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Manokwari, 09-08-2022
Hormat Penulis

Dr. Mahmud,S.Hut.,M.Sc

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Herewith we submit a manuscript,

Title : **Impact of Wosi Watershed Characteristics On Hydrological as A Basis For Flood Management And Mitigation In Manokwari**

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1	2	3	4	5	6	7	
v	□	□	□	□	□	□	Conceived and designed the analysis
v	v	v	□	□	□	□	Collected

v	☐	v	☐	☐	☐	☐	Contributed data or analysis tools
☐	☐	☐	v	☐	☐	☐	Performed the analysis
☐	☐	☐	☐	v	☐	☐	Interpret the results
☐	☐	☐	v	☐	☐	☐	Wrote the paper
☐	☐	☐	☐	☐	☐	☐	Other contributions (specify in more detail)

IMPACT OF WOSI WATERSHED CHARACTERISTICS ON HYDROLOGICAL AS A BASIS FOR FLOOD MANAGEMENT AND MITIGATION IN MANOKWARI REGENCY, INDONESIA

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Abstract. Disaster flood has become biggest disaster in 10 years last. This study aims for determine impact Wosi watershed characteristics on hydrological the expected could give contribution in planning management and mitigation flood in Manokwari. This study used survey method, analysis spatial and field observation. The results showed that characteristics Wosi watershed have type climate very wet tropical with rainfall throughout the year without being recognized the dry season. Watershed morphometry includes shape watershed is triangular, there are 4 rivers that is river of rendani 1, river of rendani 2, kentek river and the dingin river. Flat topography wide of 970.58 hectares and to the slopes steep of 1,366.91 hectares with land use dominated non forest 62.32% and forest 37.68%. Flow regime coefficient (FRC) categorized low, medium and predominantly very high. Very high FRC means that river water flow is easy to change, sometimes low or even very high which can cause flooding. The annual flow coefficient (AFC) is categorized as low and very high. Low AFC means that the carrying capacity of the watershed is good, while a very high AFC indicates that the carrying capacity of the watershed is decreasing.

Keywords: impact, characteristics, Wosi watershed, hydrology

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Comment [A1]: Disaster flood has become the biggest disaster in the last 10 years. This study aims to determine the impact of Wosi watershed characteristics on hydrology that could give contribution in planning management and mitigation of floods in Manokwari. This study used survey method, analysis spatial and field observation. The results showed that characteristics of the Wosi watershed have a type climate very wet tropical with rainfall throughout the year without being recognized as the dry season. Watershed morphometry includes shape watersheds that are triangular, there are 4 rivers that are river of Rendani 1, river of Rendani 2, Kentek river and the Dingin river. Flat topography wide of 970.58 hectares and to the slopes steep of 1,366.91 hectares with land use dominated by non forest 62.32% and forest 37.68%. Flow regime coefficient (FRC) categorized low, medium and predominantly very high. Very high FRC means that river water flow is easy to change, sometimes low or even very high which can cause flooding. The annual flow coefficient (AFC) is categorized as low and very high. Low AFC means that the carrying capacity of the watershed is good, while a very high AFC indicates that the carrying capacity of the watershed is decreasing.

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INTRODUCTION

Throughout 2021 out of a total of 3,058 disasters in Indonesia 42.1 % were dominated by floods (BNPB, 2021). The trend of flooding continues to increase from year to year including the first half of 2022, from a total of 954 disasters, 379 floods (BNPB, 2022). Floods indicate the inability of the watershed ecosystem to provide environmental services as a result of degradation and deforestation of forest and land resources (Papaioannou *et al.*, 2015). Floods as a result of climate change, forest conversion and land use changes as a result of increasing population have increased the ratio of rainfall to surface runoff, the amount of water that directly becomes runoff increases significantly, so that peak discharge becomes larger (Yan *et al.*, 2013; Nasir *et al.*, 2017). The conversion of forest functions into plantations, settlements, and built-up areas is sometimes not realized. Whereas in general the rain in an area does not experience changes that have an impact on retained water, being accommodated which causes puddles.

Watershed is part of a complex ecosystem because it involves various bio-geophysic, social, economic, cultural and institutional components that interact with each other. The interactions between biotic and abiotic components in a watershed ecosystem have direct or indirect impacts both large and small. According to Junaidi & Tarigan (2011), the factors that influence the function of the water system of a watershed ecosystem are land use. According to Supangat (2012) watershed characteristics and land use are two important factors that affect the hydrological characteristics of the watershed. A comprehensive understanding of the hydrological characteristics of the watershed and the influencing factors is needed for sustainable watershed management, especially with regard to the use of water resources and land use (Azizah *et al.*, 2021).

