Cloud Publications
International Journal of Advanced Remote Sensing and GIS
2015, Volume 4, Issue 1, pp. 1130-1141, Article ID Tech-394
ISSN 2320 - 0243

Review Article | Open Access

Geomorphic Evolution of Chambal River Origin in Madhya Pradesh using Remote Sensing and GIS

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Publication Date: 27 July 2015

Article Link: http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-394

Abstract The Fluvial geomorphology of Chambal River basin is so vast in terminology; therefore remote sensing and GIS application and technique to analyzing the whole Chambal geomorphology in interval of space and time has been used. Chambal River is a perennial river and carries large quantity of water and sediment load to transportation. Chambal River is famous for the past prehistoric and as unpolluted river. Chambal origin considered from the Janapav valley (Janapav Shiv Temple) at Malwa ridge surrounded by Manpur Reserve Forest, Madhya Pradesh, India. The source of Chambal water is considered from seepage of groundwater from the Basaltic columnar joint rock (Malwa Ridge) where the water flows from the weak columnar joints of Basalts and follows gradient slop facing in Northward direction. Chambal River has Deccan trap Basalt as river bedded rock, Mesozoic age formation with dendritic drainage pattern at Malwa region. Chambal River origin lies at an elevation of 840.6 meter with Latitude $22^0$27′36.5″N and Longitude $75^0$41′14.4″E *(source by: ground truth field data)*. Physiographically the area to the North of Chambal is characterized by moderately dissected plateau and formed undulating topography. However, to determine the changes in flow, meandering, and geomorphic landforms development in the Chambal river origin, primarily the toposheet no 46N, 46M and Landsat imagery ETM+ data are used for geomorphic evolution maps and digitization and georeferencing has done by using ArcGIS v10 software. Identification of geomorphological landforms with their specific geomorphological processes either erosional or depositional in the fluvial system of the Chambal River will certainly help in assessing the environmental and hydrological problems in this Malwa region.

Keywords *Chambal River Origin; Janapav Kuti; Malwa Ridge; Dissected Plateau; Remote Sensing & GIS; Geomorphic Evolution*

1. Introduction

India is enriched for their variable fluvial geomorphic features and riverine pattern is one of them. Chambal is one of the important rivers of central India which not only famous for its geomorphic pattern as well as their historical significance, sculpture, hydrological and structural set-up. In due

course of time, this river becomes famous as Charmanvati and this is one of the chief tributary of Yamuna River in central India (Jain et al., 2007). Chambal River origin is situated under the valley of the Manpur Reserve Forest, Janapav Kuti Village Madhya Pradesh, India. Chambal River shows different gradient in different areas. Chambal is Pollution free river (Saksena et al., 2008). The Chambal River originate in the form of groundwater seepage from columnar joint of basaltic Malwa ridge at latitudes $22^0$27′36.5″N and $75^0$41′14.4″E at an elevation 841m (±3m) (ground truth data). This river follow the consequent slope of ridge and this is the reason flowing in Northwards direction (Figure 1). Chambal River basin is bounded by the Aravalli mountain ranges and the great Vindhyan hill ranges (Jain et al., 2007). The Chambal basin located between 22º27'N-73°20'E to 27º20'N-79°15'E and its rain fed catchment and drains a total area of 143,219 sq.km². This river is also characterized by undulating flood plains, gullies, forest, ravines and scrub land (Husain & Badola, 2001; Gopal & Srivastava, 2008). Chambal River is bounded by Vindhyan range (West-East-South) and Aravallis range (NW) (Tarun & Chaitanya, 2013).

