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A Classification System for Streams and Watersheds in Rivers of Kerala for Effective Watershed and River Basin Management: A Case Study in Chalakkudy River

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Abstract

The paradigm shift of natural resource management had been shifted to watershed based in the early 1970s in Kerala, but the conceptual and ecological shift for integrated watershed management assimilating the concept is still ambiguous. The Watershed Atlas and classification of the 44 rivers into small watersheds of 500ha, i.e. Microwatersheds is the main document used. It is imperative that the area alone not determine the property of a watershed but is determined by the factors such as topography, slope, rainfall ultimately the drainage density. A micro watershed in a flood plain is entirely different from a watershed with the same area in hilly terrain. The streams were mapped for the Chalakkudy River and categorised into its orders (1st order, 2nd order etc.) All the tributaries were numbered clockwise manner, and each stream was classified with a letter indicating order and numbered. Hence, properties of the stream can be obtained from the code indicating the stream order and number. This is proposed as an addition to the classification of each micro watershed in the river basin for an effective landscape – river basin – watershed level resource management. This could be adapted to other river basins as well and can contribute to effective communication and standardisation of river subunits in a restoration process.

Keywords: The Western Ghats, Stream classification, Ecology, Tropical

1. Introduction

Rivers are the complex natural ecosystems which connect all the ecosystems in a mountainous landscape. The Kerala state is blessed with 44 rivers, the catchments in the Western Ghats receives more than 300cm of rainfall. The Western Ghats has an intense influence on the distribution of rainfall over the region (Simon and Kumar, 2004). The undulating topography created by the Western Ghats, its varying microhabitats, along with rich biodiversity, brought this land as one of the beautiful landscapes on earth.

The streams classification first developed in Davis and the additional classification systems are adding the stream classification (Davis, 1899; Melton, 1936; Matthes, 1956). The classification of streams assists in organizing the observations of river data and moulding the many pieces together into a logical, useable, and reproducible system (Rosgen, 1994).

The river basins have been recognized and acknowledged as basic and optimal units for planning, management and conservation of natural resources (UNCED, 1992; Brooks and Eckman, 2000; UN, 2006). Hydrologically, the watershed is an area from which the runoff flows to a common point on the drainage system. Every stream, tributary, or river has an associated watershed, and small watersheds aggregate together to become larger watersheds. It plays a crucial role in determining food, social, and economical security and provides life support services to rural people (Wani *et al*., 2008). A watershed also called as a drainage basin or catchment area is delineated as an area in which all water flowing into it goes to a common outlet. Watershed management is a form of ecosystem management, and it is an interactive process of integrated modifications of lands and waters within a watershed (Vannote *et al.*, 1980).

The watershed atlas (1996) provides maps and other relevant basic information including watershed characteristics, geography and climate 44 river basins of Kerala. Classification of the watershed as Micro, Mini, Milli watershed which is a classification based on the watershed area or extent and that has been in used identification of micro-watersheds in Kerala to have watershed level programs and planning. But the watershed characters from hilly terrains to plains differ even-though both are micro, mini or milli-watersheds with the same area of extent. Hence the watershed atlas could not reflect the nature or characteristics of watersheds, which is more dependent on drainage density and order of the streams. Identification of major streams and its classification based on stream characters and its integration into higher levels of watershed units (sub-basin and river basin) is important in ensuring the continuity of watershed-based planning and implementation.

The Chalakkudy river basin is mapped for its drainage; each stream was mapped, numbered, ordered and classified into respective micro and macro watersheds. A classification system for the streams is attempted here as an addition to the watershed atlas for more effective and scientific communication for integrated watershed management.

