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RIVERS OF RAJASTHAN: A CARTOGRAPHIC PRESENTATION AND ASSESSMENT OF THEIR CONDITION

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Abstract: *Based on the interpretation of all the Survey of India topographical sheets of Rajasthan on 1:50,000 scale and Google Earth Images, basin wise a total of 455 rivers are identified and mapped and flow charts are prepared. Basin wise water resources development & planning documents are consulted to find out their characteristics, problems and potentials. Chambal, Mahi and Luni basins have good network of rivers. A large number of small rivers/nallah originating from low hills and uplands, are lost in sandy/alluvial plains. Overall unwarranted human activities are sole responsible for deterioration of river condition. Encroachment over river bed for agriculture and habitation is common where river passes through alluvium or sandy plain. This happened particularly in Sabi, Banganga, Shekhawati and Ruparail basins. Here large stretches of river have lost their existence. Other menace are: river sand mining; discharge of sewage and industrial effluents; dumping mining waste and slurry of marble, sandstone and granite processing units. Large scale mining activities have blocked natural drainage system and reduced free flow of rainwater in rivers. Suggestions are given to improve the river condition and increase water yield.*

Key words: Mapping, River Basins, Deterioration of River Health, Surface Water Resources, Reservoirs.

Introduction

Rivers are prime source of fresh water, nutrient flow, food, transportation, energy supply and ultimately improving national economy. Flow is the most important and significant variable of a river ecosystem. It recharges ground water in its flood plain (Sekhar, 2016). Thus, a river, is ultimate sink for surface runoff in its basin. This necessitates man's duty to protect and maintain river's health and existence. But in recent past, the natural fresh water flow in the rivers has been overexploited by diversion of river water for agriculture, industrial and domestic uses on one hand and contamination of rivers by industrial and domestic pollutants. This has led to deterioration of river health and damage to river ecosystem. The impact of this menace is more serious in water scarce Rajasthan State. Its 39.65 percent terrain virtually has no drainage and all the existing rivers excepting Chambal and Mahi, are seasonal. Ground water is too scarce, deep to very deep and saline. As such per capita availability of water reported by Neeti Ayog (TERI, 2017) in Rajasthan is just 736 cubic meters. In order to manage and plan this precious and limited natural resource, we should have updated data base of each river/stream and nallah within the State. Of course good work has been done to bring document of all the river basins by Water Resources Planning Department of Rajasthan (2014) through Tahal Group and Hydrogeological Atlases by GWD and EUSPP (2013). At basin level CAZRI has carried out detailed study of Luni Basin (Dhir et al. 1982, Shankarnarayan and Kar, 1983, Singh and Ram, 1997, Singh et al. 1999, Bajpai, 2004, Vohra, 2007, Kumar, 2019).Important studies are carried out for Banas river basin by Ali and Khan, 2013, Dubey et al. 2015); Raj Rachna et al. 1999 on Mahi river basin; Yadav et al. 2019 on Banganga basin; and Jain, D. 2018, on Khari river basin respectively. But in all the river basin maps names of only selected rivers are given. As such to have better perception of such a planning unit, all possible rivers and local nallah are shown with their name for all 13 effective river basins in the State. Besides, for each of the river basin flow charts are prepared to show sequence of left and right bank tributaries and sub-tributaries. Using multi-faceted dataset, the present condition of the rivers including their degradation, constraints, threats and challenges are highlighted. Possible remedial measures are given to restore, rejuvenate and improve the physical and environmental status.

