GEOMORPHOLOGICAL AND LAND USE / LAND COVER STUDIES OF APRUPA WATERSHED BASIN: TALUKA SANGOLA,DISTRICT SOLAPUR, MAHARASHTRA"

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ABSTRACT

Evaluation of the morphometric parameters involves preparation of drainage networks maps ordering of the various streams, measurements of catchment area, perimeter, relative relief, and relief ratio, length of drainage channels, drainage density, drainage frequency, bifurcation ratio, texture ratio, circulatory ratio and constant channel maintainers which helps to understand the natures of the drainage properties of basin. Morphometric parameters could be used in many of the watershed based application like terrain analysis, delineations of geomorphological features, quantitative geomorphology, pedo-geomorphological studies, land degradation studies, watershed prioritization, calculating flow direction, calculating flow accumulation assessment of runoff and top soil loss, hydro geomorphology, estimate peaks runoff rate, delineation of groundwater potential zone, flood zone and mapping etc.

This study is carried out to evaluate the nature of the drainage basins and relationship with characters of the terrains and for deriving means to conserve and manage natural resources and combating natural hazards. The study is so used on lined, aerial and Relief aspects of the catchment area using geographic information system tools. In the present study GIS software are used to preparation of elevation map and base map of aprupa basin.

Keywords: Aprupa basin, watershed, Morphometric analysis, LULC, GIS

INTRODUCTION

Geomorphology is literally the study of the form or shape of the Earth, but it deals principally with the topographical features of the Earth's surface. It is concerned with the classification, description, and origin of landforms. Geomorphology is closely allied with a number of other scientific disciplines that are concerned with natural processes. Many systems of classifying landforms have been devised since the late 19th century. Some systems describe and group topographic features primarily according to the processes that shaped or modified them. Others take additional factors into consideration (e.g., character of the surface rocks and climatic variations) and include the developmental stage of landforms as an aspect of their evolution over geologic time.

Geomorphology is the scientific discipline concerned with the description and classification of the earth's topographic features. Earth-surface processes are forming landforms today, changing the landscape, albeit often very slowly. Most geomorphic processes operate at a slow rate, but sometimes a large event, such as a landslide or flood, occurs causing rapid change to the environment, and sometimes threatening humans. The different climatic environments produce different suites of landforms.

The methods of quantitative analysis of drainage basin was developed by Horton and modified by strahler in conventional means but recently geographic information system and satellite remote sensing is a complete tool to analyze to update and to correlate the measurement with periodic changes. Therefore, the results are more realistic and the time consuming. This study is to evaluate the nature of the drainage basins and relationship with characters of the terrains and for deriving means to conserve and manage natural resources and combating natural hazards. The study is soused on linear aspects and LULC of the catchment area using geographic information system tools. Geographic information system (GIS) are and Remote sensing have prove to be efficient tools in delineation of drainage patterns and water resources planning. Geographic information systems (GIS) has been widely used in several geomorphologic, morphometric, flood management, and environmental application (eg .Dawod and Mohamed , 2009 , EI Bastawesy et al , 2010, Rao et al , 2010 , Dawod and Mahamed , 2008 and Dongquan et al , 2009) .

Evaluation of the morphometric parameters involves preparation of drainage networks maps ordering of the various streams, measurements of catchment area, perimeter, relative relief, and relief ratio, length of drainage channels, drainage density, drainage frequency, bifurcation ratio, texture ratio, circulatory ratio and constant channel maintainers which helps to understand the natures of the drainage properties of basin. Morphometric parameters could be used in many of the watershed for application like terrain analysis, delineations of geomorphological features, quantitative geomorphology, pedo-geomorphological studies, land degradation studies, watershed prioritization, calculating flow direction, calculating flow accumulation assessment of runoff and top soil loss, hydro geomorphology, estimate peaks runoff rate, delineation of groundwater potential zone, flood zone and mapping etc

OBJECTIVES

- Geomorphological study of the basin.
- To evaluate the watershed characteristics of the study area.
- To study drainage pattern and its influence on hydrology.
- To study the Land Use / Land Cover pattern of the study area.

