River in Planform and Variation in Sinuosity Index : A Study of Dhamni River, Kolhapur (Maharashtra), India

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Abstract— An attempt has been made to study the planform of Dhamni River, which is a major tributary of Kumbhi River flowing in the Kolhapur district of Maharashtra. The study area forms a part of Dhamni River having a total length of 46 km. Channel in planform (pattern) means, the channel patterns with straight, sinuous, meandering and braided. Planform of the river studies provide the relationship of the differentiate processes acting in the river channel, also shows the inter-relationship between hydrological parameter and river material. Continuous variation in the sinuosity index in the channel gives the signs of changing characteristic and behaviour of the river. The sinuosity index for the various stretches of Dhamni River ranges from 1.11 to 1.83. The average sinuosity index of river Dhamni is 1.313. It has perceived that the river is passing through a very narrow elongated valley and its tributaries and small streams meet the main stream with an abrupt gradient with large and uneven size of bed material. The variability in material type and size causes bank erosion and bank slumping that leads to shifts in channel and deviations in sinuosity index.

Index Terms— Meandering channel, Sinuous, Straight channel, Alluvial channel, Bed material, Variation in river discharge.

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1 INTRODUCTION

A River which is flowing from the higher altitude to the downslope valleys and plains is an enormously complex in nature which operates number of processes that maintains the balance of river ecosystem. Rivers benefits to the natural vegetation, animals, organisms and human societies. River provides drinking water and irrigation facilities to the agricultural fields. River is very active agent of land carving arises with erosional and depositional processes. There are some negative effects of rivers in terms of flood as a natural calamity. Such natural catastrophes become more disastrous when the rivers are disturbed by manmade activities by changing its shape and planform. When the rivers are confined more with sinuous and large meanders, then the region is more vulnerable to the floods. Therefore, the river studies, in view of its hydraulic characteristics, its sediment, width-depth ratio, morphology and its planform are significantly important. According to the Leopold and Wolman, in 1957 the channel pattern considered to be a 'plan view' of a river stretch and the river comprises meandering, braided, and straight channels [Leopold and Wolman], [1]. Toy in 1987 described that in addition to changes that occur in stream channel cross section and slope; channels also have characteristic patterns in a down-stream direction when observed in plan-view. The most easily recognized are braided and meandering pattern; long straight reaches are not common in natural streams. All of these patterns are a reflection of the water discharge, sediment load, channel slope and cross section [2]. According to

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Schumm (1972) an increase in sinuosity of river generally occurs with an increase in valley slope and channel gradient [3]. Schumm (1977) also observed that the proportion of bed load to total load has a major influence on the nature of alluvial channels. Those transporting large quantities of suspended sediment are relatively sinuous and have a low width-depth ratio, whereas those, in which the bed load sediment discharge is large, tend to be relatively wide, shallow, and less sinuous. Both the total sediment load and its particle size distribution influences channel shape. In general, the channel pattern or map view of a river is almost considered as straight, meandering or braided [4]. Alluvium excavations from river banks are also extremely responsible in channel erosion and shifts in channel locations (Sapkale, 2008, 2010, 2014), that is one of the causes for the variation in sinuosity index of the channel [5], [6].

On the basis of bed material, slope characteristics, river morphology, shape and planform; the rivers are classified into various types. Rosgen, in 1994 described 7 major stream type categories that 'differ in entrenchment, gradient, width/depth ratio, and sinuosity in various landforms. Within each major category there are six additional types delineated by dominating channel materials from bedrock to silt/clay along a continuum of gradient ranges' [7]. 'Widening in sinuous channels occurs when the retreat of the outer bank exceeds the advance of the opposite bank. An analytical model is presented to simulate width adjustment in meandering channels of noncohesive bank material resulting from bank erosion of two interactive processes: basal erosion and bank collapse' [8].

