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***Type of Article*** *(Original Article / Review Article / Short Communication)* (Size 11)

# Testing the Infiltration Rate of Datar Ajab Village, Hulu Sungai District

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***Abstract –*** *The problem of flooding is something that often occurs during the rainy season and its coverage area has expanded not only to areas that are used to flooding but also to the surrounding areas. South Kalimantan Province's Hulu Sungai Tengah Regency and a number of its districts had a flood disaster to start the year 2021. Tilahan or Hanntak is the Meratus Mountains Region which is the origin of the floods due to the overflow of the Benawa River and the continuing flow of the Barabai River. The practice of illegal logging in the Meratus Mountains Region is still rife. On January 14, 2021, extreme rainfall occurred which caused flooding in the South Kalimantan region. The low absorption of water into the ground is one of the causes of flooding when heavy rains occur for a long duration. In this study, infiltration in the Hantakan Sub-District, Hulu Sungai Tengah, will be measured in order to examine the rate of infiltrated water that happens. To assess the infiltration rate, primary data from a direct survey of the research region was collected, and the Horton technique was used to analyze it.. Based on the test results and the results of the analysis of counts at nine points, in test 1 there were four points with very slow classification, two points with moderate classification, two points with a rather fast classification, and one point with fast classification. Whereas in test 2 there were five points classified as very slow, one as medium, and three fast.*

***Keywords –*** *Rainfall, Landuse, Flood, Infiltration, Hulu Sungai Tengah District*

## 1. Introduction

The problem of flooding is something that often occurs during the rainy season and its coverage area has expanded not only to areas that are usually flooded but also to the surrounding areas. Floods are natural disasters caused by natural events, namely high-intensity rainfall which often causes physical and material losses [1].

The year 2021 in Hulu Sungai Tengah Regency and several districts in South Kalimantan Province began with a flood disaster [2]. A total of six districts were hit by flooding, one of which was Hulu Sungai Tengah (HST) Regency which was caused by rivers that overflowed due to high rain intensity. There are at least seven sub-districts in HST that were affected by the floods namely, Batang Alai Timur, Batang Alai Selatan, Pandawan, Barabai, Hantakan, Batu Benawa, and Haruyan sub-districts [3]. Tilahan or Hantakan is an area of the Meratus Mountains which is the origin of flooding due to the overflow of the Benawa River and the continuing flow of the Barabai River [4].

The practice of illegal logging in South Kalimantan, especially in the Meratus Mountains area, is still rife. Environmental damage and reduced forest cover are believed to be the main causes of major floods and landslides [5]. Inappropriate land use by the community causes ecosystem disturbances which result in changes in land use. Changes in land use from forest areas to built-up areas will result in falling rainwater not being able to seep into the ground but overflowing a lot, thus increasing flood discharge during high-intensity rains [6]. The land use system with the distribution of tree-type cover vegetation which is also accompanied by the presence of ground cover plants is a land system that can retain rainwater better than the shrub or pole land system [7].

This is extreme rainfall, according to statistics from the Banjarbaru Class I Climatology Station of 255.3 milimeter and the Class II Meteorological Station Syamsudin Noor Banjarmasin of 149 milimeter on January 14, 2021 [8]. It is evident that the region of South Kalimantan experienced flooding as a result of the day's intense rain [2].

When heavy rains last for a long time, one of the reasins for floods is the soil's poor ability to absorb water [9]. If a place has poor groundwater absorption capacity, then when it rains, surface water that flows will cause puddles and the water cannot seep properly into the ground. This can cause flooding when there is rain with high intensity and long duration. The ability of groundwater absorption can be measured by measuring the infiltration rate. If the ratio of rain intensity is smaller than the infiltration rate, then all the rainwater that falls will seep into the ground [10]. Water infiltration will be more effective on land overgrown with plants because plants can increase infiltration [11]. In this study, infiltration in the Hantakan Sub-District, Hulu Sungai Tengah, will be measured in order to examine the rate of infiltrated water that happens.

## 2. Research Method

Datar Ajab Village, Hantakan Sub-District, and Hulu Sungai Tengah District are the locations where this study was carried out. Direct surveys of the study region were used to collect primary data, and a double-ring infiltrometer was used to measure the infiltration rate (turf-tec infiltrometer). The Horton Method was the analytical technique employed in this investigation. The test locations are divided into three based on land cover.

## 3. Result and Discussion

### *3.1 Research Sites*

Datar Ajab Village, Hantakan District, Hulu Sungai Tengah Regency, South Kalimantan Province served as the site of this study. Nine places, each with three different land cover types-bare, medium, and high-were observed.

