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A study on hydogeomorphological status of kadalundi river basin in kerala using geospatial technology

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***Abstract*---**Detailed hydro geomorphologic study has been carried out for Kadalundi River Basin in Kerala to understand the drainage pattern, spatial and temporal water availability using secondary data collected from different Departments. Geomorphological parameters have been estimated as a part of this study and it is found that Kadalundi river basin is a sixth order stream. The drainage pattern is complex with considerable variation in spatial arrangements, which are controlled by topography, slope, rock type and structural deformations. The basin is characterized by dendritic type of drainage pattern with variable density. The densest dendritic pattern is developed on the hard Charnockite and Gneissic rocks. In some areas, the drainage pattern is sub dendritic reflecting structural control. The existing land use pattern is derived from Indian Remote Sensing Satellite (IRS – LISS II1, P6) using ERDAS software. Using hydrological toolset of Spatial Analyst, an extension of ArcGIS software, slope map, aspect map and Digital Elevation Model (DEM) have been derived. In addition, the basic thematic map on geology and soil also been derived.. For annual period, the rainfall varies from 1800- 4100 mm, 1400- 2600 mm for South –West monsoon period and 600-1100 mm for the North-East monsoon period. About 94% of the annual discharge flows during the monsoon period and only 6% during the lean flow period. Although the normal annual rainfall is very high, a major portion of it is confined to 3-4 months in a year, leaving the rest of the year practically dry. Because of the unique geological and hydrogemorphological characteristics of Kadalundi River Basin, the Malappuram District of Kerala experiences severe water scarcity during non monsoon period. This hydro-geomorphological studies for Kadaluindi River Basin in GIS platform will be useful for planners and decision makers in establishing integrated river basin plan for Kadalundi River. The thematic layers derived using GIS can be adopted to evolve sustainable plan for optimum development of the land and water resources of this River Basin.

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Keywords---Hydro geomorphology , dendritic pattern, spatial and temporal variation.

Introduction

The nature of stream flow in a region is a function of the hydrologic input and the physical, vegetative and climatic characteristics of that region. The description of the geometric aspects of a watershed in quantitative terms is an important factor in hydrology and can be traced back mainly to the efforts of Hortan (1926) ,Langbein (1947) and Strahler (1952). To quantify the geometry of a river basin, the fundamental dimensions of length, time and mass are used. Many river basin features that are important to the hydrologists can be quantified in terms of length, square of length or cube of length. Examples are elevation, stream length, basin perimeter, drainage area etc. A classification of watersheds based on stream orders was introduced by Horton, which was later modified by Strahler (1952). There are certain laws governing stream numbers, stream length, basin area and relief characteristics (Horton 1945 and Morisawa 1968). The hydro geomorphology of Kadalundy river, one of the west flowing river of Kerala is different from other rivers and studied in detail here.

General features of kadalundy river basin
The Kadalundi river is formed by the confluence of its two main tributeries, the Olipuzha and the Veliyar. The Olipuzha takes its origin from the Cherakkombhanmala and the Veliyar tributary from the forests of Eratakombanmala. The total length of the river is 130 Kms, with a drainage area of 1099 sq. kms (Yasodharansuresh and Bindu 2015; Bindu & Jayapal 2016; 2017; 2019). The river flow towards Chaliyar and joins into the Arabian Sea at about 5 Kms south of Chaliyar river. The Pooraparamba river, a small stream, is also included in this basin, as its length is only 8 kms with a drainage area of 23 sq.km. The estuaries is situated in Kadalundi and Vallikunnu panchayats. The total drainage area of the basin is 1122 sq. km. Fig. 1 shows the location map of Kadalundi River Basin.

Method

The boundary, drainage and contour (20 m interval) have been digitized from SOI toposheets of scale 1: 50,000 using ArcGIS 10 software and stream ordering has been done following the laws established by Strahler (1964). In order to find out the spatial and temporal surface water availability, the rainfall and streamflow data from Water Resource Department, Govt of Kerala have been used. In addition, the river gauging data of Karathode station maintained by Central Water Commission also has been used.