The present research work has attempted to calculate the sinuosity index of river Dhamni. The Dhamni River is flowing in the north-east direction, and passes through the confined hilly region (fig 1, 2, 3,). The left and right side region of the basin shows very steep slopes. Some sites of the river bed are having very sharp turns and bends. The channel gradient, uneven
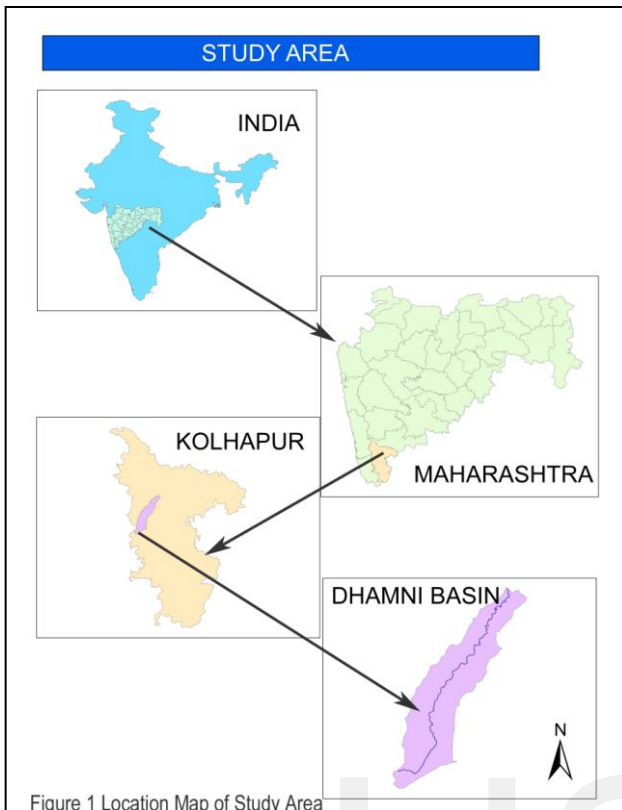
Figure 1 Location Map of Study Area

sized bed material of Kumbhi River and eroional processes have resulted for the increase in width of the channel at some locations and influenced on the channel form and plan.

2 MATERIALS AND METHODS

The Dhamni River for a length of 46 km has divided into 10 sections, more or less equally for a distance of 4-4.5 kms each (Fig. 4). For these sections sinuosity index has been calculated. S.O.I. Toposheets at a scale of 1: 50,000, T.M. and Google images were used for the observation of channel patterns and calculation of Sinuosity Index. The analysis, measurements of channel length, basin length were carried out using GIS software i.e. Arc-Info/Arc-Map. The data for river characteristics were generated using Remote Sensing images, and ASTER data with Global Mapper software. Based on ASTER data, Tin Model and Slope map of the study area are prepared. Leopold and Wolman (1957) calculated the sinuosity of a reach considering the ratio of thalweg length to valley length [1], [9]. The sinuosity index is the ratio of length of channel to length of meander-belt axis also. That means the sinuosity index can be computed as the ratio of the length of channel to length of valley axis (Brice, 1964). According to the Brice, if the sinuosity index of a reach is 1.3 or greater, the reach is considered as meandering, a straight reach has a sinuosity index of 1 and reaches which is having sinuosity indices between 1.05 and 1.3 are defined as sinuous [10].
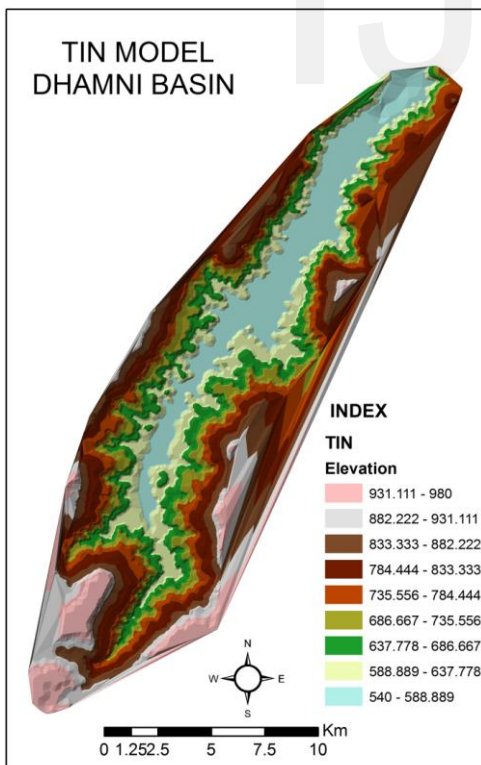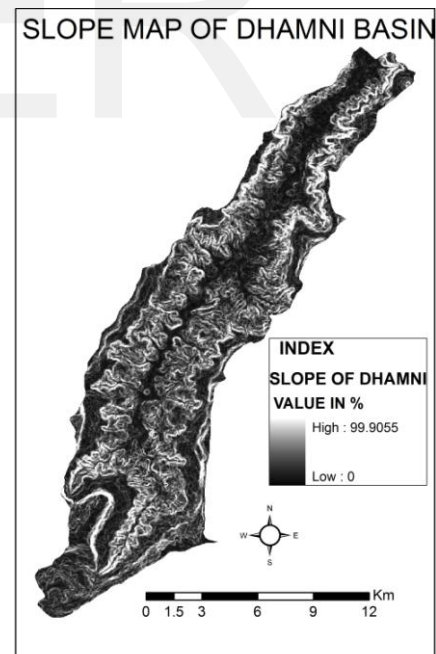