STUDY AREA

The study area covered 230 sq. km. the upper aprupa watershed basin is in sangola,taluka of Solapur,district 450 km SE of Mumbai , 260 km S of Pune , 180 km from Kolhapur , 100 km from Solapur city . Part of S.O.I. Toposheet 47 O/3, 47 O/4, 47 O/7, 47 O/8, Bounded by N Latitude 17º10'-17º 24' ,E Longitude 75º12'-75º20'. Covering the villages Alegaon, Digewadi,Ambewadi,Medsinghi,waghma,Shirshi,shindewadi,Gheradi,waki,dikhsal,pare,sutarwadi,chavanwadi which is found almost to be dry throughout the year, excepting for surface water flow for few days in a year during rainy season (fig.no.-1).

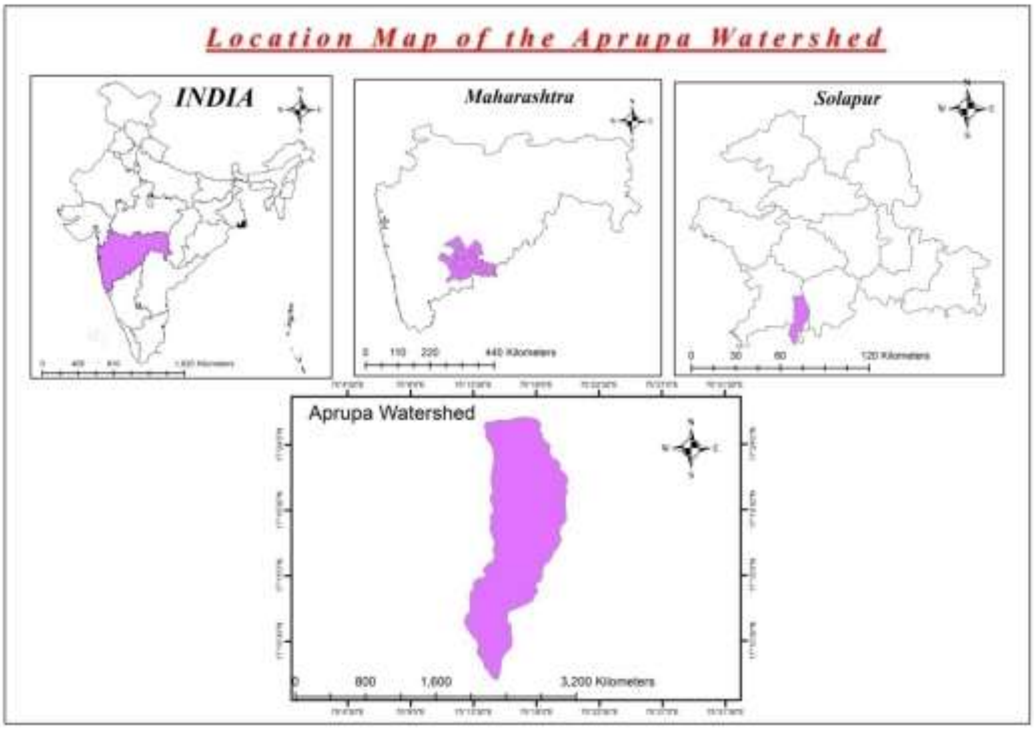

Fig no 1- Location map of the study area

Geology of the study area

From the accompanying map showing the regional geological setting, it will be seen that the area includes Deccan trap lava flows and they have assumed a great importance in Indian stratigraphy because of the great variety of rock types, complex structural features.

The study area shows the basaltic lava flows which represent the peripheral portions of the Deccan traps. They occupy the western, central and southern India. The Deccan traps are the most extensive geological formations of the Indian peninsula, ranging in age from upper cretaceous to Oligocene (Krishnan, 1968). The traps are divided into three main divisions, viz the upper, the middle and the lower with the inter –trapping beds at the base . They are generally composed of fine grained compact basalts which at places are vesicular and amygdaloidal, amygdales containing secondary minerals like zeolites and different from the silica. However, in some places the basaltic flows are intercalated with ash beds, volcanic breccia's and acid and intermediate differentiate like rhyolites and andesite, Deccan traps considered to be theolelitics plateau basalts.

