SUBSTAINABLE GROUND WATER RECHARGE AND MITIGATIVE MEASURES FOR WATER RESOURCE DEVELOPMENT AROUND RAIPUR CITY, CHHATTISGARH, INDIA

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ABSTRACT

Water is an important ingredient for the survival of human beings, animals & plants. Ground water resource has assumed significant controlling role in water demand of surface water Resource. The G.W. utilization in India for Domestic - 4600mcm/yr. Irrigation 143500. Industries 1900 Total 150,000 mcm/yr. Chhattisgarh faces challenges related to its water resources and their management. Unplanned urban development create over abstraction of water resources. The region around Raipur city is mostly covered by hard rock formations where the availability of G.W. is limited. The proper development and management practice is required for sustainable water resources utilization. The geological setup of study area is nearly flat sedimentary rocks of chandi formation. River Kharun and its tributaries are depositing the alluvial flood plains and sandy valley fills which are intensively cultivated. Lateritic uplands and surrounding fallow lands covers 27.87% of the region which acts as recharge zone & yields less ground water, which need proper management like afforestation & contour bunding agriculture practice. Ground water in limestone is controlled by karstification and secondary porosity and high yield wells encountered to the west of Raipur city i.e. at Raipura, Rohinipuram, University and Bhatgaon villages. Small ponds (155 Nos.) and water tanks (72 Nos.) are good source for recharging the ground water in the area and further check dams can be constructed at suitable sites, and these can be developed as a part of artificial recharge system. Raipur city has faced severe water crisis since 1991. The existing water resources, mainly ground water depleted due to which the residents have been facing a lot of problem. In present study five sites have been found suitable to construct check dams in sub basins 3, 7, 10, 12 & 15 to restore the surface water and control the soil erosion & recharge the ground water regime in the catchment area.

KEY WORDS: RECHARGE, KANHAR SOIL, HYDROPOTENTIAL ZONE, W.R. DEVELOPMENT, MITIGATIVE MEASURES, CHANDI FORMATION, RAIPUR CITY.

INTRODUCTION -

Water is one of the most precious natural resource and essential for human society. About 71 percent of the earth's surface is covered by water. The distribution makes a small portion, fraction of

0.3% of total volume available utilizing by human consumption of total water. The main source of water in the state chhattisgarh includes rivers, tanks, ponds and ground water. Increasing use of G.W. is made in many areas, like agriculture and Industries.

The Chhattisgarh region is served by effective network of irrigation projects. Mahanadi River, the life of the terrain which has influenced the cropping pattern of the region. Due to irrigation facilities paddy is grown more than once in a year. Other crops like urad, lakh, linseed, groundnut, wheat and gram are also practicised. The important and secured ground water resource is overexploited and utilized by industries and irrigation, thereby the G.W. level in the region have been declined to a dangerous stage. The rock types or hydro-geological conditions of the region does not support quick recharge due to hard rock aquifer zones and limited ground water yields. It is necessary to plan the g.w. conservation & recharge for long term with water usage. Physical sustainability of g.w. resource and g.w. recharge programmes has to be implemented under water Resource Development policy and planning's.

(A) CLIMATE & RAINFALL -

The study area lying between $21^0$12' to $21^0$22N latitude and $81^0$30' to $81^0$40' E longitude, covers and area of 323.75 sq. kms (Fig. 1). The mean annual rainfall of the area is 1380 mm. The mean maximum & minimum temps. in summer are 39.7^{0}C and 26.9^{0}C respectively. The mean maximum & minimum temps. in winter are 28.03^0 and 14.23^{0}C respectively.

(B) METHODOLOGY :-

The IRS LISS II FCC data (Scale 1:1,25,000) hard copy was visually interpreted & analyzed for different drainage pattern & soil classification. Subsequent field checks regarding collection of ground data on soil types, depth to water levels, hydrologic behavior of rocks, have been carried out in the study area. The Survey of India toposheet numbers 64 G/11 and G/12 on 1:50,000 scale were taken as base map. The Remote Sensing data was analyzed visually with the help of magnascope and interpretation keys were made on the basis of colour, pattern, texture, location and association of recognition criteria and then compare with the imagery by super - imposing methods. For drainage density, area was divided into grids of 1 km^2 and constructed the isopleth maps.

(C) GEOLOGICAL SETTING :-

The study area lies in the central part of the chhattisgarh sedimentary basin of Protereozoic age. The lithological assemblages comprises limestone (stromatolitic), sandstone and shle. The rocks posses medium to fine grained and having reddish brown to dark brown in colour, mainly belonging to Deodongar member of Chandi formation (Kundu etal. 1990) The laterites & ferrugenous platy sand stones are capped on elevated mounds above 290 m. AMSL. Alluvium of recent to sub recent age confined to the flood plains of river channel & streams.

(D) LANDSCAPE AND DRAINAGE NETWORK :-

Surface water Resource. The landscape of the study area is represented by subdued undulating plains developed by weathering and fluvial erosion. The landscape evolution can be interpreted by the fluvial morphometric analysis and recognition of land forms and features. The region exhibits gentle slopes and fluvial features, stream tends their passage pathways through the fractured/jointed lineament feature and evidents with the lithological variations and erosional processes.

