# River Morphometry Analysis and Its Capacity to Introduce Tourism Attraction in Sedim River, Kedah

## *Analisis Morfometri Sungai dan Keupayaannya untuk Mengetengahkan Daya Tarikan Pelancongan di Sungai Sedim, Kedah*

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## Abstract

The stream has a variety of functions and each of it can be known through morphometric analysis. Morphometric analysis comprised three aspects, namely linear, aerial and relief. The studies carried out at Sungai Jemerli in sub-basin of Sungai Sedim Kulim, Kedah is a study to fill the knowledge gap in the field of stream hydro-geomorphology in Malaysia. ArcGIS 10.2.2 was used as assistant tool in this study and morphometry analysis give emphasis to the parameters such as the stream order, stream length, mean stream length ($L_{sm}$), stream length ratio ($R_L$), bifurcation ratio ($R_b$), drainage density ($D_d$), drainage frequency (Fs), texture ratio (T), form factor ($R_f$), circularity ratio (RC), maximum basin length ($L_g$), constant of channel maintenance (C), relief ratio ($R_h$), and ruggedness number (RN). Computable measurement of the earth's surface geometry was carried out which aims to explain the drainage characteristic of the Sungai Jemerli, in addition to analysis the morphometry of Sungai Jemerli by using ArcGIS and give information on sub-basin morphometry parameter data. The results showed that the sub-basin of Sedim River is the river basin with low sedimentation rate, simple drainage density, rugged terrain, simple gradient of 3° and mark the formation of the stream at the early stage, as well as the fine texture of the stream. This finding could help in further study on the behaviour of hydrology at the Sungai Jemerli and its significance to the prospects of hydro-tourism in the area of Sungai Sedim, Kedah.

**Keywords** stream, morphometry, stream order, bifurcation, hydro-tourism

## Abstrak

Sungai mempunyai pelbagai fungsi dan setiap satunya boleh diketahui dengan melakukan analisis morfometri sungai. Analisis morfometri merangkumi tiga aspek iaitu relif, keluasan dan linear. Kajian morfometri Sungai Jemerli di hulu Sungai Sedim, Kulim Kedah, merupakan satu kajian untuk mengisi jurang ilmu dalam bidang hidro-geomorfologi sungai di Malaysia. ArcGIS 10.2.2 digunakan sebagai alat bantu dalam kajian ini dan analisis morfometri memberi penekanan kepada parameter seperti oder, panjang, min panjang sungai (Lsm), nisbah panjang sungai (RL), bifurkasi (Rb), kepadatan saliran (Dd), frekuensi saliran (Fs), nisbah tekstur (T), faktor bentuk (Rf), nisbah kebulatan (Rc), panjang aliran darat (Lg), saliran berterusan (C), nisbah pelepasan (Rh), dan kelasakan (Rn). Pengukuran kuantitatif geometri permukaan bumi dilakukan bertujuan menerangkan ciri-ciri saliran Sungai Jemerli selain menganalisis gambaran morfometri Sungai Jemerli menggunakan ArcGIS dan memberi maklumat parameter morfometri sublembangan. Hasil kajian menunjukkan lembangan hulu Sungai Sedim adalah lembangan sungai ini melonjong dengan kadar sedementasi yang rendah, dengan kepadatan saliran yang sederhana, bentuk muka bumi yang sederhana lasak, kecuraman sebanyak 3° dan menandakan pembentukan sungai di peringkat muda, serta tekstur sungai yang halus. Dapatan ini dapat membantu kajian yang lebih lanjut tentang perilaku hidrologi Sungai Jemerli dan kepentingannya kepada prospek hidro-pelancongan Sungai Sedim, Kedah.