METHODOLOGY

Data analysis in Geographical Information System (GIS):

The order was given to each stream by following Horton (1969) stream ordering technique. The parameters like the number and length of stream of each different orders, drainage area, basin perimeter and basin length were calculated using Arc Gis software (10.0). From the above parameters drainage density drainage frequency, shape, form factor, circulatory ratio, elongation ratio etc. we calculated. The methodology adopted for the compotation of morphometric parameters is given below. With the help of covers ion tools in the Arc tool box; the data is converted into raster to vector form. Coverage tools and personal geodatabase tools were used in the area to estimate stream length. Topology tool was used to edit he line errors like polygon, point and node of overlapping and gap for accuracy. With the help of data management tools projection and transformation was made by registering of raster image with satellite image and topographical map. After this process bifurcation ratio, form factor, elongation ratio, drainage density, drainage frequency, steam frequency and drainage texture were analysed. The drainage basin analysis was arried out quantitatively aspects wise such as linear aspects, aerial aspect and relief aspect. I the linear aspects, stream order stream length, bifurcation ratio, mean stream length, stream length ratio and mean stream length ratio were analysed. In aerial aspect Basin area, drainage density, drainage frequency, infiltration number, drainage texture, form factor ratio, elongation ratio, circulatory ratio was calculated. In relief aspects basin relief, relief ratio, dissection Index, channel gradient and basin slope were analysed. The method of calculation and the procedure involved in estimating each parameter is briefly descried.

Toposheets:

The study area falls in the survey of India (SOI) toposheet no 47 O/3, 47 O/4, 47 O/7, 47 O/8.

Morphometric analysis:

According to Clarke (1966), morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimension of its landform. The morphometric analysis is carried out through measurement of linear, aerial and relief aspects of the basin and slope contribution.

Linear Aspects:

Linear aspects of basin are related to the channel pattern of drainage network where in topological characteristics of stream segment are analysis. The drainage network which consist of all the segments of stream of a particular river, is reduced to the level of graphs, where stream junction acts a points (junction) become links or lines where in the number of all segment are counted their hierarchical order are determined, the length of all steam segments area measured and their different inter relationship are studied (table 2.1).

Linear aspects include the measurement of linear features of drainage such as stream order, Mean stream length, stream length ratio, bifurcation ratio, mean bifurcation ratio, stream length, length of overland flow, basin parameter, basin length.

Stream order:

The first step in drainage basin analysis is designation of stream orders, following a system introduced into the United State by Hoston (1956) and slightly modified by strahler (1964) assuming that one has available drainage network map including all intermittent and permanent flow lines located in clearly defined villages, the smallest tributaries are designated as order 1. Where two first order channels join, a channel segment of order 2 is found and so fifth. After the drainage network elements have been assigned their order numbers the segment of each order are counted to yield the number Nu of segments of the given order u. The stream order is a measures of the degree of stream branching with in a basin.

Stream number:

The count of stream channel in its order is known as stream number. The number of stream segments decreases as the order increases. The higher amount stream order indicates lesser permeability and infiltration. It is obvious that the number of stream of any given order will be fewer than for the net lower order but more numerous than for the next higher order. The number of stream decreases as the stream order increases. The stream number shows stream number usually decreased in geometric progression as the stream order increase. In the present study the order wise stream numbers estimated are given in the table no 1.

Stream lengths:

Mean stream length (Lsm) of a stream channel segments of order u is a dimensional property revealing the characteristics size of components of a drainage network and its contributing basin surfaces. Channel length is measured with the help of Arc GIS software directly from the stream order map. To obtain the mean stream length of channel (Lsm) of order u, the total length is divided by the number of streams segment Nu of that order; thus.

Lsm=Lu/Nu

Where, Lu= Total stream length of all orders ,Nu= Total number of stream of all orders

The mean stream length is presented in table. It is seen that Lsm value exhibits variation from 0.68 to 28.99. It is observed that Lsm values of aprupa watershed basin indicate that Lsm of the given order is greater than that of the lower order stream length shows linear graph when plotted against stream order which shows stream number usually decreases in geometric progression as the stream order increases.