Rajasthan State: Location and Environment

The Rajasthan State covers 342239 sq. km. or 10.4 percent of country's total geographical area. It is located between 23^{o} 30' to 30^{o} 11' north latitudes and 69^{o} 29' to 78^{o} 17' east longitudes. The district has 33 districts, 244 tehsils and 249 Panchayat Samiti (Development blocks). Estimated total population of the state in 2021 comes to 82.4 million and total livestock 56.8 million as per livestock census 2019. Density of population varies from 17 in Jaisalmer to 595 in Jaipur district with decennial growth rate of 21.3 percent. From 1961 to 2011 the state population has increased from 20.16 million to 68.55 million. The hot arid region towards west of Aravalli is covered with blown sand dotted with dunes which belong to the Pleistocene and recent times and forms part of 'Thar' Desert. The alluvium covering part of eastern plain and flood plain belong to recent and sub-recent period. The ravines flanking the Chambal and its tributaries are of very recent origin. Rest central, southern and eastern parts are characterized by variety of exposed rocks which include schist, quartzite, marble, and gneiss of Cambrian age. The Aravalli, the oldest hill range of the world, comprises of the Aravalli super group and Delhi super group with banded gneissic complex. South eastern part is occupied by basaltic flow of Deccan trap of Cretaceous period.

The climate of Rajasthan ranges from semi-arid to arid on the west of Aravalli and semi-arid to sub-humid on the east of Aravalli. The mean annual rainfall varies from less than 100 mm in the extreme western part of Jaisalmer to more than 920 mm in the eastern parts of Jhalawar and Banswara. The annual potential evapotranspiration (PET) vary from less than 1300 mm in the district of Banswara and Dungarpur in eastern Rajasthan to more than 2000 mm in Jaisalmer district in the extreme west. There is wide variation in temperature ranging from below freezing point in winter to as high as 47 ^{o} to 48 ^{o} C in summer.

There are 14 major river basins divided into 59 sub-basins but most of them are ephemeral and flowing just for one and a half month during rainy season. Rajasthan has only 1.16 percent of country's total surface water resources. The surface water available at 50 percent dependability is 21.71 BCM out of which only 16.05 BCM is techno-economically utilizable. The storage capacity generated as yet is 11.29 BCM. Out of total reporting area of the state forest constitute 8.08 percent, area put to non-agricultural uses 5.85 percent, barren and uncultivable land 6.92 percent, permanent pasture/grazing land 4.86 percent, land under misc. tree crops & groves 0.08 percent, culturable waste land 10.84 percent, current fallow 4.54 percent, other fallow land 6.25 percent, net area sown 52.58 percent, gross cropped area 80.24 percent and area sown more than once 27.66 percent as per land use statistics 2019-20 (Anon 2021).

The State has been divided into 15 defined and remaining outside basin. In total these basins have 58 sub-basins. Further, there are 727 water storage bunds with a total storage capacity of 12626.32 Mm^3/yr. These include 22 large bunds, 256 medium & small bunds and 449 minor bunds. The present (16.04.22) water storage capacity is estimated to 4963.25 Mm^3/yr. (Anon.2022). Kota division has highest percentage (63.8) of water storage in tanks while Jodhpur Division has just 2.4 percent. Estimated surface water resources of the State is 25318.62 Mm^3/yr (Tahal Group. 2014). So far the irrigation resources are concerned, there are 24 major, 84 medium and 3331 minor irrigation projects with a live storage capacity of 6259.94 Mm^3/yr, 2133.53 Mm^3/yr and 3448.92 Mm^3/yr. respectively. Out of 3302 minor dams, 693 are under Water Resources Department and 2609 under Panchayti Raj Department.

Method and Materials

Survey of India Topographical Sheets on 1:50,000 scale consulted to locate the rivers and important 'nallah' of a particular basin and record their names; order of tributaries and sub-tributaries; topographical characteristics; place of origin and confluence; and dams/reservoirs. District Gazetteers are consulted to find out missing names of rivers. Rajasthan State Map on 1:1,000,000 scale has been used to form base of river basins. Basic details of the active river basins of Rajasthan has been obtained from the basin wise report of Water Resources Planning Department of Rajasthan (2014) and Hydrogeological Atlases by Ground Water Department, Rajasthan and EUSPP (2013). Flow charts for each of the river basin has been prepared to show the order of left bank and right bank tributaries and sub-tributaries joining the main river from its origin to confluence with the major river/sea. Appraisal of degraded condition, physical end environmental problems and threats of rivers has been done through interpretation of Google Satellite Images and study of related reports and articles.