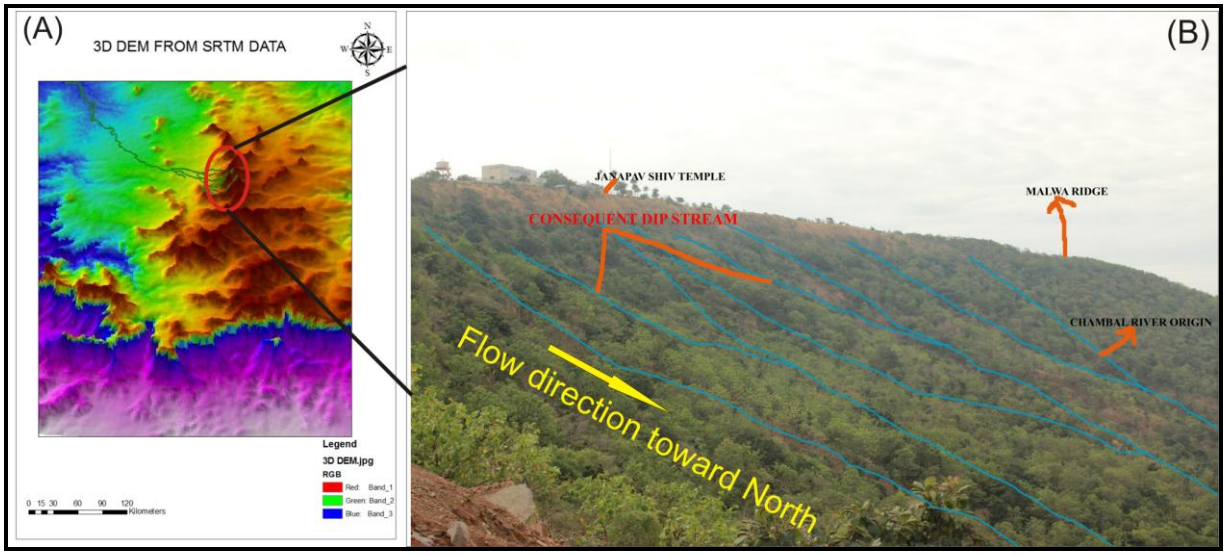

Figure 1: *Map and photograph show the systematic flow of Chambal river origin from Janapav valley of Malwa ridge, MP, India*

In the present study the geomorphologic features of the Chambal River basin in wider prospective studies and for further detailed mapping of landforms for the entire Chambal River basin on 1:50,000 Scale has been done, which includes mapping of lineament studies, tectonics and structural aspects. Apart from this depositional environmental system and morphometric analysis of the river are the major elements for describing the whole geological setup for the Chambal River Basin.

2. Methodology

Chambal River geomorphologic features are recognized by using ArcGIS (V10.0) and Landsat imagery Data and morphometric analysis have done by the SRTM technique (Table 1). Chambal River shows dendritic pattern, trellis pattern, rectangular pattern, which infer some sort of structural control and therefore we represent the SRTM-DEM map on the 1:50,000 scale. Through aerial images this data displayed in Google Earth.

Table 1: *Data, Resolution Scale and Methodology Tools used for Chambal River Geomorphologic Analysis*

Serial No.	Data Used	Resolution/ Scale	Methodology Tools
1	Landsat ETM+ Imageries	30 m	Arc-GIS(v10), ERDAS IMAGINE(9.1), Corel Draw v12
2	SRTM Data	90 m	
3	SOI Toposheet	1: 50,000	

Enhanced Geocode image Soft/Hardcopy from Bhuvan ISRO website and toposheets of the Chambal River basin by Survey of India (SOI) on 1:50,000 scale. Aerial satellite data by Google Earth, preparing of KML file etc. Apart from this Lithological/Geomorphologic map has been prepared by digitization and Geomorphological field with keen observation for ground truth attribute data (Table 1).

2.1. Location of Chambal River Basin in India

In present study, Chambal River is perennial and it has been cited in various prehistoric scriptures. Chambal River located in western and central part of India and flows through three Indian states i.e. Madhya Pradesh, Rajasthan and Uttar Pradesh. Chambal River is actually chief tributary of Yamuna River (Jain, 2007) (SOI-Toposheet) (Figure 2).