The characteristics becomes very important to do as a reference for the preparation of watershed management plans based on Government Regulation (PP) Number 37 of 2012 concerning watershed management. The characteristics of the watershed can be identified through the analysis of the characteristics of the watershed which is the character and nature of the watershed. Among the characteristics of a watershed that often causes natural disasters, namely flooding, which is one of the conditions of the water system as a result of the output of a watershed (Paimin *et al.*, 2012). To determine the characteristics of a watershed is the biophysical condition of the watershed which is characterized by parameters related to climate, morphometry, topography, soil, geology, vegetation, land use, hydrology, and humans.

These climatic and biophysical characteristics will provide specific responses from the watershed to rainfall which will affect the character parameters and special features of water systems such as evaporation, transpiration, surface runoff, infiltration, interception, groundwater, and river discharge (Ningkeula, 2016). Increased surface runoff will have an impact on river discharge which if the water cannot be accommodated then flooding is inevitable. These parameters have been widely used in various hydrology-morphology studies such as flood characteristics, sedimentation and changes in watershed morphology. In addition, land use by human activities and the morphology of the watershed also affect the water system, including the sediment yield.

The Wosi watershed is part of 2,145 watersheds in Indonesia with the status of needing restored (KLHK, 2019). The Wosi watershed is also part of seven watersheds in Manokwari Regency which are classified as critical which borders the Soribo Bay. According to Pamuji and Hardianti (2019) that the Wosi river cannot accommodate the peak flow during high rainfall, so flooding is inevitable. The Wosi area located in the capital city of West Papua Province, continues to grow and develop, but its carrying capacity is decreasing (Mahmud *et al.*, 2021). The Wosi watershed in recent years has become a source of catastrophic flooding for some residents of Manokwari, especially those living around the downstream watershed such as: the Wosi market, the green valley, around the Rendani airport, the Bugis village, and the Javanese village. As a consequence of the development of the city of Manokwari, the forest conversion and land and climate change have resulted in flooding in the downstream area of the Wosi watershed in recent years. This study aims to determine impact watersheds characteristics on hydrological that are expected to contribute to flood management and mitigation planning in Manokwari.

Comment [A3]: There are two papers published in 2021, please add a or b..?

METHODS

Research Location

The study was carried out for 4 months with a location in the Wosi watershed which is geographically located at 133^{0} 0' 0.722"–134^{0} 3' 34,55"E and 0^{0} 54' 8.24"–0^{0} 54' 8.24"S with an 2,346.32 ha (Figure 1). Downstream of the Wosi Watershed is a built-up area and the capital of West Papua Province. The upstream of the Wosi watershed covers a fairly steep hill and its estuary in the Doreri Bay.

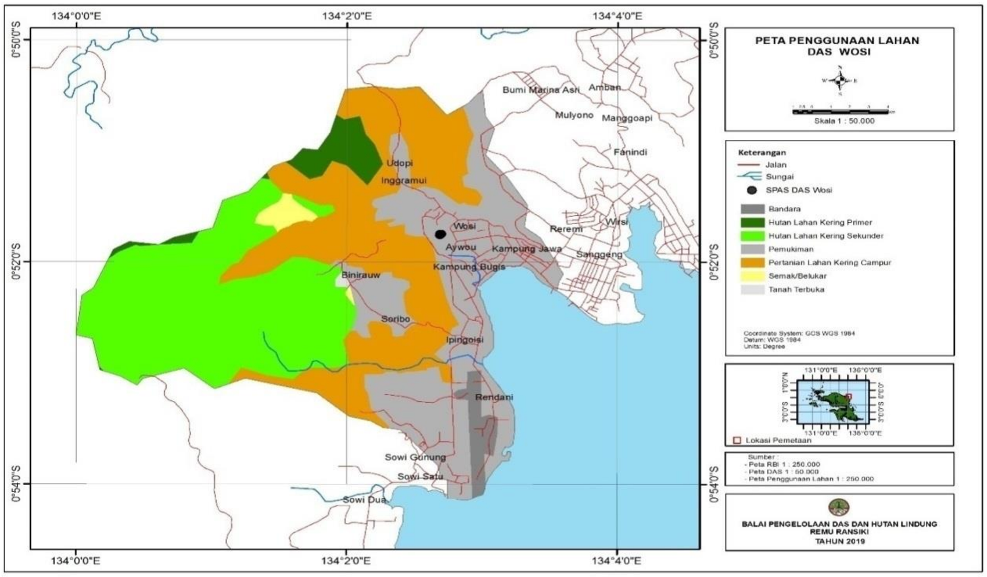

Figure 1. Research Location

Comment [A4]: Please translate the title of the map into English, also the information/legend of the map is, please translate into English.