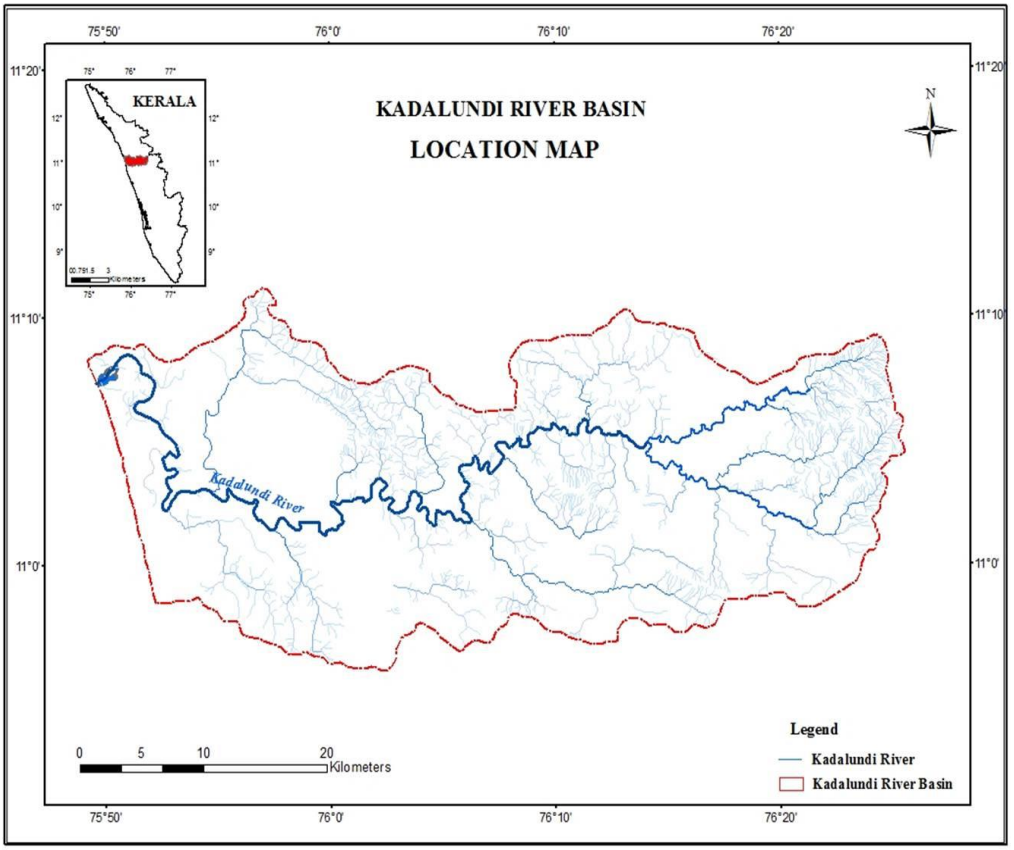


Fig 1 : Location map of Kadalundi River Basin

Apart from the information derived from GTS toposheets, satellite images (IRS – LISS II1, P6) are used to derive the present landuse information of Kadalundi river basin . Based on the data derived from both GTS and Satellite images the landuse map has been derived

Data layer generation

A geographic database is a collection of spatially referenced data that acts as a model of reality. From the digitized contour map, the DEM, slope, aspect map have been derived using ArcGIS software. Figs 2, 3,and 4 shows the DEM, Slope and Aspect map respectively. Land use map from IRS data is derived using ERDAS software and is given in Fig 5.Geology, Soil and physiography map derived using secondary data are shown in Figs 6 ,7 and 8. ,Topographically this region exhibit undulating terrain with steep slope (Fig 3). The ground elevation ranges from 0 MSL to 1200 MSL within the basin length of 60 km (Fig 2). Based on the physiographic condition, the study area comes under three well defined natural divisions – low land, mid land and high land (Fig 8).

