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POTENTIAL, PROBLEMS AND MANAGEMENT OF WATER RESOURCE IN SIWAN DISTRICT, BIHAR, INDIA

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ABSTRACT

Water being a basic resource plays a vital role in the development of an area whereas the population growth and other affecting components have influenced the water resource potentialities. In this order, Siwan district has been taken for the in depth study. The present study is the outcome of the detailed analysis of the secondary as well as intensive field study, which fulfills the gap of possible remedy for the management of water resource potential. This study is rich in the potential of water resource. But now-a-days, the water resource potential has been decreasing day by day. It has been facing the depletion in surface water potential as non-perennial rivers such as Jharahi, Daha, Gandak, Dhannai and Chhoti Gandak in summer season. The sub-canals, tanks and ponds have created the shortage of surface water potential. Along with the groundwater potential has diversified through the variability of water level in the blocks of the study area. To achieve the objectives, various components have been dealt with a view to gain fruitful results to find out various problems of water resource potential had gone through intensive observation. Our result reveals that the high groundwater potential has decreased while low groundwater potential has increased by the ecological, hydrological and topographical changes. Thus, we may conclude that the water resources potential has directly influenced by natural environment and human environment.

KEYWORDS: Depletion, Ecological, Hydrological, Topographical, Shortage**.**

Water is a scarce and indispensable natural resource. It is finite in quantity, tangible in nature, and un-equally distributed throughout the world. Only 2.5% of 1386 million cubic kilometers of water available on earth is fresh water and one third of this small quantity is available for human use (Postel, Daily and Ehrlich, 1996). That is to say that total fresh water is 19000000000 cubic metres in which 86% fresh water is available in form of rivers, lakes and ponds in India (Singh, 2015). This water potential fluctuates spatially and temporally by the impacts of climatic change. Our climate change has been affected the distribution of rainfall, which is the main source of water supply in the form of surface and ground water. As the water resource potential, rainfall is the only source of water as run off as well as underground collection. The water resource potential is assessed through surface water potential and groundwater potential. Total water resource potential in terms of natural run off (flow) in rivers as 1869 BCM/ year in India, out of it 1123 BCM/ year is for usable water resources. The share of surface water is 690 BCM/ year and groundwater is 433 BCM/year (Water and Related Statistics, 2015). Further, the availability of water has been decreasing in unbalanced situation in India. The per capita availability of water was 5177 cubic meters in 1951 and 1544 cubic metres in 2011. It has fallen 70.17% from 1951 to 2011 (Water and Related Statistics, 2013). This figure suggests that water availability has been decreasing in terms of water resource potential by Central Groundwater Board, Patna in 2004. Total groundwater resource is 823.78 MCM in Siwan district in which Mairwa block covers highest ground water potential whereas Bhagwanpur block covers lowest groundwater potential (Govt. of India, 2008). This variability in water resource potential is influenced by water level, rainfall, temperature, soils, geomorphic structure and physiographic characteristics.

Water level is open wells usually rises in the rainy season and it fluctuates between 7.62 cm to 391.16 cm/ year below ground level (bgl), which shows the diversity in the potential of water resources during the investigation period. The study area receives 553.9 rainy days during 2001 to 2011. About 88.75% of the total rainfall is occurred by south-west monsoon and remaining 11.25% of total rainfall is recorded by winter and summer monsoon (Table 1). Stressing this point further, the geomorphic structure of the study area is covered with horizontal deposits of alluvium. It is probably underlain by the peninsular rocks, which were subjected to down buckling due to the load of the accumulating sediments (Govt. of India, 1939). Along with the physiographic characteristics viz. low lands, uplands and diara land are found to have extensive influence on water resource.

The above mentioned parameters of physical, geological and physiological have diversified the potential of water resources and created the acute problems for the assessment of water resources. Therefore, in recent few

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years the water resources potential has been depleting in surface water potential in non-perennial rivers, sub-canals, tanks and ponds, which create water crisis for the people of that region where these are found. Moreover, our study area also has been facing the depletion of groundwater level. Thus, the district faces the alarming position in the field of water resource potential due to the lacunae of proper management. Therefore, there is a great need to solve the problems to manage the water resources. The main reason of depletion of water resource is the reckless exploitation of natural environment and vaulting desire for the economic development of the study area.