Table no.1- Illustrates the morphometric parameter from the study area

Sr No.	Morphometric Parameter	Formula	References	Values Obtained for Aprupa Nala Basin				
1	Stream Order and their no.	Hierarchial Rank	Strahler 1964	I	II	III	IV	V
				493	101	20	5	1
2	Total Stream length in each order	Hierachial Rank	Strahler 1964	I	II	III		IV
				333.34	103.59	63.67	18.05	28.99
3	Mean Stream Length(Lsm)	LSM=Lu/Nu Where LSM=Mean Stream Length Lu=Total stream Length of order 'u' Nu=Total no.of stream segments of order'u'	Strahler 1964	I	II	III	IV	V
				.68	1.02	3.68	3.61	28.99
4	Basin Length(Lb)	Total length of the Basin	Horton 1945	35.03 Km				
5	Stream Length Ratio(RL)	RL=Lu/Lu-1 Where,RL=stream Length Ratio Lu=Total stream length of orders 'u' Lu-1=Total stream length of its next lower order	Horton 1945	II/I	III/II	IV/III		V/IV
				.31	.61	.28		1.7
6	Bifurcation Ratio(Rb)	Rb=Nu/Nu+1 Where,Nu=total no.of stream segments of orders 'u' Nu+1=Number of Segments of next higher order	Schumm 1956	I/II	II/III	III/IV		IV/V
				4.84	4.8	3.34		2.5
7	Mean Bifurcation Ratio(Rbm)	Rbm=average of Bifurcation Ratios of all orders	Strahler 1957	3.10				
8	Drainage Density (D)	D=Lu/A Where,D=Drainage Density Lu=Total Stream length of all orders A=Area of Basin	Horton 1932	2.37				
9	Stream Frequency(Fs)	Fs=Nu/A Where, Fs=Stream frequency Nu=Total no of streams of all orders A=Area of basin	Horton 1932	2.69				

10	Drainage Texture(Rt)	Rt=Nu/p Where,Rt=Drainage Texture Nu=Total no. of stream segments of order ‘u’ P=Perimeter(Km)	Horton 1945	7.44
11	Circularity ratio(Rc)	Rc=4×π×A/p2 Where,Rc=Circularity Ratio π =Pi value i.e.3.14 A=area of Basin P2-perimeter square	Miller 1953	0.41
12	Elongation Ratio(Re)	Re=√(A/π)/Lb Where,Re=Elongation Ratio A=Area of Basin π =pi value i.e 3.14 Lb=Basin Length	Schumn 1956	0.24
13	Form Factor		Strahler 1968	0.18

Mean Stream Length:

According to Strahler (1964), the mean stream length is a characteristics property related to the drainage network and its associated surface. The mean stream length (Lsm) has been calculated by dividing the total stream length of order ‘u’ and number of stream of segment of order ‘u’.

It is calculated by the formula

Mean Stream Length (Lsm) = Lu / Nu

Where, Lu = Total stream length of Order ‘u’, Nu = Total no. of stream segment of order ‘u’.

Stream length ratio:

Stream length ratio is defined as the average length of stream of any order to the average length of stream of the next lower order and it is expressed as

Rr= Lu/Lu-1

Where Lu= Total stream length of all orders,Lu-1= Total stream length of its next order.

The length ratio in the basin area is ranging from 0.31 to 1.7.

Bifurcation ratio:

The bifurcation ratio (Rb) is defined as the ratio of number of the stream segments of given order to the number of segments of the next higher order (scheme, 1956)It is calculated by Rb=Nu/Nu+1

Where Rb= Bifurcation ratio,Nu= Total number of streams of all order ,Nu + 1= Number of segment of next higher order.

Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment except where the power full geological control dominates. Bifurcation ratios characteristically range between 2.5 to 4.84 for watersheds in with the geologic structure do not distort the drainage pattern (Strahler 1964). Bifurcation ratio is mainly controlled by the basin shape and is not only influence the landscape and morphometry but also control the surface runoff.

Mean Bifurcation Ratio:

The mean bifurcation ratio may be defined as the average of bifurcation ratio of all orders and all sub – watershed fall under normal basin category (Strahler, 1957).

Mean bifurcation Ratio (Rbm) = Average of bifurcation ratio of all order = 3.10

Ruggedness number (Rn)

It is the product of maximum basin relief (H) and drainage density (D), where both parameters are in the same unit. An extreme high value of ruggedness number occurs when both variables are large and slope is not only steep but long as well (Strahler,1956). The result shows that the study area is extremely rugged with stream density.

