Application of Geographical Information Systems in the study of Morphometric Characteristics of the Progo-Opak River Watershed Area in Yogyakarta, Indonesia

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Abstract

The study aims to harness and utilize the technology of geographic information systems in extracting Morphometric characteristics of the Progo-Opak river watershed area in Yogyakarta relied on the analysis of a digital elevation model for the basin area of the SRTM satellite, with an accuracy of up to 90 meters. The study aimed to derive the water basins and the river network of Progo-Opak river watershed area through the DEM images using Arc GIS10.5, Arc hydro program. There is Four main aspects: Relief aspects, Linear aspects, Areal parameters, Drainage texture analysis. It was noticed that the Progo-Opak river watershed area from the fifth order according to the Strhles classification, while the total number of streams in opak river (354) and (437) for progo. The results showed the opak River where it tends to be oval according to the classification. And showed in progo river where it tends to be elongated according to the classification. The study shows the drainage density was in the area of the opak- progo river watersheds (0.71 km/km2 in opak) and (0.77km/km2 in progo), This value is considered very low, according to the (Strahler1964) classification. The study also showed that there is little chance of floods in the study area, except in some places in the estuarine areas. The study achieved the objectives is to evaluate various morphometric parameters of the study area using GIS tools, by establishing and adopting a database of Morphometric characteristics, establishing accurate digital maps to the basin area.

Keywords: Drainage · GIS · Progo-Opak River Watershed Area · SRTM DEM · Morphometry. Stream

Introduction

The world now suffers from the problem of availability of fresh water, the main causes of which are population growth, urbanization, climate change, irregular rainfall, and lack of sustainable water management and storage plans. Therefore, there is an urgent need for the evaluation of water resources because they play a primary role in the sustainability of livelihood and regional economics throughout the world. (Singh *et al*. 2011, 2013). In a watershed, the base unit is the Waterways that shows the structural, geological and hydrological configuration of the basin. The knowledge of topography, stream network and its pattern, geological and geomorphological setup in the watershed is requisite for its management plan and the implementation of conservation measures (Sreedevi *et al*., 2013). Morphometric studies are considered to be modern and important applications in geomorphology, geographers and those interested in running water resources and runoff surface characteristics. The morphological analysis is a significant tool for understanding the topographic situation and hydrological condition of a catchment area.

Morphological parameters within certain value range directly indicate the runoff generation and erosion hazard of a catchment (Deshmukh *et al*., 2010). Therefore, the study of morphometric characteristics assumes greater significance in developing the surface and groundwater resources more particularly in Indonesia. With the technical and technological development, GIS, remote sensing and digital elevation models have emerged, which have played a prominent role in serving researchers and students in the field of hydrological and morphological studies of water, which can be used in many morphometric studies quickly, easily and accurately and produce accurate maps and results.

This study will focus on analyzing the morphological characteristics of the Progo-Opak river watershed area of Yogyakarta using geographic information systems and digital elevation models. These basins are one of the largest water Watershed in Yogyakarta. GIS and remote sensing technology will be used by Arc Gis, the hydrologic modeling tools in the ArcGIS Spatial Analyst extension toolbox provide methods for describing the physical components of a surface and morphometric parameters could be calculated, the hydrologic tools allow you to

analysis of various drainage parameters such as ordering of the various streams and basin area, perimeter and length of drainage channels, drainage density, stream frequency, bifurcation ratio, texture ratio, basin relief, ruggedness number, and time of concentration, identify sinks, determine flow direction, calculate flow accumulation, delineate watersheds, and create stream networks (Esri). Therefore, the main objective of this study is to evaluate various morphometric parameters of the study area using GIS tools.

Methodology

Fig 1. Astronomical site of Yogyakarta province

Source: Prepared by the researcher based on the data of the Department of Land and Spatial Planning, Sleman Regency, Special Region of Yogyakarta, Geoportal Sleman. 2019

Fig 2. Location Map of Opak-Progo Watershed

The study area is located in the province of Yogyakarta, in the middle of Java Island. Java is one of five islands comprising Indonesia (Java - Sumatra - Kalimantan - Papua - Sulawesi). In Yogyakarta there are three main areas called (River District), which are (Das Opak, Das Brogo, Das Serang), opak-progo river watersheds area is divided into 52 Water Districts, consisting of 31 Water Districts in the progo river watersheds area. The area of opak-progo river watersheds area River is 4,077.43 km2. The study will focus on the opak-progo river watersheds area of Yogyakarta province, the topographical conditions at the Opak - Progo generally consist of mountainous, mountainous and lowland areas. (Fig 1- 2) (Law of WATER RESOURCES, number 590 / 2010.)

