The Basic Concept to Study Morphometric Analysis of River Drainage Basin: A Review

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Abstract: ***Morphometry is the measurement and mathematical evaluation of earth's surface, form and the dimension of the landforms. The morphometric analysis of the drainage basin and channel network plays a significant role in comprehension of the geo-hydrological nature of drainage basin and expresses the prevailing climate, geological setting, geomorphology and structural antecedents of the catchment area. A quantitative evaluation of drainage system is significant aspect of drainage basin.***

Keywords: Morphometry, drainage basin, drainage system.

1. Introduction

Geomorphology is the science of origin and evolution of topographic features or attributes caused by physical and chemical processes operating at or near the earth surface. Geomorphology determines the variation in earth's surface from past to present and its causative factors. Whereas, the term Morphology is a science and measurement of forms or structures which is quantitative determination of landform [1], [2].The term 'Morphometry' literally means measurement of forms introducing quantitative description for landform [2]. The most dominant geomorphic systems of earth's surface are rivers and fluvial processes which leads to morphometric changes in drainage basin or the watershed. Wherein, rivers are generally controlled by geological nature of basin and its platform which equally influences on channel slope and demonstrates erosional and depositional signs of the river [3]. Morphometric analysis is the measurement and mathematical evaluation of the earth's surface, shape and dimension of its landform (Clarke 1996; Agrwal 1998; Obi Reddy et al. 2002) [4], [5], [6], [7]. River drainage morphometry plays vital role in comprehension of soil physical properties, land processes and erosional features.

Drainage line of any basin area illustrates existing three dimensional geometry of region but assists for understanding its evolution processes [5]. The streams arrangement in drainage system leads to the drainage pattern that successively reflects structural and lithological controls of underlying rocks. More precisely, widely acknowledge principle of morphometry is the drainage basin morphology renders varied geological and geomorphological processes over time, as studied by illustrious peoples (Hurton 1945; Strahler 1952; Muller 1968; Shreve 1969; Evans 1972, 1984; Chorley et al. 1984; Merritts and Vincent 1989; Ohomori 1993; Cox 1994; Oguchi 1997; Burrough and Mcdonnell 1998; Hurtrez et al. 1999) [2], [5], [8], [9], [10].

The morphometric examination of the basin is achieved through computation linear, aerial relief and gradient of channel network and contributing ground slope basin. [11], [12], [13].

a) Stream Order

The primary step in drainage basin analysis is to designate order. Herein, the number of streams gradually decreases with increase in stream order**.** Strahler (1964***)*** noted that the number of for the stream segment of any given order will be fewer than for the next lower order but more numerous than for the next higher order [14]. The fluctuation in the number of stream order is aftermath of variation in the physiographic conditions. When Faisal Zaidi carried out work in drainage basin morphometry wherein he distinctly observed that mature topography is figured by the less number of streams in a given basin whereas presence of large number of streams manifests the topography is still undergoing the erosion [15], [16].

b) Stream Number

The count of stream channel in given order is termed as stream number. Horton's law states that " the number of streams of different orders in a given basin tends closely to approximate as inverse geometric series of which the first term is unity and the ratio is the bifurcation ratio" [2]. The stream frequency is inversely proportional to stream order and stream number is directly proportional to size of contributing basin and to the channel dimension. Higher the stream number indicates lesser permeability and infilteration. It leads to inference that several stream usually upsurges in geometric progression as stream order increases. The variation in rock structure in the basin are responsible for disparity in steam frequencies of each other.

c) Stream Length

Stream length is the total length of stream segment of each of the consecutive order in the basin tends approximate a direct geometric series in which the first term is the average length of the first order. It's the quantification of hydrological characteristics of bedrock and the drainage extent. When bedrock is of permeable character then only subtle number of relatively longer streams are formed in a well drained basin area. On the other hand, when the bed rock is less permeable then large number of smaller length of streams in the basin are produced.