Aerial Aspect:

Arial aspects (Au) of a water shed of given order u is defined as the total area projected upon a horizontal plane contributing overland flow to the channel segment of the given order and includes all tributaries of lower order. Area of basin (A) and perimeter (p) are the most important parameters in quantitative morphology. The area of basin is defined as the total area projected upon a horizontal plane contributing to cumulate of all order of basins. Perimeter is the length of the boundary of the basin which can be drawn from topographical maps. The aerial aspects of the drainage basin such as drainage density (D), stream frequency (Fs), Drainage texture (Te) elongation ratio (Re), circulatory ratio (Rc), were calculated and results have been given in table no 1.

Drainage Density:

Horton (1932), introduced the drainage density (D) is an important indicator of the linear scale of land form element in stream eroded topography. It is the ratio of total channel segment length cumulated for all orders within a basin area, which is un pressed in term of mil/sq. Mi or km/ sq. Km. It is expressed as.

Dd=Lu/A

Where, Dd= drainage density,Lu= Total stream length of all orders,A= Area of basin (km^2)

The drainage density indicates the closeness of spacing of channels, thus providing quantitative measures of the average length of stream channel for the whole basin. It has been observed from drainage density measurement made over a wide range of geologic and climatic types that a low drainage density is more likely to occur in region of highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. High drainage density is the resultant of weak or impermeable sub surface material, sparse vegetation and mountain relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (strahaler 1964). Drainage density is controlled by the type of formation in the basin areas with impervious formation will have higher drainage density than those with pervious formations (Gokhle, 2005). In the study area Drainage density is 2.37. The drainage density is governed by the factor like rock type, run off intensity, soil type, infiltration capacity and percentage of rocky area(fig.no.2).

Drainage pattern:

In the watershed, the drainage pattern reflects the influence of slope, lithology and structure. Finally, the study of drainage pattern presents some characteristic of drainage basins through drainage pattern and drainage texture. It is possible to deduce the geology of the basin, the strike and dip of depositional rocks, existence of faults and other information about geological structure from drainage patterns. Drainage texture reflects climate, permeability of rocks, vegetation and relief ratio etc. The drainage pattern of the study area shows dendritic to sub parallel in nature.

Form Factor Ratio*:*

Form factor may be defined as the ratio of the area of the basin and square of basin length (Horton, 1932). It can be formulated by

Rf = A / L

Where Rf = Form Factor,L = Total length of basin.,A = Area of basin.

The value of form factor would always be greater than 0.78 for perfectly circular basin. Smaller the value of form factor, more elongated will be the basin. The form factor of the study area is 0.18

Circulatory Ratio:

The circulatory ratio is mainly concerned with the length and frequency of stream, geological structure, land use / land cover, climate, relief and slope of basin. It is the ratio of the area of the basins to the area of circle having the same circumference as the parameter of the basin (Miller, 1953). It can be expressed as

$Rc = 4\pi A / P2$

Where Rc = Circulatory Ratio.,A = Area of basin.,P = Perimeter of basin.

It is the significant ratio which indicate the stage of dissection in the study region. Its low, medium and high value are correlated with youth, mature and old stage of the cycle of the tributary watershed of the region and the value obtained. The circulatory ratio of the study area is 0.41.