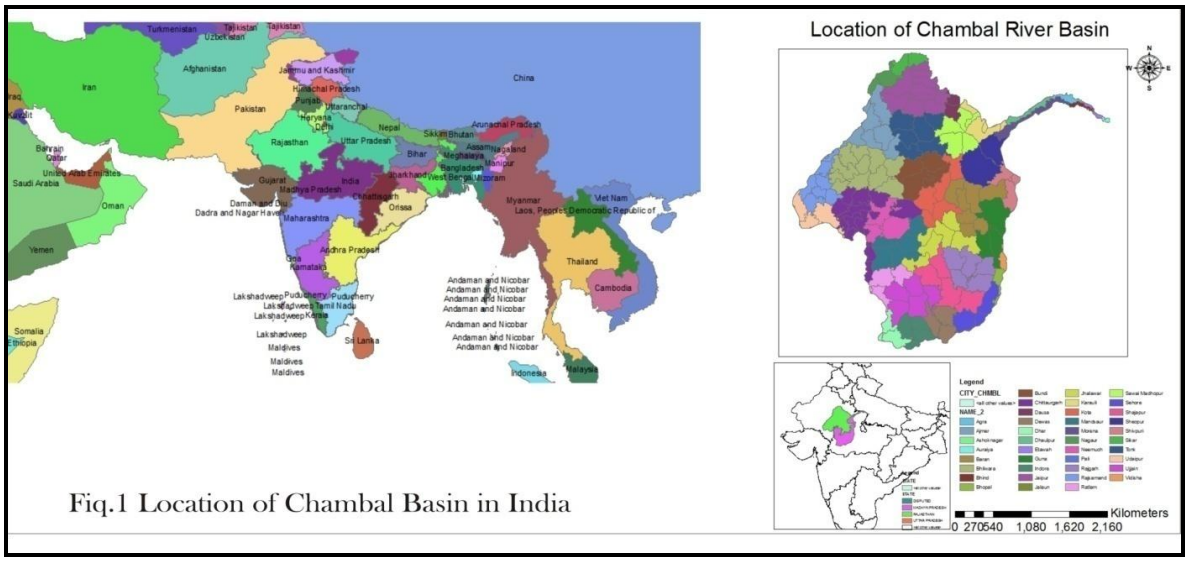

Figure 2: *Location of Chambal river basin in India*

2.2. Climate of Chambal Basin

The origin of Chambal River has followed the wet and dry savannah tropical climate. After reaching Mandsaur and up to its confluence to Yamuna, Chambal River follows the semi-arid climate. It's tributary Banas River flowing in arid climate and Parbati and Kalisindh follow the humid sub-tropical climate.

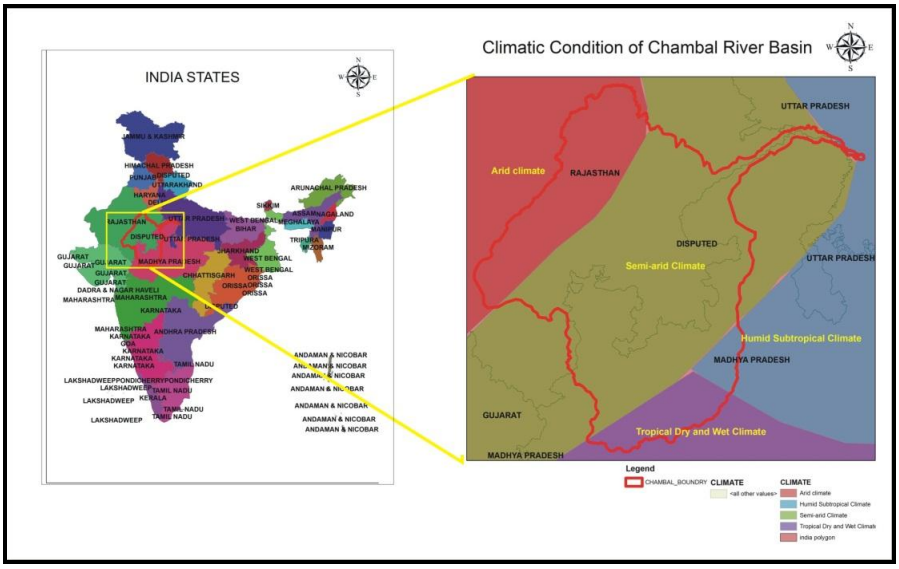

Figure 3: *Climatic condition of Chambal River Basin (Climate data source by India climate zone map by Koppen's classification updated by Peel, M.C., Finlayson, B.L. and McMahon)*

2.3. Geomorphology of Chambal River Origin

Chambal River is thought to be structurally controlled river due to some neotectonic activities have been occurred in due course of time (Sharma, 1976). The Chambal River originated from structural formation Malwa ridge which is moderately dissected and flowing denudational formation in northward direction (Figure 4).