d) Bifurcation Ratio

Horton (1945) considered bifurcation ratio as an index of relief and dissection. According to Strahler (1957), bifurcation ratio exhibit subtle fluctuation for different region with varied environment except where powerful geological control dominates [10]. According to Schumm (1956), bifurcation ratio is the ratio of number of stream segment of given order to the number of segment in the next order, it is dimensionless property and indicates the degree of integration prevailing between streams of various orders in drainage basin [17]. Strahler significantly marked that geological structures do not affect drainage pattern for bifurcation ratio is in between 3.0 to 5.0. When bifurcation ratio is low, there will be high possibilities of flooding as water will tend to accumulate rather than spreading out [15]. The human intervention plays important role to reduce bifurcation ratio which in turn augment the risk of flooding within the basin, this was noted significantly by [15].

e) Mean Stream Length

Mean stream length reveals the size of component of drainage network and its contributing surface [14]. It's directly proportional to the size and topography of drainage basin

f) Stream Length Ratio

Horton's law of stream length states that mean stream length segment of each of the consecutive of a basin tends to approximate a direct geometric series with stream increasing towards higher order of stream. The stream length ratio has important relevance with surface flow and discharge and erosion stage of the basic [2], [18].

g) Drainage Density

Drainage density is the computation of the total stream length in a given basin area to the total area of the basin [14]. The measurement of drainage density is a useful numerical measure of landscape direction and runoff potential. It relates to the various aspect of landscape dissection such as valley density channel head source are climate and vegetation soil and rock properties relief and landscape evolution processes [16], [19]. Strahler (1964) distinctly observed that drainage density is directly proportional to basin relief. A high drainage density indicates weak basin and impermeable subsurface material with sparse vegetation and high relief. Whereas low drainage density manifests weak coarse drainage texture, high potential runoff and potential erosion of basin area [14]. The dissected drainage basin with a relatively rapid hydrology response to rainfall events, while low drainage density demonstrates poorly drained basin with a slow hydrological response. Eze Bassey Eze conducted work in the Calbar river bain, Nigeria wherein he distinctly noted that the very low value of drainage intensity renders that drainage density and stream frequency have subtle effect on the extent to which the surface has lowered by agents of denudation. Therefore, the values of drainage density and stream frequency plunged and also, implies that surface runoff is not quickly removed from basin.

h) Drainage Texture

Drainage texture is an aggregate of product of drainage density and stream frequency [19].The drainage texture depends upon several natural aspects or strands such as climate, vegetation type and density, rock and soil type infilteration capacity, relief and stage of development [20]. Low drainage density leads to coarse drainage texture while high drainage density leverages fine drainage texturewhich is dependant of infilteration capacity of mantle rock or bed rock.

i) Stream Frequency

Stream frequency is sum of all stream segment of all orders per unit area (Horton, 1932). Basically it depends upon the basin lithology and indicates distinctly texture of the drainage network. Stream frequency is density serves as a tool in initiating erosional processes operating over an area; more precisely, in relation to stream orders and their characteristics provides data that elucidate the succession of relief development and degree of ruggedness in area [5]. It also acts as index of various stages of landscape evolution. The influencing strands are rock structure, infilteration capacity, vegetation cover, relief nature, and amount of rainfall and subsurface material permeability. Hence, the low value of stream frequency exhibits presence of a permeable subsurface material.

j) Relief Ratio

In accordance to Schumm (1956), the maximum relief to the horizontal distance along the largest dimension of the basin parallel to the principal drainage line is termed as relief ratio. It computes overall steepness of the drainage basin. Relief ratio is an indication of the intensity of erosional process operating on slope of the basin [17].