**Kata kunci** sungai, morfometri, oder sungai, bifurkasi, hidro-pelancongan

## INTRODUCTION

Upper Sungai Sedim is a famous tourist attraction place, especially for extreme water sports, kayaking and white water rafting activities, which is associated with the behaviour of the hydrological basin drainage in the region. To understand the hydrological behaviour, morphometric analysis plays an important role, which can provide interpretation and analysis of accurate morphology of the stream. Stream hydro-tourism, which defined as the potential strain, force based on the tourism sector at different streams. Hydro tourism interpreted as water base tourism, which depends on the aspect of landscape and stream activities such as jungle trekking and white water rafting (Gössling et al., 2012). Stream morphometry are the elements liaise directly with slope, depth, width and sinusoidal. Information about slopes and depth are significant for regulating the assessment section of the stream, which is suitable for a broad scope of Hydro-tourism. Stream morphology can synthesize aspects of attractions like stream rapids, steep slopes, waterfalls, large falls, gorges and stream mouth. For understanding, the closer relationship with the development of hydro-tourism or environmental issues, morphometry analysis are necessary. Morphometry is the survey of measurement of the external form of the stream and in the area of hydrology Horton (1945) and Strahler (1953), excellence around the commencement in the 1940s and 1950s, leaded it. The aim of the evaluation is to find morphometry or property of stream treasures holistically based on measurements of various properties of the stream.

Morphometry is a quantitative appraisal of the properties or characteristics of the stream and it is a technique employed in the analysis of the stream drainage area. Hence, through the morphometric analysis, terrain characteristics understood equally well as the flow of fluvial. Drainage basin is the fundamental flow system that constructed in a quantitative manner through flow, density, running and long drainage ratio (Horton, 1945). It combines quantitative studies of various components of the basin as, segment trends, length, perimeter, area, the height of the basin, the number of streams, slopes and land profile, which shows the nature of the development of a basin. This method was subsequently modified and Horton developed by some other geomorphology members in particular by Strahler (1953; 1964), Schumm (1956), Morisawa (1968, 1985), Scheidegger (1965), Shreve (1967), Gregory (1966, 1968), Gregory & Walling (1973). Characteristics of watershed considered an important indicator in the process of controlling factors in geomorphological modifying. Hence the morphometric parameters were used in various studies of geomorphology and surface flow hydrology, such as the characteristics of the deluge, sedimentation, morphological development of the basin (Noraini & Main, 2012) as well as for hydro-tourism (Gössling et al., 2012).

Many deeds have been emerge out in stream morphometric associated studies, by using several methods as used by Waikar and Nilawar (2014), Ramu et al., (2013), Ravikumar & Somashekar (2011) in India. Yang et al., (2016) execute the research on the fluvial morphometric network of Supraglasier in Greenland to know the state of the terrestrial stream landscape during snow, melting it does not relate to elevation relief but significantly correlate with ice surface elevation. Akar (2009) research at Kasatura drainage network in Turkey used Remote Sensing (RS) and GIS to define the characteristics of stream morphometry. Parameters such as the number of sections of the drainage morphology, drainage density and frequency, the result shows the Kastro bay at maturity level.

The watershed study also appeared at the corner of the River Capahan branch merge because this aspect is supposed to be able to show the shape and course of the drainage network. Christopher and Poul (2011) that make study in the Mekong River found the corner of the meeting decided by the status of the drainage basin except if there is a disturbance in geological structure. This makes morphometry the bottom of the basin offers a more complex relation than at the upstream because of geological properties more homogeneous.

Meanwhile morphology on quantitative measurement of surface geometry or topography, such as the reliefs on the size of the watershed, basin shape, angle of slope, drainage patterns, the duration and frequency of irrigation drainage. This parameter is very significant in the analysis of morphology for hydrological circumstances in interpreting in a particular watershed, the process of erosion and water quality distribution in studies such as the Sungai Semenyih (Shu, 1989; Yin, 1989; Muhammad Barzani et al., 2005).