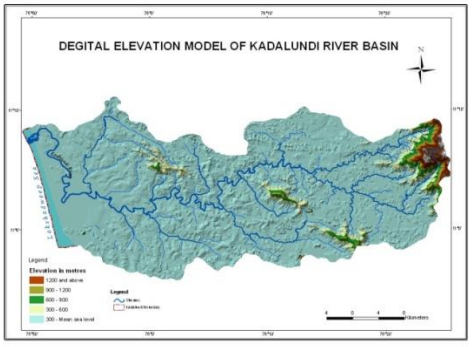


Fig 2

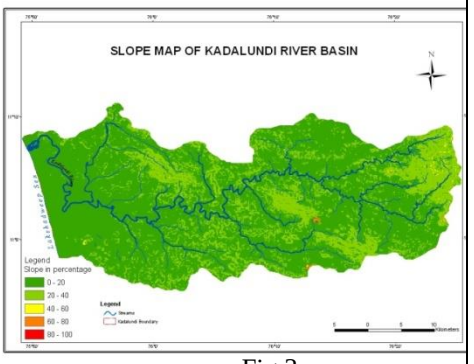
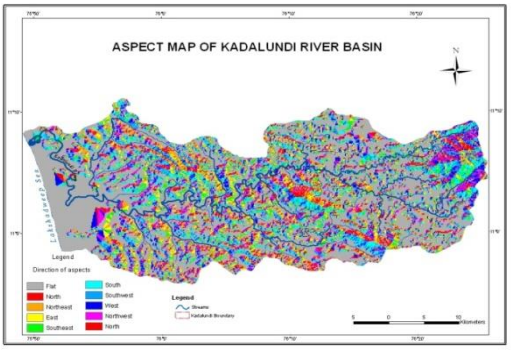


Fig 3



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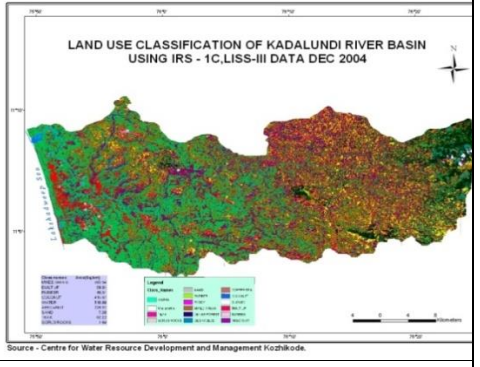

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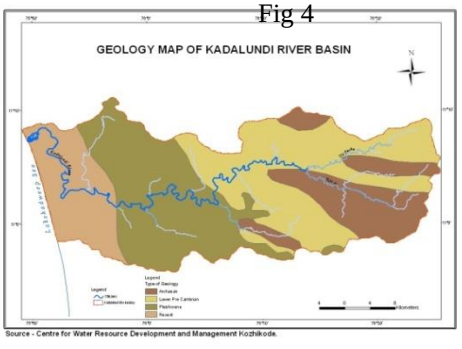

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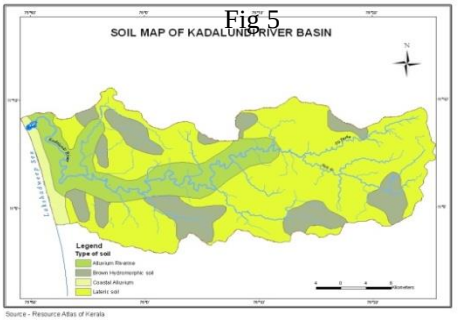

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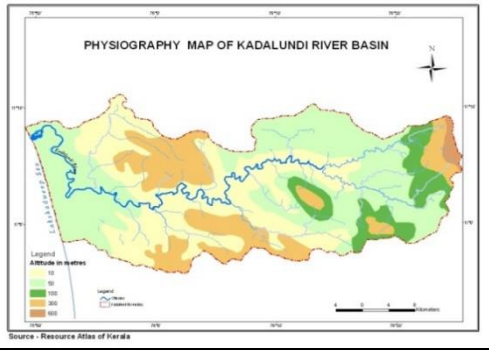