Data Collection

The research method used is survey and field observation. Watershed morphology includes: land-use and topography observed directly and through digital elevation models. The morphometry includes: the shape of the watershed, the area of the watershed, the level of branching, the density of the flow, the flow pattern and the length of the main river, which are measured digitally based on the guidelines for identifying characteristics of the watershed. Meanwhile, for the hydrology the observed data installed on the SPAS consists of flow regime coefficients (FRC) and annual flow coefficients (AFC). Rainfall data in the last 10 years obtained from the BMKG Rendani, Manokwari Regency include: daily, monthly, annual rainfall, wet months, dry months and rainfall intensity. Wet month (WM) : the amount of rainfall is more than 100 mm/month, humid month (HM) : the amount of rainfall is between 60-100 mm/month and dry month (DM) : the amount of rainfall is less than 60 mm/month. The rainfall data is used to classify the climate according to Schmidt & Fergusson (1954) in (Soewarno 1991).

$$Q = \frac{DM}{WM} \times 100\% \quad [1]$$

Note : Q = climate; DM = Number of dry months; WM = Number of wet months

To determine the shape of the watershed, it is necessary to value the circulation ratio or RC (Strahler, 1964) and the extension ratio or RE (Schum, 1956) with the following formula:

$$RC = \frac{4 \pi A}{P^2} \quad [2]$$

$$RE = 1.129 \left\{ \frac{A^{0.5}}{} \right\} \quad [3]$$

L

Note :RC = circulation ratio; RE = elongation ratio; A = watershed area (m2); L = length of the watershed; P = perimeter of the watershed (m); = 3.14 If RE <RC means the watershed is rounded and RE> RC means the watershed is elongated. Data on circulation ratio, extension ratio, total river length, and watershed circumference were obtained through a geographic information system (GIS). River density, number of long rivers including tributaries and wide watersheds were obtained through GIS. River density is an index that shows the number of rivers and tributaries in a watershed. The index is obtained by the following equation (Soewarno, 1991):

$$Dd = \frac{L}{A} \qquad [4]$$

Note :Dd = river density; L = total length of the river including its tributaries; A = watershed width The flow regime coefficient (FRC) is obtained from the comparison between the maximum discharge (Qmax) and the minimum discharge (Qmin) in a watershed referring to Permen N0. 61 /Menhut-II/2014.

FRC = Qmax/Qmin
[5]

FRC ≤ 20 = very low; 20 < FRC ≤ 50= low; 50 < FRC ≤ 80 = moderate; 80 < FRC ≤ 110 = high; FRC >110 = very high. The annual flow coefficient (AFC) is obtained from the comparison between the annual flow rate (Q) and the annual rainfall thickness (P) with the following calculation:

AFC = Q/P [6]

P is obtained from the annual rainfall x the area of the Wosi watershed. AFC ≤ 0.2 = very low; 0.2< AFC ≤ 0.3 = low; 0.3< AFC ≤ 0.4 = moderate; 0.4 < AFC ≤ 0.5= high; AFC > 0.5 = very high (Permen N0.61/Menhut-II/2014).

Data analysis

Meteorological, morphological, and morphometric calculation data were interpreted to obtain a descriptive qualitative description of the Wosi watershed characteristics using the ArcGIS 10.5 application. Analysis for hydrological impacts begins with determining the value, weight, score of the AFC and FRC indicators which refer to Permen N0. 61/Menhut-II/2014.

RESULTS AND DISCUSSION

Watershed Characteristics

Watershed characteristics show specific characteristics related to hydrology, such as: land use, rainfall, topography, river density slope, and slope length. As much as big evaporation, transpiration, infiltration, surface runoff, soil water content, and water discharge greatly depends on the character and nature of the watershed in response to rainwater. Among the character and nature of the watershed are: rainfall, watershed shape, river density, watershed slope, and land use.