## STUDY AREA

Sungai Sedim is a sub watershed for Sungai Muda basin, Kedah. It is one of the sub watershed out of 189 watershed in Kedah, which can reconcile the demands of water for 2,044,188 people with 9,426 km$^2$ (Jabatan Perangkan Malaysia, 2014). The sums of 46.85% of the entire area of Kedah are located in the watershed (JPS, Kedah, 2015). The Sungai Sedim basin has 16-sub watershed and this study, use Sungai Jemerli sub watershed as a case study to analyse parameters of stream morphometry. Sungai Jemerli located in Hulu Sungai Sedim, about 18 km of the downstream Sungai Sedim. The geographic coordinates of the area range from longitude 100 ° 45 ' 0.982154 "N, 5 ° 24 ' 0.420406" E to 100 ° 50 ' 0.245449 "N 5 ° 29 ' 0.876605" E latitude. This is a spacious watershed 61.42 km$^2$ and there are 420 streams in the Sungai Jemerli sub basin. The highest points are 732.64m and lowest are 598.443m respectively (Figure 1). The length of the stream measured from the lowest to the highest are 15.8km.
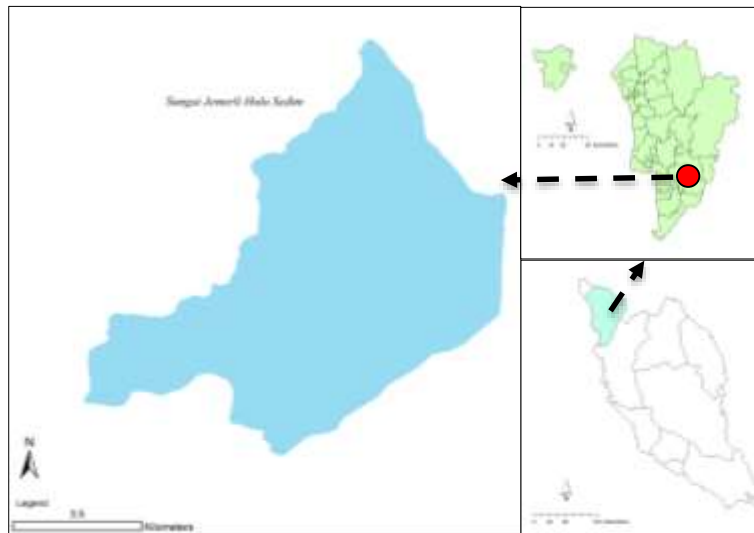


**Figure 1** Sungai Jemerli sub watershed study area

Sungai Jemerli located in the administrative territorial division of Sedim and beside Mahang area in Kulim, Kedah. Its position beside to the Sungai Mempelam sub watershed of the North and the Sungai Reyau sub watershed in the South. The climate in the field area is equatorial climate is hot and moist throughout the year. The mean yearly rainfall is 2600 mm with maximum temperature is 32 °C and a minimum of 28 °C. The main vegetation in the area was forested, dipterocarp apart sections of the crop at the bottom of the basin.

## METHODOLOGY

With the aid of GIS by using ArcGIS 10.2.2, scalable topographic map with the scale of 1:50000 digitized. To calculate Stream number ($N_u$), Horton's approach considered, start from of the peak as the first stream order, meeting of two first order produces second order and then next meeting two order produce third order and so on. The amounts of stream order taken into account as well as the basin length of each stream order. Each order assigned by a particular code in a GIS environment, for calculations according to standards has been set (Horton, 1932, 1945; Smith 1958; Strahler, 1964). Basic parameters such as the length of the stream, area, stream number and length calculated from the basin. While further calculation using the formula from Horton (1945), Miller (1953), Schumm (1956), Strahler (1964), which are the Stream order (U), Stream length ($L_u$), Mean stream length ($L_{sm}$), Stream length ratio ($R_L$), Bifurcations ratio ($R_b$), Drainage density ($D_d$), Texture ratio (T), Form factor ($R_f$), Circulatory ratio (RC), Length of overland flow ($L_g$) and Constant channel maintenance (C). Three aspects such as linear, aerial and relief used in the calculation (Table 1).