The study will rely on the use of GIS in the processing of satellite data Known as DEM digital elevation models with a spatial resolution of 90 meters, to extract. The following methods have been used for this purpose: 1- Data collection and entry into the GIS environment: The Digital elevation model (DEM) was obtained through of the (SRTM satellite). For the NASA space agency and the United States Geological Survey. and it is freely available with a spatial resolution of 90 meters, through Digital elevation model we can obtain digital topographic data Of the Earth, which has a major role in hydrological processes. The DEM of the catchment was extracted from Shuttle Radar Topography Mission (SRTM) data obtained with a resolution of 90 /m (downloaded from the http://srtm.csi.cgiar.org). 2- Derive data from the DEM layer: Derive the boundaries of the basin area, Using the ARC Gis10.5 program and Arc Hydro tools, the study area was derived were deducted based on digital elevation models data. The study area, watershed derivation, and river area were identified by comparison with the topographic images approved in Indonesia, and Law about CRITERIA AND DETERMINING THE RIVER AREA. The law considers A river area is a unit of water resources management area in one or more watersheds and / or small islands with an area of less than or equal to 2,000 km2. A watershed is a land area that is an integral part of a river and its tributaries, which functions to accommodate, store and flow water that comes from rainfall to lakes or to the sea naturally, the boundary on lan is a topographic and boundary separator in the sea up to the waters that are still affected by land activities. In Yogyakarta, there are three main areas called (River District), which are (Das Opak, Das Progo, Das Serang). Where the Opak area includes all the watersheds of the river (Oyo - Opak - Code - Gajahwong) The progo area includes all the watersheds of the (progo - Winongo) (Law Number 04 / PRT / M / 2015). (Fig 2). 3- Quantitative Analytical Approach: The data used in the study are analyzed by describing and analyzing the forms in quantitative terms in preparation for the work of gauging measurements using GIS and the program (Arc gis, Arc Hydro), and then creating a database of those variables to

be used in the creation of analyzes and morphometric measurements for the study area. All the extracted parameters as the number and length of streams with different stream order, drainage area, basin perimeter, total basin length and width were calculated using Arc GIS software. Drainage density, drainage texture, stream frequency, shape, circulatory ratio, elongation ratio, etc. (Table 1) 4- Cartographic Approach: Geographic data analysis and maps for the study area using GIS and remote sensing. 5- Comparative approach: will be based on the comparison in the study of the phenomenon where it will highlight the similarities and differences between the two phenomena, where the comparison between the two basins based on the results of the analysis process.

Results and Discussion

Considered as Opak-Progo watershed has several main tributaries and is quite important for the balance of nature in the Province of Yogyakarta, the opak watershed is located in Yogyakarta Special Province, The Opak river watersheds area is located at the coordinates of (X: 447815.171299, Y: 9129191.03097). The length of the main river ± 106 km. The area of the opak watershed is ± 1788 km2. opak watershed has several main tributaries and is quite important for the balance of nature in the Province of Yogyakarta, namely (Kali Gajahwong, Kali Code, Kali Winongo, Kali Kuning, Kali Belik, Kali Tambakbayan, Kali Gendol). The opak river watershed area extends to the lands of (Bantul - D.I Yogyakarta - Sleman - Gunung Kidul) (Fig 2). And a small portion of (Wonogiri - Klaten). Administratively, the Progo watershed is located in Central Java Province and Yogyakarta Special Province. The Progo river watersheds area is located at the coordinates of (X: 415108.562939, Y: 9171609.95253). The area of the Progo watershed is ± 2,421 km2, with the length of the main river ± 138 km. The Progo watershed has several main tributaries (Progo - Winongo). The progo river watershed area extends to the lands of (Kulon Progo - Magelang - Temanggung), And a small portion of (Boyolali) (Fig 2). In morphometric analysis, an integrated use of DEM for the generation of database and extraction of various drainage parameters. The configuration of the earth's surface and the dimensions of the reliefs are measured. Characteristics of catchment area and describes how catchment area controls and regulates the hydrological behavior. This analysis is carried out for the quantitative assessment of the watershed, for planning and management of water resources. And setting future plans for managing water resources. There is Four main aspects: Relief aspects, Linear aspects, Areal parameters, Drainage texture analysis (Table 1). The following paragraphs describe the physical meaning of various morphometric parameters.