The area is drained by master Kharun river and its tributaries. The main tributaries & sub watersheds includes chokra Nala, 2016, Dman unit, Atari, Sondongari, Kumhari, Bhatagaon etc. (Fig. ___) The recent flood plain zones adjacent to river composed of fluvial sediment/ posses excellent g.w. potential zones.

(i) DRAINAGE PATTERN :-

Drainage pattern is the spatial arrangement of natural stream lines in an area. It reflects the lithologic and landscape attributes of the region. The study area shows coarse drainage lines with subdendritic pattern, indicates pervious nature of ground surface and medium infiltration of ground water recharge in the area.

(ii) DRAINAGE DENSITY :-

Kharun river flows 130 kms. in length attains 30 kms. channel length in the study area with 100 to 150 m width. This main mappable river divides Raipur and Durg Districts. The study area is a plain terrain with sub-dendritic drainage pattern (Fig.) The drainage density of the region is classified extremely low (>1), low (1-2), medium (2-3), and very high (>4) (Fig.). A large portion of the area (42.0%) has medium and low density, whereas the area with extremely low density is (55.5%) of the region. The area with very high density is negligible and accounts for (0.16%). The uplands shows very low density values. A major portion of the region (97.5%) has density below 3 whereas high and very high density comprises only 2.5% area of the terrain (Table). Drainage density analysis reveals that 77.5% area having low density (less than 3) which indicates low run off yield and high infiltration capacity of the terrain.

(iii) DRAINAGE FREQUENCY :-

The drainage frequency represents number of drainages per square Km. in the study area. It has average value of below1 Nos/km. which indicates the pervious nature of substrata in the region, possibility of potential g.w. resources of substrata.

(E) HYDROLOGIC PROPERTIES OF SOILS :-

Four major types of soils occupied in the study area. The soil shows catenary in nature. i.e. they follows topographic elevations/heights of the terrain and built insitu in nature.

The geographical spatial area occupied by each of the soil types has been estimated and presented in the Table & Fig. The av. composition of silt, clay and sand classifies the solil types and hydrologic behaviour of soil-water infiltration & percolation reaching to the aquifer zones of G.W. reservoirs. The general characteristics and hydrologic properties of soil Group is described & given as -

I. BHATA SOIL (LATERITE OR ENTISOL) :-

This soil appears reddish to reddish brown in colour, contains 60-80% sand, 15-29% silt and 10-20% clay-fraction. It has rapid in filtration rate (5 to 7 cm/hr) and restricted to upland geomorphic unit zone (Roy, 1965, pande, 1993). Laterite soil occurs above 290 m AMSL elevation of ground surface. Quick recharging and depletion conditions exists in laterite due to their porous and permeable nature.

II. MATASI & DORSA SOILS (ALFISOLS) :-

Matasi soil is yellow in colour and contains 20-32% sand, whereas Dorsa having brownish grey in colour, 25-30% silt, 35-55% clay content. They occupy pediment and shallow buried pediment units having 5^0-7^0 ground slope. It is found in ground elevation of 280 m AMS land above. Due to presence of sand content the permeability and infiltration of water is high in Alfisols.

III. KANHAR SOILS (VERTISOL) :-

Kanhar soil occurs mainly along depressions of ground surface, undulating plains and drainage courses, ditches etc. It is found as dark grey to black coloured soil, contains more than 45% clay content. It shows stick and plastic in nature. The deep buried pediplain unit is generally covered with taick vertisols. It is confined in low lying ground between 270-280m AMSL. The clay content derived from shale's due to which the Kanhar soils are incapable of transmitting significant water quantity. It has limited scope for percolation of water.

IV. ALLUVIAL SOILS :-

Alluvial soils are restricted to flood plains, along the banks and course of river and major stream or nalas. It comprises mostly sand (80%) and silt-clay ranges 10-20% It occupies river & stream channel valleys, below 270m AMSL. In the region these soils are mostly used by the Brick kilns. The equigranular nature of soil and sand particles increase. The value of porosity and yields sufficient quantity of g.w. for exploitation.

(F) RECHARGE AND DISCHARGE OF GROUND WATER :-

Ground water recharge in the study area occurs mainly from rainfall (Mean annual rainfall 1380 mm.), tank and cannal seepages whereas discharge occurs by pumping from wells and effluent seepage from Kharun river. Total recharge has been calculated by rainfall infiltration method adopting ARDC III Norms (Karanath, 1987) and this reaches 2890.7 ham. (Table).

Considering sand content in soils, alluvium and Bhata soils may have high recharging capability (14-18% infiltration index) whereas kanhar soil shows poor performers (4% infiltration index) (Pande & Shrivastava, 1993). In the study area topographic high lands are capped with porous laterites which makes sufficient inflow or infiltration and acts as a recharge zones.

(i) TANK ANALYSIS GROUND WATER RECHARGE :-

The tank analysis reveals that 72 tanks are bigger than 2 hactare in area and tanks like Burha Talao are bigger than 36 hactares whereas smallest are less than 0.25 hactare in area.