**Table 1** Morphometric parameter

| Bill. | Morphometric Parameter | Symbols | Formula | Reference |
|---|---|---|---|---|
| 1 | Stream Order | U | U= Stream Order | Strahler (1964) |
| 2 | Stream Length | $L_u$ | $L_u$=Stream Length | Horton (1945) |
| 3 | Mean Stream Length | Lsm | $L_{sm}= L_u/N_u$; $L_u$=Stream Length U; $N_u$= Stream Order | Strahler (1964) |
| 4 | Stream Length Ratio | $R_L$ | $R_L=Lu/Lu-1$; Lu= Stream Length u, $L_{u-1}$=Length of stream order | Horton (1945) |
| 5 | Bifurcation Ratio | $R_b$ | $Rb=N_u/N_{u+1}$ $N_u$=No of Stream Order, $N_{u+1}$=Highest Stream Order | Schumm (1956) |
| 6 | Drainage Density | Dd | $Dd=L/A$; L=Stream Length; A=Basin Area | Horton (1945) |
| 7 | Texture Ratio | T | $T=N_1/P$; $N_1$= Stream Order 1, P= Basin Parameter | Horton (1945) |
| 8 | Stream Frequency | Fs | $Fs=N_u/A$; $N_u$=Stream order, A= Basin Area | Horton (1932) |
| 9 | Stream Texture | $R_t$ | $R_t=N_u/P$; $N_u$=Stream Order, P=Basin Parameter | Horton (1945) |
| 10 | Form Factor | Rf | $R_f=A/L_b^2$; A=Basin Area, $L_b^2$=Basin Length | Horton (1932) |
| 11 | Mean Bifurcation | $R_{bm}$ | $R_{bm}$ = Mean Bifurcation | Strahler (1953) |
| 12 | Circulatory Ratio | Rc | $R_c=4*\pi/P^2$; $\pi$=3.14, P=Basin Parameter. | Miller (1953) |
| 13 | Over Land Flow | $L_G$ | $L_G =\frac{1}{2}D_d$; $D_d$= Drainage Density | Horton (1945) |
| 14 | Constance Channel Maintenance | C | $C= \frac{1}{Dd}$; $D_d$=Drainage Density | Horton (1945) |
| 15 | Ruggedness Ratio | Rn | $R_n=B_h*D_d$; $B_h$ =Basin Relief, $D_d$=Drainage Density | Schumm (1956) |
| 16 | Relief Ratio | $R_h$ | $R_h=B_h*L_b$; $B_h$ = Basin Relief, $L_b$= Basin Length | Schumm (1956) |
| 17 | Elongation Ratio | $R_e$ | $R_e=\sqrt[2]{\frac{A}{\pi}}/Lb$; A=Basin Area $\pi$=3.14, $L_b$=Basin Length | Schumm (1956) |

## RESULTS AND DISCUSSION

### Morphometric Analysis

Morphometric parameters can identify the physical condition or a stream landscape. Each value obtained by using methods as used in the literature in their respective sections. The discussion on morphometry analysis focuses on three main aspects, namely, linear, areal and relief.

### Liner Aspect

Linear aspects will deal with fewer of stream morphology, structure such as stream order (U), the length of the flow ($L_s$), mean stream flow length ($L_{sm}$), stream length ratio ($R_L$) and bifurcation ratio ($R_b$).

(a)   Stream Order (U)

The streams flow of a basin divided into several stream orders. Stream order is a stream running in the grooves in sequence to the main stream in a basin. Bifurcation ratio is the ratio or is determined based on the full flow of the stream to an ordination. When two streams from different stream order, order merged higher upheld. The mainstream is the highest division of the stream order in this sphere and the stream has ordered five. Total number of streams in the Sungai Jemerli are 420 in which 320 are first order streams, 81 are second order, 14 are third order, 4 are of fourth order and one belongs to fifth order (Figure 2). The

Sungai Jemerli basin, the stream branches classed as a type of dendritic branches. It shows that the drainage pattern of Sungai Jemerli has properties of homogeneity in terms of texture and less structure control (Zernitz, 1977; Muhammad Barzani et al., 2005).