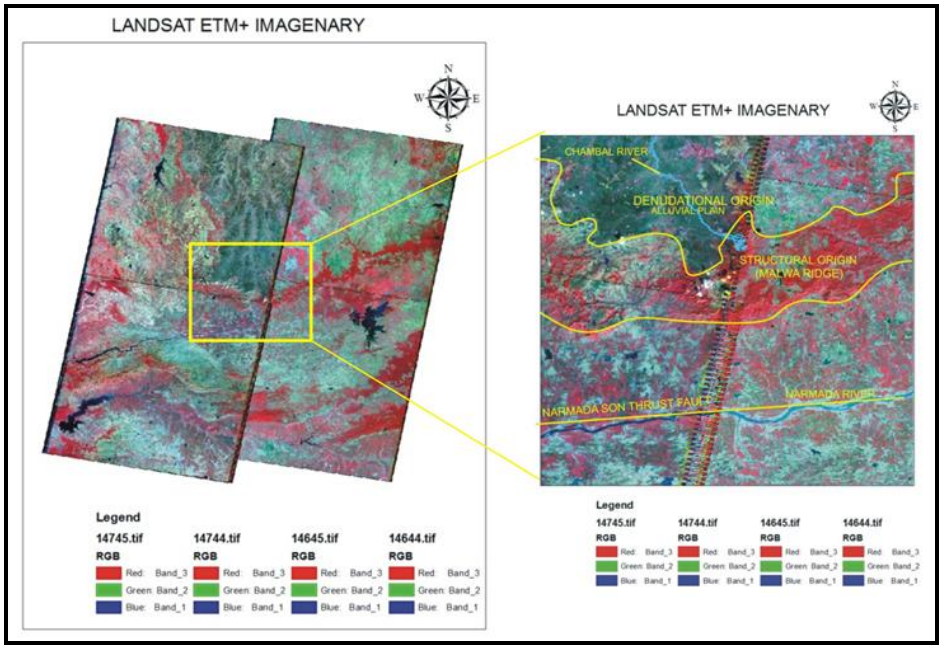

Figure 4: *Geomorphological Map of Area of Chambal River Origin*

Accordingly, there are many changes which have been observed in time and space such as many fault zones and other lineament pattern with controlled meandering pattern having 90 degree turn for flow of the River (Suryavanshi, 2011). These features are very well identified on the Google Earth and in Survey of India Toposheet. Existence of the Chambal River starts from the Malwa range in Manpur

(Janapav valley) and it extend into NE part of Rajasthan then it flow at Madhya Pradesh and Rajasthan state boundary (Length 217km), Afterwards, Madhya Pradesh and Uttar Pradesh boundary (Length-145km) and finally meet to Yamuna in Uttar Pradesh (Length- 32km) (Jain et al., 2007).

Chambal River flow in Mesozoic area (Mani, 1974), and flow away in form a dendritic drainage pattern of the river and it is not so wide around 6-8 meter and even low water quantity. It may be due to seepage from internal flow of ground water in basaltic ridge through columnar joints and weak planes. Chambal River hence, there is low sediment load and has low ravenous due to forestation and settlement of Manpur Reserve Forest. The Chambal River has consequent system origin follow the regional slope (Figure 5). Because consequent stream has follow the regional slope (Singh, 2004). So, we can also consider its origin has a dip slope. On the basis of classification of stage of river (Singh, 2004), the youth stage of the river has lacking active flood plain observed with lateral bar, channel bar, point bar, meandering etc. So, present study origin point is in consideration and on the basis of this geomorphologic landforms and processes the Chambal River origin follows youth stage of river system. It flows through a regional slope but some changes have been observed through time and space from 1976 to 2015 if we compare SOI Toposheet with Google Earth (see SOI Toposheet 46N, 46M, 45P and KMZ File). Major change could see within the origin point which could clearly see in KMZ file taken by Google Earth.

