 hect., in this comparision 128165 hect. (61.51%) area is an under irrigation [45, 46].

4.10 Population

Bhandara district has a population of 12,00,334 with 979 females per 1000 males. Apart from Marathi, Hindi, Gondi, Powari, Urdu, Sindhi, Gujarati, Holiya, Telugu, Kosthi, Kalari etc. Languages are spoken. The staple food of the people is rice and lime. The meal consists of bread or poli, lakholi varan and vegetables. Flaxseed oil is widely used. Horns are obtained from the lake. In Bhandara district, 771 residential colonies have been developed in total geographical area, 3779.25 sq.km. having 1200334 total population (as of 2011). The density of population is 293.70 people per sq.km. The average literacy rate is 90.74% (191532 people) including men's literacy is 94.38% (100267 people) and female's literacy is 87.06% (91265 people). The agriculture is main economic activity of peoples in Bhandara district, out of the total working population 73% population engaged in this business, 36% are agricultural labours and 37% are farmers. 72.87% people are engaged in primary economic activity in the district. The development of paved roadways have been on large scale also national highway, state highway, district main road, other road are on large scale in the district [47].

Table 1 : Salient Features of Ground Water Exploration (March 2011).

S. No.	Salient Features	Details
1	No. of exploratory wells drilled	EW-19, OW-8
2	Depth range (m.bgl)	55.15 to 222.23
3	Depth Range of zones encountered	24.40 to 154.00
4	Thickness of individual zone (m)	1 to 10
6	SWL range (m.bgl)	3.75 to 12.10
6	Yield range (lps)	2.50 to 8.98
7	No./ % of boreholes with yield more than 3 lps	4/27%
8	Formation	Weathered Granites and Gneisses
9	Transmissivity (m^2/day)	10.43 to 59.54
10	Storativity	1.5×10^{-4} to 8.70×10^{-4}

Table 2 : Ground Water Resources

Tehsil	Area Type	Net annual Ground water Availability (ham/yr.)	Annual Ground water Draft (ham/yr.)			Allocation for Domestic & Industrial Requirement Supply up to next 25 years (ham/yr.)	Ground water Availability for Future Irrigation (ham/yr.)	Stage of Ground water Develop-ment (%)
			Irrigation	Domestic & Industrial uses	Total			
Bhandara	C	4317	240.00	265.00	504.90			
	NC	4788	825.00	113.10	937.83			
	TOTAL	**9105**	**1065.00**	**378.10**	**1442.73**	**749.00**	**7320.00**	**15.85**
Mohadi	C	3246.00	855.60	225.51	1081.10			
	NC	2351.00	734.30	124.40	858.70			
	TOTAL	**55597.00**	**1589.90**	**349.91**	**1939.80**	**661.70**	**3209.00**	**34.68**
Tumsar	C	4233.80	889.77	179.82	1069.50			
	NC	3718.40	1229.32	153.57	1382.80			
	TOTAL	**7952.20**	**2119.09**	**333.39**	**2452.30**	**703.00**	**5230.00**	**30.83**
Pauni	C	268.00	25.65	94.20	119.80			
	NC	7267.37	3535.99	190.85	3726.89			
	TOTAL	**7535.37**	**3561.64**	**285.05**	**3846.69**	**534.19**	**3430.36**	**51.00**
Sakoli	C	2187.00	182.23	137.95	320.17			
	NC	4650.00	781.70	98.80	880.5			
	TOTAL	**6837.00**	**964.03**	**236.75**	**1200.72**	**480.20**	**5428.99**	**17.57**

Lakhandur	C	4224.81	82.06	26.27	108.37			
	NC	3968.35	1781.53	181.36	1962.88			
	TOTAL	**8193.16**	**1863.59**	**207.63**	**2071.25**	**461.00**	**5889.54**	**25.27**
Lakhani	C	1500.46	64.34	33.22	97.50			
	NC	38889.70	922.60	143.45	1066.00			
	TOTAL	**5390.16**	**986.94**	**176.67**	**1163.50**	**347.20**	**4014.42**	**21.60**
District Total	**C**	**21517.80**	**2339.63**	**961.91**	**3301.99**			
	NC	**65632.82**	**9810.17**	**1044.68**	**10815.00**			
	TOTAL	**87150.62**	**12149.8**	**2006.59**	**14116.99**	**3936.29**	**34522.31**	**28.12**