Studies have indicated that seepages from tanks varies, tanks occupy 671 sq. km. in the area and 40 to 60 cm per year infiltrate over the total water spread. In lateritic tanks water may percolate as high as 50% of the gross storage and in shale and sandstone tanks a value of 8 to 18% of the live storage capacity (Sahu, 1990)

(ii) EFFLUENT RIVER SEEPAGE :-

Influent and effluent seepage from Kharun river section is evident at Bhatagaon & Gomchi villages. The sudden increase in stream flow effluent seepage has occurred in south reaches due to karstic resurgence.

(iii) DISCHARGE OF GW :-

Ground water discharge in the study area occur mainly by pumping from different types of wells. The yield of dug wells in shales ranges 10 to 15 klpd. and dug cum bore wells give 40 to 50 klpd. In confined limestone aquifers well yield reaches 100 to 300 klpd and in unconfined limestone it limited to 40 to 75 klpd. In highly cavernous zones and dug wells in alluvium and old channels along flood plains they have high yield amouting 350 to 650 klpd. (Wadhwa, 1995).

(G) WATER RESOURCE DEVELOPMENT :-

(i) SURFACE WATER BODIES :-

The surface water resource depends on the terrain condition of Natural River & stream channels. The study area is a part of middle kharun catchment of the Shivnath River drainage system. The Kharun river flows about 30 km. linear stretch in NS direction with narrow valley of 100-150 meters width. The river rock bed is covered with sandy alluvium and three depositional Alluvial terraces recorded near Chandinidih village. The equigranular nature of soil and sand particles increase the value of porusity and this zone yields sufficient quantity of water for exploitation. particularly adjacent to Kharun river belt of 1.25 km wide zone of alluvium. Under mitigative measures the construction of check dams and Infiltration Dykes are Suitable for the ground water recharge in alluvial zones. In the regions traditional Tank ponds water recharge to the ground water increment is possible in pervious & cavernous limestone layers beneath the ponds/Tanks.

(ii) GROUND WATER RESOURCE - POTENTIAL AREA :-

Alluvium and karstic limestones are the main water bearing zones in the area. In case of alluvium, these formations area good potential zones whereas in limestone strata it depends on the position of limestone with respect to shales and degree of fracturing, opening, karstification and development of solution cavities in the limestone. In highly cavernous interconnected limestone wells give water amounting 450 klpd. The average water yield capacity of jointed varies from 0.008 to 0.10 Adyalkar (1984) observed the specific capacity ranges from 100-250 Ipm/m of drawdown in potential wells with coefficient of permeability ranges from 5-15 m/day (Adyalkar, 1984). Apart from limestone, adjacent to Kharun river course plains (1.25 kms. wide zone, thickness 3 to 18 metres), provide very good hydropotential area.

(iii) MITIGATIVE MEASURES :-

Under Mitigative measures and conservation practices the Groundwater Recharge can be carried out through small hydraulic structures at suitable sites. The major types of Artificial recharging system suitable in the study area includes check dams, Nala bunds, Gabion structure, percolation Tank, Underground Dykes etc. It will improve the aquifer conditions and ground water level increment. In urban and Industrial areas the Rain water harvesting practices will be useful. The brief description of these structures and their characteristic features is given in Table.

(H) WATER SUPPLY AND REQUIRMENT :-

The water supply to Raipur township started in 1890 from the intake well constructed at Kharun river bed. The present water supply is 277 MID, which is inadequate to the city. for the population of 12 Lakhs the average per capita water supply is about 200/per day. Mostly the water is supplied intermittently for a period of 1/2 hrs two times per day. In Future the water supply in Raipur under RSCP Raipur smart city project is promising 24x7 water to the inhabitants of urban areas. Under MRCC (More Raipur City Centre Area) the water supply, Transmission and Distribution network will be carried out through ppp model (Public Private Partnership) scheme. It will take up 777 Acres area of core city. The Raipur smart city limited (RSCI) incorporated under Indian companies Act. 2013 to improve water supply situations under MRCC area with operation and maintenance for 10 yrs. The objectives include water supply with Quality of water as per IS : 105000 specifications i.e. standard drinking water quality. for drinking purposes. At present, it is required to have a long term planning for augmentation of water supply through Mahanadi and Shivnath river catchment interlinking to subbasins i.e. River Kharun.

I. WATER POLICY AND WRD PLANNING :-

The National water policy have been formulated in 1987. The main aim of this policy includes to perform the adequacy of WR and to arrange drinking water, water for irrigation, industries and power generation. Policy considers utilization of water resources in a integrated manner both surface and ground water. The limited quantity of ground water is available in any region & the use of G.W. is very expensive. Ground water is not available everywhere. it depends on aquifer conditions. Under the State policy the C.G. Govt. formulated state policy under water Resource development Draft 2012. The key elements of the Draft 2012 includes 1. W.R. planning 2. WR Development 3. WR Management 4. Rationalization of water Rates 5. Water conservation. (Fig.)

The Chhattisgarh plain represents an oval or saucer shaped depression drained by the upper Mahanadi River system. In the Chhattigarh state major portion is covered by the stream lines of Mahanadi catchment, others are Godavari, Ganga, Narmada Brahmani river systems (Table_)

Under priorities, the management of Five River Basins are necessary to increase the irrigation potential to 64 percent of the sown area. The plan for ground water conservation and recharge has been taken for long term i.e. 25 years Master plan for water use efficiency. Mahanadi Drainage system (MDS) - the Mahanadi river draining the vast central region of chhattisgarh state. The study area Raipur lies in the sub basin Kharun of Shivnath River Catchment. The present status of water supply and future requirement is given in Table.