RESULTS AND DISCUSSION

Salient Features and River System

There are 41 major rivers in Rajasthan which drain into Arabian Sea and Bay of Bengal while some form inland drainage. The state has been divided into 15 river basins and 58 sub-basins. Of them 13 are active basins leaving behind Ghaggar and outside basin area under inland drainage. Under each basin, the details of sub-basins, catchment area, number of dams/reservoirs, mean annual water yield and volume of water storage are given in table 1. In total there are 24 large dams, 84 medium dams and 3331 minor dams with storage capacity of 11870.98 MCM and mean annual virgin water yield of 25378.62 Mm^3. Chambal catchment has got maximum runoff water followed by Mahi, Banas, Luni etc. (NBSS&LUP, 2000). The drainage density is comparatively low in north-western sandy plain (0.20 to 0.40 km/ sq. km.) and higher (0.41 to 1.21 km/ sq. km.) in south-eastern plateau. Basin wise salient features and characteristics are given below.

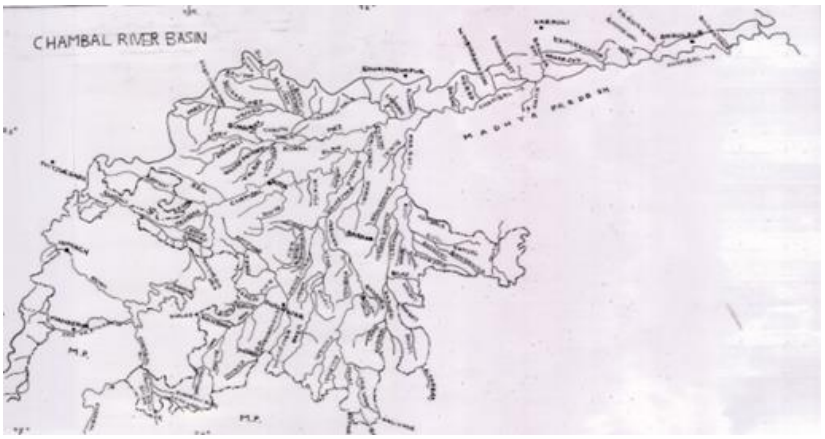
Banas River Basin: Banas is the most important river basin comprising 47060.27 sq. km. or 13.75 percent area of semi-arid eastern plain of Rajasthan covering 11 districts right from Udaipur in south west to Karauli in the east. It has 10 sub-basins viz. Banas, Berach, Dain, Gudia, Kalisil, Khari, Kothari, Mashi, Morel and Sodra (Figure 1). In total 71 rivers and important nallah are located and mapped. The basin has 9 major dams viz. Bisalpur, Chhaparwara, Galwa, Gosunda, Kalakh Sagar, Morel, Rajsamand and Tordi Sagar. Besides, there are 33 medium and 1314 minor irrigation bunds. Pollution from mining, sewage and impact of sand mining are major challenges.

Figure 01: Banas River Basin

Chambal River Basin: Chambal is the perennial river, contribute greatly in development of Rajasthan on one hand and putting challenge to manage its vast ravine land. The basin with a catchment area of 31242.50 sq. km. has 7 sub-basins viz. Chakan, Chambal downstream, Chambal upstream, Kalisindh, Kunu, Mej, Parbati covering 8 districts viz. Jhalawar, Baran, Kota, Bundi, Chittorgarh, Sawai Madhopur, Karauli and Dhaulpur of flood prone eastern plain and humid south east plain (Figure 2). Over all 112 rivers/ nalah are identified and mapped within the basin. There are 6 major, 21 medium and 250 minor irrigation dams/reservoirs. Major dams are Rana Pratap Sagar, Jawahar Sagar, Kota Barrage. Guda, Harishchandra Sagar and Parbati Pickup Weir. Rampant sand mining, industrial and domestic pollutants and