1. Rainfall

The input of water on the earth's surface only comes from rainfall. Soil absorption is also influenced by the distribution and intensity of rain. When it rains before the water is absorbed by the soil in the vegetated area, the water will be temporarily held in the stand crown and then flow through the stem flow and escape the canopy. Rainfall that flows through stems and canopy escapes, if it rains with high intensity then the soil cannot absorb then the water stagnates or flows on the soil surface. Furthermore, surface runoff goes to lower areas such as in water bodies such as reservoirs, lakes and rivers. High rainfall is not only beneficial but also threatens water quality, landslides, sedimentation, and even floods (Vannier, 2016). Likewise, according to Biswas et al.(2017) for flooding, distribution and the amount of rainfall are very influential.
The rainfall that reaches the ground partly becomes water flow above the surface and partly infiltrates Asdak, 2010; Ngongondo et al., 2011; Zhang et al., 2017. The rainfall that seeps down is low and then the water may stagnate and collect if there is no lower channel. Annual rainfall data is grouped based on the criteria of wet month, medium month, and dry month to get the type of climate in the Wosi watershed area (Table 1).

Table 1. Wet month, medium month, and dry month

Year	Dry Month (<60mm)	Medium Month (60-100mm)	Wet Month (>100mm)
2012	0	0	12
2013	1	1	10
2014	0	1	11
2015	1	0	11
2016	0	0	12
2017	0	1	11
2018	0	2	10
2019	1	3	8
2020	0	3	10
2021	0	2	10
Amount	3	13	105
Average	0.3	1.3	10.5

Source: BMKG, 2022

$$Q = \frac{0,3}{10,5}$$

Q = 0.028

Based on the Schmidt and Fergusson system, the Wosi watershed has a very wet tropical climate type/climate type A (0.028) with a value of $Q < 0.143$. As a result of the very wet tropical climate/climate type A in the Wosi watershed and its surroundings, the air pressure in areas with a tropical climate is relatively low and changes are regular and slow. Evaporation of water either through soil, vegetation and water bodies is high enough so that there are many clouds. Clouds with the help of the wind unite in large numbers and the already large water droplets can't be held in the atmosphere, so it rains. Soils in tropical climates are relatively more fertile as a result of high rainfall. The temperature difference is not too big between day and night, sunshine throughout the year and fertile land impact the biodiversity of the Indonesian region and the Wosi watershed is abundant. In areas with very wet tropical climates plants are always dense and green which can affect the global climate.

Water in the forest, litter or soil is a form of cloud through the process of evapotranspiration. With the forest, the above process will produce a good pattern of rainfall and the amount of rainfall so that long droughts and the danger of flooding will be avoided. Tree types have different evapotranspiration and infiltration capabilities so that surface runoff and erosion can be minimized (Budirianto et al., 2015). The river border that should have been trees has turned into a plant that can't reduce runoff and sediment that enters the river. Trees with deep roots and dense crowns have turned into fibrous plants so that easily if there is a heavy runoff, the plants are uprooted and washed away.

According to Zhang et al. (2017); Worman et al. (2017); Fuchs et al.(2016) the relatively large runoff is caused by high rainfall when there is no vegetation. Table 1 shows that in the last 10 years it has been dominated by rain/wet month (>100 mm). The impact of heavy rainfall if the area is damaged then the water easily reaches the ground surface. This rainfall causes greater surface runoff while low infiltration is very likely that flooding caused by surface runoff will often occur. This heavy rain when the river's capacity is full, of course it will overflow on the ground and into settlements.

According to Vannier (2016), floods will often occur if the rainfall lasts long enough, the distribution is uneven and the river capacity is limited. As the Cimanuk flood in 2017 was caused, among others, high rainfall (110 - 255 mm day^{-1}), land use that was not in accordance with its capabilities, and forest area which was only 17.9% (Savitri and Pramono, 2017). However, according to Mahmud et al (2018), rainfall is not the only cause of flooding. Floods are caused by land conversion, sedimentation, river narrowing, and watershed damage. Floods will not occur despite high rainfall as long as the soil is able to absorb large amounts of water, the river flows smoothly, the water is accommodated in the rivers, and the community does not reduce the cross-sectional area of the river. On the other hand, according to Neuvel & Knaap (2010), flooding will occur if the rain is not absorbed by the soil, the water is not accommodated in the water body, the narrowing of the river has an impact on the flow of water is not smooth and the community reduces the size of the river border.