Source: Central Ground Water Board, Bhandara

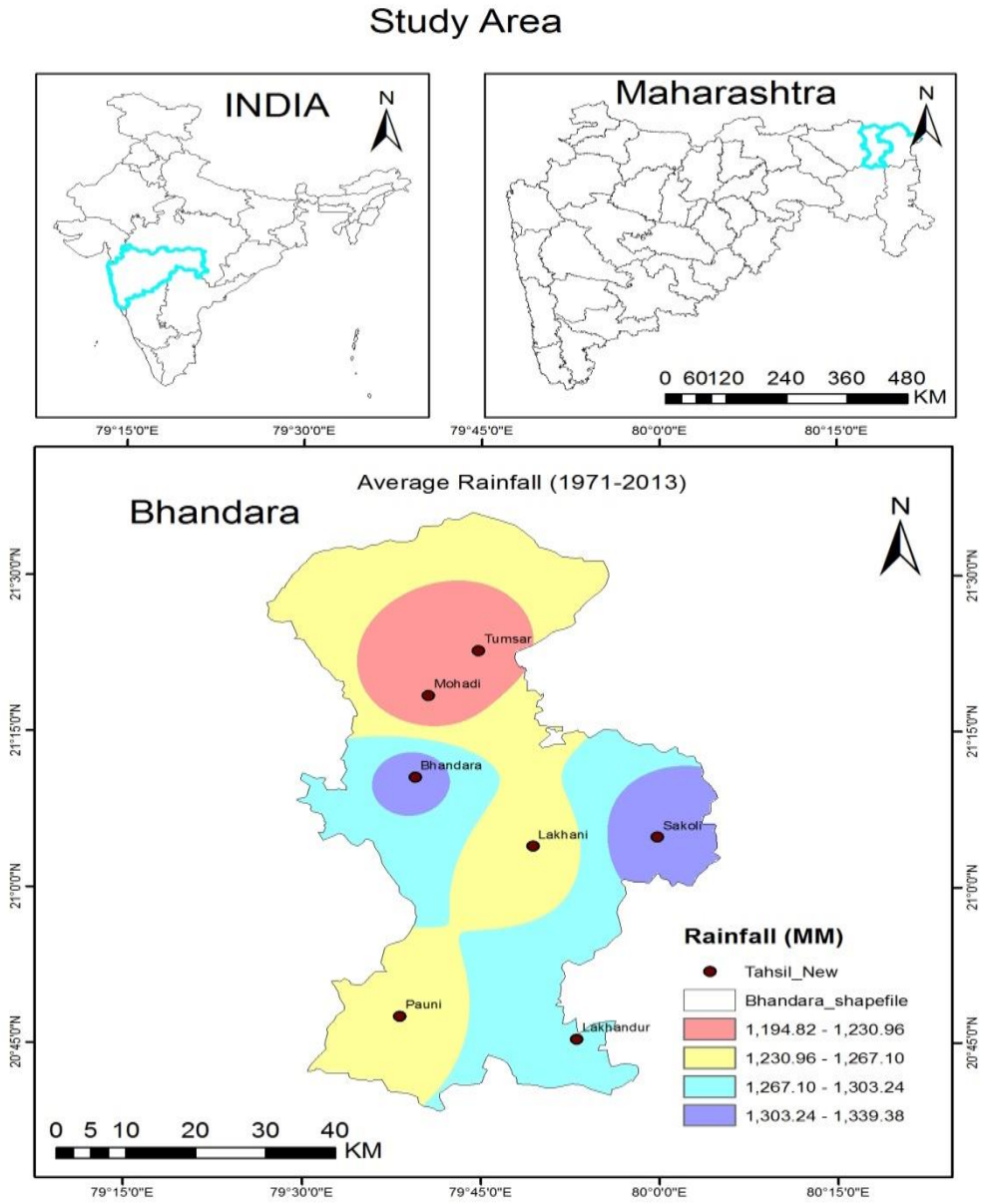

Figure 1: Study area

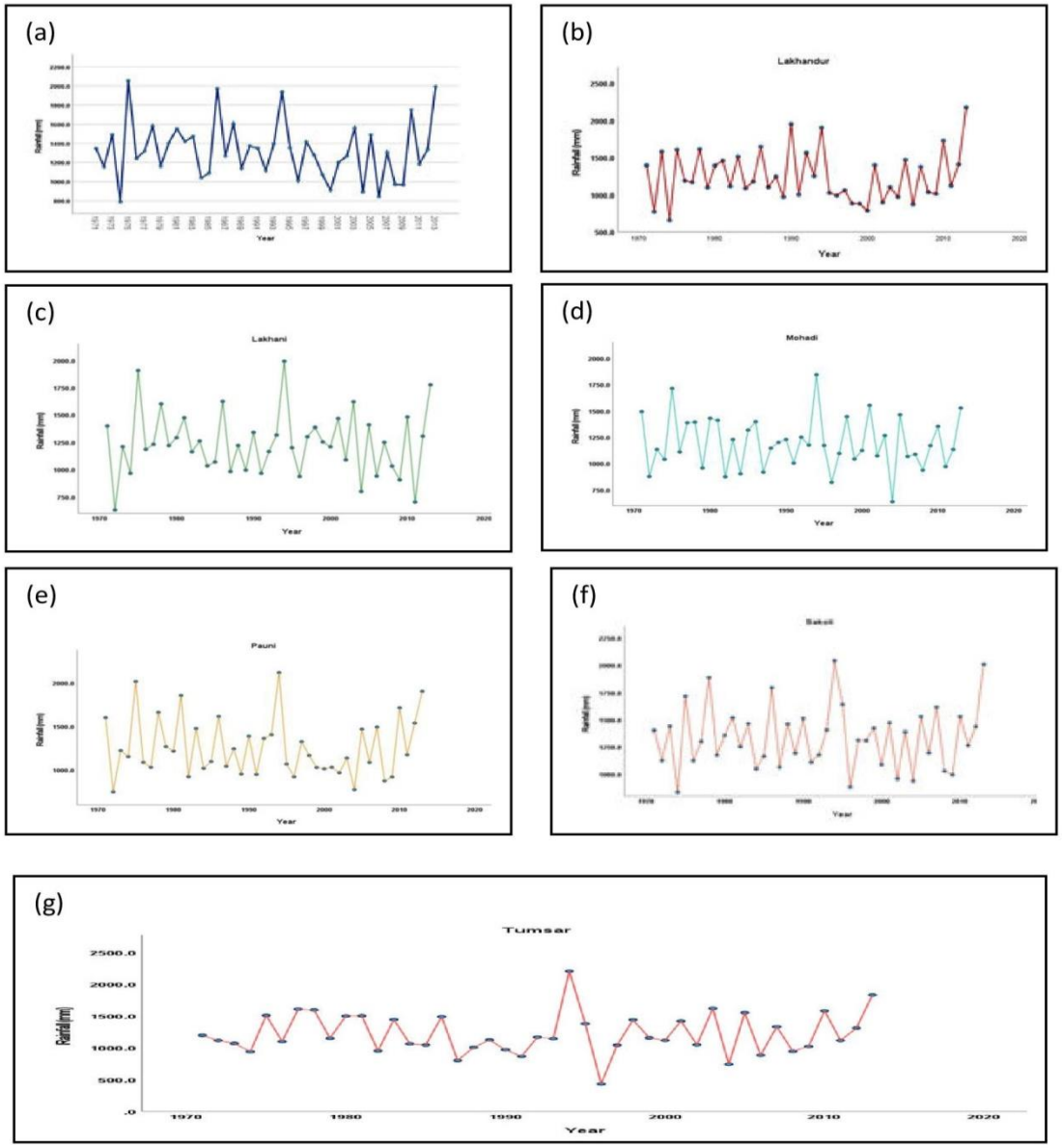

Figure 2: Annual average rainfall trend a) Bhandara, b) Lakhandur, c) Lakhani, d) Mohadi, e) Pauni, f) Sakoli and g) Tumsar stations over the period of 2071-2013.