The requirement of water for 2025, it is proposed to connect the present source of Kharun river with interlinking with Mahanadi Reservoir system through canals. feeders. During last 10 years

the Raipur city has faced severe water crisis. The existing water resources. mainly ground water depleted due to which the residents has to face a lot of problem. To meet the future requirement the following sources of water are proposed for integrated planning. 1. River Kharun 2. Mahanadi Reservoir system 3. Interlinking of Kharun & seonath 4. Tanks & Pmds percolation Tanks for G.W Recharge 5. Irrigation Tanks 6. Dug wells and Tube wells for G.W. utilization.

DISCUSSION & CONCLUSION :-

Alluvium and Karstic Limestones are the main water bearing zones in the study area. The availability of G.W. resource in limestone strata, largely depends, on the Position of Limestone Formation with respect to shales and degree of fracturing, opening, voids, Karstification and development of cavities. Drainage Density Analysis (DDA) indicates low run off yield and high infiltration capacity of the region. The soil - infiltration Index shows that the study area is getting total recharge of 2890.7 ham. The Kanhar soil (vertisols) occurs in 55.70% of the study area and confined mainly in lowlying zones or buried pediment zones. The study reveals that Artificial Recharge through existing ponds and conservation structures like percolation Tanks, check dams at suitable sites will be very much beneficial to face the growing demand of water.

TABLE - I

Surface water Drainage Systems of C.G.

S.No.	RIVER BASIN	SUB BASIN	DRAINAGE AREA km2	%Area
(i)	Mahanadi	Shivnath, Hasdeo, Mand. IB. Pairi, Jonk, Kelo, Tel	77,302	56.40
(ii)	Godavari	Indravati, sabri, pranhita, Lr. Godorori Wainganga	38,361	27.70
(iii)	Ganga	Son, Bansa, Gopad, Rihand, Kanhar	18,885	13.42
(iv)	Narmada	Upper catchment	1,316	00.95
(v)	Brahmani	Upper catchment	2,113	01.53
	Total		**1,37,977**	**100.00**

TABLE - II

Drainage Density variation around Raipur city

S.No.	Category	D.D. value Range Km/km2	Area km2	%Area
(i)	V. Low	>1	179.85	55.5
(ii)	Low	1-2	110.00	34.0
(iii)	Medium	2-3	25.90	8.0
(iv)	High	3-4	7.50	2.34
(v)	V. High	<4	0.50	0.16
	Total		**323.75 Km²**	**100.00%**

TABLE - III

RECHARGE OF GROUND WATER AROUND RAIPUR CITY

S.No.	Soil Type	Area in Hact.	%Area in (m.)	Rainfall Index	Infiltration in ham.	Recharge
(i)	Alluvium	2380	7.35%	1.380	18%	591.19
(ii)	Bhata (laterite)	2841	8.78%	1.380	14%	548.88
(iii)	Matasi + Dorsa	9121	28.17%	1.380	6%	755.21
(iv)	Kanhar	18,033	55.70%	1.380	4%	995.42
	Total	**32.375**	**100.00%**			**2890.70Ham.**

TABLE - IV

Raipur : Requirement of water

S.No.	Description	Water in MGD
(i)	Present Development capacity by all sources	36.00
(ii)	Present requirement @ 40 gallons/ day/person. (12 lacs)	48.00
(iii)	Present inadequacy Requirement for 15 lakhs	12.00
(iv)	Population @ 60 gallons per capita per day	90.00
	Total requirement for 2025 12.0 + 90.00 =	**102.00 MGD**

(Source : T&C, PHE & RMC)

TABLE – V

G.W. Recharge/conservation structures (Proposed)

S.No.	G.W. Recharg Conservation - Structures		Characteristic Features
I	Percolation Tank	-	Small water ponds/Tanks. The undulating plains below 3^0 slope is suitable site with fractured/fissured limestone and jointed sand stones.
II	Nala Bund	-	The Check dams to impound the upstream waters of surface drainages at narrow valleys. It improve the surface and ground water supplies to nearby fields and resist the soil erosion.
III	Under Ground Dyke	-	It is an impervious wall structure constructed across the stream, below 1.2^0 ground level. suitable site requires thick permeable soil in uptream side of Nala and resistant foundation on down stream side. The accumulated infilled g.w. improve aquifer conditions
IV	Rain Water Harvesting	-	The collection of rainfall water during precipitation, From the roof of Buildings in urban settlements, and drains to filtration pits and Borewells. It serves to improve the G.W. potential in Residential/Industrial areas.