MATERIALS AND METHODS

The Study Area

The study area covers Siwan District and it has 19 community development blocks. The Siwan district falls in the Mid-Ganga Plain and forms a part of the Ghaghara and Gandak sub-basin and lies between 25^0 53' to $26^0$23' N latitude and 84^0 0' to 84^0 47' E longitude. It is also surrounded by two major rivers of India i.e. Ghaghara in south-western and Gandak in west directions. Total geographical area is 2220.51 km^2 with a population of 3330464 and 1530 villages (Census, 2011). After all, the present study area comes under agro-climatic zone IV. This study area has monsoon type of climate and naturally the climate is sub-tropical to sub-humid. This area is extreme hot in summer and severe cold in winter. May and June are the hottest and dryness months with a temperature range from 20.75^0C and 31.1^0C respectively. The average annual temperature is 24.98^0C and highest maximum temperature is 39.45^0C (Metrological Department of India, 2010). The seasonal temperature varies from 16.3^0C to 31.1^0C during the study. Rainfall occurs between June to September during the onset of the south-west monsoon. The average annual rainfall is 1005.71mm. The rainfall decreases south-west to north-west. The south-west monsoon decreases south-east to north-west. The south-west monsoon contributes about 89% of total rainfall. The concentration of rainfall is unpredictable during north-east monsoon period.

Geomorphologically, the study area consists of flood plains, alluvial plains and natural levee. The slope of the topography is gradual from north-west to south-east part of the district. Mairwa covers highest part of the district being 65.830 m above mean sea level (MSL) and Gangpur Siswan covers lowest part (56.90 m above mean sea level (MSL). Geologically, the study area along with the Gangetic low lands is sensitive to the seismic waves. A number of reasons may be adduced to its sensitivity. The tectonic strain (Wadia, 1953) on the northern rein of the Gangetic plain due to progressive down warping is one of the major causes of seismic disturbances in the region. The erosion leading to deluding from the Himalayas and the deposition leading in the Gangetic plain brings out disturbances in the terrain (Singh, 2012). Besides, the study area forms are of recent (Holocene period). It is estimated that the district covers the deposits of alluvium more than 5000 feet (Siwan district Notescom. Reference).

Objectives: The major objectives of the study area are as follow:

1. To find out the water resource potential in the study area.
2. To know the different sources of water resources.
3. To search the problems of water resources potential.
4. To elaborate the possible remedial for the management of water resource potential.

Data Base and Methodology

The present paper is based on secondary data sources, journals and web sources. The secondary data has been collected from 1975 to 2013 through the various department e.g. District Flood Division, Siwan; District Canal Division, Siwan; PHE Department, Siwan, District Census Reports, Siwan. All collected data are examined in the light of said objectives and tested on the hypothesis. Overall, data has been analyzed and represented though suitable tables, maps and diagrams. This research work is based on descriptive as well as analytical methods. Both statistical and cartographical techniques are computed for the study.

RESULTS AND DICUSSION

The potential of water resource can be evaluated through surface water potential and groundwater potential.

Surface Water Potential

Rivers, Canals, Tanks and Ponds are the main sources of surface water potentials. The Ghaghara River is one of the most important rivers of the study area in the form of perennial river, which covers 24% of the total water potential of the rivers. Total Six rivers constitute the Ghaghara sub-basin and Gandak sub-basin in the district. The Ghaghara sub-basin has three rivers likely Ghaghara, Jharahi and Daha. These rivers covers 70% of the total

water potential of the rives (Figure 1) such as Ghaghara (24%), Jharahi (18%) and Daha (28%) Along with the Gandak sub-basin covers 30% of the total water potential of rivers, such as Gandak(12%) Dhanai(12%) and Chhoti Gandak (6%) (Table 2).

The water potential of Ghaghara River is recorded from the danger level at the station of Darauli and Gangpur Siswan in different years. The potential of Ghaghara River varies seasonally and temporally. During the stimulated periods, the average potential of Ghaghara River is recorded as 15.64 metres and 13.35 metres at the station of Darauli and Gangpur Siswan respectively (Table 3). Maximum discharge is to be found in rainy season while minimum to be found in winter season. During the rainy season, the Ghaghara spreads from 8 to 12 km in width, reveals the situation of floods on the bank of the river. The Gandak River does not touch the boundary of study area, Siwan but actually flows at a higher level than the adjoining plain along the eastern boundary of Saran plain. Its tributary is Gandaki, which flow through the banks of Goriakothi and Maharajganj block having the length in about 30 km in the study area. Total discharge of Gandak River is 30800 cusec and below the Baraj is 23100 cusec (Water Resource Department, 2013). The River Dhanai is a tributary of stream Gandaki. It has got a length of about 30 km and flows through the blocks of Basantpur and Bhagwanpur from north to south and drops to the river Gandaki. Choti-Gandak flows for about 15 km on the district in the north-west before meeting the River Ghaghara near Amarpur in Darauli block in Siwan district.