Figure: 2 Tin Model of Dhamni River Basin

Figure : 3 Slope Map of Dhamni Basin

3 DISCUSSIONS AND RESULTS

Table no. 1 shows the analysed values of river lengths (for sections 1-10); straight valley lengths and shows the calculated sinuosity index (fig.4, 5). The sinuosity indexes are increased

towards downstream side of the river basin. The sinuosity index gives the values from 1.11 to 1.63. The middle part of the basin is more sinuous than the upper and lower part of the river stretches. The channel passing through the middle and downstream basin is more or less shows the signs of alluvial type. The material in the bed of the channel and along the bank is deposited by alluvium, drained from the basin area. The tributaries and streams of the Dhamni River deposited the sediments in the river course. Further the deposited material is transported and re-located in the downstream part of channel gives rise to change in the river course (fig. 6-A). At some locations the River is supplied with large load of pebbles, gravels and sand, which are transported as bed load. Simultaneously erosional and depositional processes resulting for the migration of the channel and increases the sinuosity. Few locations have observed with straight channel (fig.6-B), also gives the signs of vertical deep erosion. The velocity of river is found more in these sections.
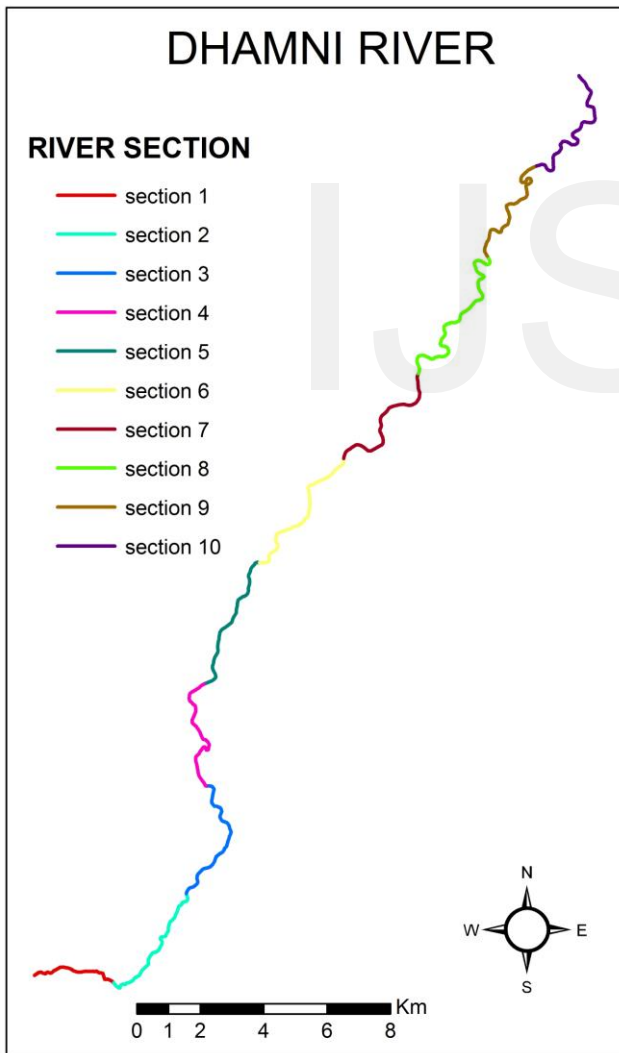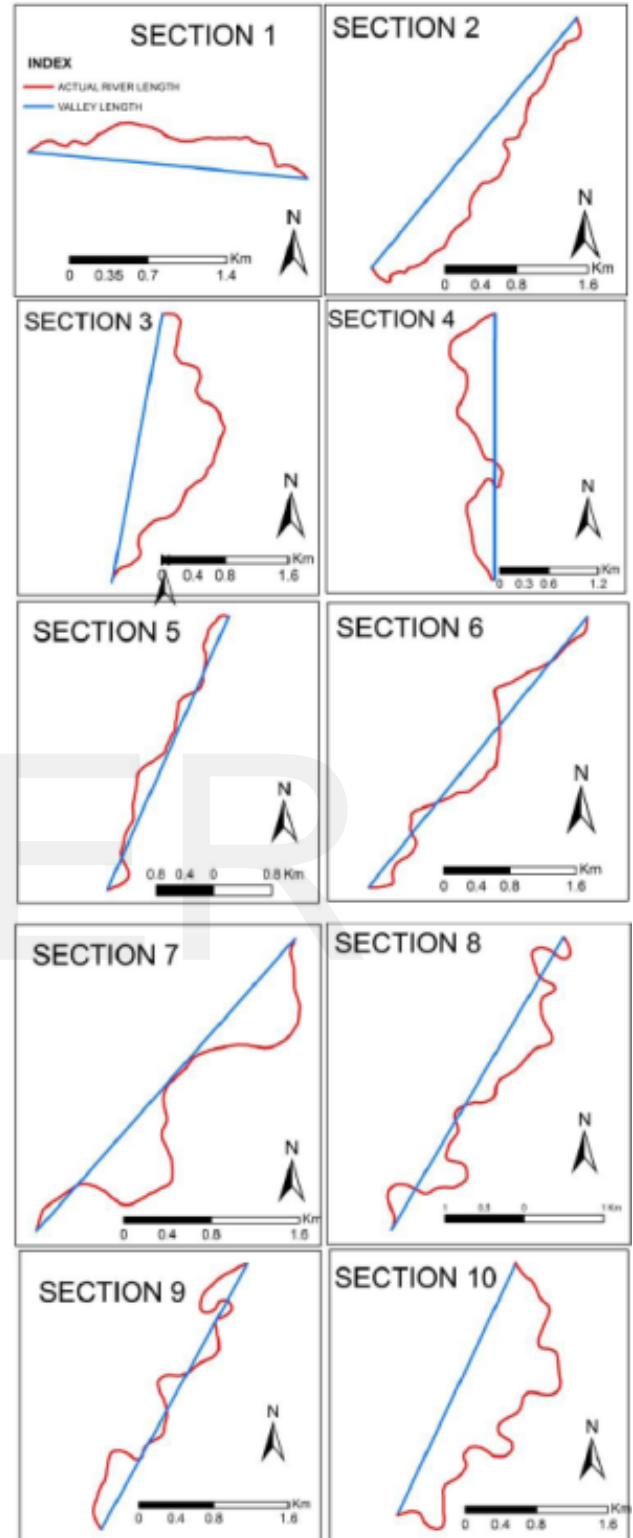