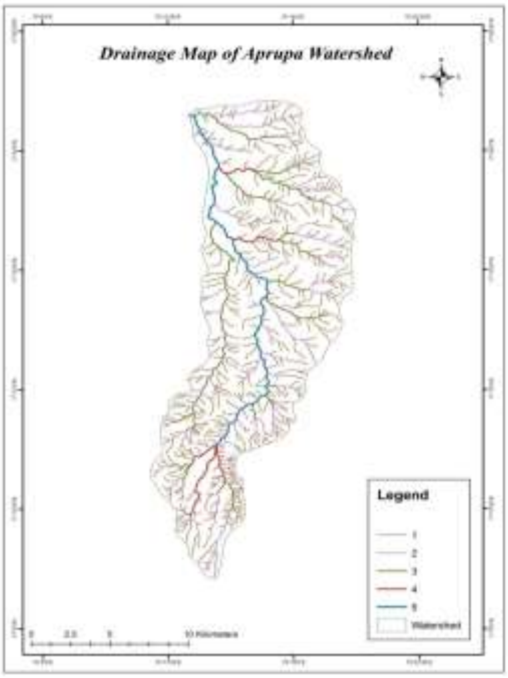

Fig. no.2- Illustrates the drainage map of watershed basin

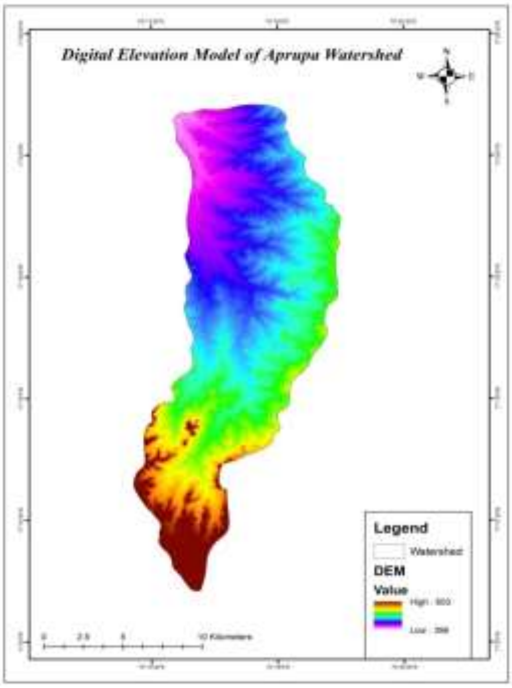

Fig. no.3-Illustrates the digital elevation model of aprupa the study area

Land Use / Land Cover Analysis: -

The Land Use and Land Cover map of the study area. The total area under study is 230 sqkm, contain total built up coverage at about 2.30sqkm. High concentration of settlement situated in Gheradi and Pare which covers West side of the study area. The water bodies that are present in the study area are Pare Lake, Jawala Lake and Waki Lake which covers area 1.18 sqkm. Which is situated in North direction of the map and. Agricultural land occupies 143.63 sqkm,barren land occupies 84.72 sqkm.(Fig. no.4).

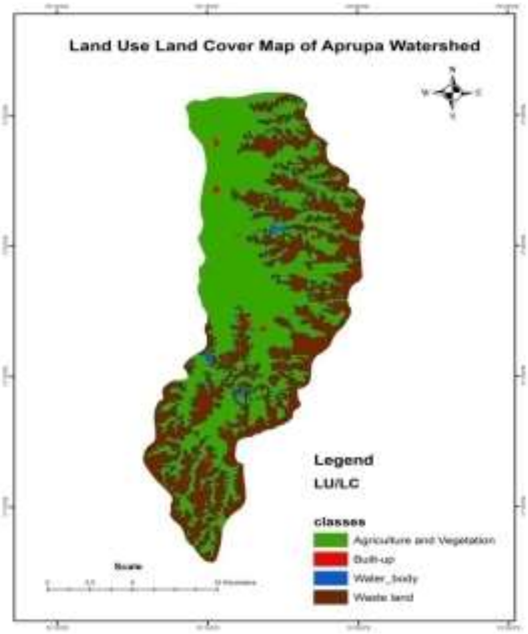

Fig. no.4-Illustrates the LU/LC map of the study area

CONCLUSION

The study reveals that Toposheet data and GIS based approach in evaluation of drainage morphometric parameters and their influence on landforms, drainage characteristics at Watershed basin level is more appropriate than the conventional methods. GIS based approach facilitates analysis of different morphometric parameters and to explore the relationship between the drainage morphometry and properties of landforms. The morphometric analyses were carried out through measurement of linear,areal aspects of the watershed with morphometric parameters.GIS study allows reliable most accurate and most updated database on land resources. It has also been very useful in deriving geomorphometric parameters. In the present study GIS software are used to preparation of Base map, elevation map and base map of aprupa watershed basin.

Aprupa watershed basin is fith order elongated basin which shows dendritic and sub parallel drainage pattern with extremely rugged with stream density.The Land Use and Land Cover map of the study area shows agricultural land occupies 143.63 sqkm, barren land occupies 84.72 sqkm.

Geological and geomorphological aspects supports the formation of soils like – embryonic soils such as Clayey and Loamy. Fracture filling carbonates noticed in the highly dissected plateau in upper reaches prohibit infiltration of rainwater. The soils in the plains of the aprupa watershed basin are prone to saline and alkaline in nature.

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