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2. Materials and Methods

Study area

The Chalakkudy River Basin lies between 10^0 13' to 10^0 55' North latitudes and 76^0 25' to 77^0 Eastern longitudes in the Anamalai landscape unit of the southern Western Ghats immediate south of the Palghat Gap. The river originates from the north-western part of the Anamalai hills and flows westward to reach Lakshadweep sea near Kodungallur in the west. It has an average length of 144 km, and the total drainage area covers 1704 km^2 in the Thrissur, Eranakulam and Palakkad districts of Kerala (1404 km^2) and Coimbatore district of (Valparai part) of Tamil Nadu (300 km^2). The river basin is bounded by the Karuvannur and Bharathapuzha river basins in the North, Upper catchments of Bharathapuzha river and Anmalais of Tamil Nadu part in the East, Periyar basin part of Anamalais, Edamalayar-Pooyamkutty valleys in the South-East, Lower plains of Periyar river in the Eranakulam in the South and Lakshadweep sea near the Kodungallur coast in the West. It is the fifth longest, sixth largest by catchment size and eighth high yielding river in Kerala (GoK, 1974; George,2001; CESS, 2003; Ravi *et al*., Bachan, 2010).

Drainage map was prepared by using the Survey of India Topographic Sheets, i.e. 58 B/8, 58 B/7, 58 B/10, 58 B/11, 58 B/14, 58 B/15 and 58 F/3 in 1: 50000 scale and the map was digitized using the QGIS 3.10 software (Bachan *et al*., 2014). The field-level data were collected during field visits into the forest areas, especially for the Sholayar tributary in the summer months. Participatory methods like community mapping have been attempted for the incorporation and further refining of stream characters. Other sub-basins visited at least once during the period and data collected.

Watershed atlas for the Chalakkudy River Basin including the area under the Tamil Nadu State, for all the sub-basins of major tributaries 1. Karapara, 2. Kuriyarkutty, 3. Parambikulam, 4. Sholayar and Chalakkudy Main River. Databases were prepared for each stream of all the four sub-basins and the main river and also for the integrated levels, i.e. sub-basins and the river basin. The database includes provisions for all the major aspects necessary for describing a watershed, i.e. watershed area, number, length, and order of streams, important places, peaks and inhabitations etc.

According to Robert E Horton (1945), stream orders are so chosen that the fingertip or unbranched tributaries are of the 1st order streams which receive 1st order tributaries. Still, these only are of the 2nd order, third order streams receive 2nd or 1st and 2nd order tributaries, and so on until the main stream is of the highest order and characterizes the order of the drainage basin.

The watersheds were classified here based on the order of the major streams (first order, second order, etc.) as a criterion and it was found to be more scientific for explaining watershed into its ultimate unit level and also for its integration into higher levels. In all levels, the streams are numbered in the clockwise manner. All the streams were identified with a number code of its order and codes for other streams and tributaries to which they are attached.

3. Results and Discussion

Chalakkudy river is coded as 16C (CWRDM, 1995) and the river basin is estimated her is 1484 km^2, perimeter 271 km and length is 145 km. This data matches with other studies (Madusudhanan, 2009). This study revealed that the Chalakkudy main river is of 7th order. Tributaries are of 5th order, and the main tributaries are Kuriyarkutty, Karappara, Parambikulam, Sholyar based on the literature and traditional record. According to the present study Kannankuzhythodu, ThunakadavuAr, PeruvaripallamAr etc also has to be considered as tributaries since they are