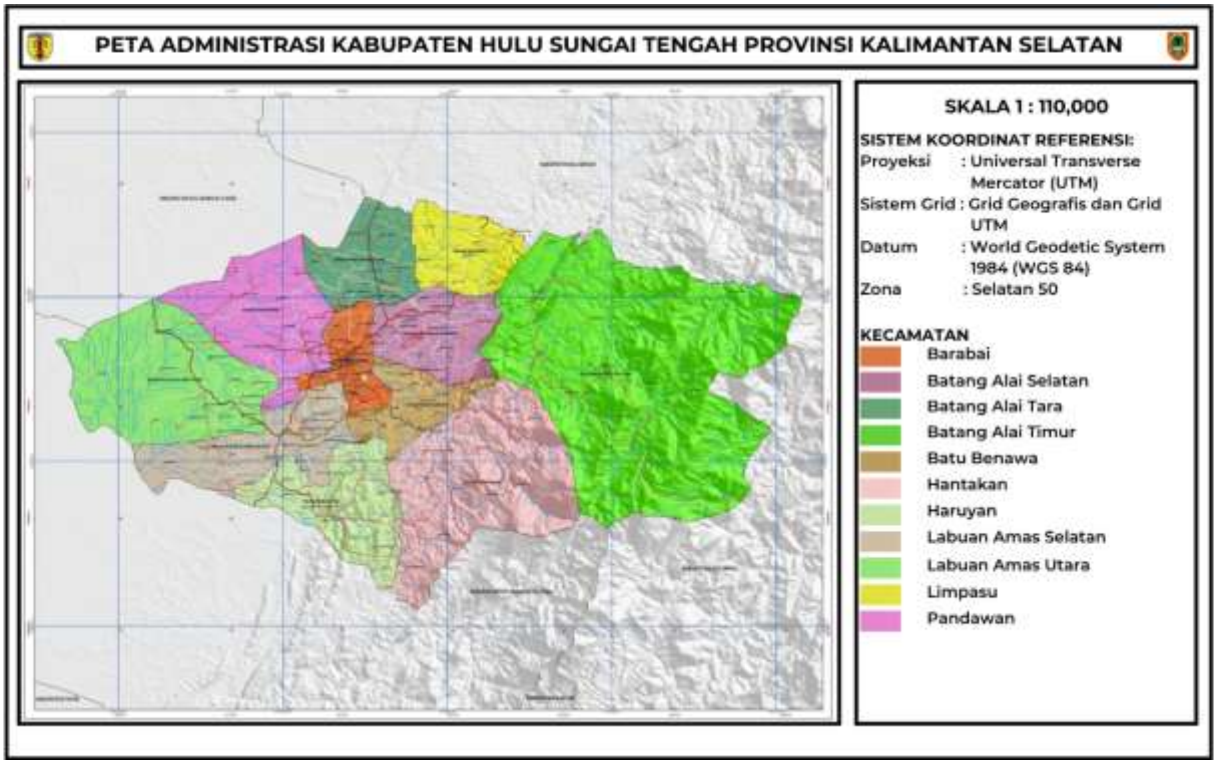


**Figure 3. 1 Administrative Map of Hulu Sungai Tengah Regency**
Source; https://petatematikindo.wordpress.com/


**Figure 3. 2 Infiltration Rate Test Point in Datar Ajab Village**

The coordinates of the research location are as follows:

1. Point B1 at coordinates 2º39'52.50" S, 115º32'13.50" E.
2. Point B2 at coordinates 2º39'52.50" S, 115º32'13.70" E.
3. Point B3 at coordinates 2º39'53.40" S, 115º32'13.40" E.
4. Point T1 at coordinates 2º39'52.00" S, 115º32'16.30" E.
5. Point T2 at coordinates 2º39'52.60" S, 115º32'16.10" E.
6. Point T3 at coordinates 2º39'52.90" S, 115º32'15.70" E.
7. Point S1 at coordinates 2º39'49.80" S, 115º32'11.80" E.
8. Point S2 at coordinates 2º39'50.80" S, 115º32'11.50" E.
9. Point S3 at coordinates 2º39'50.10" S, 115º32'11.40" E.

### *3.2 Infiltration Capacity*

The impact of a flood can sometimes be disastrous. Extreme floods will get worse due to the increasing intensity and frequency of extreme rainfall modifications caused by climate change [12]. It might be difficult to lessen the risk of damage from floods and their effects on water quality when they happen in metropolitan areas [13]. This certainly affects the soil's ability to absorb water or infiltration processes. The process through which water seeps into the soil is known as infiltration [14] caused by lateral forces (water movement in a lateral direction) and gravitational forces (water movement in a vertical direction) expressed in units (cm/hour) [15]. If the top layer of soil is saturated, excess water will be forwarded to deeper parts of the soil due to the earth's gravitational force (vertical). The infiltration mechanism is made up of three processes: allowing water to enter the soil through its surface pores, storing the water in the soil, and transporting the water to other places [16].

When rainwater collects above the ground surface, the air will infiltrate through the surface and into the soil with the initial infiltration rate ($f_0$) displayed depending on the soil moisture content at that time [17].

Infiltration capacity can be calculated using the Horton Method formula. In hydrology, the infiltration rate is calculated using the Horton model. Horton understood that the infiltration capacity drops over time before approaching a fixed amount. The Horton Method calculation requires a constant value of k, this value can be found by using the m value on the comparison curve between t (hours) and log $(f - f_c)$.

$$F_t = f_c + (f_0 - f_c)^{-kt}$$

Information:

$F_t$ = infiltration rate or infiltration capacity at t (hour)
$f_c$ = constant infiltration rate
$f_0$ = initial infiltration rate
$e$ = 2,71828
$k$ = soil saturated hydraulic conductivity (constant)
$t$ = time

[10]

To obtain a constant value of k to complete the equation on the infiltration capacity curve, the Horton equation is processed and the formula k is obtained as follows [18].

$$k = -\frac{1}{0{,}434\ x\ m}$$, where m = gradien

Testing the infiltration rate in the field is intended to determine the speed and amount of water entering or seeping into the soil [19]. The infiltration process is an important part of the hydrological cycle, especially in the process of converting rain into river flow [20][21].

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**Table 3. 1 Infiltration Capacity Calculation Results with the Horton Method**

| No | Point Name | t (hour) | $f_0$ (cm/hour) | $f_c$ (cm/hour) | $(f_0 - f_c)$ (cm/hour) | m | k | e | -k.t | f (cm/hour) |
|---|---|---|---|---|---|---|---|---|---|---|
| **TESTING 1** | | | | | | | | | | |
| 1 | B1 | 0,250 | 5,52 | 1,20 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 4,835 |
| 2 | B2 | 0,083 | 3,60 | 3,60 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 3 | B3 | 0,250 | 7,92 | 3,60 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 7,235 |
| 4 | T1 | 0,250 | 16,32 | 12,00 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 15,635 |
| 5 | T2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 6 | T3 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 7 | S1 | 0,167 | 6,30 | 8,40 | -2,10 | -7,541 | 0,306 | 2,718 | -0,453 | 6,047 |
| 8 | S2 | 0,167 | 8,70 | 0,00 | 8,70 | -4,226 | 0,000 | 2,718 | -0,453 | 8,465 |
| 9 | S3 | 0,083 | 18,00 | 18,00 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| **TESTING 2** | | | | | | | | | | |
| **No** | **Point Name** | **t (hour)** | **$f_0$ (cm/hour)** | **$f_c$ (cm/hour)** | **$(f_0 - f_c)$ (cm/hour)** | **m** | **k** | **e** | **-k.t** | **f (cm/hour)** |
| 1 | B1 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 2 | B2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 3 | B3 | 0,167 | 23,40 | 18,00 | 5,40 | -11,594 | 0,199 | 2,718 | -0,453 | 22,677 |
| 4 | T1 | 0,167 | 20,70 | 18,00 | 2,70 | -14,530 | 0,159 | 2,718 | -0,453 | 20,191 |
| 5 | T2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 6 | T3 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 7 | S1 | 0,083 | 6,30 | 3,60 | 2,70 | -7,541 | 0,306 | 2,718 | -0,227 | 6,047 |
| 8 | S2 | 0,250 | 19,68 | 13,20 | 6,48 | -7,125 | 0,323 | 2,718 | -0,680 | 18,245 |
| 9 | S3 | 0,083 | 6,00 | 6,00 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |

Based on Table 3.1, in the first test, four points out of nine that did not decrease, namely points B2, T2, T3, and S3. As for the infiltration capacity in the second test, there were five points did not decrease from nine points, namely, B1, B2, T2, T3, and S3.