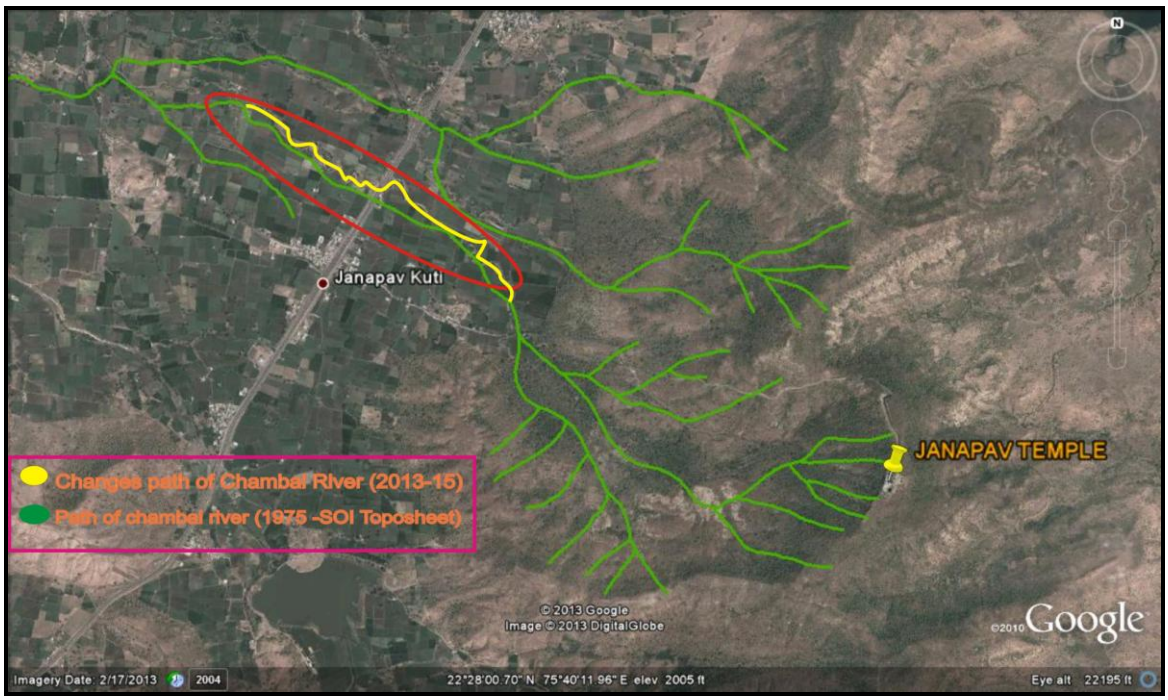

Figure 5: *A systematic view of consequent dip stream of Chambal River origin with changed path of flowing 1976 -SOI Toposheet to present Google Earth image*

In this KMZ file shows the Chambal River origin with dendritic pattern and also showing the detailed history of geomorphic changes in Chambal River pattern in time and space from 1976 to present.

Hence, sedimentation, transportation, and active flood plain, older flood plain are developing at high rate of velocity of river and sediment load and marine lateral erosion. It is long river though great channelization pattern developed in the Chambal River. Chambal is structurally controlled river (Sharma, 1976). The most important thing about the Chambal River, ravenous area which is special characteristic of neotectonic activity but present field study show the ravenous are used by the people foe agricultural activities and village settlements.

3. Drainage of Chambal River Origin till Mandsaur

The drainage basin is like a system which receive and loosing energy from the basin (Gregary and Walling, 1973). However, the basin receives energy in two forms viz. atmosphere (form of precipitation off) and earth (form of endogenetic forces through which erosional processes occur) (Singh, 2004). The Chambal river origin lies within Vindhyan region with dendritic pattern shows structural and lithological control and associated with areas of homogeneous lithology. However, Chambal river has wide range of trellis pattern near and around the Mandsaur and Neemuch district of Madhya Pradesh which show the inter deposition of different type of beds (SOI Toposheets). These areas are less characterized by the sedimentary Kaimur formation. Therefore, major dam Gandhi Sagar Dam and Pratap Sagar Dam built up in that area. At around the Shipraj village Chambal River starts to grow in water quantity with the confluence of Dangul River, Angrer nadi, Khunikha nadi, Undwakhal nadi, Rijalakhal nadi at an elevation of 553-556 meter (Ground truth data). The most important point in geomorphological processes of this area is lateral erosion of Chambal valley and the basic reason behind it the basaltic nature of river bed which is compact and resistant to fluvial erosion so, rivers cuts the surrounded soft rock valley that why the course of Chambal river and its all tributary whether short and long course in nature are wide U shaped valley. The transportation of sediment is not occurring at high rate so the sub-angular sediments are deposited along river bank and at the river bed (elevation – 502 m). The Chambal tributary as Chambala, Pilengi nadi and Maleni River show the river terraces which show the lateral spreading and angular sediments with low velocity in water at confluence with 92-96 m wide at an elevation 428 meter (Ground truth data) (Figure 6).

Figure 6: *Showing the River terraces of Maleni River near confluence with Chambal River*

The most important thing about the Chambal River i.e.; Ravenous area which is special characteristic of Neotectonic activity but present field study shows the ravenous are used by the people for agricultural activities and village settlement.

4. Relief Surface Analysis of Area of Chambal River Origin

The SRTM Data (90m) used to analysis the surface Morphometrics. These all processes had done under Arc-GIS software (v10).

1) **3D Dem (CDED)** of Chambal river Origin area where the brown colour shows the structural high hills area of Malwa ridge and green colour shows the low upland peneplain area and blue pink colour shows the low and high slope of area in 3D manner (Figure 7). (CDED Data).