Table 1. Method of Calculating Morphometric Parameters of Drainage basin

	Morphometric Parameter	Method/ Definition	Reference
Linear aspects	Stream order (U)	Hierarchical order	Strahler (1952)
	Number of Streams (Nu)	Nu = N1 + N2 + ……. + Nn	Horton (1945)
	Stream Length in km (Lu)	Length of the stream Lu= L1+L2…+L6	Strahler (1964)
	Mean stream order length (Lsm)	Lsm=Lu/Nu; Where, Lu=Mean stream length of a given order (km), Nu=Number of stream segment.	Strahler (1964)
	Stream length ratio (Lur)	Lur = Lu/ (Lu – 1) RL = Lu/Lu - 1, where, Lu = total stream length of order ''u'', Lu - 1 = the total stream length of its next lower order.	Horton (1945) Strahler (1964)
	Bifurcation Ratio (Rb)	Rb = Nu / Nu+1 Where, Nu=Number of stream segments present in the given order Nu+1= Number of segments of the next higher order	Strahler (1964)
	Mean bifurcation ratio (Rbm)	Rbm = (Rb1 + Rb2…. + Rbn)/n	Strahler (1964)
Relief aspects	Total Basin relief in m (Bh)	Bh = Z - z Vertical distance between the lowest and highest points of basin.	Schumn,1956
	Relief Ratio (Rh)	Rh = Bh / Lb Where, Bh=Basin relief, Lb=Basin length	Schumm (1956)
	Ruggedness Number (Rn)	Rn=Bh×Dd Where, Bh= Basin relief, Dd=Drainage density	Schumn,1956
Drainage texture analysis	Drainage density (Dd)	D = Lu/A, where A is the total area of the basin (km)2, Lu is the total stream length of all orders	Horton (1932)
	Stream frequency (Fs)	Fs = Nu/A, where Nu is the total number of streams of all order, A is basin area in km2	Horton (1932)
	Drainage texture (Dt)	T = Dd * Fs	Smith (1950)
	Circulatory ratio (Rc)	Rc= 12.57*(A/P²), where A is the area (km)2 and p is the perimeter (km) of the watershed,	Miller (1953)
	Constant channel maintenance(C)	C = 1/Dd Inverse of drainage density	Schumm (1956)
	Infiltration Number (If)	**Di= Fs*Dd**	Faniran (1968)
	Length of overland flow (Lg)	Lg = 1/(D*2), where D is the drainage density	Horton (1945)
	Elongation ratio (Re)	*Re* = (2/*Lb*) ×√(*A*/π) where, *A* = area of basin, π = 3.14, *Lb* = basin length	Schumn (1956)
Areal aspect	Basin area (A) (km2)	GIS analysis/DEM	Schumm (1956)
	Basin length (Lb) (km)	GIS analysis/DEM	Schumm (1956)
	Perimeter (*P*) (km)	GIS analysis/DEM	Schumm (1956)
	basin width (Wb)	Wb = *A*/Lb	Horton (1932)
	Form factor ratio (Rf)	Rf = A/Lb2 is the square of the basin length (km), A is the basin area in km2	Horton (1932)

Areal aspect

Perimeter: Through the applications of geographic information systems and the ArcGis10.5 program, the perimeter of the Progo and Opak River has been identified, Overall perimeter of Watershed in river Opak area is 272.61 km, And the number of sub-catchments in the river area is 630 catchment, and the biggest one with parameter 53.67 km in north of the area (Table 2). Overall perimeter of Watershed in river Progo area is 272.20 km, And the number of sub-catchments in the river area is 763 catchment, and the biggest one with parameter 44.83 km in Southwest of the area (Table 2). We notice

here that the perimeters of the two Watershed are similar, despite the large area of the Progo River Watershed. Basin area: It is the first step in computing the basin morphometric characteristics. The total area of the Opak and Progo watersheds (3997.04 km square). Area of opak river watershed is (1788.65 km square) (Table 2), while the area of progo river watershed is (2208.39 km square) (Table 2). The opak River watershed occupies the largest area of Yogyakarta Prefecture and passes in (Sleman - Bantul - Yogyakarta City - Gunung Kidul), while the Progo River watershed covers (kulon progo - and a small part of Bantul and Sleman - extending to the top to cover the city of Magelang) (Fig 2). Basin length: It is one

of the important variables that are associated with many other characteristics of the drainage basin Drainage, the most important of which is the shape of the pelvis. The length of the pelvis is defined as the distance of the straight line from the mouth of the Abbas to the exit point (Horton. 1932). And the Schumm knew him Measure the length of the line connecting the mouth of the estuary and the farthest point on the circumference of the valley, parallel to the main stream, passing through the center of the basin (Schumm. 1956). In this paper we used the Schumm method for its accuracy. Where the length of opak watershed is (58.98 km) (Table 2) While length of progo watershed is (88.36 km) (Table 2). And longest flow path in opak watershed is 109.67 km. While longest flow path in progo watershed is 138.29 km. Note that the proportion of the length of the progo river watershed is greater due to its longitudinal shape that stretches from the Sindoro and sumbing in mountains in magelang city (Fig 3). Basin width: The width of the basin plays a major role in determining the shape of the basin. The width also affects the amount of water it receives from precipitation and evaporation. Where the greater the width, the more the basin receives the precipitation and, consequently, the increased flow (Horton 1932). The width was measured by applying an equation Wb = A/Lb (Horton. 1932). where length of basin / area of basin. The width of the opak river watershed was (30.32 km) (Table 2). While the width of the progo river watershed was (24.99 km) (Table 2). We note that the ratio of opak width is greater due to its shape close to the circular shape.