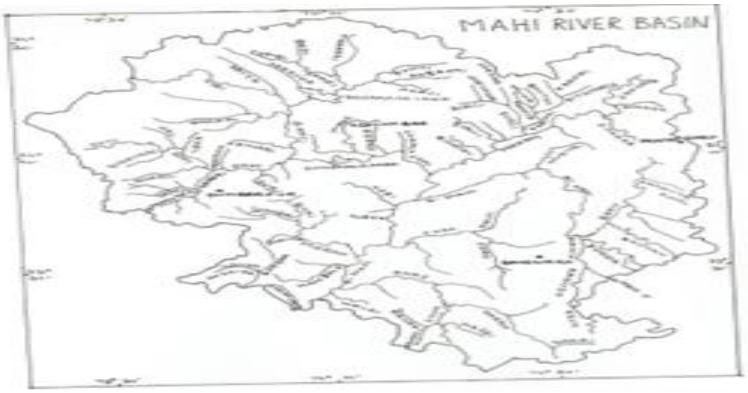
increased number of water harvesting structures affecting flow (Tahalka, 2013). Performance of Gandhi Sagar, Rana Pratap Sagar and Jawahar Sagar has been reduced to 72.86 percent, 47.71 percent and 32.695 respectively declined by more than 25 percent during the last 25 years (SANDROP, 2016).

Figure 02: Chambal River Basin



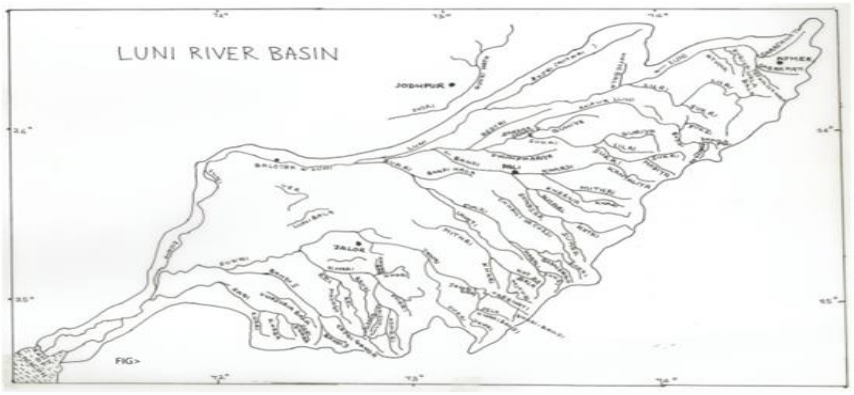
Mahi River Basin: After Chambal, Mahi is the only perennial river in Rajasthan. It originates from Mahi Kanta hills in northern slops of Vindhyan Range in Dhar district, M.P. It enters Banswara district in Rajasthan near Chandargarh. The basin occupies 16610.63 sq. km. covering Banswara and Dungarpur and Pratapgarh districts and southern part of Udaipur district (Figure 3). It falls in sub-humid southern plateau & Aravalli and humid southern plateau agro-climatic zones. There are 6 sub-basins viz. Anas, Bhadar, Jakham, Moran, Som and Mahi. In total 56 rivers are identified and mapped across the basin. Significantly the basin comes under tribal region of southern Rajasthan. The basin has 4 large, 2 medium and 244 minor irrigation projects. The large dams are Jaisamand, Som Kamla Amba, Mahi Bajaj Sagar and Jakham.

Figure 03: Mahi River Basin



Luni River Basin: Luni is the largest river basin of arid western Rajasthan with a catchment area of 69302.10 sq. km. or 20.25 percent occupying mainly Pali, Jalor, Jodhpur and Ajmer districts (Figure 4). It has 12 sub-basins viz. Bandi, Bandi (Hemawas), Guhiya, Jawai, Jojri, Khari, Khari (Hemawas), Luni, Mithri, Sagi, Sukri, Sukri (Sayla). All over 54 rivers are identified and mapped. There are a number of local nallah whose names could not gathered. The basin has 2 major irrigatin dams (Jawai and Sardar Samand), 11 medium and 904 minor irrigation projects. High sewage, industrial pollution, rampant mining and reduction in flow are major impact.