The River Jharahi is a tributary of River Ghaghara. Total length of this river is 80.60RD (24.56km) with sub-drain Basudeva chaur (5RD), Domdih chaur (10.60RD), Chaur Barahia, Punak Sarahaura, Kanhauli, Bitholi chaur (58.20RD), Sardaha chaur (2.80RD), Sadalpur chaur 4.00RD). The highest chaur of Jharahi River is found in Barahia, Punk Saraharawa, Kanhauli and Bitholi chaur (72.22%) of the total length and lowest chaur of Jharahi River is found in Sardaha chaur (3.47%) of the total length of the river (Table 4). Daha River originates from a chaur of Sasamosa of Kuchaikot at Gopalganj district and flows thorough the blocks of Siwan, Hussainganj, Andar, Siwan and merges with the River Ghaghara near Tajpur Fulwaria (About 10 km south-west of Manjhi Railway Station). This River stretches 70 km from the place of Ormaorai to Siwan in the study area. Total seven sub-drain of Daha River is found in the name of Bhadora chaur (2.40RD), Chap Mathia chaur (8.00RD), Sarsar chaur (13.00Rd), Amlori chaur (12.20RD), Kalispur chaur (8.00RD), Baghauni Sahuli Link drain (5.00RD) and Baikunthpur chaur (5.00RD). Sarsar chaur is highest chaur (24.24%) and Bhadora chaur is lowest chaur (4.48%) of the total sub-drain of Daha River (Table 5). These chaur cover all such streams are dry channels in summer.

Canals are exhibited under artificial water masses, which are found from the perennial rivers and other reservoirs in the district. These are served by the Saran canal system. It has total length of 1341.37 km and a capacity for supplying water to over 11.30 Lakh hectares of the gross cropped Land (Singh, 2012). Total maximum discharge of water is 1117.00 cusec and demand of water is 590 cusec, which is 52.82% of total discharge of water (Siwan Canal Division, 2013) and 527 cusec water has been overflowing though the different canals in the district (Table 6). It is 47.18% of the total discharge of water, which is a great problem to manage the surface water potential (Figure 2).

In the uneven and relatively topographical land of Siwan tanks and ponds are constructed to store surface water.In this connection, table 7 shows the availability and non-availability villages under surface water in the blocks of Siwan district. Total non availability of villages is 1467 in the form of tanks and ponds and availability villages are 63 in the blocks of the district in 2011(Table 7).

Groundwater Potential

The climatic conditions, character of soils, slope of land, Vegetative cover, Land use, water absorbing capacity of soil and geological structure constitute the real framework of groundwater potential. The groundwater potential is stored in different layer of the earth by soil infiltration through pores and fissures of permeable rocks. Although the geological structure like porosity, specific yield and permeability of rock formation determines the availability of groundwater potential. These components of geological structure determines the capacity of rock-bed to hold, deliver and transmit water variations in grain size, degree of assortment and cementation of the constituent grains affects the porosity and the rate of poorly assorted sand hardly exhibits any to these qualities. (Rajoria, 2006).

In this context, the study area is composed of sand layers of the quaternary alluvial sequence form the major repository ground. This sand layers are found in horizontal deposit of alluvial, which was formed during the tertiary times .It is probably underlain by the peninsular rock (Wadia, and Auden, 1939).Hence the sand layers of the quaternary alluvial sequence form the major repository of ground in the study area, which occurs under confined condition in the deeper zone which shows the variability of groundwater potential. The groundwater potential is evaluated by ground water level on the basis of rainfall. Thus, the spatial and temporal variation of groundwater potential is discussed below:

High Groundwater Potential

High groundwater potential is measured above 500 cm from the earth surface. It was found in Siwan, Hussainganj, Maharajganj and Siswan block in 2011 and in 2012 it was only Siwan. No block has been found in 2014. This trend also indicates the range of high groundwater potential has been decreasing with space and time by changing trend in rainfall and climatic condition. Under this category, the groundwater potential has been decreeing after 2011, which indicates the scarcity of high ground water potential. Only two blocks such as Siwan, Siswan have maintain their potentiality out of four block during 2011 to 2014, which highlight the present potential of groundwater in the study area (Table 8).