Table 2 Areal aspect of the WS Progo Opak watershed

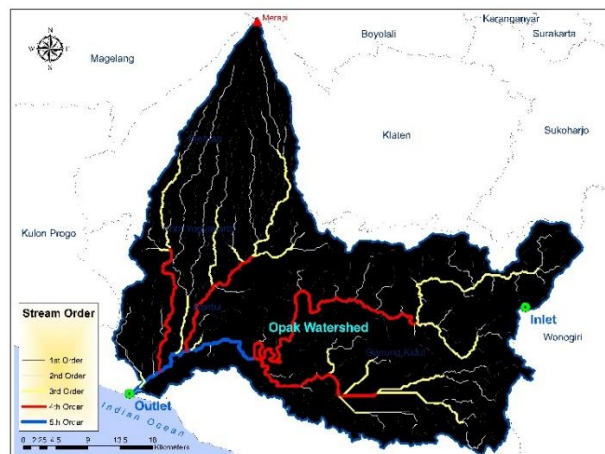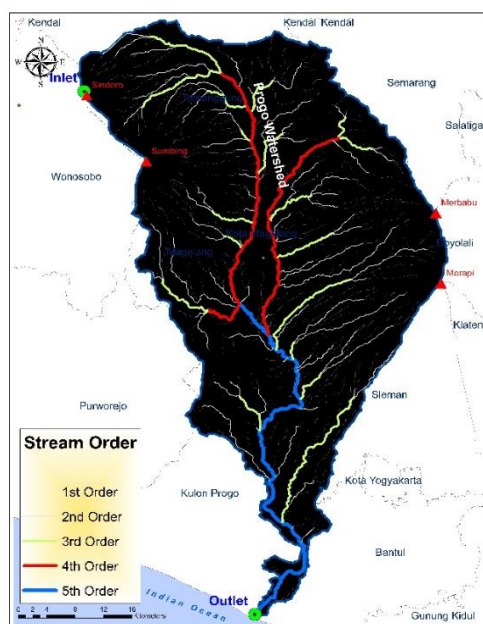| Parameter(s)	Opak	Progo
Basin length (Lb) (km)	58.98	88.36
Perimeter (*P*) (km)	272.61	272.20
Mean basin width (Wb) (km)	30.32	24.99
Basin area (km2) (*A*)	1788.56	2208.39

Fig 3. Drainage and stream order map of the Opak -Progo Watershed River

Linear aspect

Stream order: is an important aspect for Morphometric Characteristics and drainage basin analysis. It expresses the position of the waterways in the hierarchy of streams (Horton 1945; Strahler 1957; Leopold *et al.* 1964). In this study, the Strahler 1957 method was adopted to determine the order of ranks, where by the method depends on considering the smallest stream in the sources is the order (1), When meeting two Stream of the first degree it give the rank of (2), When meeting two Stream of the second degree it give the rank of (3), And so on (Fig 3). When two channels of different order join then the higher order is maintained (Strahler 1964). It has been found that the study area for opak river watershed is a (5th) order drainage basin having (354) total streams. And for progo river watershed is (5th) order with drainage basin having (437) total streams (Table 3). Number of Streams: It refers to the digital gradient of the group of tributaries that make up the basin (Tale & Manjare, 2015). Horton Law provides escribes that the number of streams of each order forms an Inverse relationship with against stream order (Horton 1945). Where the higher the stream order, the less the number of water stream, will reach one stream at the mouth at the fifth rank, As the number of streams in the first order of the opak river watershed reached 270, the number of the second order 63, the number of the third order 16, the number of the fourth order 4, and the number of the fifth order 1 (Table 3) (Fig 3). In the northern sub-basins area showed a large number of streams of the first order, and this indicates the severity and complexity of the terrain there in the Merapi Mountains region (Vincy *et al.* 2012). At the end of the river near the estuary, fewer streams and an increase in orders indicate the possibility of sudden flooding in the future course of the river at heavy rains (Chitra *et al.* 2011). As the number of streams in the first order of the progo river watershed reached 333, the number of the second order 81, the number of the third order 19, the number of the fourth order 3, and the number of the fifth order 1 (Table 4) (Fig 3).

Table 3. Linear aspect of the Opak watershed

Stream order (u)	No. of streams (Nu)	Bifurcation ratio (Rb)	Mean bifurcation ratio (Rbm)	Total length of streams (Lu) (km)	Mean length of streams (Lsm) (km)	Stream length ratio (Lur)
Opak						
1	270	4.28		666.00911		
2	63	3.93		314.969456		0.47
3	16	4	4.05	154.906268	3.60	0.49
4	4	4		114.502864		0.73
5	1			24.107828		0.21
Total	354	16.21		1274.495526		

Table 4 Linear aspect of the Progo watershed

Stream order (u)	No. of Streams (Nu)	Bifurcation ratio (Rb)	Mean bifurcation ratio (Rbm)	Total length of streams (Lu) (km)	Mean length of streams (Lsm) (km)	Stream length ratio (Lur)
Progo						
1	333	4.11		944.859369		
2	81	4.26		454.765255		0.48
3	19	6.33	4.42	157.099583	3.90	0.34
4	3	3		84.878502		0.54
5	1			65.064956		0.76
Total	437	17.7		1706.667665		