Figure0 4: Luni River basin



Banganga River Basin: West-east flowing Banganga river basin through Jaipur, Alwar, Dausa and Bharatpur districts constitutes 8583.43 sq. km. catchment area and yield 754.83 Mm^3 virgin water. Important right bank tributaries are Dudhala, Suri and Kaloa kho, and while Kharori, Sanwan and Palasan are left bank tributaries (Figure 5). In total 18 rivers/nala are identified and mapped. Gravel and sand mining have been two most destructive activities on Banganga river basin. River bed is encroached at various places by adjacent farm owners who keep expanding their area. From Bawanpada and Shekhpura onward, the river bed is extensively encroached for agricultural use. Near Dausa wells have been sunk right into river bed from where water is pumped through motor pump. Jamba Ramgarh Dam near Jaipur is dry since 2006 with no respite. Excessive encroachments, increased number of water harvesting structures and sand mining.

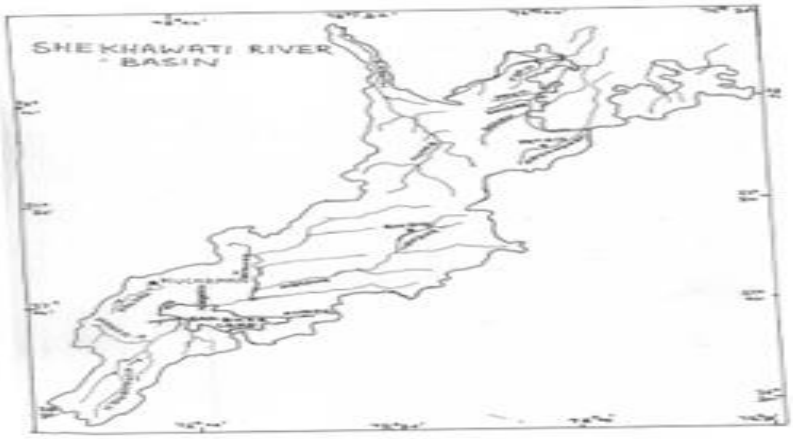
Figure 05: Banganga River basin

Gambhir or Utangan River Basin: Gambhir river originate from Langa P.F. upland south east of Karauli town, flow 288 km and drains into Yamuna River from right bank near Rithauli village, Agra district. The basin mainly includes Karauli, Bharatput and Dhaulpur districts. Besides, a small parts of Sawai Madhopur and Dausa are also included (Figure 6). With total catchment area of 4693.52 sq. km., the basin has five right bank tributaries viz. Nehro, Khari, Jagar, Kukund and Kawar rivers as well as another 10 rivers/nala. Mean annual virgin water yield from the basin comes to 700.89 Mm^3. There are 3 medium dam viz. Baretha, Jaggar and Panchana and another 98 minor bunds. Total availability of fresh water comes to 1607.28 Mm^3. Obstruction and reduction in river flow, pollution from industrial and municipal sewage, encroachment of rivers/tanks and rampant mining are major factors for deterioration of river health and ecosystem.

Figure 06: Gambhir River basin

Shekhawati River Basin: The basin 9750.88 sq. km. catchment area has three sub basins viz. Mendha, Kantli and Doha. Mendha (covering Sikar, Jaipur and Nagaur districts) with its 5 nalah flow towards west and drain into Sambhar Lake. 4 more rivers/nalah join Sambhar Lake from Ajmer side (Figure 7). Similarly 3 small rivers join Ranoli Tank towards SE of Sikar town. Kantli sub-basin with flow direction towards north cover Sikar, Jhunjhunu and Churu district. Kantli with few streams from upper reached ultimately terminate within alluvial plain near Naurangpura village in Churu district. Dohan sub-basin with flow direction towards north east has 4 tributaries and flow through Sikar, Jhunjhunu and Alwar districts. Shekhawati basin has just one medium reservoir (Raipur Patan on Krishnawati River) and 63 minor irrigation projects. Overall, there are 22 listed rivers /nalah in the basin.