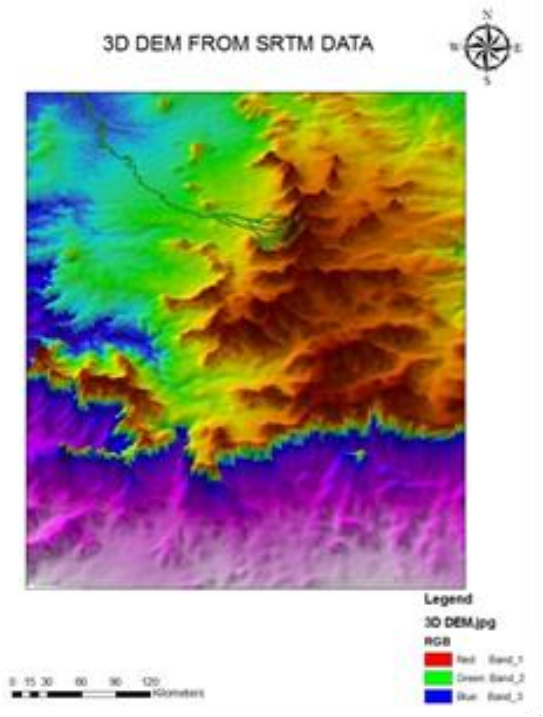

Figure 7: *3D DEM from SRTM data*

2) **Slope map** showing the angular inclination of terrain between highest point of Hills and its lower bottom of valley. Malwa ridge and surrounded area. Where the blue color shows the high altitude area means slope is high of Malwa ridge and orange color shows the low pediplain areas. The slope varies from 0º to 47.40° (approximately) which shows very steep slope (Nongkynrih, Hussain, 2011) and most of the area is slope is Northern and Eastern part of area (Figure 8).

3) **Hillshade map** showing the difference in highest and lowest point in elevated area (Nongkynrih and Husain, 2011) of Chambal river origin area (Malwa region) which is varies from 23m to 250m which show moderately relative relief area (Figure 9) (A).

   Aspect (GSI manual) the orientation of the downward sloping terrain is indicated by different colors, rotating from red (North) blue (West), to magenta (South) and yellow (East). This used as a base layer in maps. However, the red color show the Northwards direction where the Chambal river flowing. This areas show most of the Southwards, Northwards and Eastwards direction slope gradient (Figure 9) (B).