2. Watershed Morphometry

Watershed morphometry is a term used to express the state of the river channel network, including the area, length, width, slope, order of river branching level, river density, and the shape of the watershed. The shape of the watershed has an important meaning in relation to river flow/flow velocity. The watershed shape allegedly affects the water to reach the outlet (the end point of water release), while the morphometry of the Wosi watershed is shown in Table 2.

Table 2. Morphometric conditions of the Wosi watershed

Wosi watershed	Watershed Morphometry	Wosi watershed	Watershed Morphometry
Watershed Area (A)	23,463,200 m^2	Watershed Center Point Cg)	X = 4.5 ;Y = 4.08
Main River Length (Lb)	8.38 km	River Flow Mean Slope (So)	0.79%
Watershed Width (W)	3.01 km	Circulation Ratio (Rc)	0.33
Watershed Length (Ln)	5.32 km	Limniscate Constant (k)	1.01
Density River Flow (Dd)	0.35 Height	Biforcation Ratio (Rb)	Rb ½ : 3; Rb 2/3 : 2
Flow Length (Lg)	4.63 km	Elongation ratio (R e)	1.027
Watershed Average Elevation (Ma)	250 m asl	Watershed Average Slope (Sb)	0.126
Circumference of the watershed (p)	29.95 km	Weighted average (Wrb)	3.75
Longest River (L)	8.38 km	Factor Symmetry (SIM)	1.21
Coefficient Watershed Form (F)	0.37		

Source : BPDASHL Remu Ransiki , 2019

Table 2 shows the Wosi watershed has an area of 2346.32 ha, a watershed circumference of 29.95 km2, a river length of 8.38 km, so Rc is 0.33 (triangle) and Re is 1.027 (triangle). From the results of calculations and Figure 2, it can be concluded that the shape of the watershed is rectangular and slightly oval (triangular). According to Paimin et al. (2012), the speed of water flowing to the outlet is influenced by the shape of the watershed. The shorter the time required for water to reach the outlet, the more round the shape of the watershed, so the greater the potential for flooding. On the other hand, the longer the water goes to the outlet if the shape of the watershed is more oval, so that the runoff flood is low. Likewise, according to Wirosoedarmo et al. (2010) a relatively small peak flood discharge value with a relatively long flood peak time in on elongated watershed shape.

Comment [A5]: Please make sure, table 2 shows the data of Wosi or Arui watershed?

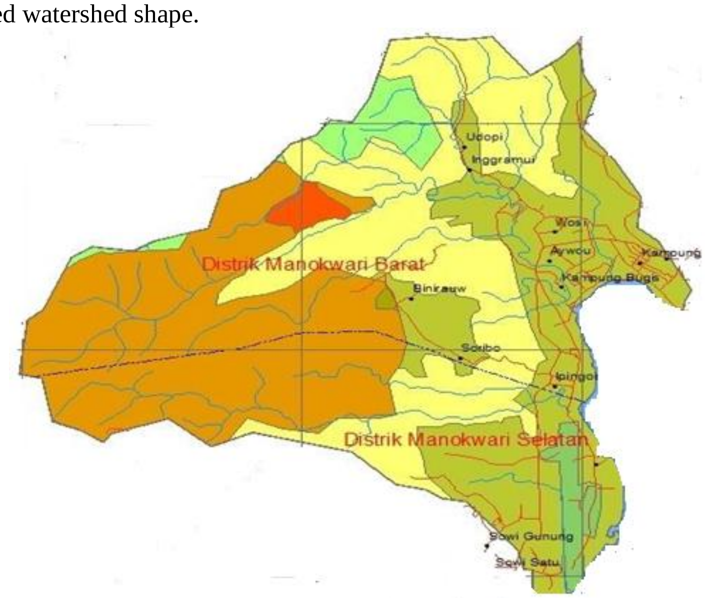

Figure 2 . Watershed shape, density , and river network

Comment [A6]: Please revise the map and use the standards of map, includes the boundary, title, legend, scale, source etc.

The shape of the watershed allows while the river is getting shallower, surface runoff during high rainfall will easily stop and cause work. even though the rainfall is high, the water easily flows / does not stagnate to go downstream and easily reaches the sea if there is no S-shaped bend. The peak discharge value will increase significantly and relatively quickly for large-scale land use changes and watershed forms to occur (Wirosoedarmo et al., 2010). The longer and larger the watershed is not the main cause of peak discharge if it is not affected, such as: high rainfall, large-scale land use changes, changes in density and drainage. The area will be very prone to flooding if the rainfall is high, the land use is dominated by development, there are many bends that hinder the flow and the shape of the watershed is limited. Rainwater easily reaches the ground surface, collects and becomes inundated, causing floods.