(b)   Stream Length ($L_u$)

Number of streams with various order counted one by one. In basin hydrology $L_u$ plays an important role in stream hydrology, interpreted the land surface in a watershed. Shorter $L_u$ indicates the valley steepness with fine texture, while the longer $L_u$ indicates the less steep or smoother slope (Waiker & Nilawar, 2014). After the measurement of each stream, the total length of the   Sungai Jemerli is 228,965.31m (229 kilometre), Lu of the first stream order is 137,918.71m (138 km), the second stream order is 47,355.06m (47.4 kilometre), third-order 25,234.69m (25.2 kilometre), fourth order 6,488.36m (6.5 km) and fifth order is 11,968.52m (12 kilometre). It shows that the length of streams would decrease with the increment of stream order as mention by Waiker & Nilawar (2014). It is in line with the Horton stream order, saying the number of segments of the stream flow is inverse proportional geometrically with stream order itself. However, in the case of Sungai Jemerli the fifth stream order is longer than the forth stream order. According to Singh & Gou (1997), these changes reflect directly condition the flow of the stream from high altitude, lithology and gradient variation with moderate slope.

(c)   Mean Stream Length ($L_{SM}$)

$L_{SM}$ at a drainage relate to the surface of the plains (Strahler, 1964). To obtain $L_{sm}$, stream lengths divided by stream order. The $L_{SM}$ of the first order is 431.0 m (0.43 km), the second order is 584.63 m (0.58 km), third order is 1,802.48 m (1.8 km), the fourth order is 1,622.09 m (1.6 km) and the fifth order is 11,968.52 m (12 km). The gradient of the stream can be seen from the length of a stream (Singh & Gou, 1997), in this study, found the steep slope are at first order following second order,  third order, then fourth order and the less steep is a fifth order (Figure 2).



**Figure 2** Sungai Jemerli sub watershed profile from order 1 to order 5, with coordinates with altitude (m) and slope percentage (Insert table)

(d)   Stream Length Ratio ($R_L$)

$R_L$ has strong relation with surface flow and stream discharge (Horton, 1945). The difference in the ratio of the $R_L$ of each stream order portrays the difference in angle of gradient and topography. $R_L$ value symbolizes the relationship between the total frequency of stream flow with a bifurcation ratio and the relationship between the different angles of the flow of the stream order. $R_L$ values will normally range between 1.5 to 3.5 and the study value $R_L$ for Sungai Jemerli from first order to fifth order are at a value from 0.34 to 1.84. Based on the ratio of the stream length, Sungai Jemerli categorized as small-sized (Muhammad Barzani et al., 2005). The mean ratio of the stream length ($\Sigma R_L$) on the other hand amounted to 2.98.

(e)  Bifurcation Ratio ($R_b$)

A study by Schumm (1956) reflects the bifurcation ratio as an index of temporary relief while Strahler (1953) confirmed the difference that influenced by geological and environmental impact. The outcomes showed the bifurcation ratio of Sungai Jemerli falls in between 3.5 to 5.79. This value regarded as the natural basin of Rb 2 to 5 and is in line with the findings of the Rb describing this watershed categorized as small, i.e. below the 6, values 6.1 to 7 are considered medium-sized sub watershed while 7.1 to 10 is representative of a large watershed (Horton, 1945). Rb value determined by the contact angle of the stream with the stream density. Rb value also varies according to the orientation of the watershed. The lower Rb is prone of the flooding issue because the water would be focused in a branch flows only and not spread to all branches of the stream as a high ratio of Rb. The low Rb usually found in the watershed in the lower areas while in the high area often have a greater value Rb (Horton, 1945) (Table 2) (Figure 3).