Medium Groundwater Potential

Ten blocks have been found in 2011 and 2012 under (400 to 500 cm) this category. But it was sixteen blocks and in 2013 .It has been five blocks only, which reflects the changing potential of groundwater form one region to another. The five blocks namely Andar, Darauli, Guthani, Nautan, Mairwa fall under this groundwater potential category, which has maintained the ground water potential during 2011 to 2014. It is observed that above 400 cm of groundwater potential was found in Ziradei , Hasanpura, Raghunathpur, Andar, Drauli, Guthani, Nautan, Mairwa, Goriakathi, Basantpur block in 2011. It was Pachrukhi, Hassainganj,Hasanpura,Raghuathpur,Andar,Darauli,Guthani,Nautan,Mairwa,Siswanin2012.Beside, Siwan, Pachrukhi, Hassainganj, Hasanpura,Ziradei, Raghunthpur, Andar, Darauli, Guthani, Nautan, Mairwa, Maharajganj, Goriakothi, Bhagwanpur, Basantpur, Lakri Nabiganj have been found in 2013.Apart from, Andar, Darauli, Guthani, Nautan, Mairwa have been found in 2014 (Table 8).

Low Groundwater Potential

This category of groundwater potential has enhanced in their potential ity. Total five blocks viz: Barharia, Pachrukhi, Daraundha, Bhagwanpur, Lakri Nabiganj were in 2011 while Barharia, Ziradei, Maharajganj ,Goriakothi, Daraundha, Bhagwanpur, Basantpur, Lakri Nabiganj fall under(below 400 cm) this category in 2012. Basides, it was found in Barharia, Daraundha in 2013. But the ground water potential has increased under this category in 2014. It has been fourteen blocks, which reflects the low availability of groundwater potential (Table 8).

Problems of Water Resource Potential

1. At village level, most of the villages have the lack tanks and ponds. So, they feel the acute problem at dry season in irrigation and domestic purposes.
2. Most of the non-perennial rivers create the problems of water potential in the summer season (Rivers like Jharahi, Daha and Dhanai).
3. Due to the dump of the wastages materials into the rivers, the catchment areas of the water storing capacity have been reduced.
4. Poor maintenance of canals provides the several problems like wastages of water potential, destroying the bandh etc. in the study area.
5. Rapidly cleared plants on the bank of the canals and rivers create the problems of erosion. With this result, the surface water lost their potential.
6. Due to biodiversity, the potential of groundwater is losing its strong hold on water resource. With the result, it has increased the anxiety of the environmentalist as well as hydrologists.
7. People are taking less interesting less interest in intensive cultivation. Sometimes, it is observed that due to increasing dearness people of Siwan district not showing keen interest in cultivation. With the result, those lands which are cultivable have been left uncultivated and in ploughed. Hence, the water holding capacity is reported to have weakened.

Table 1: Distribution of Seasonal Rainfall and their Variability in the Study Area, 1989 to 2011

Months/ Season	Total Rainfall	Mean Monthly Rainfall (mm)	Seasonal Rainfall in Percentage	Average Seasonal Rainfall (mm)
June	3456.5	150.28		
July	6716.1	292.00		
August	6053.4	263.19		
September	4304.3	187.14		
Rainy	**20530.3**	**892.62**	**88.75**	**223.15**
October	890.4	38.71		
November	103.0	4.47		
December	48.0	2.08		
Post Monsoon	**1041.4**	**45.27**	**4.50**	**15.08**
January	212.0	9.21		
February	262.2	11.40		
Winter	**474.2**	**20.61**	**2.05**	**0.89**
March	116.0	5.04		
April	156.0	6.78		
May	813.5	35.36		
Summer	**1085.5**	**47.19**	**4.70**	**2.05**
Total Season	**23131.4**	**1005.71**	**100.0**	

Source: Directorate of Statistics Evaluation, Bihar, Patna.