There are 4 important rivers flowing in the Wosi watershed, namely the Rendani 1 river, the Rendani 2 river, the Kentek river and the Dingin river (Figure 2). The drainage pattern of the Wosi watershed in general resembles the shape of a tree branch/twig (dendritic pattern). River currents in the upstream and middle watersheds are relatively heavy given the slope/slope of the riverbed, very steep, and many conversions for settlements. The upstream area where the water flows is quite heavy must be maintained as a forest, because if there is a transfer of function to the built area, it will easily become a source of erosion. According to Barokah & Purwantoro (2014) upstream areas such as mountainous areas, hills, or mountain slopes are areas of erosion.

3. Watershed Slope

Topography is the appearance of the land surface caused by the difference in height between the two areas. Slopes is one of the elements of the occurrence of floods, erosion, and landslides. The steeper and longer the slope, the greater the rate and amount of runoff for major erosion or landslides. Land with a large slope, the surface flow has a large velocity so that infiltration tends to decrease (Triatmodjo, 2010; Helman et *al.,* 2017). According to Mujiyo *et al*.(2021) the land degradation is very influenced by land slope. Area that is flat and tends to be sunken will be prone to flooding considering that in this area water is easily concentrated towards lower areas, the slopes of the Wosi watershed area are listed in Table 3.

Table 3. Slope class in the Wosi watershed

Slope (%)	Area (ha)	Percentage (%)
0-8%	970.58	41.522
25-40%	1,366.91	58.478
Total	2,337.49	100

As Table 3 shows, only two of the slope classes in the Wosi watershed are predominantly steep. The slope of the slope will have an influence on the velocity and volume of surface runoff. Flat topography (0 – 8%) covering an area of 970.58 hectares (41.52%) has become an urban area of West Papua Province including Wosi village, Bugis village, Javanese village, Makassar village, and Rendani. The flat topography of the lower and middle watersheds has become overcrowded into built-up areas and has begun to shift towards steep slopes. According to Oktinova and Rudiarto (2019) that the reduced land area in the city, humans began to change their behavior in land use in the suburbs from non-built land to built-up land. While the steep slopes (25 – 40%) covering an area of 1,366.91 hectares (58.47%) of the Wosi watershed area include the villages of Udopi, Ingramui, and Soribo with slopes ranging from flat to very steep at an altitude of 0 – 1450 m from sea level. The steeper the slope, the greater the speed of runoff if the area is empty of vegetation, as a result it will be difficult for water to seep into the soil and will increase runoff. This will be exacerbated if it is not in accordance with its designation, for example for built-up areas. As according to Mahmud *et al.* (2021), land use for settlements/built areas has higher runoff and sediment than land use for forest.

From the results of a survey of areas located on steep slopes, previously plantations and forest areas began to be converted to settlements (Figure 3).

Figure 3. Inggramui village settlement adjacent to a steep hill without vegetation (left), a residential area adjacent to a steep hill with vegetation (right).

Figure 3 shows a house building adjacent to a steep slope which if not built a talut the threat of landslides is very high. With the reduction of land in the city, humans began to change the use of land in the suburbs from non-built land to built-up land. Considering the area with a rather steep topography and very steep if the area is open when it rains water easily flows on the soil surface, eroding the top layer of soil and causing the soil to shift / move in large numbers because nothing is able to bind the soil. On the other hand, areas whose topography is rather steep and very steep are well maintained (designated as protected forest/protected areas) so that they will function to maintain soil fertility, protect the soil from the threat of landslides, and provide water especially in the dry season.

According to Kusumandari & Soedjoko (2006), topography is very influential on rainfall, where if it rains on a steep surface without vegetation, runoff will arise which will flow downstream or to a lower place. The excess flow and cannot be accommodated by the river causes flooding. Areas with a flat topography to slightly concave when it rains water is easily concentrated, inundated and if the amount of water increases, inundation flooding is inevitable (Marfai, 2011). One of the flooded locations has built a mbankment (Figure 4), but the the embankment is not fully able to cope with flooding. Many the embankment were built in flooded areas, but because the upstream watershed had a lot of land use change, water with great speed was able to destroy the shores, eventually the gutters broke and the flood reoccurred.

Figure 4. The flooded area where the embankment has been built

Comment [A7]: If this figure was published before, please mention the reference/ source and the year.