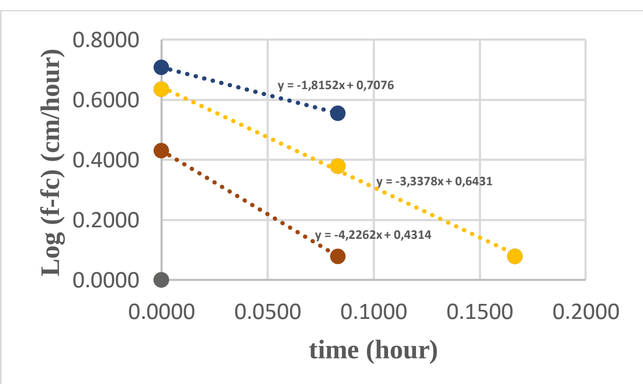


**Figure 3. 3 Graph of Relationship Between Time (hours) and Log $(f - f_c)$ (cm/hour) in Test 1**

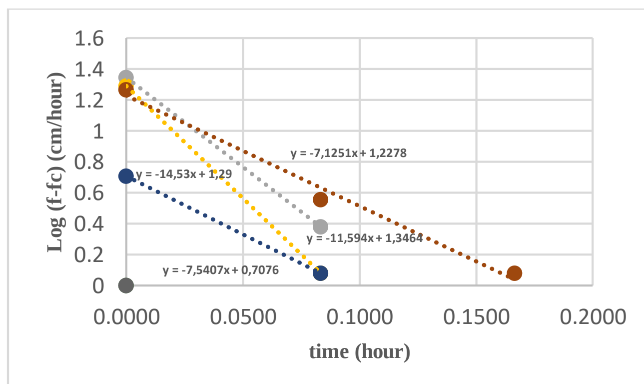


**Figure 3. 4 Graph of Relationship Between Time (hours) and Log $(f - f_c)$ (cm/hour) in Test 2**

### *3.3 Infiltration Rate*

The infiltration rate, measured in milimeters per hour (mm/hour) or centimeters per hour (cm/hour), is the volume of water that percolates into the soil during rainfall. The rate of infiltration will often be quicker when the soil is dry. The infiltration rate will be gradual and steady when the soil is saturated water. [22].

The amount of vegetation on the soil is one of the elements that can influence the rate of infiltration [23]. Other factors affecting infiltration rate are as follows.

1. Inundation depth and saturated layer thickness
2. Soil moisture
3. Placement by rain
4. Blockage by fine grains
5. Cover crops
6. Topography
7. Rain intensity

Large infiltration rates are used to describe changes in infiltration that take place. The amount of soil storage capacity will be impacted by this infiltration rate. The infiltration rate is also affected by the high groundwater level so each soil property will have a different infiltration rate [24].

**Figure 3. 5 Infiltration Rate Testing in Datar Ajab Village, Hulu Sungai Tengah District**

The Horton method was used to calculate the infiltration rate, and Uhland and O'Neal's classification system was used to determine the speed of water absorption.

**Table 3. 2 Classification of Infiltration Rate According to Uhland and O'Neal, 1951**

| Classification | Infiltration Rate (cm/hour) |
|---|---|
| Very Fast | >25,4 |
| Fast | 12,7 – 25,4 |
| Kinda Fast | 6,3 – 12,7 |
| Currently | 2 – 6,3 |
| a Bit Slow | 0,5 – 2 |
| Slow | 0,1 – 0,5 |
| Very Slow | <0,1 |

Source: [25]

The findings of the infiltration rate analysis utilizing the Horton technique and classification based on Uhlan and O'Neal are presented in Table 3.3.

**Table 3. 3 Classification of Infiltration Rate Testing 1**

| TESTING 1 | | | |
|---|---|---|---|
| **No.** | **Point Name** | **f (cm/hour)** | **Classification** |
| 1 | B1 | 4,835 | Currently |
| 2 | B2 | 0,00 | Very Slow |
| 3 | B3 | 7,235 | Kinda Fast |
| 4 | T1 | 15,635 | Fast |
| 5 | T2 | 0,00 | Very Slow |
| 6 | T3 | 0,00 | Very Slow |
| 7 | S1 | 6,047 | Currently |
| 8 | S2 | 8,465 | Kinda Fast |
| 9 | S3 | 0,00 | Very Slow |

Based on Table 3.3 from test 1 at nine points there were four points with very slow classification, namely, B2, T2, T3, and S3 of 0.00 cm/hour. Then there are two points with moderate classification namely B1 of 4.835 cm/hour, S1 of 6.047 cm/hour, two points with a rather fast classification namely B3 of 7.235 cm/hour, S2 of 8.465 cm/hour, and one with fast classification namely T1 15.635 cm/hour.

**Table 3. 4 Classification of Infiltration Rate Testing 2**

| TESTING 2 | | | |
|---|---|---|---|
| **No.** | **Point Name** | **f (cm/hour)** | **Classification** |
| 1 | B1 | 0,00 | Very Slow |
| 2 | B2 | 0,00 | Very Slow |
| 3 | B3 | 22,677 | Fast |
| 4 | T1 | 20,191 | Fast |
| 5 | T2 | 0,00 | Very Slow |
| 6 | T3 | 0,00 | Very Slow |
| 7 | S1 | 6,047 | Currently |
| 8 | S2 | 18,245 | Fast |
| 9 | S3 | 0,00 | Very Slow |

Based on Table 3.4 from test 2 at nine points there were five points with very slow classification, namely, B1, B2, T2, T3, and S3 of 0.00 cm/hour. Then there is one point with moderate classification, namely S1 at 6.047 cm/hour, and three points with fast classification, namely, B3 at 22.677 cm/hour, T1 at 20.191 cm/hour, and S2 at 18.245 cm/hour.

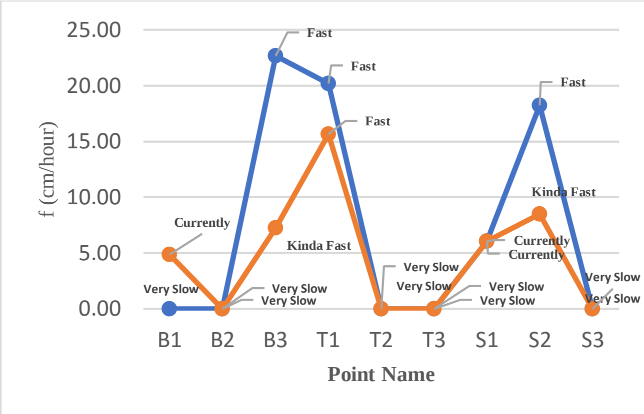


**Figure 3. 6 Graph Comparison of Classification in Test 1 and Test 2**

## 4 Conclusion

According to the test result and analysis of calculations made using the Horton Method, out of a total of nine points, four of them in test 1 had classifications that were extremely slow, two were moderete, two were quite fast, and one was rapid. Whereas in test 2 there were five points whose infiltration capacity was classified as very slow, one point classified as medium, and three points classified as fast. Based on this, the research location area is prone to flooding if it rains with high intensity. This is because the soil cannot absorb water properly due to changes in land use, so it takes quite a long time or does not absorb at all.