Table 2: Basin and Sub-basin wise Water Potential and Availability in the Study Area, 2013

Ganga Basin	River	Potential and Availability in Length (in Km)	% of Total Length
Ghaghara Sub Basin	Ghaghara	60	24.00
	Jharahi	45	18.00
	Daha	70	28.00
	Total	175	70.00
Gandak Sub-Basin	Gandaki	30	12.00
	Dhanai	30	12.00
	Chhoti Gandak	15	6.00
	Total	75	30.00
District	**All Rivers**	**250**	**100.00**

Source: District Flood Division, Siwan, 2013

Table 3: Level and Availability of Water in the Ghaghara River in the Study Area, 1975-2012 (in Metres)

Year	Measurement Station	Danger Level	Maximum Availability of Water	Excess Water Availability from Danger Level
1975	Darauli	60.82	60.99	0.17
	Gangpur Siswan	52.04	57.13	5.09
1976	Darauli	60.82	61.12	0.3
	Gangpur Siswan	52.04	57.24	5.2
1977	Darauli	60.82	61.12	0.3
	Gangpur Siswan	52.04	56.69	4.65
1978	Darauli	60.82	61.22	0.4
	Gangpur Siswan	52.04	57.47	5.43

1979	Darauli	60.82	60.65	-0.17
	Gangpur Siswan	52.04	56.44	4.4
1980	Darauli	60.82	61.03	0.21
	Gangpur Siswan	57.04	57.25	0.21
1981	Darauli	60.82	61.12	0.3
	Gangpur Siswan	57.04	56.86	-0.18
1982	Darauli	60.82	61.56	0.74.
	Gangpur Siswan	57.04	57.83	0.79
1983	Darauli	60.82	61.56	0.74
	Gangpur Siswan	57.04	8.01	-49.03
2013	Darauli	60.82	59.66	-1.16
	Gangpur Siswan	57.04	55.79	-1.25

Source: District Flood Division, Siwan, 2013

Table 4: Distribution of Chaur of Jharahi River in the Study Area, 2013

Name of Chaur	Length (RD)	% of Total Length
Basudeva Chaur	5.00	6.20
Domdih Chaur	10.60	13.15
Chaur Barahia, Punak Saraharawa, Kanhauli, Bitholi Chaur	58.20	72.22
Sardaha Chaur	2.80	3.47
Sadalpur Chaur	4.00	4.96
All Chaur	80.60	100.00
Abbreviation : 1 RD =	304.79 M	

Source: District Drainage Division, Siwan, 2013

Table 5: Distribution of Chaur of Daha River in the Study Area, 2013

SL. No.	Name of Chaur	Length/Availability (RD)	% of Total Length
1	Bhadora Chaur	2.40	4.48
2	Chap Mathia Chaur	8.00	14.93
3	Sarsar Chaur	13.00	24.25
4	Amlori Chaur	12.20	22.76
5	Khalispur Chaur	8.00	14.93
6	Baghauni Sahuli Link Drain	5.00	9.33
7	Baikunthpur Chaur	5.00	9.33
	All Chaur	**53.60**	**100.00**
	Abbreviation : 1 RD =	304.79 M	

Source: District Drainage Division, Siwan, 2013

Table 6: Status of Surface Water in Canal in the Study Area, 2013

Name of Canal	Length (RD)	Discharge Maximum (in Cusec)	Demand of Water (in Cusec)	Excess Flowing (in Cusec)
Siwan Sub Branch Canal	122.47	571.00	325.00	246.00
Pithauri Distributory Siwan	68.50	265.00	150.00	115.00
Khalispur Distributory	43.43	281.00	115.00	166.00
All	**234.40**	**1117.00**	**590.00**	**527.00**
Abbreviation : 1 RD =	304.79 M			

Source: Siwan Canal Division, 2013

Table 7: Block wise Status of Tanks and Ponds in the Study Area, 2011

Name of Block	Status of Tanks and Ponds As Per Village Availability			
	Availability	Non-availability	Total	% Availability
Nautan	0	45	45	-
Siwan	5	77	81	6.17
Barharia	1	139	140	0.71
Goriakothi	1	80	81	1.23
Lakri Nabiganj	0	40	40	-
Basantpur	0	41	41	-
Bhagwanpur Hat	2	112	114	1.75
Maharajganj	3	68	71	4.23
Pachrukhi	0	84	84	-
Hussainganj	0	46	46	-
Ziradei	0	81	81	-
Mairwa	1	52	53	1.89
Guthani	7	98	105	6.67
Darauli	0	115	115	-
Andar	7	60	67	10.45
Raghunathpur	1	126	127	0.79
Hasanpura	2	63	65	3.08
Daraundha	8	74	82	9.76
Siswan	7	83	90	9.76
District	**63**	**1467**	**1530**	**7.78**