Figure 7: Shekhawati River basin

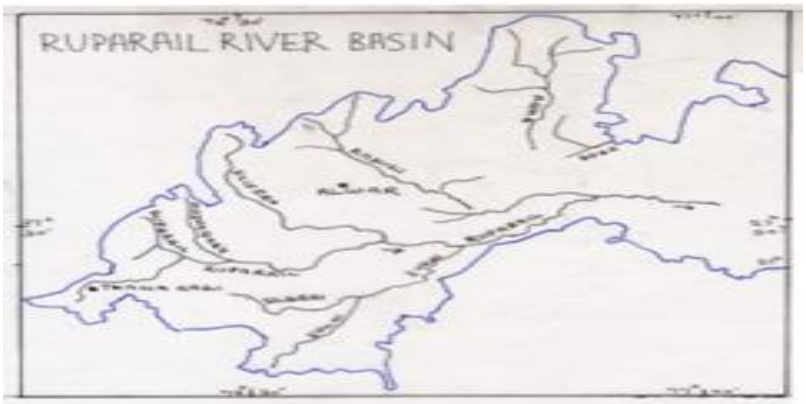


Sabi River Basin: Sabi river basin with a catchment area of 4523. 67 sq. km. occupies major area of Alwar district (62.11 percent) followed by Jaipur (29.3 percent) and Sikar (8.59 percent).From its origin in Sikar, Sabi runs157 km in Rajasthan up to Akali village and finally merge in Dhasa bund in Haryana. Sota, Karmali, Banganga and Chaundi are its important tributaries (Figure 8). Another 10 rivers/local nala are identified in the basin. The mean water yield from this basin is 348.09 Mm^3. Buchara and Chhitalo are two medium irrigation dams. Besides, there are 67 minor irrigation bunds. Change in landscape, urbanisation, introduction of industries and intensive agriculture. Several streams vanished due to construction and urban growth particularly of Bhiwadi, Neemrana and Behror. Sabi hardly flow now. Right from Barnagar and Bagawas the river bed is almost grabbed and put under agriculture.

Figure 08: Sabi River basin

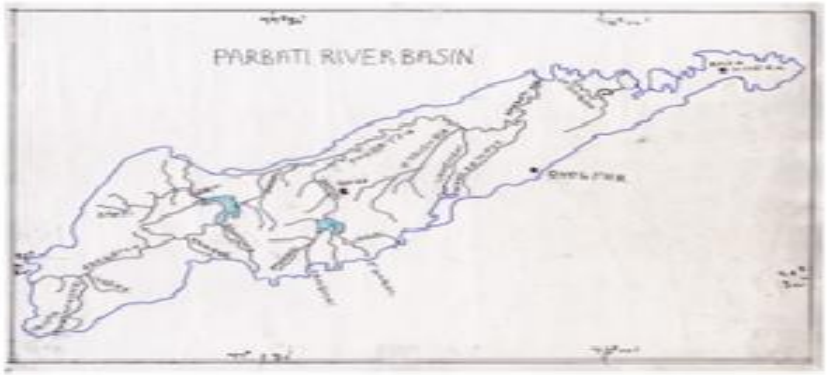
Ruparail River Basin: Ruparail river basin has a catchment area of 4033.66 sq. km. spread over Alwar and Bharatpur districts. Originating from Udainath hills, flow 104 km and terminate at Sikri Patti Bund near Wazir Kheri (Figure 9). Thanaghazi, Madhogarh, Siliserh, Sukhri, Silveri and Keduki are its tributaries. Mean water yield from the basin is 641.38 Mm^3. Sikri Ber is major and Jaisamand is medium bund. There are 54 minor irrigation bunds. Obstruction and reduction in runoff, shrinkage and encroachment of river catchment, thinning of water channels, and unprecedented increase of built-up area are main impacts on the river eco-system. The river bed of Ruparail from Khareli Gujaran onward is almost converted under agriculture.

Figure 09: Ruparail River basin



Parbati River Basin: A tributary of Gambhir, Parbati river basin constitutes 1883.07 sq. km. area within Karauli and Dhaulpur districts in eastern most part of Rajasthan (Figure 10). Parbati has 16 tributaries and sub- tributaries which yield 427.18 Mm^3 mean virgin water. It has a major parbati dam, 2 medium dams Urmila Sagar and Ram Sagar and 17 minor irrigation bunds.