**Table 2** Linear parameter of Sungai Jemerli, Kedah

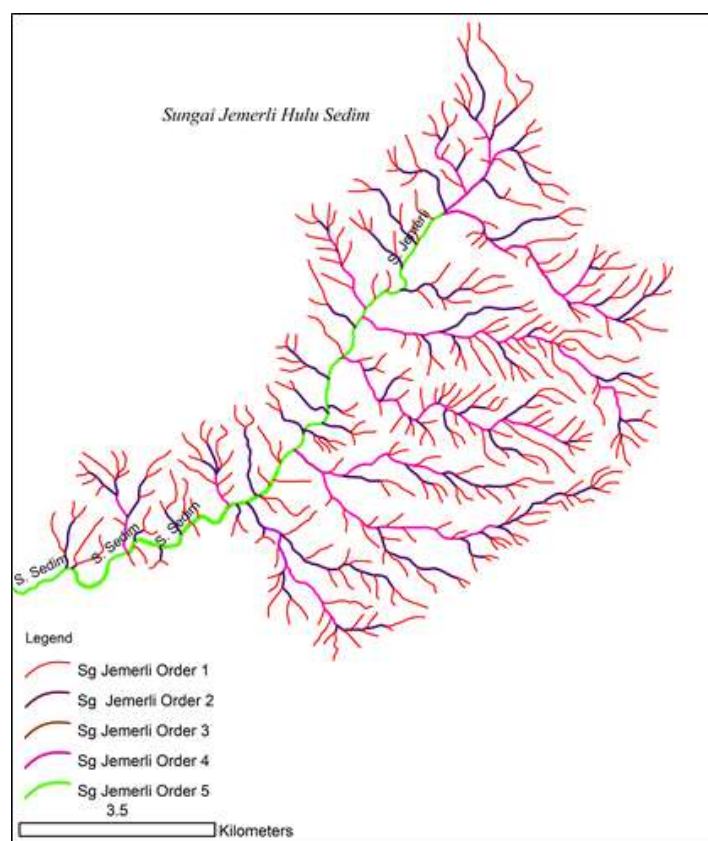| Stream Order. | Total u (Nu) | Length (m) Lu | Area (km$^2$) | Dd | Mean Lsm (m) | RL | Rb | Log Nu | Log Lu |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 320 | 137,918.71 | 21.8 | 6.33 | 431.00 | | | 2.51 | **5.14** |
| 2 | 81 | 47,355.06 | 18.8 | 2.52 | 584.63 | 0.34 | 3.95 | 1.91 | **4.68** |
| 3 | 14 | 25,234.69 | 9.56 | 2.64 | 1802.28 | 0.53 | 5.79 | 3.50 | **4.40** |
| 4 | 4 | 6,488.36 | 4.88 | 1.31 | 1622.09 | 0.26 | 3.5 | 0.6 | **3.81** |
| 5 | 1 | 11,968.52 | 6.42 | 1.86 | 11,968.52 | 1.84 | 4 | 0 | **4.08** |



**Figure 3** Sungai Jemerli Stream Order 1 to order 5, with scale in km

**Area Analysis**

The analysis involves the drainage density ($D_d$), stream, frequency ($F_s$), texture ratio (T), form factor ($R_f$) and a circulatory ($R_c$).

(a)  Drainage Density ($D_d$)

$D_d$ is the main thing in the efficiency of drainage from the drainage basin to the stream mouth. High-density gradient and flow reflect sedimentation is high. According to Horton (1945), $D_d$ analysis can give clues about the eroded topography. Information about $D_d$ gives many benefits to researcher's hydrology and geomorphology. For example, numerical calculations critical to the assessment of the landscape as well as the potential for runoff. In a landscape that has permeable soils, high water it will have little potential for runoff and $D_d$ is usually less than one kilometre in length per square kilometre (Pidwirny, 2006). Moglen et al. (1998) studies found that the $D_d$ elements reflect the influence of climate on the topography and determine limitations on surface hydrology. This means, $D_d$ has a close relationship with the sensitivity of supply of water resources in the future. The study found in Sungai Jemerli Dd is high at 3.73 km / $km^2$ and this happens because the area covered with primary forest (Table 1). When analysed in detail, first stream order has the highest density of 6.3 per $km^2$, followed by third stream order (2.6: 1), second stream order (2.5: 1), fifth stream order (1.8: 1) and follow by forth stream order (1.3: 1). Impervious soil type and presence of host rock exposed on surface soils that exhibit rough terrain and steep topography are two factors that encourage the existence of high Dd in the zone of the order.

(b)  Texture Ratio (T)

T is the number of textured drainage basin of the stream order segments per perimeter watershed. In the context of a relatively significant geomorphological drainage. Guided by a basic ratio of lithologic texture drainage, infiltration and relief aspects (Horton, 1945). A study carried by Smith (1958) classify if T is 7.71 means the watershed having high infiltration. The study found that the T Sungai Jemerli is between 0.024 to 7.708 while the stream texture is $R_t$ ($R_t = N_u$ / P) is 10.11.