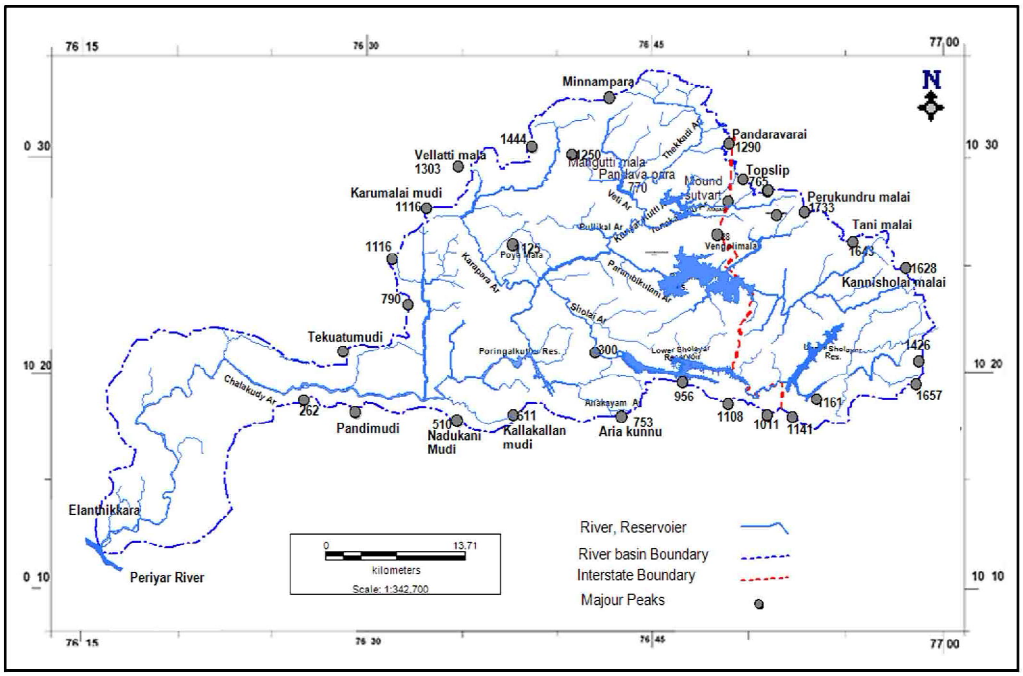

Fig. 1. Physical Map of Chalakkudy River Basin

also of 5th order. These were not considered as tributaries in the existing literature. Hence, the Chalakkudy River has a total of seven tributaries 1. Kannankuzhythodu, 2. KarapparaAr, 3. PeruvaripallamAr, 4. ThunakadavuAr, 5. KuriyarkuttyAr, 6. ParambikulamAr, 7. Sholayar.

The stream –Watershed Classification

The tributaries are coded as T1, T2, T3 etc. Each stream is named as their orders, i.e. **A-** for first order stream, **B-** for second order streams, **C-** for third order stream, **D-** for fourth order stream and **E** -for the fifth order stream. Above this order the streams become a tributary. All the streams were numbered in a clockwise direction.

The first major stream attached to the tributary has given a number '**C1'**, indicating that this stream is the first major stream of the sub-basin in a clockwise direction. When applying the code of the river, it becomes '**16Ch-C1'**. It also indicates the status of the stream i.e. the first major stream attaching to the river is a third order stream. Similarly, **16Ch-D1** indicate the first fourth order stream attached to the sub basin. This watershed composed of third order streams they are numbered as **D1C1, D1C2, and D1C3** etc. Which indicate that a third order stream attached to a first fourth orders stream of the Sub Basin.

First Sixth order river is formed from the confluence point of Thekkadiyar and Vettiyar at Kuriyarkutty area and the second, sixth order river is formed from the Orukombankutty area and this confluence to form the first 7th order part of the river. Hence the Orukombankutty onwards can be treated as the Chalakkudy main river the same as it is in the previous works. But at the same time if we consider all the tributaries with 6th order position the Chalakkudy River from the Kuriyarkutty onwards can be considered as the main river of the Chalakkudy. According to this, the Chalakkudy river basin and its sub-basins of the tributaries are classified from the clockwise direction as i. Kannankuzhythodu (Kn). ii. Karappara (Ka), iii. Peruvaripallam (Pe) iv. Thunakkadavu (Thu) v. Kuriyarkutty (Ku), vi. Parambikulam (Pa), vii. Sholayar (Sh) and Chalakkudy main river.

This method of classification can be added to the micro watershed level and to understand the micro watersheds, its terrain, stream numbers, locality etc. This is more effective for integrated watershed level programs.