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***Abstract –*** *The problem of flooding is something that often occurs during the rainy season and its coverage area has expanded not only to areas that are used to flooding but also to the surrounding areas. South Kalimantan Province's Hulu Sungai Tengah Regency and a number of its districts had a flood disaster to start the year 2021. Tilahan or Hanntak is the Meratus Mountains Region which is the origin of the floods due to the overflow of the Benawa River and the continuing flow of the Barabai River. The practice of illegal logging in the Meratus Mountains Region is still rife. On January 14, 2021, extreme rainfall occurred which caused flooding in the South Kalimantan region. The low absorption of water into the ground is one of the causes of flooding when heavy rains occur for a long duration. In this study, infiltration in the Hantakan Sub-District, Hulu Sungai Tengah, will be measured in order to examine the rate of infiltrated water that happens. To assess the infiltration rate, primary data from a direct survey of the research region was collected, and the Horton technique was used to analyze it.. Based on the test results and the results of the analysis of counts at nine points, in test 1 there were four points with very slow classification, two points with moderate classification, two points with a rather fast classification, and one point with fast classification. Whereas in test 2 there were five points classified as very slow, one as medium, and three fast.*

***Keywords –*** *Rainfall, Landuse, Flood, Infiltration, Hulu Sungai Tengah District*

## 1. Introduction

The problem of flooding is something that often occurs during the rainy season and its coverage area has expanded not only to areas that are usually flooded but also to the surrounding areas. The year 2021 in Hulu Sungai Tengah Regency and several districts in South Kalimantan Province began with a flood disaster. A total of six districts were hit by flooding, one of which was Hulu Sungai Tengah (HST) Regency which was caused by rivers that overflowed due to high rain intensity. There are at least seven sub-districts in HST that were affected by the floods namely, Batang Alai Timur, Batang Alai Selatan, Pandawan, Barabai, Hantakan, Batu Benawa, and Haruyan sub-districts. Tilahan or Hantakan is an area of the Meratus Mountains which is the origin of flooding due to the overflow of the Benawa River and the continuing flow of the Barabai River.

The practice of illegal logging in South Kalimantan, especially in the Meratus Mountains area, is still rife. Environmental damage and reduced forest cover are believed to be the main causes of major floods and landslides. In this study, infiltration in the Hantakan Sub-District, Hulu Sungai Tengah, will be measured in order to examine the rate of infiltrated water that happens.

## 2. Literature Review

### *2.1 Flood*

Floods are natural disasters caused by natural events, namely high-intensity rainfall which often causes physical and material losses [1]. The impact of a flood can sometimes be disastrous. Extreme floods will get worse due to the increasing intensity and frequency of extreme rainfall modifications caused by climate change [2]. It might be difficult to lessen the risk of damage from floods and their effects on water quality when they happen in metropolitan areas [3]. Flooding is caused by a number of factors, including land use conditions and heavy rainfall. Inappropriate land use by the community causes ecosystem disturbances which result in changes in land use [4]. Changes in land use from forest areas to built-up areas will result in falling rainwater not being able to seep into the ground but overflowing a lot, thus increasing flood discharge during high-intensity rains [5]. The land use system with the distribution of tree-type cover vegetation which is also accompanied by the presence of ground cover plants is a land system that can retain rainwater better than the shrub or pole land system [6].

This is extreme rainfall, according to statistics from the Banjarbaru Class I Climatology Station of 255.3 milimeter and the Class II Meteorological Station Syamsudin Noor Banjarmasin of 149 milimeter on January 14, 2021 [7]. It is evident that the region of South Kalimantan experienced flooding as a result of the day's intense rain [8][9].

When heavy rains last for a long time, one of the reasins for floods is the soil's poor ability to absorb water [10]. If a place has poor groundwater absorption capacity, then when it rains, surface water that flows will cause puddles and the water cannot seep properly into the ground. This can cause flooding when there is rain with high intensity and long duration. The ability of groundwater absorption can be measured by measuring the infiltration rate [11]. If the ratio of rain intensity is smaller than the infiltration rate, then all the rainwater that falls will seep into the ground [12]. Water infiltration will be more effective on land overgrown with plants because plants can increase infiltration [13].

### *2.2 Infiltration Capacity*

The process through which water seeps into the soil is known as infiltration [14] caused by lateral forces (water movement in a lateral direction) and gravitational forces (water movement in a vertical direction) expressed in units (cm/hour) [15]. If the top layer of soil is saturated, excess water will be forwarded to deeper parts of the soil due to the earth's gravitational force (vertical). The infiltration mechanism is made up of three processes: allowing water to enter the soil through its surface pores, storing the water in the soil, and transporting the water to other places [16].

When rainwater collects above the ground surface, the air will infiltrate through the surface and into the soil with the initial infiltration rate ($f_0$) displayed depending on the soil moisture content at that time [17].

Infiltration capacity can be calculated using the Horton Method formula. In hydrology, the infiltration rate is calculated using the Horton model. Horton understood that the infiltration capacity drops over time before approaching a fixed amount. The Horton Method calculation requires a constant value of k, this value can be found by using the m value on the comparison curve between t (hours) and log $(f - f_c)$.

$$F_t = f_c + (f_0 - f_c)^{-kt}$$

Information:

$F_t$ = infiltration rate or infiltration capacity at t (hour)
$f_c$ = constant infiltration rate
$f_0$ = initial infiltration rate
$e$ = 2,71828
$k$ = soil saturated hydraulic conductivity (constant)
$t$ = time

[12]

To obtain a constant value of k to complete the equation on the infiltration capacity curve, the Horton equation is processed and the formula k is obtained as follows [18].

$$\boldsymbol{k = -\frac{1}{0{,}434\ x\ m}}, \text{ where m = gradien}$$

### *2.3 Infiltration Rate*

The infiltration rate, measured in milimeters per hour (mm/hour) or centimeters per hour (cm/hour), is the volume of water that percolates into the soil during rainfall. The rate of infiltration will often be quicker when the soil is dry. The infiltration rate will be gradual and steady when the soil is saturated water. [19].

The amount of vegetation on the soil is one of the elements that can influence the rate of infiltration [20]. Other factors affecting infiltration rate are as follows.