(c)  Form Factor ($R_f$)

$R_f$ used to represent the form the stream watershed (Horton, 1945). The study found the $R_f$ of the stream Sungai Jemerli sub watershed is 0.25. This means that form the sub watershed in an oval.

(d)  Circulatory Ratio ($R_C$)

The Rc has the same meaning in the context of the incoming flakiness and form factors (Miller, 1953). According to Miller, Circulatory Ratio (Rc) of basin equal to AC / A in which A is an area and AC is the perimeter of the circle / basin area. The AC can be obtained using the following equation, $A = 2\pi r$. R = A / 2 where $AC = \pi r2$, then $AC = A2 / 4$. If the value of Rc = 1, it shows the sub watershed is circulatory. Circulatory Ratio for Sungai Jemerli is 0.30. This means Sungai Jemerli having a less rounded or rather of the oval.

(e)  Length Overland Flow ($L_g$)

Lg is a parameter that used to identify the flow of water in the ground up to directed into the stream (Horton, 1945). The long overland flow indicates the amount of time taken in the sub watershed, to the headwaters of the Sungai Jemerli is at 0.13. The higher the longer the length of time the flow overland flow in a sub watershed.

(f)  Constant Channel Maintenance (C)

The constant C provides information of the number of square feet of watershed surface required to sustain one-liner foot of the stream. (Schumm, 1956). Sungai Jemerli constant channel maintenances value is 0.27. It means 0.27 sq. foot surface needed in the basin for creation of one-liner foot of the stream channel.

**Relief Analysis**

The reliefs include relief ratio ($R_h$) and ruggedness number (RN).

(a)  Relief Ratio ($R_h$)

This index used to compare one catchment basin in one another in the same area. This value can reflect differences in tectonic rock on, rock, geological, geomorphological processes and climate impacts. The value of the Sungai Jemerli is 0.08.

(b)   Ruggedness Ratio ($R_n$)

Is the result of Relief Ratio ($R_h$) and the drainage density ($D_d$). When these two values are high and the basin has a high steepness and ruggedness into high value. The ruggedness of the stream of Sungai Jemerli is 3.2.

**Hydro-Tourism and Morphometric Analysis**

Tourism activities among local tourists mainly focused on travelling within the country, namely domestic tourism. Society who is mostly stressed with their daily mundane routine, choose to indulge in a short vacation trip (Jayakali & Fauziah, 2017). The identification of hydro tourist potential of the rivers' network is based on a set of indicators morphometric, morphological, quantity and quality, dynamicity, a biotic which define the tourist potential of different river sectors (Cigher, 2012). The sub watershed of Sungai Jemerli ($R_f$ and RC) is oval and based bifurcation ratio ($R_b$) obtained, it can be categorized as an ordinary homogenous basin. Number of first stream order and short length of first order with a high gradient slope indicated that the current flow in the Sungai Jemerli is rapid or fast. The results of morphometric analysis can also give an idea of the terrain and the characteristics of the area, especially the character of the watershed hydrology (Aminuddin et al., 2001; Thakkar & Dimand, 2007; Mohd et al., 2012; Srinivasa et al., 2008). Study form Gregory & Walling (1968) demonstrate an understanding of the watershed characteristic, physiographies features, such as rock type and shape of the watershed, which can help understand the behaviour of the hydrology of streams such as the relationship between drainage density and the occurrence of floods. Similarly, issues related to the landslide that occurred with the parameter such as Elongation Ratio, Circulatory Ratio ($R_C$) and Form Factor ($R_f$) (Arpita, 2009). Drainage density also gave information to conclude the volume of water flow and the limited ability of the soil surface hydrology in which it has a close link in the supply of water resources (Moglen et al., 1998; Ngah et al., 2014).