Figure 10: Parbati River basin



Sabarmati River Basin: Sabarmati river basin with a total catchment area of 4130.12 sq. km. located in southern Rajasthan within Aravalli range of hills comprising major part of Udaipur (83.47 percent), Dungarpur (14.81 percent) and small parts Sirohi and Pali districts (Figure 11). Virtually it may be called as 'Upper Sabarmati basin' since part of Rajasthan just comprise 23.68 percent of the entire basin area. The basin has 4 sub-basins viz. Sabarmati, Akal, Vatrak and Sei with a total of 18 rivers. It has 54 minor irrigation tanks. Among them Sei Dam is important. Water erosion, high level of deforestation, diversion of water from its tributaries to meet needs of urban areas, are major constraints.

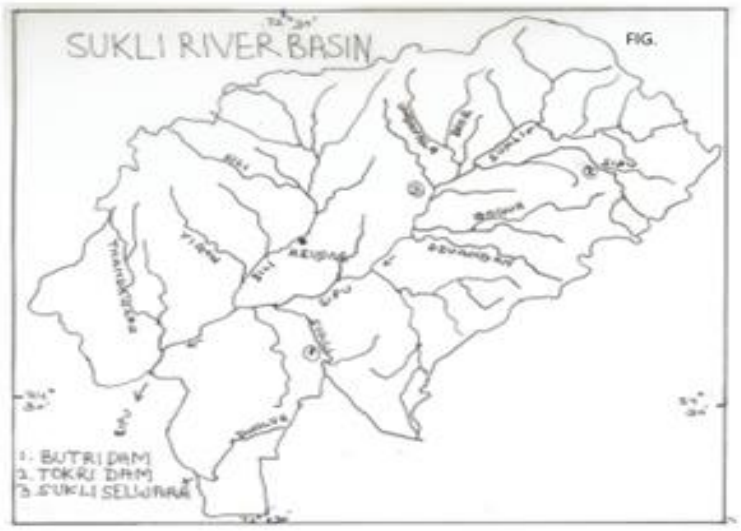
Figure 11: Sabarmati River basin

West Banas River Basin: West Banas River basin with a catchment area of 1831.34 sq. km. is located within sub-humid southern plain and Aravalli agro-climatic zone covering mainly Sirohi district (Figure 12). The historic Mount Abu is spread within this region. 14 rivers and few 'nallah' are identified and mapped. West Banas Dam is only medium irrigation project. There are 19 minor irrigation bunds. Mean surface water availability is 299.21 Mm^3 while availability of saline ground water is 5.15 Mm^3. On the other hand, there is high demand of fresh water for Mount Abu tourism circle. Thus proper planning for storage, management and distribution of water is very essential.

Figure 12: West Banas River basin

Sukli River Basin: Sukli or Sipu River is right bank tributary of West Banas River joining near Rampur, NE of Deesa in Gujarat. It has 10 tributaries and equal number of local nallah. Dior, Gogua, Devangan Sili and Vigan are some of them (Figure 13). The basin has a catchment area of 990.44 sq. km. entirely within Sirohi District and falls within transitional plains of Luni basin agro-climatic zone. Sukli Selwara is the only medium irrigation project. However there are 18 minor irrigation bunds. Revdar is an important town of the region.

Figure 13: Sukli River basin



Other Nallah Basin: It is most insignificant small river basin covering an area of 1900.3 sq. km. of Jalor and Sirohi districts. Bargaon and Sukal are important rivers (Figure 14). Besides, there are 16 plus nallah. All these originate western slopes of Jaswantpura and Nandwana hills which are covered with obstacle sand dunes having a height up to 35 meters from mean ground level and as such from gullies. These streams running 10 to 15 km towards west, are ultimately disappear in sandy plains. There is no water harvesting structure. Hence the basin rarely contribute to meet drinking water needs in the area or benefiting agriculture.