The above two micro watersheds provide an insight into the hypothesis that the classification of watershed-based on area alone cannot provide the fundamental ecological conscience of a Watershed. Here both the watershed with an area of 500 ha, i.e. micro watershed can effectively be communicated if it is coupled with attributes of stream classification, which provides the difference between a watershed in the plains and a watershed in the hilly terrain with similar extant. The more number of streams in first and second orders, the order of the mainstream varies, the drainage density and terrain feature is also diverse. Hence the watershed characters, properties such as aspect, drainage density etc. are different and this can be well narrated in the present model if the Watershed atlas (1996) is coupled with a scheme for stream classification. This can effectively communicated among the practitioners of watershed management and will have a fruitful impact and is relevant in the era of landscape management in the post-flood management of watershed in Kerala (Plate, 2002; Bachan *et al*., 2019)

Table 1. Stream ordering & Classification

Sl No	Order of streams / Tributary	Codes Used for stream/Watershed	Description
1	Chalakudy River	16Ch	
2	Sub-basins/Tributary		
	a. Kannankuzhythodu	T1 E1 Kn	Kannankuzhythodu is the First tributary of Chalakkudy river and a Fifth order stream
	b. Karapara	T2 E1 Ka	Karappara is the Second tributary of Chalakkudy river and a Fifth order stream
	c. Peruvaripallam	T3 E1 Pe	Peruvaripallam is the Third tributary of Chalakkudy river and a Fifth order stream
	d. Thunakkadavu	T4 E1 Thu	Thunakkadavu is the Fourth tributary of Chalakkudy river and a Fifth order stream
	e. Kuriyarkutty	T5 E1 Ku	Kuriyarkutty is the Fifth tributary of Chalakkudy river and a Fifth order stream
	f. Parambikulam	T6 E1 Pa	ParambikulamAr is the sixth tributary of Chalakkudy river and a Fifth order stream
	g. Sholayar	T7 E1 Sh	Sholyar is the Seventh tributary of Chalakkudy river and a Fifth order stream
3	1st Order Stream	A	
	2nd Order Stream	B	
	3rd Order	C	
	4th Order	D	
	5th Order	E	