On the basis of work carried out by Shumm (1963), it is dimensionless height-length ratio equal to the tangent of angle formed by two planes cross at the mouth of the basin, one exhibit the horizontal and the other passes through the highest point of the basin [21]. When the basement rock of the basin is resistance and low degree of slope heralds or give rise to low value of relief ratio [20]. Relief ratio is inversely proportional to the drainage area and the size of given drainage [22].

k) Elongation Ratio

Elongation ratio is the ratio of a diameter of a circle having the same area as of the basin and maximum basin length [17]. To gain notion of the hydrological character of drainage basin for computation of basin shape, elongation ratio plays a vital role. The value of elongation ratio varies from '0' which indicates elongated shape to unity i.e. '1.0' which shows circular shape of a drainage basin. As elongation ratio is analyses of the shape of river basin and it precisely depends on various climatic and geological factors. Therefore, value of elongation ratio generally varies from 0.6 to 1.0 over a wide range of climatic and geologic types. Values close to 1.0 are typical of regions of very low relief, whereas that of 0.6 to 0.8 are usually associated with high relief and steep ground slope [14]. These values can b ramified into 3 categories, viz. circular (>0.9), oval (0.9 to 0.8) and less elongated (<0.7). The study conducted by Faisal Zaidi in Gagas river basin, India demonstrates the elongation ratio of the Gagas Basin is 0.83, which is believed to be due to sin to the successive effect of thrusting and faulting in the basin [15], [16].

l) Circularity Ratio

Circularity ratio is the ratio of an area of basin to an area of circle having same circumference as the perimeter of basin [5]. According to Miller (1953), it's significant ratio that exhibits dendriatic stage of drainage due to variation in the slope and relief pattern of the basin. It's used as quantitative measure for the shape of the basin [14]. This ratio is prominently relevance to the length and frequency of streams, geological structures, land use/ land cover, climate, relief, and slope of the basin. Low, medium and high value of circularity ratio manifests the young, mature and old stages of the life cycle of tributary drainage basin [23].

2. Conclusion

Prominently drainage basin morphometry is significant approach that reflects existing geomorphic process operating in fabric of a drainage basin. Drainage basin morphometry explicitly reveals quantitative information on landform. In simple words, the quantitative evaluation of morphometric parameters is essential tool in river basin analysis in terms of soil and water conservation and natural resource management [24]. In regards to formation and development i.e. evolution of land surface process depends on morphometric nature of basin. The morphometric assessment of drainage system is imperative to any hydrological studies. Also, co-relation of stream network behaviour plays significant role. Therefore, various hydrological phenomena of drainage basin can be in relevance to size, shape of drainage basin [25]. Meticulous study of morphometry of all sub-basin reveals drainage pattern which further infers to lithological nature. One can co-relate the morphometric nature of basin with the sediment-yield coming from the basin, similarly, the aspect of morphometry can be linked with the flow characteristics, sediment transports and fluvial process [26],[27], [28].

The change in discharge fluctuation through study of river morphology and morphometry reveals that the dynamism of river morphology is aftermath of natural processes as well as anthropogenic intervention. The functional relevance exist in river morphology which comprises of longitudinal profile and cross-sectional geometry. Also, river morphometric parameters shows relevance between river capacity to adjust incoming runoff and sediment load. The plunged values of drainage density, stream frequency and drainage intensity implies that surface runoff is not quickly removed from basin [3], [29], [30], [31].

There is distinct change among the drainage basin morphometric parameters and flood potential. For instance higher density faster is the runoff and the significant degree of channel abrasion is likely to be for a given quantity of rainfall [6]. The drainage density manifest the link between the mophometry of basin and it is erosional process, which leads to higher possibilities of floods.

Similarly, bifurcation ratio affects the landscape morphometry and plays significant role to control over the "peakedness" of runoff hydrograph in homogenous bedrock. The human intervention plays important role to reduce bifurcation ratio which in turn increases risk of flooding within the basin and consequently there is discrepancies natural [3], [6], [26], [27], [31].

Moreover, the human intervention like excavation of alluvium along the tracks of river banks largely influence river morphology which in turn leads to fluctuation in flow velocity and sediment transport capacity of a river.

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