1. Inundation depth and saturated layer thickness
2. Soil moisture
3. Placement by rain
4. Blockage by fine grains
5. Cover crops
6. Topography
7. Rain intensity

Large infiltration rates are used to describe changes in infiltration that take place. The amount of soil storage capacity will be impacted by this infiltration rate. The infiltration rate is also affected by the high groundwater level so each soil property will have a different infiltration rate [21].

**Figure 2. 1 Infiltration Rate Testing in Datar Ajab Village, Hulu Sungai Tengah District**

The Horton method was used to calculate the infiltration rate, and Uhland and O'Neal's classification system was used to determine the speed of water absorption.

**Table 2. 1 Classification of Infiltration Rate According to Uhland and O'Neal, 1951**

| Classification | Infiltration Rate (cm/hour) |
|---|---|
| Very Fast | >25,4 |
| Fast | 12,7 – 25,4 |
| Kinda Fast | 6,3 – 12,7 |
| Currently | 2 – 6,3 |
| a Bit Slow | 0,5 – 2 |
| Slow | 0,1 – 0,5 |
| Very Slow | <0,1 |

**Source:** [22]

## 3. Materials and Methods

Datar Ajab Village, Hantakan Sub-District, and Hulu Sungai Tengah District are the locations where this study was carried out. Direct surveys of the study region were used to collect primary data, and a double-ring infiltrometer was used to measure the infiltration rate (turf-tec infiltrometer). The Horton Method was the analytical technique employed in this investigation. The test locations are divided into three based on land cover.

## 4. Result and Discussion

### *4.1 Research Sites*

Datar Ajab Village, Hantakan District, Hulu Sungai Tengah Regency, South Kalimantan Province served as the site of this study. Nine places, each with three different land cover types-bare, medium, and high-were observed.

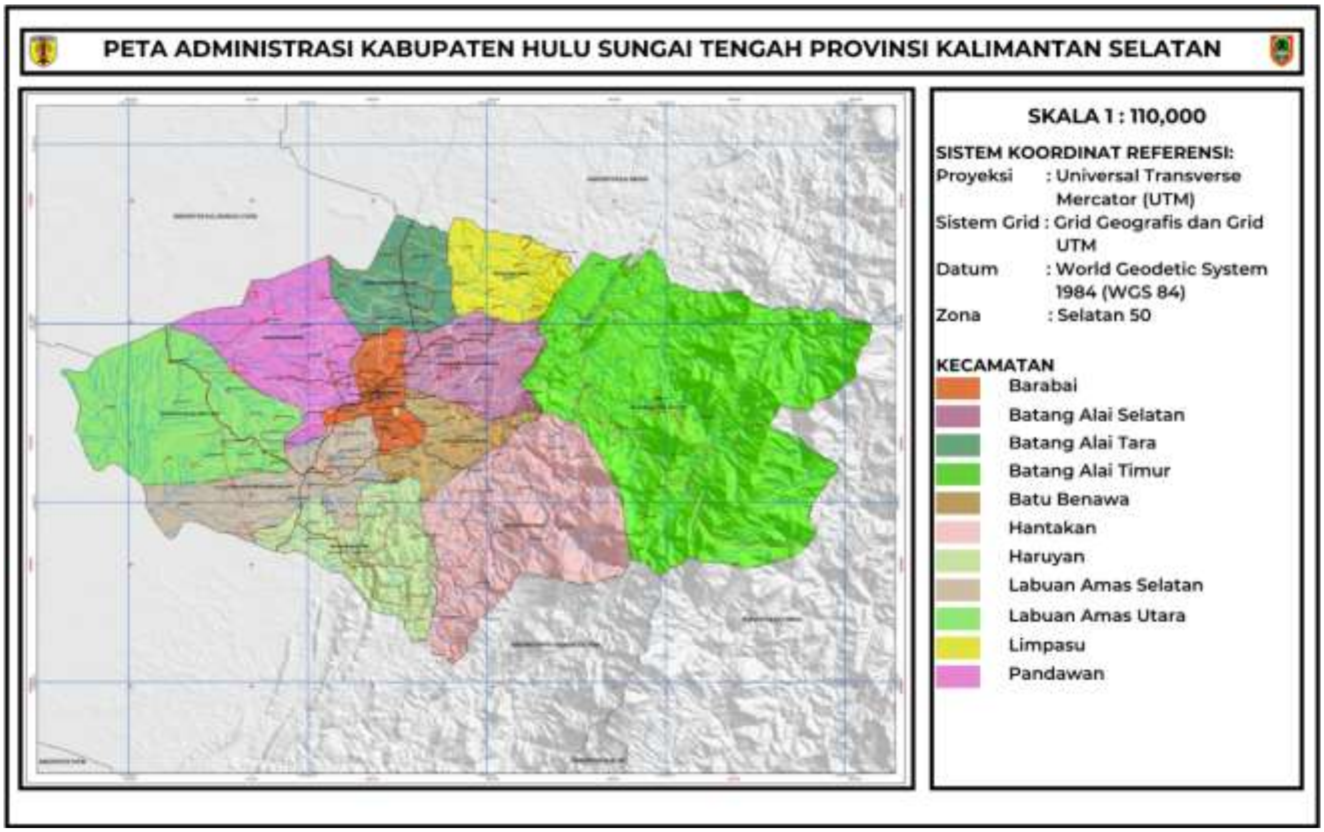


**Figure 4. 1 Administrative Map of Hulu Sungai Tengah Regency**
Source; https://petatematikindo.wordpress.com/


**Figure 4. 2 Infiltration Rate Test Point in Datar Ajab Village**

The coordinates of the research location are as follows:

1. Point B1 at coordinates 2º39’52.50” S, 115º32’13.50” E.
2. Point B2 at coordinates 2º39’52.50” S, 115º32’13.70” E.
3. Point B3 at coordinates 2º39’53.40” S, 115º32’13.40” E.
4. Point T1 at coordinates 2º39’52.00” S, 115º32’16.30” E.
5. Point T2 at coordinates 2º39’52.60” S, 115º32’16.10” E.
6. Point T3 at coordinates 2º39’52.90” S, 115º32’15.70” E.
7. Point S1 at coordinates 2º39’49.80” S, 115º32’11.80” E.
8. Point S2 at coordinates 2º39’50.80” S, 115º32’11.50” E.
9. Point S3 at coordinates 2º39’50.10” S, 115º32’11.40” E.

### *4.2 Infiltration Capacity*

Testing the infiltration rate in the field is intended to determine the speed and amount of water entering or seeping into the soil [23]. The infiltration process is an important part of the hydrological cycle, especially in the process of converting rain into river flow [24][25].