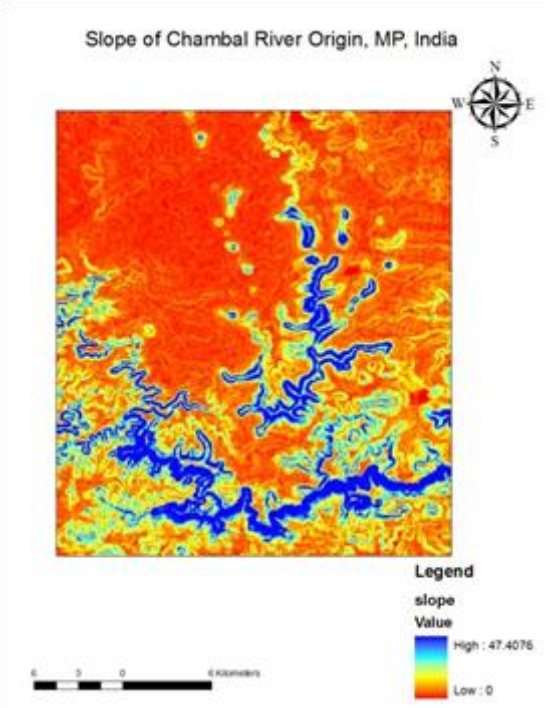

Figure 8: *Slope of Chambal River Origin*

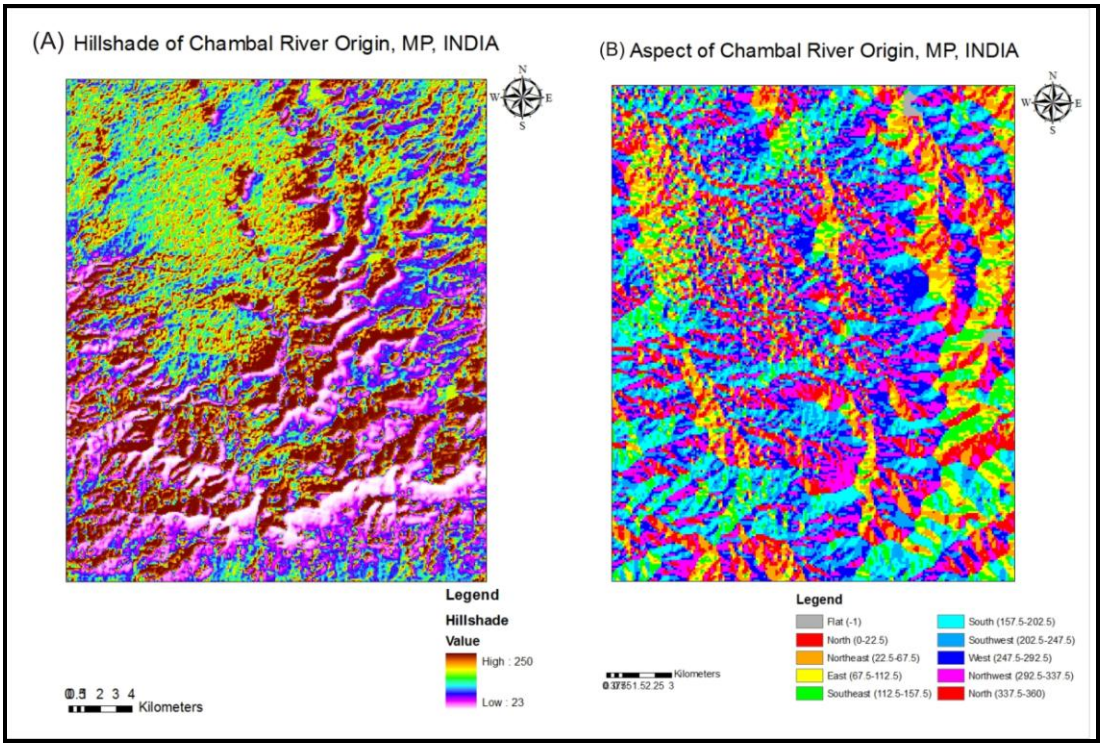

Figure 9: *Hillshade Map and Aspect Map of Chambal River Origin*

4) **Flow direction** map show the 8 adjacent cells in which water is flowing is also show the direction of gradient (Strahler, 1952), and this map shows the direction of flow in Northwards and Eastwards direction (Figure 10).

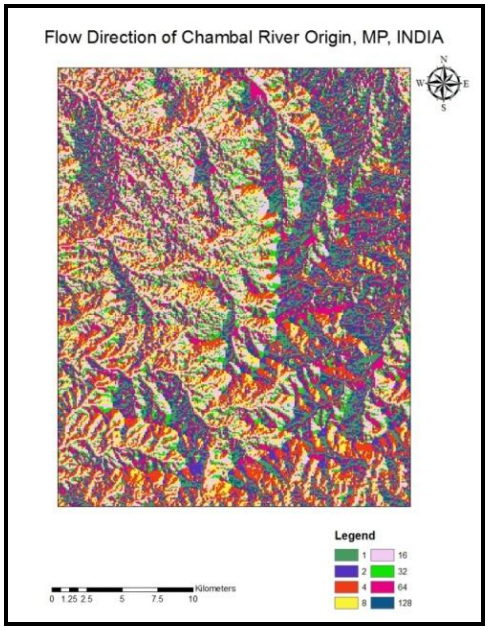

Figure 10: *Flow Direction Map of Chambal River Origin*

5) **Ground water flow direction** The Google Earth image shows the highest and lowest elevation point at Malwa ridge. On the basis of aquifer system of basalt which covers maximum area of around 47.36% in the western and south western parts of the state (CGWB, 2013). The water level depth of Chambal river origin area is 5 to 20m bgl. However, there is internal spring of groundwater which is flow from highest to lowest point, where, it shows the movement of groundwater flow from highest to lowest point in west-south-west (WSW) direction (CGWB, 2013). But because it's columnar joint characteristic of basaltic rock, the groundwater seepage from this ridge and follow the slop gradient and in this manure Chambal River formed in North direction (Figure 11).