FIG – I LOCATION MAP

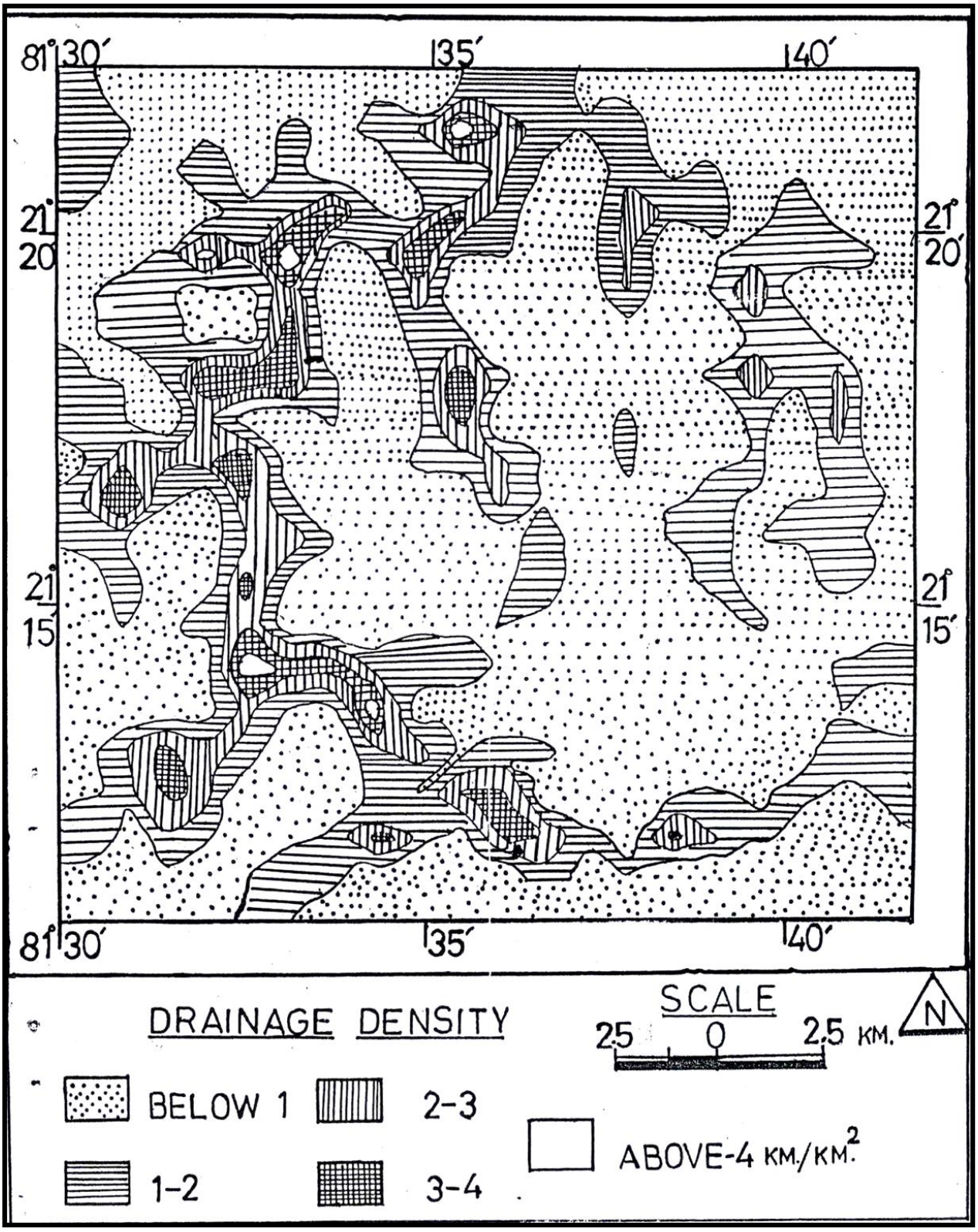

FIG-II Drainage Density Variation

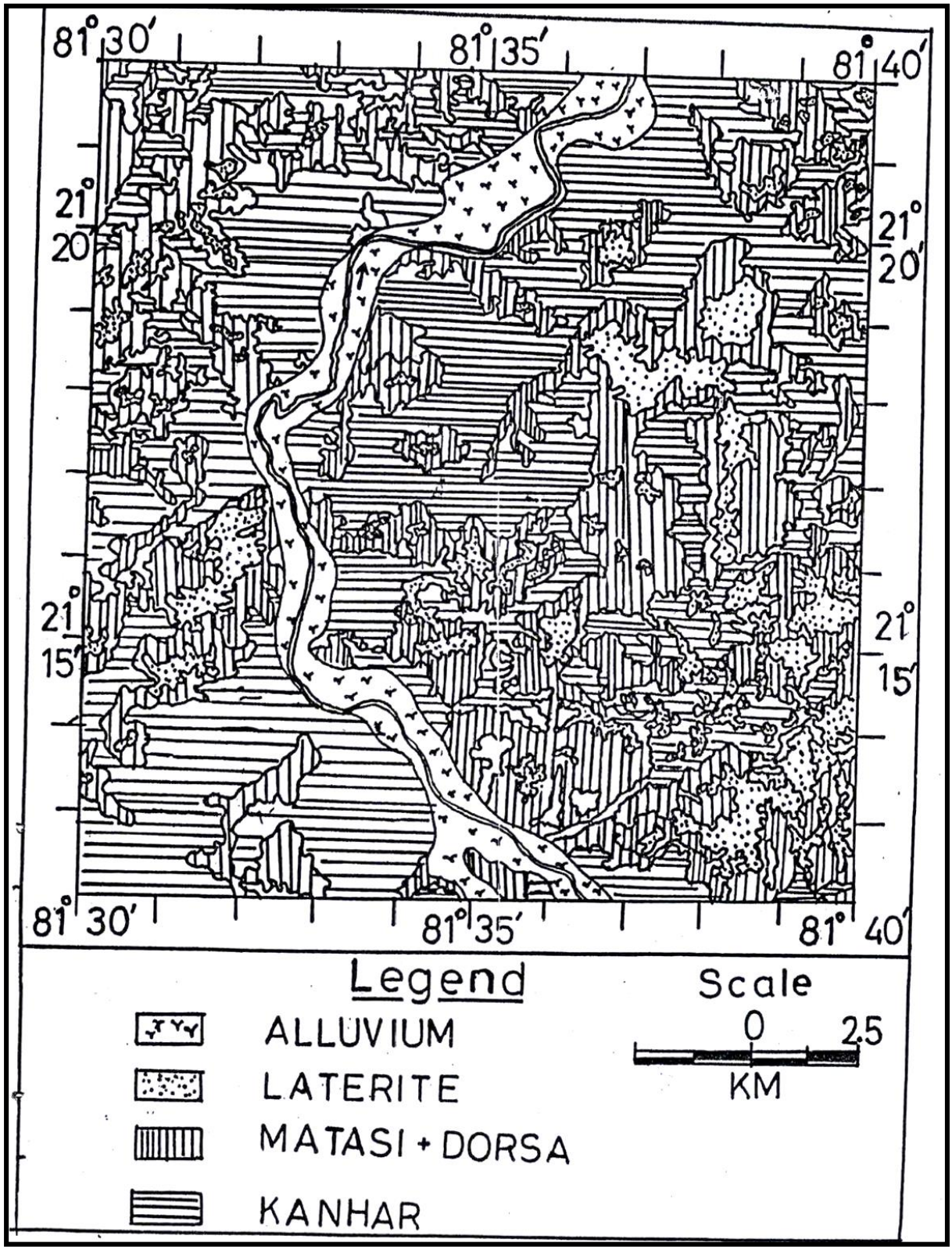

FIG – III SPATIAL DISTRIBUTION OF SOIL TYPES

(Based on Satellite Imagery-Remote Sensing)