Figure : 4 Section no. 1 to 10 of Dhamni River.

Figure : 5 Sections of Dhamni River

TABLE NO. 1 SINUOSITY INDEX OF DHAMNI RIVER

Section No.	Actual River Length (km)	Valley Length (km)	Sinuosity Index
1	2.77	2.41	1.14
2	4.29	3.57	1.20
3	4.52	3.43	1.31
4	4.30	3.23	1.33
5	4.56	4.1	1.11
6	4.85	4.15	1.16
7	4.61	3.49	1.32
8	6.34	4.24	1.49
9	4.60	3.20	1.44
10	5.1	3.11	1.63
Average Sinuosity Index of Dhamni			1.313

A- Meander at Akurde

B – Straight channel at Harpavde

Figure : 6 Meandering and Straight channel.

Generally most of the rivers experienced the catastrophes, like flood, when channel migrates and becomes wider due to degradation. Widening in sinuous channels occurs as a result of outer bank retreat, also causes due to toe scouring and due to the growth of alternate or point bar [11], [12], [13]. Degradation of channel in terms of bank erosion takes place due to river energy and erosive forces. Also depends on the distribution of grain size and type of bank material. Degradation also controlled by cohesiveness and non-cohesiveness of transported and bank material [13]. The erodibility of bank-soils may increases due to processes of weakening and weathering. Swelling and shrinkage of soil during wet and dry period also effects on bank erosion [13]. According to Stolum (1996), the meandering pattern of the river is characterized by recurrent river planform with self adjustment with slight variation from one river to the next irrespective of their magnitude and from one scale to another within each river. "This consistency suggests that, a higher level of processes forms by self-organization from the physical processes of deposition and erosion operating in the system" [14]. Such operational processes and problems also occur in the Dhamni river channel. Dhamni River is the right tributary of river Kumbhi and generally the bed rock is basaltic in the upstream portion of the channel. The bed material is of uneven size, causing erosion and deposition within the channel. Large size sharp bends and meanders occur due to erosional and depositional processes, inviting flood problems during the monsoon period.

4 CONCLUSION

It is concluded that the sinuosity index of river Dhamni ranges from 1.11 to 1.83. The section no. 7 to 10 of the river is meandering with a sinuosity index of 1.32 to 1.63. At very sharp bends the values are with an average range of 1.75 to 1.83. Two stretches (no.1 and 5) are very near to straight channel pattern. Overall the average sinuosity index of river Dhamni is 1.313 that shows general pattern of meandering. Last 4 sections, almost for a distance of 14 kilometres are confined with sharp meandering bends with uneven size , also one of the reason for inundating water in the agricultural fields during heavy rain and floods.

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