**Table 4. 1 Infiltration Capacity Calculation Results with the Horton Method Testing 1**

| TESTING 1 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Point Name** | **t (hour)** | $f_0$ **(cm/hour)** | $f_c$ **(cm/hour)** | $(f_0 - f_c)$ **(cm/hour)** | **m** | **k** | **e** | **-k.t** | **f (cm/hour)** |
| 1 | B1 | 0,250 | 5,52 | 1,20 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 4,835 |
| 2 | B2 | 0,083 | 3,60 | 3,60 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 3 | B3 | 0,250 | 7,92 | 3,60 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 7,235 |
| 4 | T1 | 0,250 | 16,32 | 12,00 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 15,635 |
| 5 | T2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 6 | T3 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 7 | S1 | 0,167 | 6,30 | 8,40 | -2,10 | -7,541 | 0,306 | 2,718 | -0,453 | 6,047 |
| 8 | S2 | 0,167 | 8,70 | 0,00 | 8,70 | -4,226 | 0,000 | 2,718 | -0,453 | 8,465 |
| 9 | S3 | 0,083 | 18,00 | 18,00 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |

**Table 4. 2 Infiltration Capacity Calculation Results with the Horton Method Testing 2**

| TESTING 2 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Point Name** | **t (hour)** | $f_0$ **(cm/hour)** | $f_c$ **(cm/hour)** | $(f_0 - f_c)$ **(cm/hour)** | **m** | **k** | **e** | **-k.t** | **f (cm/hour)** |
| 1 | B1 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 2 | B2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 3 | B3 | 0,167 | 23,40 | 18,00 | 5,40 | -11,594 | 0,199 | 2,718 | -0,453 | 22,677 |
| 4 | T1 | 0,167 | 20,70 | 18,00 | 2,70 | -14,530 | 0,159 | 2,718 | -0,453 | 20,191 |
| 5 | T2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 6 | T3 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 7 | S1 | 0,083 | 6,30 | 3,60 | 2,70 | -7,541 | 0,306 | 2,718 | -0,227 | 6,047 |
| 8 | S2 | 0,250 | 19,68 | 13,20 | 6,48 | -7,125 | 0,323 | 2,718 | -0,680 | 18,245 |
| 9 | S3 | 0,083 | 6,00 | 6,00 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |

Based on Table 3.1, in the first test, four points out of nine that did not decrease, namely points B2, T2, T3, and S3. As for the infiltration capacity in the second test, there were five points did not decrease from nine points, namely, B1, B2, T2, T3, and S3.

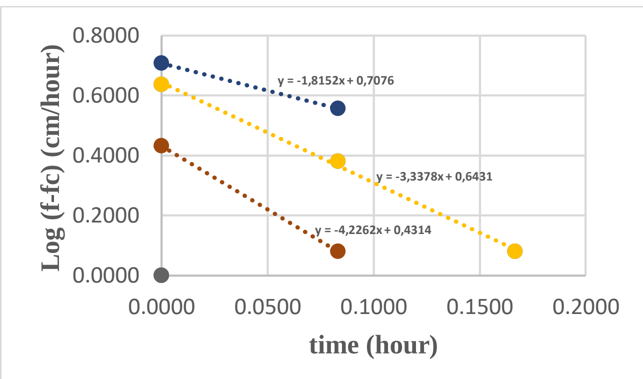


**Figure 4. 3 Graph of Relationship Between Time (hours) and Log (f-f_c) (cm/hour) in Test 1**

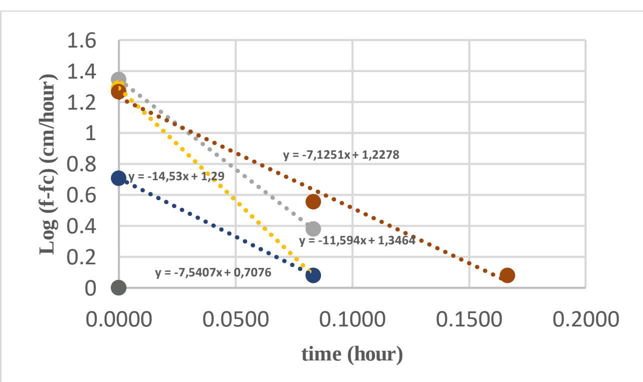


**Figure 4. 4 Graph of Relationship Between Time (hours) and Log (f-f_c) (cm/hour) in Test 2**

### *4.3 Infiltration Rate*

The findings of the infiltration rate analysis utilizing the Horton technique and classification based on Uhlan and O'Neal are presented in Table 3.3.

**Table 4. 3 Classification of Infiltration Rate Testing 1**

| TESTING 1 | | | |
|---|---|---|---|
| **No.** | **Point Name** | **f (cm/hour)** | **Classification** |
| 1 | B1 | 4,835 | Currently |
| 2 | B2 | 0,00 | Very Slow |
| 3 | B3 | 7,235 | Kinda Fast |
| 4 | T1 | 15,635 | Fast |
| 5 | T2 | 0,00 | Very Slow |
| 6 | T3 | 0,00 | Very Slow |
| 7 | S1 | 6,047 | Currently |
| 8 | S2 | 8,465 | Kinda Fast |
| 9 | S3 | 0,00 | Very Slow |

Based on Table 3.3 from test 1 at nine points there were four points with very slow classification, namely, B2, T2, T3, and S3 of 0.00 cm/hour. Then there are two points with moderate classification namely B1 of 4.835 cm/hour, S1 of 6.047 cm/hour, two points with a rather fast classification namely B3 of 7.235 cm/hour, S2 of 8.465 cm/hour, and one with fast classification namely T1 15.635 cm/hour.

**Table 4. 4 Classification of Infiltration Rate Testing 2**

| TESTING 2 | | | |
|---|---|---|---|
| **No.** | **Point Name** | **f (cm/hour)** | **Classification** |
| 1 | B1 | 0,00 | Very Slow |
| 2 | B2 | 0,00 | Very Slow |
| 3 | B3 | 22,677 | Fast |
| 4 | T1 | 20,191 | Fast |
| 5 | T2 | 0,00 | Very Slow |
| 6 | T3 | 0,00 | Very Slow |
| 7 | S1 | 6,047 | Currently |
| 8 | S2 | 18,245 | Fast |
| 9 | S3 | 0,00 | Very Slow |

Based on Table 3.4 from test 2 at nine points there were five points with very slow classification, namely, B1, B2, T2, T3, and S3 of 0.00 cm/hour. Then there is one point with moderate classification, namely S1 at 6.047 cm/hour, and three points with fast classification, namely, B3 at 22.677 cm/hour, T1 at 20.191 cm/hour, and S2 at 18.245 cm/hour.