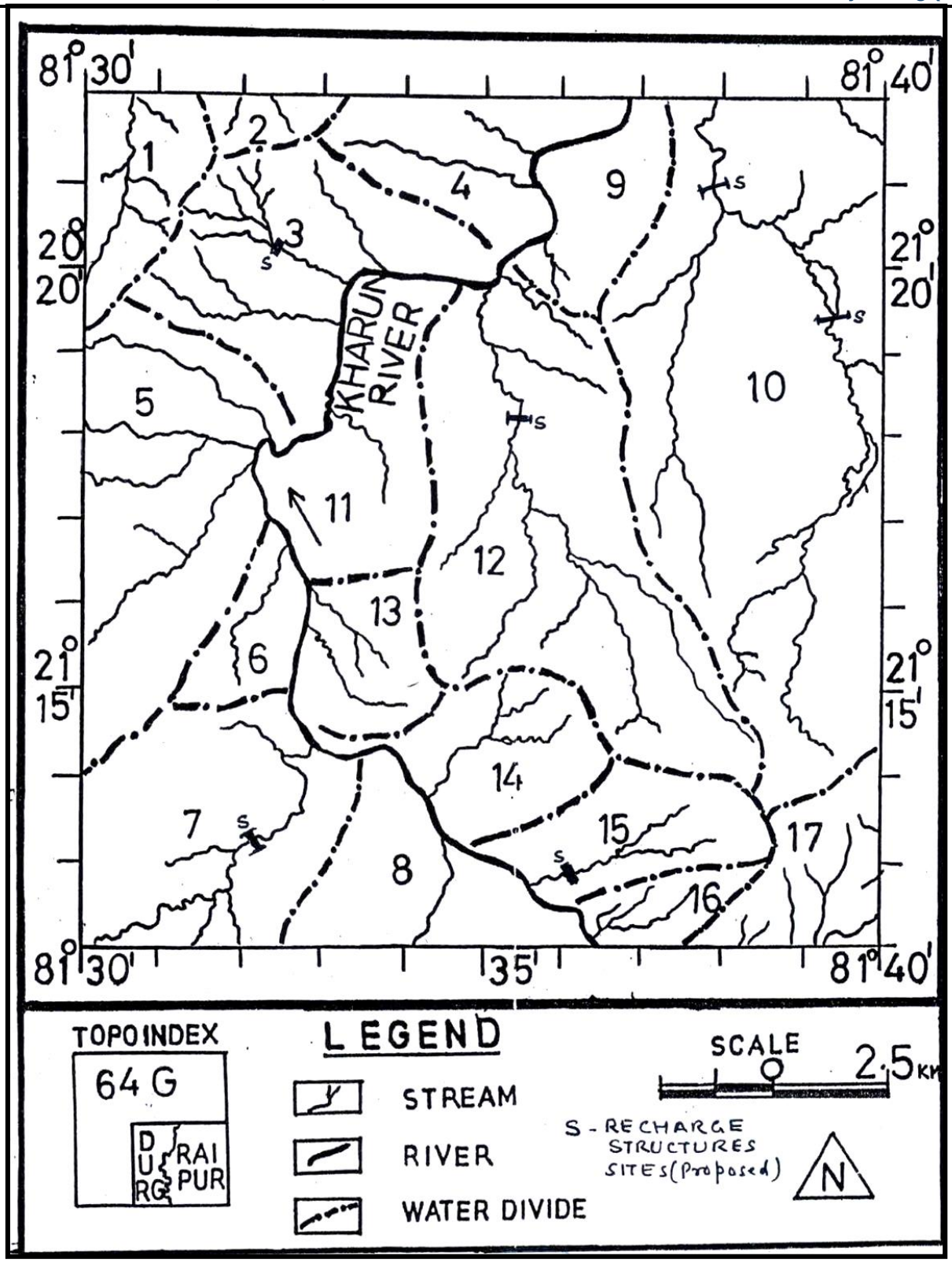

FIG – IV

Subwatersheds of Kharun River(Source: Diwan & Kuity,2016)