Stream water flow considered sufficiently sensitive to weather changes, same goes for tourism and recreation. An accurate data about the morphology is very important to plan for planning and monitoring safety features for visitors to tourism and recreation program in accordance with this sub watershed. For example, the length of the flow stream order 1 is 138 km, but it also means that the average length of the flow order 1 is only 0.43 km. Stream order two, flow the length is 47 km or about an average of only 0.3 km. Stream order three, flow length is 25 km or about an average length of 3km, stream order four flows are 0.25 km long and 6.5 km for stream order 4 flow or average length of 0.4 km. This makes the average length of the first stream order  to stream order four is only 1.38 km just before the flow of surface water to the main stream order five. In view of the findings, the Sungai Jemerli sub watershed is small, oval, and with homogeneous rock geology, this means the potential for a rainwater fall on the earth's surface will quickly flow into the main stream of order 5.

When the stream flow rate and ravines are widely available, the rate of discharge or the volume of stream flow known by place and time. In the case of Sungai Jemerli, annual stream water discharge is 4.49 $m^3$/s. As the Sungai Jemerli is a small oval-shaped and have a high steepness. The morphometric characteristics provide strong currents on the discharge rate and it is very helpful for rugged water sports activities favoured by tourists. The morphometric elements refer to rivers' real components: slope, depth, breadth, and sinuosity. Knowing the slope and depth is the main aspect in evaluating the river sectors that can be exploited through different characters and styles of tourist activities (navigation and recreation fishing, extreme water sports). Depending on these two parameters one can specify limits of the favourable sectors for whitewater sports (rafting, hydro-speed, canoeing, and leisure sailing. (Cigher, 2012). River tourism activities have the ability to stimulate regional development rapidly, which in turn benefits the locals (Fauziah et al., 2011).

Established along the class graded by level of difficulty using an international scale of kayaking (Buckley, 2006) or rafting Sungai Jemerli categorized as class I to class IV. Class I represents the portion of the stream that allows easy and activities for those who first want to try water activities. It represents order 5 Sungai Jemerli (Figure 3). A choppy water with less flow speed of 2.5 km per hour and a maximum gradient of less than 1 meter per km. Class II stream is a category for the intermediate class. Normal flow surging stream, easy waterspout, there are bends of the stream, the rapids with current speeds of 3 to 6 km per hour with a gradient of stream between 1 to 5 meters per km. Class III is for category hard and expert groups and it was found in order 4 and 3 Sungai Jemerli. It requires rapid training to cruise through strong eddies with vertical waves and stream current speed between 6 to 13 km per hour and the slope of 3 m to 8 m per km.  Class IV Sungai Jemerli only applies to the appropriate water level, particularly during the rainy

season or when it receives the impact of the rains in the sub watershed region. Stream flows become very stiff, which is over 10 km per hour with a high-power vortex and is able to produce square and big waves. Although this feature is, on the stream, that has a drop of 10 m per km but heavy rain and the presence of rapids on the stream likewise can trigger the flow of the stream and a wave of class IV.

## CONCLUSION

This study, conducted with the help of ArcGIS, the count done based on 16 morphometric parameters that suggest the upper sub watershed of the Sungai Sedim, is fifth order, type tributaries that branch off like the limbs of trees and types of dendrites. This sub watershed has a homogeneous nature of which is not influenced by the structure or rock tectonic connection tributaries of the stream order to stream order to one another are at a low angle and steep in some spots. The results showed stream order three has the steepest gradient, with moderately high infiltration rates. The Sungai Jemerli sub watershed has closely braided stream with oval shape, sedimentation rates were low and with moderate drainage density. Results furthermore show that a simple form of rugged terrain, and steepness of 3°. Steepness ratio and drainage density has a relationship with the reason value $R_b$, $R_b$ has close ties with watershed geomorphic factors. The area has a high groundwater, and potentially preserving local water resources and Sungai Jemerli flows. RL ratio equal to one indicates the formation of the stream ranked Sungai Jemerli sub watershed as young and with a smooth texture streams. Morphometric analysis of the Sungai Jemerli ArcGIS technique. The result revealed that the entire subject area has uniform lithology and is structurally permeable. Sungai Jemerli stream flows categorized between classes I to IV, which bears a great prospective to attract tourists for water sports events such as white water rafting and kayaking.

## ACKNOWLEDGMENTS

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