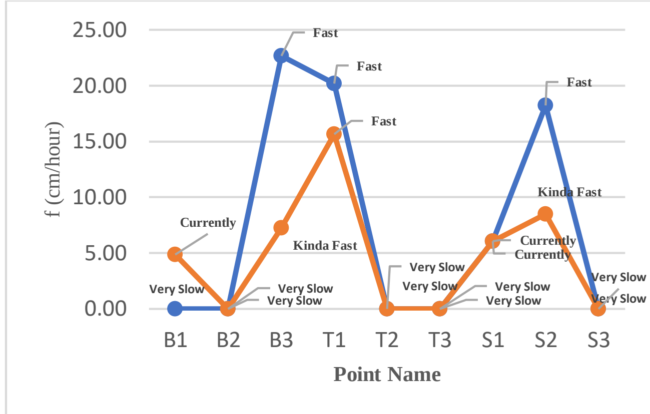


**Figure 4. 5 Graph Comparison of Classification in Test 1 and Test 2**

## 5. Conclusion

According to the test result and analysis of calculations made using the Horton Method, out of a total of nine points, four of them in test 1 had classifications that were extremely slow, two were moderete, two were quite fast, and one was rapid. Whereas in test 2 there were five points whose infiltration capacity was classified as very slow, one point classified as medium, and three points classified as fast. Based on this, the research location area is prone to flooding if it rains with high intensity. This is because the soil cannot absorb water properly due to changes in land use, so it takes quite a long time or does not absorb at all.

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*Original Article*

# Testing the Infiltration Rate of Datar Ajab Village, Hulu Sungai District

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***Abstract*** *- The problem of flooding is something that often occurs during the rainy season, and its coverage area has expanded not only to areas that are used to flooding but also to the surrounding areas. South Kalimantan Province's Hulu Sungai Tengah Regency and a number of its districts had a flood disaster to start the year 2021. Tilahan or Hanntak is the Meratus Mountains Region which is the origin of the floods due to the overflow of the Benawa River and the continuing flow of the Barabai River. The practice of illegal logging in the Meratus Mountains Region is still rife. On January 14, 2021, extreme rainfall occurred, which caused flooding in the South Kalimantan region. Low water absorption into the ground is one of the causes of flooding when heavy rains occur for a long duration. In this study, infiltration in the Hantakan Sub-District, Hulu Sungai Tengah, will be measured to examine the infiltrated water rate. Primary data from a direct survey of the research region was collected to assess the infiltration rate, and the Horton technique was used to analyze it. Based on the test results and the results of the analysis of counts at nine points, in test 1, there were four points with very slow classification, two points with moderate classification, two points with a rather fast classification, and one point with fast classification. Whereas in test 2, there were five points classified as very slow, one as medium, and three fast.*

***Keywords*** *- Rainfall, Landuse, Flood, Infiltration, Hulu Sungai Tengah District.*

## 1. Introduction

The problem of flooding is something that often occurs during the rainy season, and its coverage area has expanded not only to areas that are usually flooded but also to the surrounding areas. The year 2021 in Hulu Sungai Tengah Regency and several districts in South Kalimantan Province began with a flood disaster. A total of six districts were hit by flooding, one of which was the Hulu Sungai Tengah (HST) Regency, which was caused by rivers overflowing due to high rain intensity. There are at least seven sub-districts in HST that were affected by the floods, namely, Batang Alai Timur, Batang Alai Selatan, Pandawan, Barabai, Hantakan, Batu Benawa, and Haruyan sub-districts. Tilahan or Hantakan is an area of the Meratus Mountains which is the origin of flooding due to the Benawa River's overflow and the Barabai River's continuing flow.

The practice of illegal logging in South Kalimantan, especially in the Meratus Mountains area, is still rife. Environmental damage and reduced forest cover are believed to be the main causes of major floods and landslides. In this study, infiltration in the Hantakan Sub-District, Hulu Sungai Tengah, will be measured to examine the infiltrated water rate.

## 2. Literature Review

### *2.1. Flood*

Floods are natural disasters caused by natural events, namely high-intensity rainfall, which often causes physical and material losses [1]. The impact of a flood can sometimes be disastrous. Extreme floods will worsen due to the increasing intensity and frequency of extreme rainfall modifications caused by climate change [2]. It might be difficult to lessen the risk of damage from floods and their effects on water quality when they happen in metropolitan areas [3]. Flooding is caused by a number of factors, including land use conditions and heavy rainfall. Inappropriate land use by the community causes ecosystem disturbances which result in changes in land use [4]. Changes in land use from forest areas to built-up areas will result in falling rainwater not being able to seep into the ground but overflowing a lot, thus increasing flood discharge during high-intensity rains [5]. The land use system with the distribution of tree-type cover vegetation, which is also accompanied by the presence of ground cover plants, is a land system that can retain rainwater better than the shrub or pole land system [6].

This is extreme rainfall, according to statistics from the Banjarbaru Class I Climatology Station of 255.3 milimeter and the Class II Meteorological Station Syamsudin Noor Banjarmasin of 149 milimeter on January 14, 2021 [7]. It is evident that the region of South Kalimantan experienced flooding as a result of the day's intense rain [8][9].

When heavy rains last for a long time, one of the reasons for floods is the soil's poor ability to absorb water [10]. If a place has poor groundwater absorption capacity, then when it rains, surface water that flows will cause puddles, and the water cannot seep properly into the ground. This can cause flooding when there is high-intensity and long-duration rain. The ability of groundwater absorption can be measured by measuring the infiltration rate [11]. If the ratio of rain intensity is smaller than the infiltration rate, then all the rainwater that falls will seep into the ground [12]. Water infiltration will be more effective on land overgrown with plants because plants can increase infiltration [13].

### 2.2. Infiltration Capacity

The process through which water seeps into the soil is known as infiltration [14] and is caused by lateral forces (water movement in a lateral direction) and gravitational forces (water movement in a vertical direction) expressed in units (cm/hour) [26]. If the top layer of soil is saturated, excess water will be forwarded to deeper parts of the soil due to the earth's gravitational force (vertical). The infiltration mechanism is made up of three processes: allowing water to enter the soil through its surface pores, storing the water in the soil, and transporting the water to other places [16].

When rainwater collects above the ground surface, the air will infiltrate through the surface and into the soil with the initial infiltration rate ($f_0$) displayed depending on the soil moisture content at that time [17].