Bifurcation Ratio and Mean Bifurcation Ratio: The bifurcation ratio is defined as the ratio between the number of streams of the given order to the number of streams of the next higher orders (Strahler 1957). The importance of studying the percentage of bifurcation comes because it is one of the most important factors that control the rate of discharge, as an index of relief and dissections and it is possible to estimate the flood. (Mesa 2006, Horton 1945). So, the less the bifurcation ratio the less the density of discharge and therefore the rain water accumulates in a few and limited streams, which increases the risk of flooding. it is a reflection of the geological structure, the quality of rock in the basin and climatic conditions (Geena & Ballukrayam. 2011). (Strahler) and another explained the bifurcation ratio from (3-5), when the influences of geologic structures on the stream network is negligible, usually these values are common in the areas where geologic structures do not exercise an influence on the drainage pattern. Values greater than 10 have a great geological effect. In addition, the value of bifurcation plays a large role in determining the shape of the pelvis (Verstappen 1983; Ghosh and Chhibber 1984). Long basins have low Rb values while circular basins have high Rb values (Morisawa 1985). (Table 3,4) shows that the bifurcation ratio in opak river watershed ranged from (4.28 - 4), while in progo river watershed ranged from (4.11- 3). increases in the all orders almost similar. where is mean that the influences of geologic structures on the stream network is normal in opak and progo watershed, but in the 3th order in progo river watershed was (6.33) and this number more than (5) Because of the roughness of the terrain in the third rank streams there. and the weighted mean bifurcation ratio in opak river reached (4.05) and (4.42) in progo river. Which is within the framework specified by (Strahler). Thus, the drainage pattern is not significantly affected by the geological structure and topography (Dhawaskar, 2015). Stream Length and Mean stream order length: Stream length is one of the most significant hydrological features

of the basin as it reveals surface runoff characteristics. Whenever the length of the streams is few, it indicates the severity of the terrain in the area, The length of the stream decreases as the riverine order increases. (Table3,4) shows the length of the streams in all order, as their total amounted to (1274 km) in opak river watershed, where the length of the streams of the first order was about half of the total (666 km). And the length of the streams in progo river watershed was (1706 km) in all orders, where the length of the streams of the first order was about (944 km). The mean stream length (Lsm) is a characteristic property related to the drainage network and its associated surfaces (Strahler, 1964). The results, after applying the equations, mean that the average flow length was (3.60 km) in opak, while was (3.90 km) in progo. Stream length ratio: The stream length ratio can be defined as the ratio of the mean stream length of a given order to the mean stream length of next lower order and has an important relationship with surface flow and discharge (Horton, 1945). The stream length ratio gives an idea about the relative permeability of the rock formation (Soni 2016). In (Table 3, 4) the stream length ratio values between streams of different order in the basin reveal that there are variations in slope and topography.

Drainage texture analysis

Drainage density: Drainage density is the ratio of total stream length of all the orders per unit basin area (Horton 1945). The drainage density is an important morphometric measure of the river drainage network, and it is a reflection of the climatic conditions, especially the amount of rain, geology, rock cover, nature and amount of permeability, surface topography, and nature of vegetation (Meshram & Knadse, 2015). Drainage density influences the output of water and sediment from the catchment area (Ozdemir & Bird 2009). Dd of the

drainage basin depends on climatic condition, vegetation and landscape properties like soil and rock (Moglen *et al*. 1998). The low drainage density indicates the low number and length of stream, low value of topographic fabric, high permeable rocks, density of vegetation and low relief. (Sangita and Dulal, 2015). While high drainage density is the resultant of impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahler, 1964). The drainage density was obtained by the formula (Harton1932). (Table 5) shows the drainage density was in the area of the opak- progo river watersheds (0.71 km/km2 in opak) and (0.77km/km2 in progo). This value is considered very low, according to the (Strahler1964) classification, where a classification of three categories (less than 12) is low, (12 - 16) is medium, (greater than 16) is high (Kant, *et al*, 2015). indicating very coarse texture and the presence of both highly weathered and significantly infiltration rates. The reason for the low drainage density in the area of the opak- progo river watersheds, despite the high rate of rain, which ranges between 1700- 4000 mm annually (BMKG, 2019). It is the nature of the ground cover, the density of vegetation, the large porosity of the soil, and the density of urban cover. Based on the hydrological potentials, the north part of opak- progo river watersheds area (on the slope of Merapi, Merbabu, Sumbing) (Fig 2) is to serve as a water catchment area due to the high permeability of the area (RDPRP, 2005: 1-30). in addition to the soft and porous soil structure that allows water to cross the aquifer. Where the soil types in opak- progo river watersheds area are divided into (Alluvial soil and Regosol soil) It is one of the Great transmittance types of water. (PKS, 2010: 4). And soil type (Latosol and margalite soils) It is a sterile rocky soil that is impermeable to water and is found in highlands Gunung kidul Regency, in the hills of Kulon Progo Regency and Bantul Regency, This explains the lack of water in the dry season in these areas and the increased possibility of floods, especially in the estuarine areas due to water pressure and the increase in portable sediments that block the riverbed (law no.590. 2015). In addition to the small number of streams (354) in opak and (437) in progo and its length is short, as (148) stream of the first order are less than (2 km) out of (270) stream for opak, and 166 stream of the first order are less than (2 km) out of 333 stream for progo. Stream frequency: Stream frequency of a basin is defined as the number of streams per unit area (Horton 1945). A higher stream frequency indicates greater surface runoff, large terrain, intermittent vegetation, and low soil porosity, while a lower Stream frequency indicates little relief and high soil porosity. The results show that there is a low stream frequency in the area of the opak- progo river watersheds area, where it was (0.19 km square) for both rivers. This is due to the porous nature of the soil, the low drainage density and the large vegetation (Table 5). Where indicates the low stream frequency in the basins to high