Fig 8

Result and discussion

Geomorphological Studies of Kadalundi River Basin

Table 1
Morphometric Parameters and Their Mathematical Expressions

Sl. No	Morphometric parameter	Mathematical expression	Description
1	Bifurcation ratio (Rb)	$R_b = \frac{N_u}{N_{u+1}}$	Rb was computed as the ratio between the number of streams of any given order to the number of streams in the next higher order
2	Cumulative length of streams, L	$L = \sum N_u$	L was calculated as the number of streams in each order and total length of each order was calculated at sub basin level
3	Basin relief, B_h	B_h=h_{max}-h_{min}	B_h was defined as the maximum vertical distance between the lowest and the highest points of a sub basin
4	Ruggedness number, Rn	R_n=B_hxD_d	Rn was calculated as the product of the basin relief and its drainage
5	Drainage density,D_d	D_d=$\frac{L}{A}$	D_d was measured as the cumulative length of stream channel per unit area of drainage basin
6	Stream frequency, Fs	$F_s = \frac{\sum N_u}{A_u}$	Fu was computed as the ratio between the total number of streams and area of the basin
7	Texture ratio, T	$T = \frac{N_1}{P}$	T was estimated as the ratio between the number offirst order streams and perimeter of the. basin
8	Elongation ratio, Re	$R_e = \frac{2\sqrt{\frac{A}{\pi}}}{L_b}$	Re was computed as the ratio between the diameter of the circle having the same area as that of basin and the maximum length of the basin
9	Form factor, Rf	$R_f = \frac{A_u}{Lb^2}$	Rf was computed as the ratio between the basin area and square of the basin length
10	Constant of Channel maintenance, C	$C = \frac{1}{D}$	C is expressed as the inverse of drainage density

The geomorphological analysis of drainage basin includes the quantitative measurement of the drainage basin charecteristics and their expressions in numerical terms to evaluate the drainage system. The morphometric parameters like basin area, perimeter of basin, maximum length has been worked out by direct measurements while the parameter like bifurcation ratio, drainage density, stream frequency, circulatory ratio etc., have been worked out by mathematical expressions as shown in Table1. The Kadalundi river basin is taken as a whole for the study.

Linear Aspects

Stream order analysis shows that the main stream of Kadalundi is sixth order. Table 2 shows the linear aspects such as stream order, stream number, lengths, bifurcation ratio and cumulative length of the sub basins and relief parameters basin height, channel gradient and ruggedness ratio.

Table 2
Linear Aspects of Kadalundi Basin

Basin	Total Drainage Area (Sq.Km)	Stream Order	Stream Number	Stream Length (Km)	Bifurcation Ratio
Kadalundi	1122	1	1041	662.5	-
		2	269	219.7	3.01
		3	61	145.6	1.50
		4	14	108.2	1.34
		5	2	40.3	2.68
		6	1	98.5	0.40

Areal Aspects

The aerial aspects are estimated on the basis of S.A. Schumn (1956). The parameters considered for the study are basin area, perimeter, drainage density, stream frequency, circularity ratio, and constant of channel maintenance. (Table 3) shows the computed values of areal aspects of Kadalundi river basin.

Table 3
Areal aspects of Kadalundi Basin

Basin	Kadalundi
Area (Sq.Km)	1122
Perimeter (Km^2)	192
Drainage Density	1.13
Elongation Ratio	0.60
Form Factor	0.31
Circularity Ratio	0.38
Stream Frequency	1.23
Infiltration Number	1.38
Length of overland flow	0.44
Shape Factor	0.88
Constant of Channel Maintenance	0.88

Relief Aspects

Table 4 shows the Relief aspects of Kadalundi river basin. The relief aspects such as Chaneel gradient, relief ratio, relative relief etc are derived using mathematical expressions.

Table 4 – Relief aspects of Kadalundi Basin

Channel Gradient (m)	18
Maximum Basin Relief (m)	1190
Relief Ratio	619
Relative Relief	31.25
Ruggedness Number	1053.09

Hydrological Studies of Kadalundi River Basin

Rainfall

Five rain gauge stations (Karuvakundu, Perinthalmanna, Anakkayam, Malappuram and Tirurangadi) were identified representing all the physiographic regions of Kadalindi river basin. Fig 9 shows the locations of raingauge and discharge stations in Kadalundi river basin.