(Proposed Recharge Structure Sites)

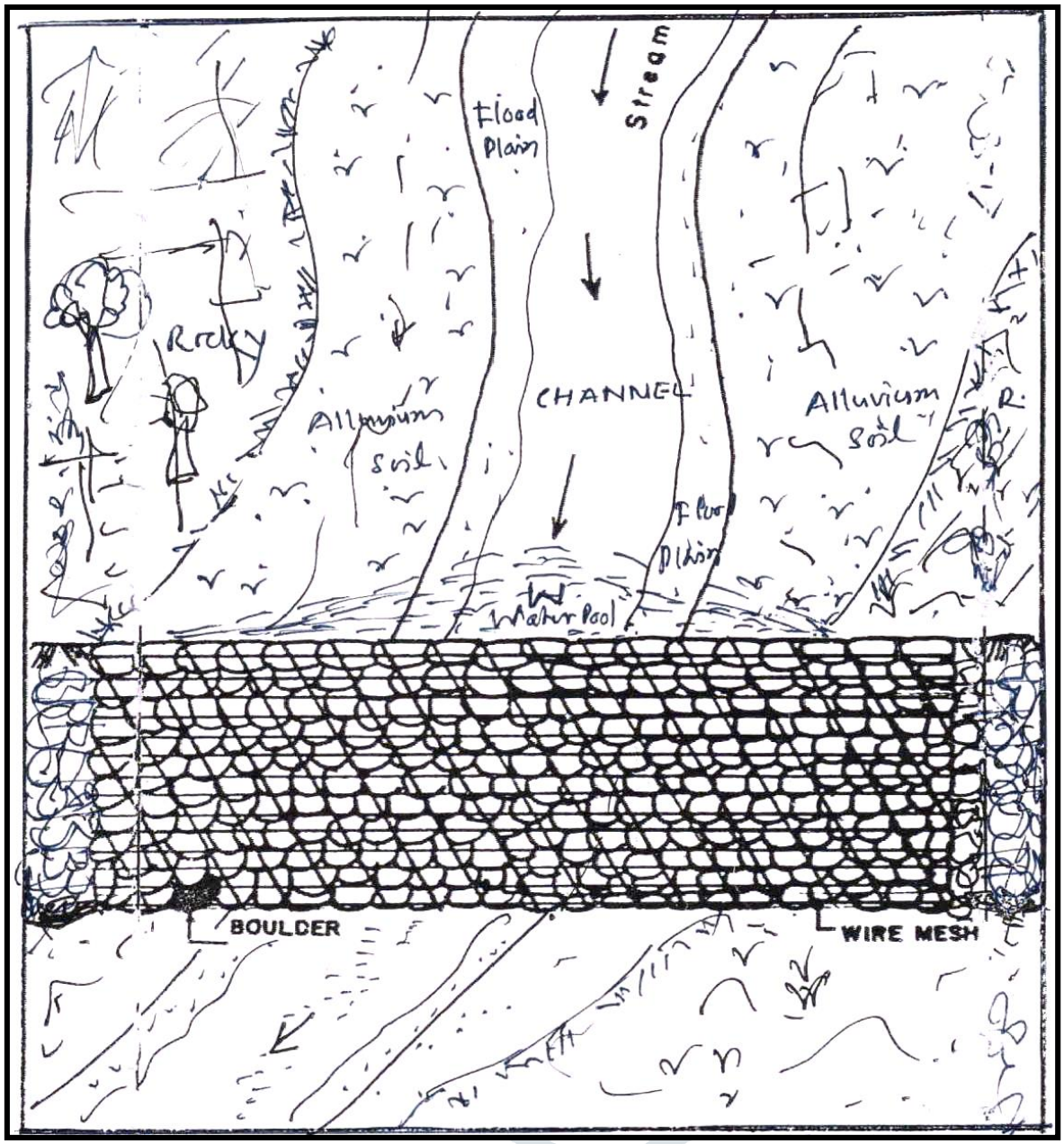

FIG – V GABION STRUCTURE

(Diwan, 2019)