4 . Land Use

The increasing population and increasingly crowded urban areas have led to an increase in land use for residential, and agricultural. Types of land use are divided into 7 groups which are dominated by settlements as shown in Table 4.

Table 4 Topography and Land Use Functions in the Wosi Watershed

Topography	Use land	Non-forest area (ha)	Forest Area (ha)	% Non forest	% Forest
Steep	Primary dryland forest	-	83.15	-	3.54
Steep	Secondary dryland forest	-	773.26	-	32.95
Steep	Bushes /scrub	-	27.64	-	1.17
Flat and Steep	Settlement	697.90	-	29.74	-
Flat and Steep	Open land	3.94	-	0.16	-
Flat	Mixed dryland farming	707.07	-	30.13	-
Flat	Airport	53.35	-	2.27	-
Total		1,462.26	884.05	62.32	37.68

Source: BPDASHL Remu Ransiki, 2019

Land use function as forest based on Table 4 is still above 30% referring to Law Number 41 of 1999 concerning Forestry which requires to protect and maintain the forest area for each watershed at least 30%. Forest cover includes: primary dry land forest, secondary dry land forest and shrubs/shrubs covering an area of 884.05 hectares (37.68%) while the non-forest area is 1,462.26 hectares (62.32%). The forest area of 37.68% is expected to be able to maintain, protect and maintain the diversity of flora and fauna, biogeophysics, and the carrying capacity of natural resources.

However, along with the development of Manokwari City as the capital of West Papua Province, the area continues to experience forest and plantation land conversion. As Figure 5 the upper Wosi watershed has been leveled, some of it is still shaped like a hill where landslides may occur. In fact, in 2012, some of the cities of Manokwari which are adjacent to the watershed have experienced major floods. City development that does not follow the district spatial plan (RTRWK) will not only cause a major flood, but also landslides and moving ground will occur. The conversion of land into built-up land of 28.02 ha (39.5%) resulted in a decrease in groundwater, landslides, and an increase in surface water discharge (Dewi and Rudiarto, 2014).

Figure 5. The planned upstream watershed for the built-up area has been partially leveled (left), some of the land is still steep and made like a ladder (right)

Impact of Watershed Characteristics on Hydrology

1. Flow Regime Coefficient (FRC)

The results of the research on the carrying capacity of the Wosi watershed are categorized as bad (Mahmud *et al.* 2021) and the Wosi watershed one of the watersheds in Manokwari Regency that must be restored (BPDASHL Remu Ransiki. 2016). Water discharge is a very important part to evaluate the extent to which rainfall affects surface runoff, river water level, and river capacity. Meanwhile, the FRC is an inseparable part of the water discharge, as shown in Table 5.

Table 5. FRC values in the Wosi watershed

Year	Maximum of Water discharge ($m^3 s^{-1}$)	Minimum of Water discharge ($m^3 s^{-1}$)	FRC	Evaluation
2016	1.23	0.06	20.53	0.75 (low)
2017	2.37	0.04	60.57	1 (medium)
2018	3.73	0.02	232.29	1.5 (very high)
2019	7.1	0.01	711.87	1.5 (very high)

Comment [A8]: Please also discuss the trend of FRC from the year 2016 to 2019. Please add the data of 2020.

Table 5 shows the trend of increasing differences in water flow. In 2016 the results of the FRC assessment were low but in 2019 the results of the assessment were very high. This shows that there is a decrease in the carrying capacity of the watershed to receive, absorb, and drain rainwater into the river. According to Mahmud *et al.* (2021), if the FRC is small, it means that the water flows throughout the year without showing a significant water level difference. The water flow is not only in the rainy season but also continues to flow even during the dry season. On the other hand, if the FRC is very large, it means that the flow of river water is easy to change sometimes low, even very high which it can cause flooding. This indicates that the river flow is not good, because the ability of forests and land to absorb, store, receive rainwater, and discharge water is not good. Rain intensity, vegetation cover, soil type, slope, and land management techniques are related to the watershed's ability to receive, store, discharge and drain water.

2. Annual Flow Coefficient (AFC)

River flow is an important part of determining the extent to which surface runoff, river water level, river capacity, and sediment affect rainwater input/input. The annual flow coefficient is listed in Table 6.