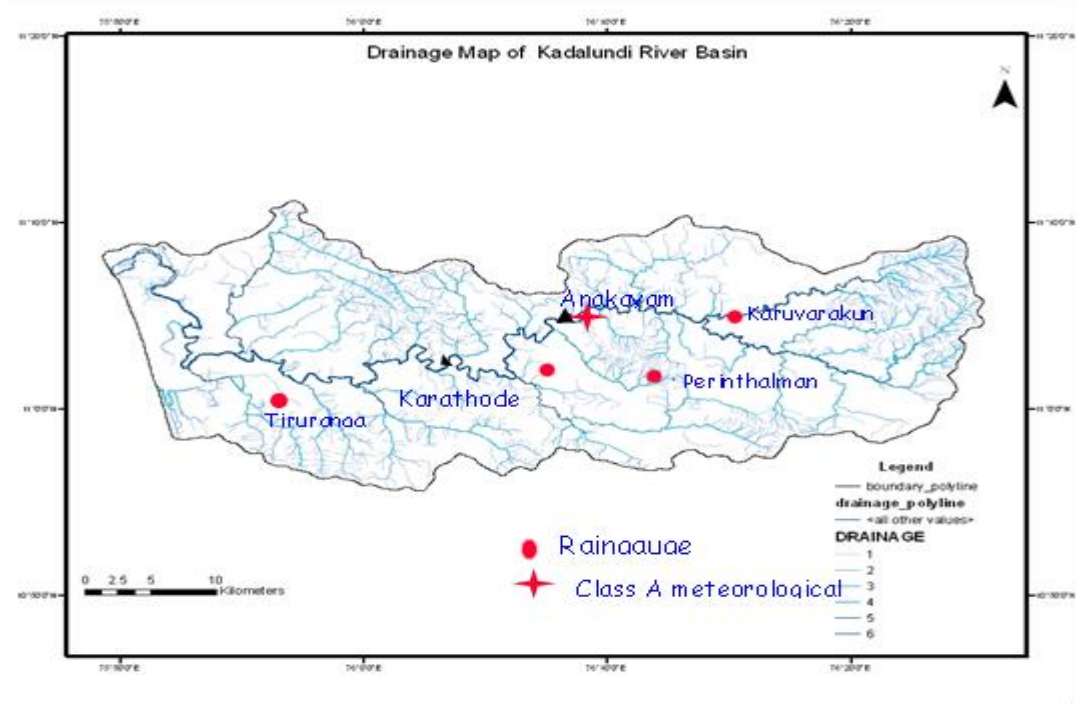

Fig 9 . Rainguage and disharge stations of Kadalundy river basin

The two monsoons southwest and northeast have a good impact on the climate of the basin. About 65 to 70% of the rainfall is contributed by southwest monsoon during June to August. The northeast monsoon, which is uncertain, strikes in October and continues till November. It contributes 20 to 25% of the annual

rainfall. 10 to 15% of the rainfall is received during January to May as summer rains. The rainfall data shows the pattern of heavy downpour during June to September, occasional showers during October to November and a prolonged dry spell from December to May. In general there is a decreasing trend in rainfall towards the south and south western tracts of the river basin. The average annual rainfall varies from 2136 mm to 2748 mm. The yearly distribution of rainfall in Kadalundy river basin is not very even and balanced. The highest rainfall occurs in the highland region and its year to year changes and disparity is not so obvious .The frequent drought in the basin results from the uneven distribution of seasonal rainfall and year to year disparity. The annual isohyetal map derived using ArcGIS software and is given in Fig 10.