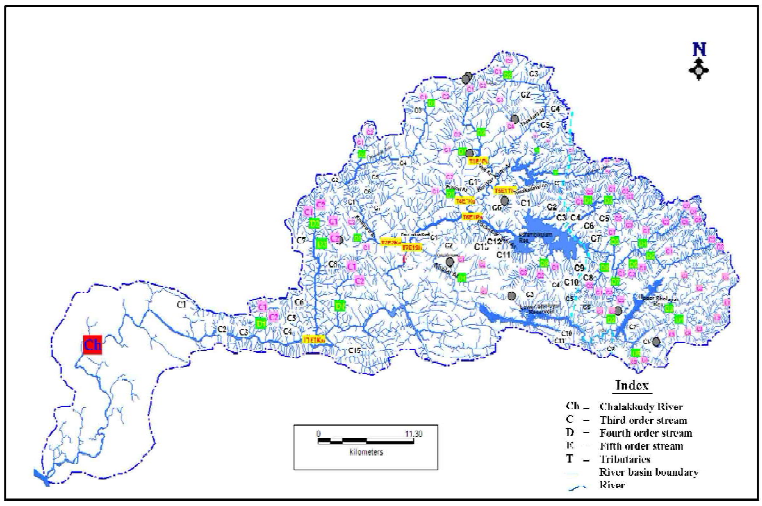

Fig. 2. Stream coded, classified Drainage map of Chalakkudy River

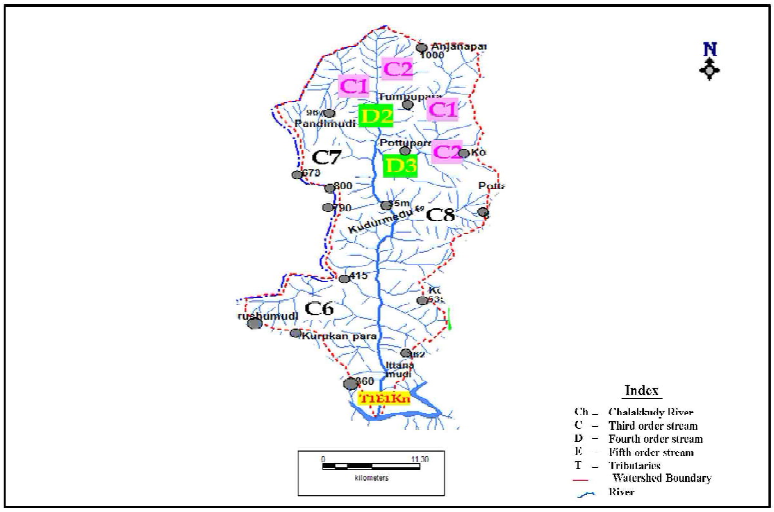

Fig. 3. Kannankuzhythodu Tributary- An Example of the stream –Watershed Classification

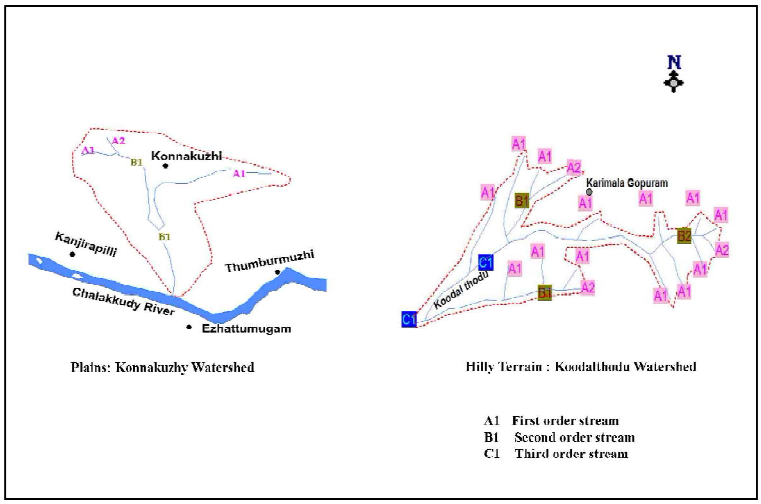

Fig. 4. Comparison of watersheds in a Hilly terrain with that in a plain

4. Summary and Conclusion

Detailed mapping of the drainage of Chalakkudy River shows that the river is of 7th order river. Based on the stream orders (5th) of existing tributaries, there are seven tributaries for Chalakkudy river Kannankuzhythodu, KuriyarkuttyAr, KarapparaAr, PeruvaripallamAr, ThunakadavuAr, ParambikulamAr, Sholyar are the main tributaries. Classification and coding of streams provided here indicate the stream order and number from the clockwise direction. The position, order and stream characters can be obtained from the stream coding, and that can also be used as important attributes for the

Table 2. Naming of Streams

Sl No	Code used for stream order	Description
1	Kn	Kannankuzhythodu tributary
2	AKn	1st Order stream directly attached to the Kannankuzhythodu tributary
3	BKn	2nd Order stream directly attached to the Kannankuzhythodu tributary
4	KnC1A1	The first order stream (A1) attached to first third order stream(C1) Kannankuzhythodu tributary
5	16Ch Kn D1 C1 A1	The first order stream (A1) attached to first third order stream of the first forth order stream of the (D2 C1) Kannankuzhythodu tributary of the Chalakudy River.

watershed programs if it is coupled with the Watershed Atlas prepared (1996). The ecological aspects of each watershed reflected from the stream characteristics could be easily communicated to have an ecological understanding of the watershed in the river basin. The study strongly affirms to the hypothesis that the area alone is not an important attribute for differentiating watershed and watersheds with same area can vary in the watershed properties unless the stream characters and related attributes are not same. The present scheme of stream classification can be added to the watershed atlas for more effective watershed management program. The locality of each watershed can be added as another attribute in the watershed atlas so that it could be easily communicated among the local people, those who are supposed to be the practitioners of the watershed management activities.

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