permeable rock formations of water (Palanisamy, *et al*.,2015). Drainage texture: Drainage texture may be defined as the total number of stream segments of all order in a basin per perimeter of the basin. Drainage texture is the product of Dd and Sf. Drainage texture depends on the, infiltration capacity and relief aspect of the terrain and on natural factors such as climate, rainfall, vegetation, rock and soil type (Smith 1950). Dt is categorized into five different classes: very coarse (0 - 2), coarse (2–4), moderate (4–6), fine (6–8) and very fine (>8) (Smith 1950). (Table 5) shows the value of the drainage texture for both rivers, as they were in opak (0.13) and in progo was (0.14). This refutes the reduced drainage density due to the heavy porosity of the opak- progo river watersheds area. Circulatory ratio: Circularity Ratio is the ratio of the area of a basin to the area of circle having the same circumference as the perimeter of the basin (Miller, 1953). The circularity ratio is influenced by the slope, relief geologic structure of the basin and land use/landcover (Soni. 2016). The Circulatory ratio of the whole opak watershed is (6.56). The high ratio of this Circulatory ratio. This indicates the tendency of the pelvis to rotate, while reached (8.11) in progo watershed (Table 5). This shows that the opak- progo river watersheds area is made up of weak rocks that assisted demolition operations, and that the basin is in advanced stages of the basal and geomorphological cycle. Constant channel maintenance: The ratio between the spatial unit needed to feed one longitudinal unit from the network ducts Schumm (1956). The greater the value of this rate, the greater the area of the pelvis, at the expense of its limited-length network ducts, which results in a lower drainage density. The lower the value of the Constant of channel maintenance rate, this indicates that the area is affected by structural structures, low soil permeability, severe slope and rapid surface runoff. (Ali & Khan, 2013: 25). By applying the equation established by (Schumm 1956), A large percentage is clear in the area of the opak- progo river watersheds area, where it was 1.40 km/km square in opak and 1.29km/km square in progo (Table 5). This means that every in 1.40 km of stream lengths is fed an area of about 1.40 km square in opak river, Versus 1.29 km / km square in progo. This indicates that there is a large area in front of the basin to extend the river network through sculpture. Infiltration Number: Infiltration number of a drainage basin is the product of drainage density and stream frequency. It is the number by virtue of which an idea regarding the infiltration characteristics of the basin is obtained, the higher the infiltration number, the lower will be the infiltration and higher will be the run-off (Nayar & Natarajan 2013). opak- progo river watersheds area showed low runoff and high infiltration capacity, where an equation (Faniran1968) was applied the ratio was (0.13) for opak. While (0.14) in progo (Table 5). Length of overland flow: The Length of Overland Flow (Lg) is the length of water over the ground surface before it gets concentrated into definite stream channel (Horton, 1945). Length of overland flow is

described as half of reciprocal of drainage density. Lg is one of the most important independent variables affecting hydrologic and physiographic development of drainage basins. when rainfall intensity exceeds soil infiltration capacity, the excess water flows over the land surface as overland flow (Suresh. 2000). This factor depends on the rock type, permeability, climatic regime, vegetation cover and relief as well as duration of erosion (Schumm. 1956). Its value in the opak river is (0.70) and (0.64) in progo (Table 5), which is relatively small. indicates the influence of low structural disturbance, high permeability, Medium and balanced slope and low surface runoff. The opak watersheds show a well-developed stream network and mature geomorphic stage. Elongation ratio: is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm 1956). The elongation ratio is one of the most accurate morphometric parameters in the measurement of drainage basin shapes, and indicates how close the pelvis is or how far away it is from the rectangular shape. The circular basin has the ability to drain runoff more than rectangle (Singh & Singh, 1997). And its value is limited to (0-1) according to the (Strahler 1964) classification, and the closer the ratio to zero means the sink approaching the rectangular shape, circular (0.9–1.0), oval (0.8–0.9), less elongated (0.7–0.8), elongated (0.5–0.7) and more elongated (\0.5). The results showed elongation rate of the opak River (0,80), where it tends to be oval according to the classification, and this indicates that the basin is located on a steep and relatively steep slope, And showed elongation rate in progo river (0.60), where it tends to be elongated according to the classification (Table 5) (Fig 3).