Table 6. AFC values in the Wosi watershed

Year	Total water discharge (m^3 $year^{-1}$)	Total rainfall in the watershed (mm $year^{-1}$)	AFC	Evaluation
2016	13,038,081.4	48,044,540.9	0.27	0.75 (low)
2017	12,909,855.2	53,176,793.8	0.24	0.75 (low)
2018	30,749,926.9	33,162,321.5	0.93	1.5 (very high)
2019	16,018,933.6	67,450,857	0.23	0.75 (low)

Comment [A9]: Please check the unit, when you calculate the AFC these two units have to be the same.

Comment [A10]: Please explain, why in the year 2018 the AFC is extremely high?

The annual flow coefficient indicates what percentage of rainfall is run off in the watershed. Table 6 also shows that AFC is always changing, from low to very high. A low AFC rating means that the carrying capacity of the watershed is good, while a very high AFC indicates that the carrying capacity of the watershed has decreased. The increasing rainfall, but not always accompanied by an increase in water discharge, is thought to be of low rainfall intensity, even distribution of rain and good canopy cover. The more crowns and the wider distribution will reduce the canopy runoff, stem flow to reach the soil surface (Mahmud *et al.*, 2019). When it reaches the ground surface, the water will seep, and if it is saturated it will become surface runoff. The better the water flow, this indicates that more water flows from the springs than from the surface runoff. The government and environmentalists must be aware of the community in land use to always implement soil and water conservation and follow the Manokwari Regency Spatial Planning (RTRW).

CONCLUSION

From the results of the research, the characteristics of the Wosi watershed have a very wet tropical climate type/climate type A (0.028) which is dominated by rain/wet month (>100 mm). The watershed morphometry includes a triangular-shaped watershed, there are 4 rivers, namely the Rendani 1 river, the Rendani 2 river, the Kentek river and the Kali Dingin river. Flat slopes (0 – 8%) covering an area of 970.58 hectares (41.52%) and steep slopes (25 – 40%) covering an area of 1,366.91 hectares (58.47%). Land use is dominated by non-forest with an area of 1,462.26 hectares (62.32%) and forest area of 884.05 hectares (37.68%). Meanwhile, the flow regime coefficient (FRC) is categorized as low, medium and dominated by very high. Very high KRA means that river water flow is easy to change, sometimes low or even very high which can cause flooding. The results of the assessment of the annual flow coefficient (AFC) are

Comment [A11]: 1. The title of the paper is about Impact, but actually this paper discuss about the relationship.
2, Although the titlle mentioned about management of flood, but this paper does not discuss about flood. So, please revise the title or add the discussion about flood management and mitigation.

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Comment [A13]: I could not find this reference in the text.

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Tim Editor JPSL
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Tempat

Salam Hormat,
Mahon maaf atas keterlambatan kami dalam mengirimkan kembali ke JPSL, sehubungan dengan perbaikan oleh seluruh tim. Beberapa perbaikan yang telah kami lakukan diantaranya:

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Mahmud Mahmud:

We have reached a decision regarding your submission to Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan (Journal of Natural Resources and Environmental Management), "IMPACT IMPACT OF WOSI WATERSHED CHARACTERISTICS ON HYDROLOGICAL AS A BASIS FOR FLOOD MANAGEMENT AND MITIGATION IN MANOKWARI REGENCY, INDONESIA: FLOOD MANAGEMENT AND MITIGATION IN MANOKWAR".

Our decision is to: minor revision

1. In general, the English language needs to improve.
2. Keywords: Please find other words that are not in the title.
3. Please revise the map and use the standards of the map, including the boundary, title, legend, scale, source etc.
4. Please also discuss the trend of FRC from the year 2016 to 2019. Please add the data for 2020.
5. Page 12: Please check the unit, when you calculate the AFC these two units have to be the same.
6. Please explain, why in the year 2018 the AFC is extremely high.
7. a. The title of the paper is about Impact, but actually, this paper discusses the relationship.
b, Although the title mentioned the management of floods, this paper does not discuss floods. So, please revise the title or add the discussion about flood management and mitigation.
8. I could not find the reference: Nugroho, H., Cahyadi, A., 2012. and Strahler AN. 1964. in the manuscript.

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Kepada Yth. Sdr/i. Mahmud

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Judul	: Biophysical Characteristics of Wosi Watershed Area in Manokwari Regency, Indonesia
Penulis	: Mahmud, Abdul Azis, Danang Wijaya, Wahyudi, Bambang Nugroho, Denisa Melanesia

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Terima kasih kami sampaikan atas kontribusinya pada Jurnal JPSL. Kami berharap dapat menerima kembali naskah-naskah hasil penelitian dari Saudara dan tim.

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