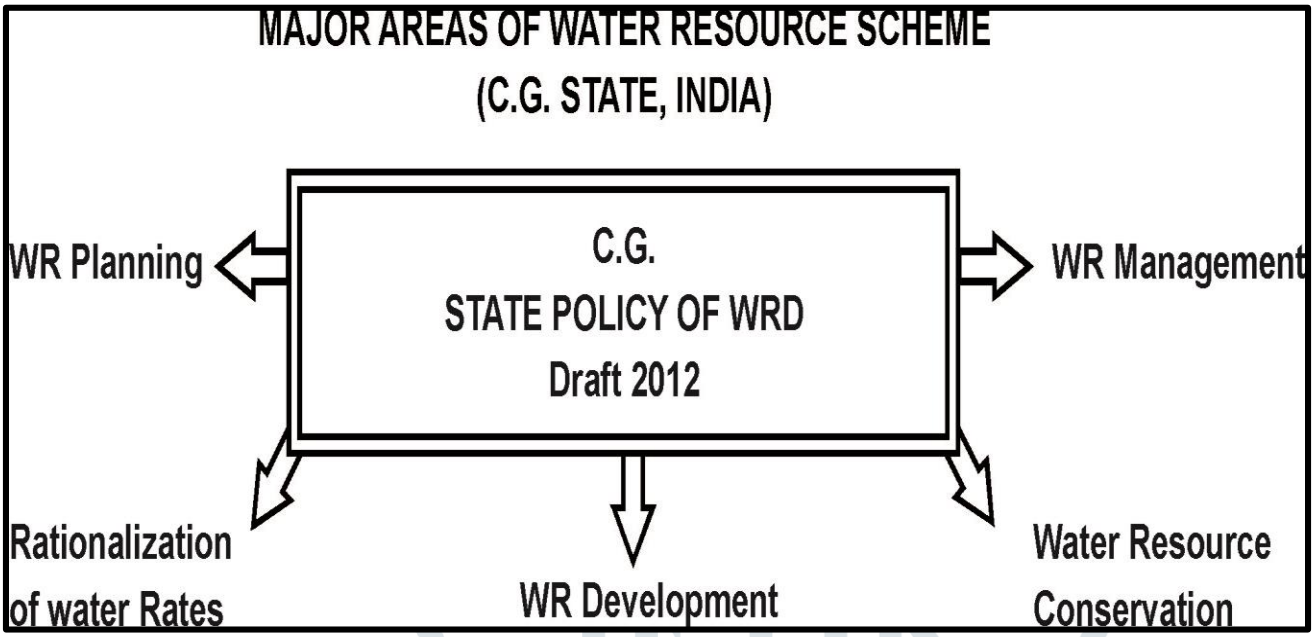

FIG VI. WRD Draft (2012) (Schematic) (C.G. Govt. State Policy)

(Source : RMC website)

REFERENCES

1. Adyalkar, P.G. 1984, Hard Rock Hydrology in India, Scenario Presidential Address 71th Indian Science Congress Ranchi, pp. 1-52.
2. ARDC, Agricultural Refinance & Development Corporation 1970, Report of the Ground Water over Exploitation committee, p. 97.
3. Das D.P., Kundu A. et. al, 1992, Lithostratigraphy and Sedimentation of Chhattisgarh Basin, Indian Minerals, Vol. 46 No. 3 & 4, pp271-288.
4. Murti, K.S. 1987, Sedimentation in Chhattisgarh Basin in Purana Basins of Peninsular In dia, Mem. Geol. Soc. Ind., No. 6, Banglore, pp239-260.
5. Karanath K.K. 1987, Ground Water Assessment Development and Management, Tata Mc Graw Hill Publ. Co. 720 p.
6. Lillesand, & Keiefer, 1979, Remote Sensing and Image Interpretation, John Wiley & Sons, N.Y.
7. Pande S.K. & Shrivastava P.K. 1993, Soil Mapping Utilising Remote Sensing Techniques and Ground Water Balance Study of Somni Nala Basin, Durg district, M.P. Vol. 4 & 5, Gondwana Geological Magazine pp. 87-105.
8. Rai P.K. Ed., 1992, Environmental Management, Vol. I, Physic-Ecological facts. Rawat Publications, pp. 73 - 87.
9. RDPD, Raipur Development Plan (2005) Draft, Directorate of T & C Planning M.P. (1995).

10. Rain Water Resources of Chhattisgarh Region in M.P. (Bulletin) Department of Physics and Agro meteorology, IGKVV, Raipur.

11. Sahu, D., 1990, Landform, Hydrology and Sedimentation, Naya Prakash, Calcutta, 383 p.

12. Vyas, P.C., 1993, Application of Remote Sensing Techniques in Land use/Land covering of Nagaur district, The Deccan Geographer, Vol. XXXI, No. 2, July - Dec., pp. 11-22.

13. Wadhwa, N.P. 1995, Project Leader, Evaluation of Ground Water Resources around Raipur, Report, Suptd. Eng. PHED, Raipur (unpubl).

14. Diwan & Kuity - (2016) Conservation and Management of small water Tanks and ponds in urban Region, Vol. I RWR Series, Abhishek Prakashan pp 102.

15. 2019, www.https RMC website. Water supply in Raipur C.G.

16. Diwan H.D.(2019), Water Quality Environment and Pollution,Satya Pravah Publishers PP. 208.