Table 5 Results of drainage texture analysis of the WS Progo Opak watershed

Parameter(s)	Opak	Progo
Drainage density (Dd)	0.71	0.77
Stream frequency (Fs)	0.19	0.19
Drainage texture (Dt)	0.13	0.14
Circulatory ratio (Rc)	6.56	8.11
Constant channel maintenance(C)	1.40	1.29
Infiltration Number (If)	0.13	0.14
Form factor ratio (Rf)	**0.51**	0.28
Length of overland flow (Lg)	0.70	0.64
Elongation ratio (Re)	0.80	0.60

Table 6 Relief characteristics of WS Progo Opak watershed

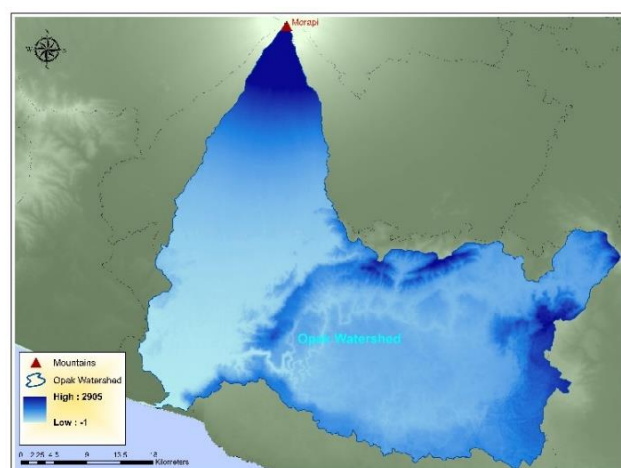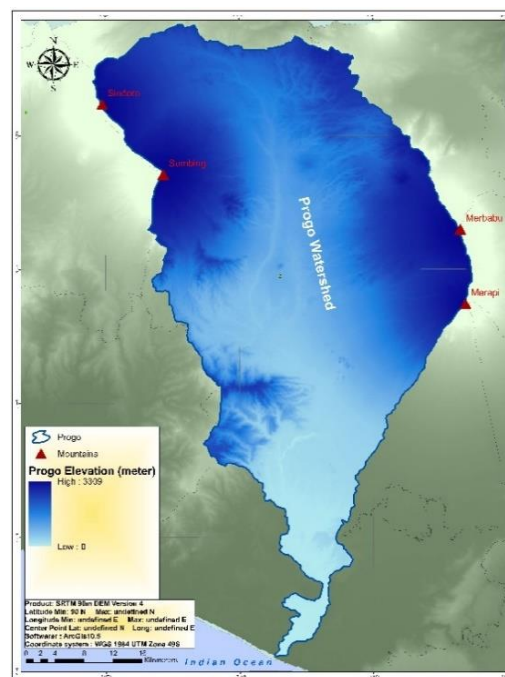| Parameter(s)	Opak	Progo
Total Basin relief in m (Bh)	**29**06	3309
Relief Ratio m/km (Rh)	49.2	37.4
Ruggedness Number (Rn)	2.06	2.54

Fig 4. Digital elevation model for (Opak-Progo Watershed River)

Relief Aspects

Total Basin relief: defined the total relief of the river basin as the difference in the elevation between the highest point of a watershed and the lowest point on the valley floor (Strahler 1957). influences flood pattern and sediment volume that can be transported. The basin relief rate in the opak river area is (2906 m) and (3309m) in progo river above sea surface (Fig 4), these values indicated high infiltration and low runoff conditions in the study area. Relief Ratio: is an important criterion for knowing the topographical nature of the area. It expresses the extent of the pelvic molar to its length (Schumm, 1956). High values indicate severe surface pelvic Terrain, while low values indicate mild pelvic Terrain. The value of the Relief Ratio is related to the geological and structural conditions and the slope of the basin (Schumm, 1956). The value of the Relief Ratio is