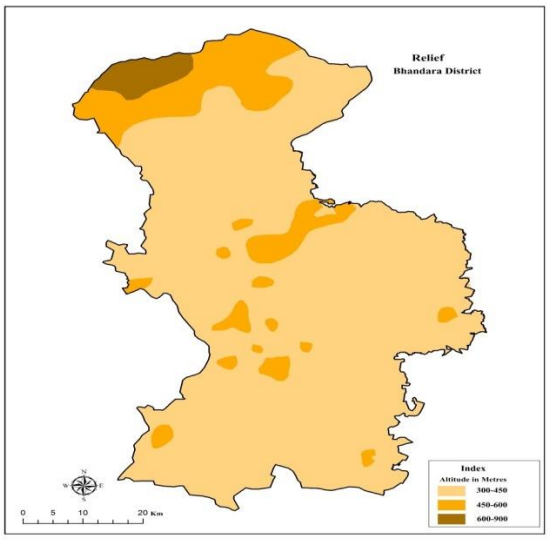

Figure 3 : Relief

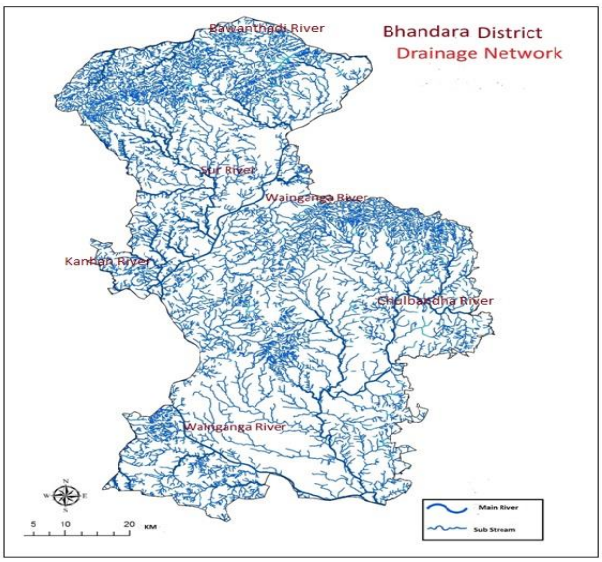

Figure 4: Drainage

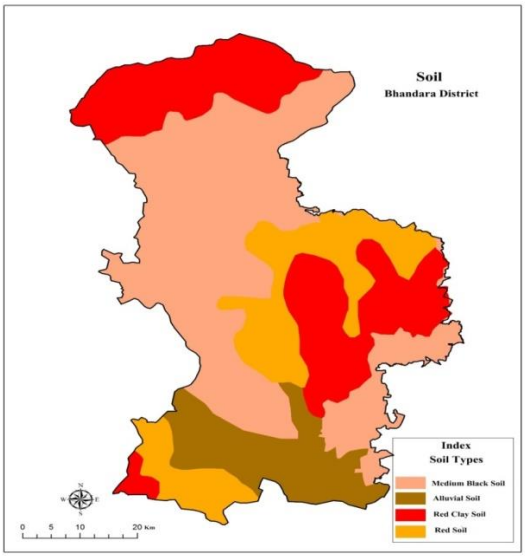

Figure 4: Soil

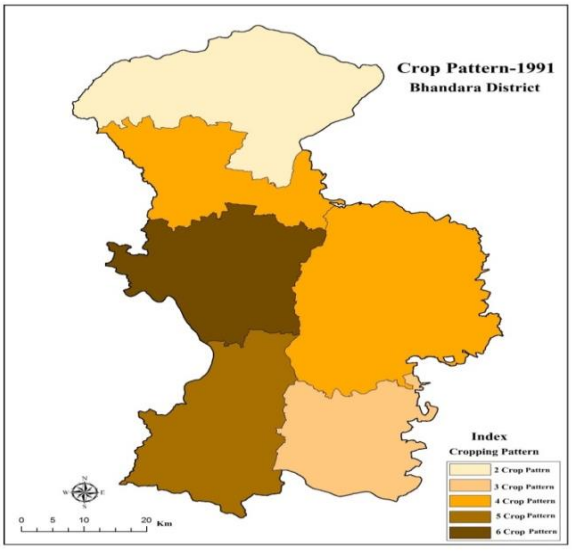

Figure 5: Crop Pattern-1991

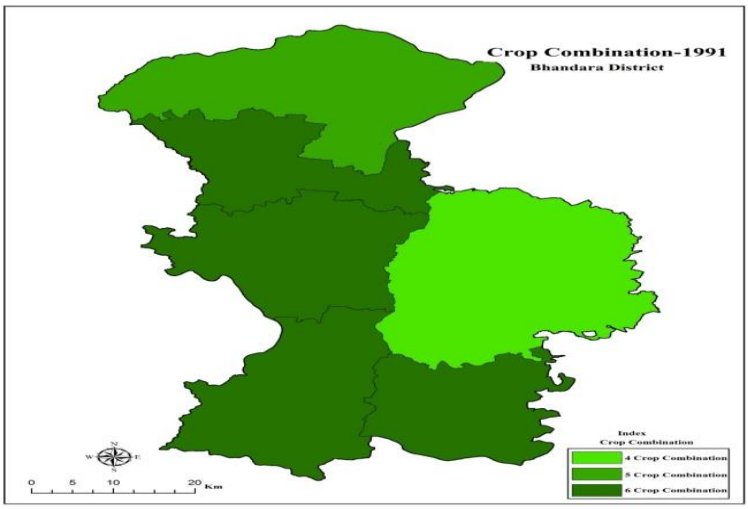

Figure 6: Crop Combination

V. CONCLUSION

Rice production can largely be sustained in Bhandara District if land and water on which it is primarily based are not degraded. District needs to exploit the benefits of rice science more than anything else. If the successful discoveries of high breed rice can be fully exploited and integrated, District fortune may change positively. There were 19 lift irrigation projects in the district. The capacity of irrigation of this 19 project is 57962 hect. and Kolhapur type projects are 310 and its capacity is 9897 hect. Thus, including the different types of irrigation sources, there are 589 total irrigation projects in the district and 148849 hect. area is under irrigation by these different types of sources. In short, 60.30% agricultural area out of 100% is under irrigation in 2010-11 in Bhandara district. Bhandara district is known as a "District of Lakes", but wells and tube wells also are playing important role in irrigation. In the period of 1981 to 2011, total wells reached at 19336 (97.08%) from 9999 (97.63%) total tube wells reached at 182 (0.91%) from 175 (1.71%).

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