Source: District Census, 2011

Table 8: Variation in Groundwater Potential in the Study Area, 2011-2014

Water Potential Index	July 2011	July 2012	Feb. 2013	Nov. 2014
High (Above 500cm)	Siwan, Hussainganj, Maharajganj, Siswan	Siwan	Siswan	Nil
Medium (Above 400 cm)	Ziradei, Hasanpura, Raghunathpur, Andar, Darauli, Guthani, Nautan, Mairwa, Goriakothi, Basantpur	Pachrukhi, Hussainganj, Hasanpura, Raghunathpur, Andar, Darauli, Guthani, Nautan, Mairwa, Siswan	Siwan, Pachrukhi, Hussainganj, Ziradei, Hasanpura, Raghunathpur, Andar, Darauli, Guthani, Nautan, Mairwa, Maharajganj, Goriakothi, Bhagwanpur, Basantpur, LakriNabiganj	Andar, Darauli, Guthani, Nautan, Mairwa
Low Below (400 cm)	Barharia, Pachrukhi, Daraundha, Bhagwanpur, LakriNabiganj	Barharia, Ziradei, Maharajganj, Goriakothi, Daraundha, Bhagwanpur, Basantpur, LakriNabiganj	Barharia, Daraundha	Siwan, Barharia, Pachrukhi, Hussainganj, Ziradei, Hasanpura, Raghunathpur, Maharajganj, Goriakothi, Daraundha, Siswan, Bhagwanpur, Basantpur, LakriNabiganj

Source: District Public Health Engineering Department, Siwan

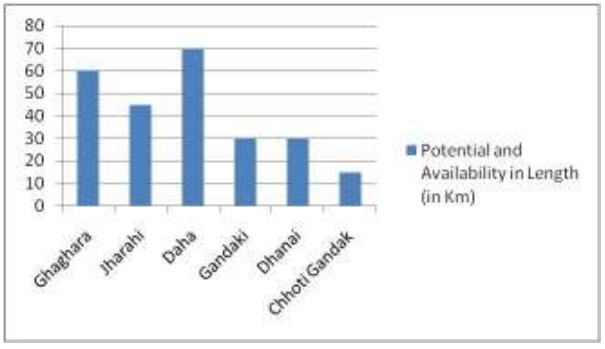

Figure 1: Bar diagram of water resource potential through rivers in the study area

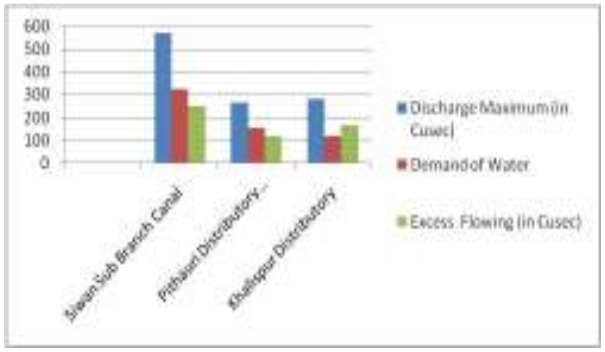

Figure 2: Bar diagram of discharge, demand and excess water in canal in the study area

CONCLUSION

The present study reflects the potentials, problems and management of water resources is Siwan district of Bihar. The data for surface and ground water have been collected and analyzed. Some problems have been found during the study period in the assessment of surface and ground water potentials. In the assessment of surface water potential, several problems have been found, .Nautan, Lakri Nabiganj, Basantpur ,Pachrukhi, Hasainganj, Ziradei and Darauli blocks have no tanks and ponds. Excess run off in rivers and canals created the problems to assess the water resource potential. The Ghaghara sub-basin covered 70% of the water potential of the rivers while Gandak sub- basin has covered 30% of the total water potential of the rivers. It is because of the large catchment area and high water holding capacity, Canals of the Siwan district provided the maximum water discharge (1117.00 cusec) and demand of water in 590 cusec.

It is observed that most of the water has been wasting from the canals during the flowing of water in the canals. Most of the blocks of the district did not provide the tanks and ponds, which indicate the decreasing trends of surface water potential. Moreover, it is seen through

the above mentioned table that the groundwater potential has decreased from 2011 to 2014 .The medium groundwater potential has increased in the year 2013 and after this year, this category of groundwater potentiality has decreased. Low potentiality of groundwater has increased in 2014. These changes in the potential of water resources have been found due to changes in the physical, hydrological, geological and geomorphologic perspectives. At last, it can be concluded that water resource potential has changed by the diversification of natural environment.

In nut shell, the water resource potential may be enhanced by adopting the water management techniques as suggested in this paper, which would be more useful for the further study in this field.

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