related to the geological and structural conditions and the slope of the basin (Schumm, 1956). The results showed a percentage of (49.2 meter/km), for the opak river watersheds area, a large percentage indicating the severity of the terrain in the basin (Table 6). The high value of the Relief Ratio in the Opak river basin is explained by the increase in the difference between the level of the highest points and the lowest points, and the variance of structural conditions and the type of rock in the basin, as indicated by the geomorphology of the basin. While the results showed a percentage of (37.4 meter/km) for progo river watersheds area (Table 6), It is less than there is in the region of the opak river. This is because the progo river is located between Mount (Merapi, Merbabu, Sumbing) (Fig 4). In addition to its longitudinal shape, which extends from north to south. Ruggedness Number: It is one of the morphometric parameters that measures the relationship between pelvic molar and drainage network density (Patil, *et al.*, 2015). (Strahler 1958) has confirmed that the greater the drainage density and the sprocket in the pelvis, the higher the roughness factor. The roughness value is an indication of the basin's progress in the geomorphological cycle. An extreme high value of ruggedness number occurs when both variables are large and slope is steep (Strahler, 1956). (Patton & Baker, 1976) conducted several tests on basins in the United States to develop an index for flood forecasting, and found that spatial coefficients for drainage intensity, sewage frequency, and Ruggedness number were the most predictable models for flooding, and found that basins have a high Ruggedness number for them A greater chance of flooding, and the high values of roughness in the study basins were approximately (4.60-10.95) (Patton & Baker, 1976: 945-948). The value of ruggedness number in opak-progo river watersheds area is (2.06) for opak and (2.54) for progo (Table 6). The value is Generally low due to the low drainage intensity. This indicates the chance of relatively weak flooding.

Conclusion

Integrated use of DEM for the generation of database and extraction of various drainage parameters. The configuration of the earth's surface and the dimensions of the reliefs are measured. Characteristics of catchment area and describes how catchment area controls and regulates the hydrological behavior. This analysis is carried out for the quantitative assessment of the watershed, for planning and management of water resources. And setting future plans for managing water resources. There is Four main aspects: Relief aspects, Linear aspects, Areal parameters, Drainage texture analysis. It was noticed that the Progo-Opak river watershed area from the fifth order according to the Strhles classification, while the total number of streams in opak river (354) and (437) for progo. The results showed the opak River where it tends to be oval according to the classification, and this indicates that the basin is located

on a steep and relatively steep slope. And showed in progo river, where it tends to be elongated according to the classification. Despite the roundness of the basin, the possibility and probability of flooding reduced due to the nature of the terrain, topography and the slope, in addition to the permeability of the surface material, vegetation and breadth and expansion of riverbeds, especially in the higher echelons and levels. The study shows the drainage density was in the area of the opak-progo river watersheds (0.71 km/km2 in opak) and (0.77km/km2 in progo), This value is considered very low, according to the (Strahler1964) classification, indicating very coarse texture and the presence of both highly weathered and significantly infiltration rates. The reason for the low drainage density in the area of the opak-progo river watersheds, despite the high rate of rain, which ranges between 1700- 4000 mm annually. It is the nature of the ground cover, the density of vegetation, the large porosity of the soil, and the density of urban cover. Based on the hydrological potentials, the north part of opak- progo river watersheds area (on the slope of Merapi, merbabu, sumbing) is to serve as a water catchment area due to the high permeability of the area. in addition to the soft and porous soil structure that allows water to cross the aquifer. The study also showed that there is little chance of floods in the study area, except in some places in the estuarine areas due to the increase and decrease of rains compared to the source areas that reach a height of about 3000 meters. The river drainage network of the Progo and Opak rivers, as they tend to have a tree shape and a parallel system in some places, due to the large area of basins and the presence of many rivers. Note that the proportion of the length of the progo river watershed is greater due to its longitudinal shape that stretches from the Sindoro and sumbing in mountains in magelang city. The width of the opak river watershed was 30.32 km. While the width of the progo river watershed was 24.99 km. We note that the ratio of opak width is greater due to its shape close to the circular shape. In the northern sub-basins area showed a large number of streams of the first order, and this indicates the severity and complexity of the terrain there in the Merapi Mountains region, At the end of the river near the estuary, fewer streams and an increase in orders indicate the possibility of sudden flooding in the future course of the river at heavy rains. And the weighted mean bifurcation ratio in opak river reached (4.05) and (4.42) in progo river. Which is within the framework specified by (Strahler). Thus, the drainage pattern is not significantly affected by the geological structure and topography. the stream length ratio values between streams of different order in the basin reveal that there are variations in slope and topography. The value of the drainage texture for both rivers, as they were in opak (0.13) and in progo was (0.14). This refutes the reduced drainage density due to the heavy porosity of the opak- progo river watersheds area. opak- progo river watersheds area showed low runoff and high infiltration

capacity, where an equation (Faniran1968) was applied the ratio was (0.13) for opak. While (0.14) in progo. The value of ruggedness number in opak-progo river watersheds area is (2.06) for opak and (2.54) for progo. The value is Generally low due to the low drainage intensity. This indicates the chance of relatively weak flooding. The study achieved and fulfilled the objectives and the aims of the study by establishing and adopting a database of Morphometric characteristics, establishing accurate digital maps to the basin area. The study recommends adopting and depending on Geographical Information software systems technology in modeling the drainage basins which they are very useful for Geomorphological studies because they offer spatial and three-dimensional analysis easily, as well as carrying out linear and survey measurements easily and accurately. The study also recommends increasing reliance on radar data and satellite visualization studies in general and natural Geomorphological studies especially because they save the time and effort of the researchers.

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