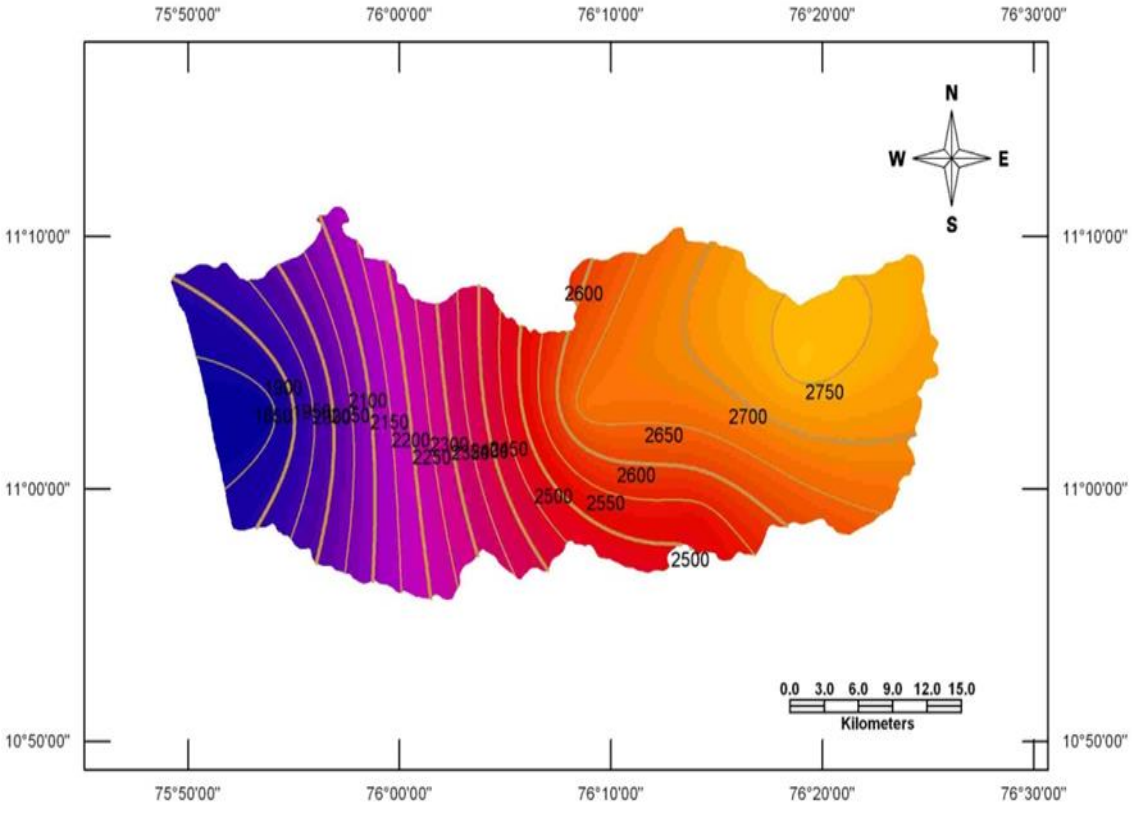

Fig 10 . Isohytal map of Kadalundi river basin

Stream Flow Analysis

The runoff data of Anakayam, the Karathode data were made use of for the analysis. In each year there are two distinct peak periods generally occur and peak discharge is in South west monsoon. The average annual runoff of Kadalundi river basin is 1279 MCM in which 1243 MCM is receiving during monsoon period the remaining 36 MCM during non monsoon period

Flow Duration Curves

Flow duration curves for Anakkayam and Karathode sites were drawn for the summer months (Dec-May) and dependable flows were estimated. Table 5 shows the 50 % , 75 % and 90 % dependable flows for Anakkayam and Karathode sites and .It is seen from the graphs, 75 % and 90 % of time, the there is no river flow during Feb – May at Karathode station.

Table 5
Dependable flows(MCM) of Karathode station

Months	50% dependable		75% dependable		90% dependable	
	Anakkayam	Karathode	Anakkayam	Karathode	Anakkayam	Karathode
December	21	15	10	12	5	1.5
January	13	3.4	5	0.8	3	0.1
February	5.9	0	2.5	0	0.57	0
March	3.5	0	0.75	0	0.44	0
April	1.34	0	0.68	0	0.2	0
May	6.45	3.5	2.87	0	1.3	0

Conclusion

The Kadalundi river basin is charecterised by dendritic type of drainage pattern and is sixth order stream. Even though the drainage density for the river basin as a whole is low, but in the eastern and north eastern part of the basin is having very high concentration of drainage network which indicates the mountainous terrain of that region. But towards the mouth of the river, it travels through plain area. Because of the geological and soil structure, rate of ground water peneteration is very low. But some portion of midland and entire low land regions in the basin are suitable for ground water exploration. Geomorphologically the Kadalundi river basin have a combination of marine and fluvial originated landform distribution. Hydrogeomorphological features such as structural hills, Alluvial plains, flood plains, beaches, coastal areas etc can be identified in this region. Hydrologically Kadalundi is very rich and self sufficient in water resources, but due to the physical, geological and soil condition the ground water exploration is difficult resulting in drought conditions. Apart from the hydrogeomorphological and environmental importance, Kadalundi is also famous for the ecotourism aspects near the mouth of the river. It is seen that the non monsoon runoff is only 3 % of total flow . This is due to the unique geomorphology and geological conditions of the river basin. The other adjacent river basins the non monsoon flow is about6-8 % of the total.

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