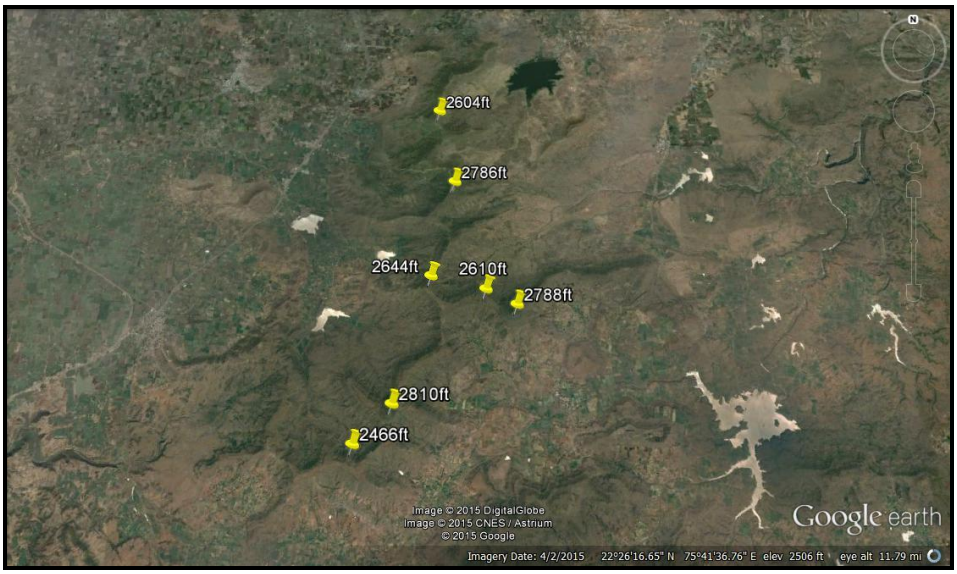

Figure 11: *Ground water flow direction*

6) **Rock Types of Chambal River Origin** The Basic rock types of Chambal River Origin area are Basaltic rock of Deccan trap formation in Malwa region. These rocks are characterized by compacted columnar joints and weak planes. The sheet rocks of basaltic in nature are found Janapav Valley to till Basai city in Mandsaur district in Madhya Pradesh. Some quartz patches and intercalation of quartz are found along the Chambal River near Gang Dhār city (Field observation data). According to Crawford (1969), the Chambal River valley is a part of the Vindhyan system which consists of massive sandstone, slate and limestone of perhaps Precambrian age, resting on the surface of older rocks. Hillocks and plateaus represent the major landforms of the Chambal Valley (Figure 12) (Lallanji et al., 2008).

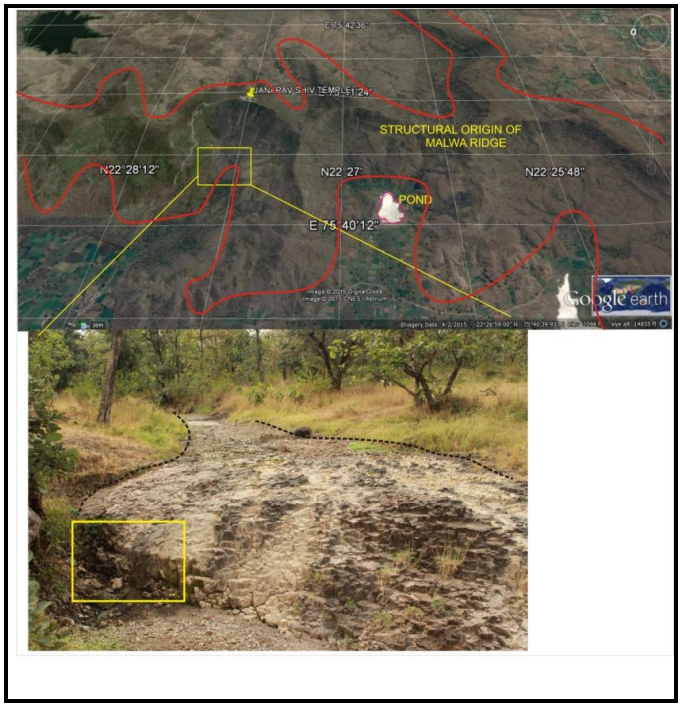

Figure 12: *Rock Types of Chambal River Origin*

Square Box in Photograph showing the Seepage of groundwater from the columnar joint of Basaltic Malwa ridge (Ground truth data photograph).

5. Conclusion

Chambal River is groundwater seepage formation which show the Chambal River is perennial and pollution free river which is great source of our hydrological water resources and settlement. Geomorphologic studies of Chambal river has been a great significance for deciphering extend of urban growth in landscape of the earth such as unstable hill slope with weak lithology and frequent slope failure and Remote sensing and GIS applications is so easy to access for its study of vast area and less time consuming. Alluvial riverine pattern of Chambal river which affected by frequent flood, are subsidence resulted by the tectonics. Seismology and the field observation of geomorphologic features is essential part of the Chambal River Origin research work. However, fluvial geomorphologic studies of Chambal River Basin is important as it is applied to water management, restoration, environmental changes, management of dams and water policy. Fluvial Geomorphology of the Chambal River is telling us about chronological history of river origin and landforms formation with different environmental conditions. The ravenous area of Chambal River is best suited for agricultural land by forestation and dam, canals; tunnel construction is preferred for watershed development resources.

Acknowledgements

The authors are thankful to Prof. Satyendra Singh, Head, Centre of Advanced Study, Department of Geology, and Banaras Hindu University for extending laboratory facilities. Pradeepika also acknowledge the financial assistance from DST–INSPIRE [IF 130386] New Delhi in the form a research fellowship.

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