Figure 14: Other Nallah River basin

Inland Drainage Area: Some of the isolated and small rivulet within this vast region are: Harsor river and Thaola nala in Nagaur; Sukri and Ghugri (near Lathi), Masurdi (south of Jaisalmer), Kakani (west of Jaisalmer) and Ratadevalwali Nadi (near Hamira); Ranigaon ka nala near Barmer, Like river between Hira ki Dhani and Gol; Kawas ka nala, Viratara nadi west of Chohtan; Kheorayal nala near Sheo; and Gajner nala, Raneri and Gurha in Bikaner districts.

Degradation of Rivers and Threats

Growth of population; urbanization & industrialisation; rampant, widespread, uncontrolled and unscientific mining activities; intensification of agriculture; high water demand, emergence of strong land mafia group; and uninterrupted conversion of common/ '*gair mumkin land'* for unwarranted uses, are most dominant factors for degradation of river ecosystem as a whole; constantly declining quality and quantity of fresh water resources; and ultimately, the pollution of land, water and air. Widespread, rampant and unscientific mining is another factor responsible for deterioration of river health.

Rajasthan has more than 33000 mine lease which is highest in the country. The State also stood second in terms of legal sand mining (SANDRP, 2019). Two major source of water pollution in Rajasthan are sewage and industrial affluent. Mining exerts pressure on environment at many stages of the processes of exploitation, extraction, processing and post closer operation. Mineral purification process generates tailing wastes which discharged into pons and further into river/lake (Joy et al. 2020). CPCB (2015) claimed that water quality of 11 rivers are non-complying with range to BOD. These locations are on eight rivers viz. Banas, Chambal, Kalisindh, Parbati, Jawai, Ujad, Chhapi and Ghaggar. The amount of sand extracted illegally in Rajasthan is around 99 lakh metric tonne. It is estimated that 4.69 MLD of industrial affluent is generated in the state. With four districts Bhilwara, Pali, Barmer and Jodhpur together generate more than 50 percent waste water. In terms of chemical load, Udaipur ranks highest followed by Chittorgarh, Bhilwara and Kota. BOD is maximum from Alwar (Moudgil, 2016). Major stretches of highly polluted rivers are: Chambal–Down stream of Kota; Kothari - Down stream of Bhilwara; Bandi -Down stream of Pali; Jojri -Down stream of Jodhpur; Aha - Down stream of Udaipur; Gambhiri -Down stream of Chittorgarh; and Berach - Down stream of Chittorgarh (India River Week, 2016). Major impact of industrial and domestic pollutants on river health are:

1. Destroyed river bed badly.
2. River bed farming has completely destroyed.
3. Affected biodiversity
4. Affected aquatic and fauna
5. Change in depth of river

Conclusion

With the help of topographical sheets on 1:50, 000 scale and visual interpretation of Google Earth images, 455 plus rivers covering 14 active river basins of Rajasthan, are identified, and mapped. However a large number of local '*nallah'* are left out for want of their names. Except Chambal and Mahi which are perennial rivers, all others are seasonal just flowing one and a half month during the year. There are a number of rivers/streams originating from low hills and uplands, do not confluence with any river and terminate in midway within alluvium or sandy plains. Chambal, Luni, Banas and Mahi are important river basins which together yield 77.98 percent of the gross mean annual virgin water yield (25378.62Mm^3). Banas, Luni, Chambal and Mahi river basins are highly affected by rampant mining activities (including river sand mining); discharge of industrial effluents and municipal sewage; over exploitation and use of water resources; deforestation and encroachments. Aquatic life, flora and fauna are highly threatened in Chambal river ecosystem due to pollution, lowering of water level disruption of free flow of water. Rivers of Banganga, Sabi, and Ruparail basins are rarely flow during monsoon period and many of them lost their existence due to large scale encroachments of river beds for agriculture, housing and commercial use. In order to improve river health and

their rejubination, there are ways, proven technologies, and development measures but in order to implement them at ground level, it is essential to have strong will to do so within all actors of this sector, coordination, cooperation and accountability.

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