Infiltration capacity can be calculated using the Horton Method formula. In hydrology, the infiltration rate is calculated using the Horton model. Horton understood that the infiltration capacity drops over time before approaching a fixed amount. The Horton Method calculation requires a constant value of k; this value can be found by using the m value on the comparison curve between t (hours) and log $(f - f_c)$.

$$F_t = f_c + (f_0 - f_c)^{-kt}$$

Information:

$F_t$ = infiltration rate or infiltration capacity at t (hour)
$f_c$ = constant infiltration rate
$f_0$ = initial infiltration rate
$e$ = 2,71828
$k$ = soil saturated hydraulic conductivity (constant)
$t$ = time
[12]

To obtain a constant value of k to complete the equation on the infiltration capacity curve, the Horton equation is processed, and the formula k is obtained as follows [18].

$$k = -\frac{1}{0{,}434\ x\ m}\text{, where m = gradien}$$

### 2.3. Infiltration Rate

The infiltration rate, measured in milimeters per hour (mm/hour) or centimeters per hour (cm/hour), is the volume of water that percolates into the soil during rainfall. The rate of infiltration will often be quicker when the soil is dry. The infiltration rate will gradually and steadily when the soil is saturated with water. [19].

The amount of vegetation on the soil is one of the elements that can influence the infiltration rate [20]. Other factors affecting infiltration rate are as follows.

1. Inundation depth and saturated layer thickness
2. Soil moisture
3. Placement by rain
4. Blockage by fine grains
5. Cover crops
6. Topography
7. Rain intensity

Large infiltration rates are used to describe changes in infiltration that take place. The amount of soil storage capacity will be impacted by this infiltration rate. The high groundwater level also affects the infiltration rate, so that each soil property will have a different infiltration rate [21].

**Fig. 1 Infiltration Rate Testing in Datar Ajab Village, Hulu Sungai Tengah District**

The Horton method was used to calculate the infiltration rate, and Uhland and O'Neal's classification system was used to determine the water absorption speed.

**Table 1. Classification of Infiltration Rate According to Uhland and O'Neal, 1951**

| Classification | Infiltration Rate (cm/hour) |
|---|---|
| Very Fast | >25,4 |
| Fast | 12,7 – 25,4 |
| Kinda Fast | 6,3 – 12,7 |
| Currently | 2 – 6,3 |
| a Bit Slow | 0,5 – 2 |
| Slow | 0,1 – 0,5 |
| Very Slow | <0,1 |

*Source: [27]*

## 3. Materials and Methods

Datar Ajab Village, Hantakan Sub-District, and Hulu Sungai Tengah District are the locations where this study was carried out. Direct surveys of the study region were used to collect primary data, and a double-ring infiltrometer was used to measure the infiltration rate (turf-tec infiltrometer). The Horton Method was the analytical technique employed in this investigation. The test locations are divided into three based on land cover.

## 4. Result and Discussion

### *4.1. Research Sites*

Datar Ajab Village, Hantakan District, Hulu Sungai Tengah Regency, South Kalimantan Province, served as the site of this study. Nine places, each with three different land cover types-bare, medium and high-were observed.

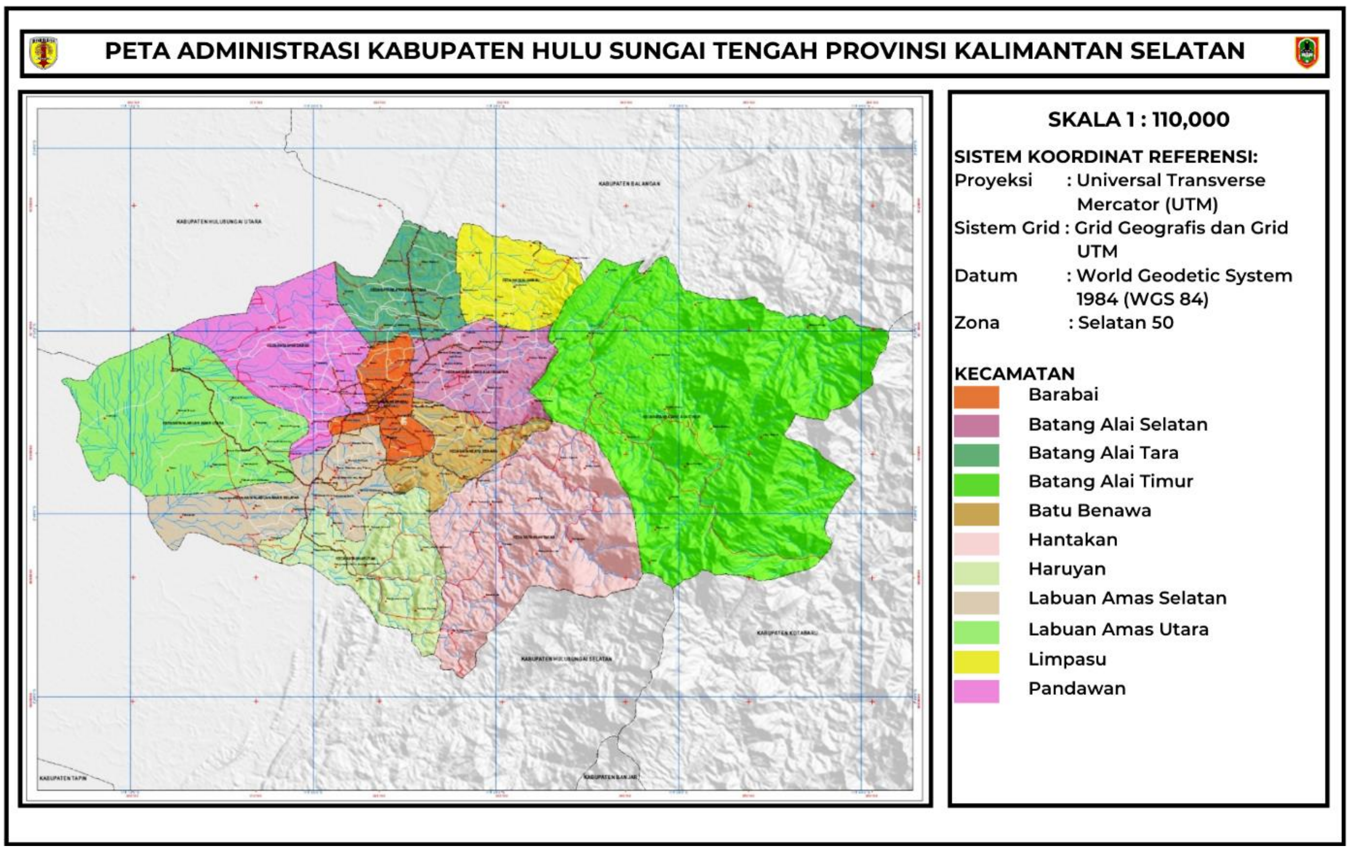


**Fig. 2 Administrative Map of Hulu Sungai Tengah Regency**

*Source: https://petatematikindo.wordpress.com/*

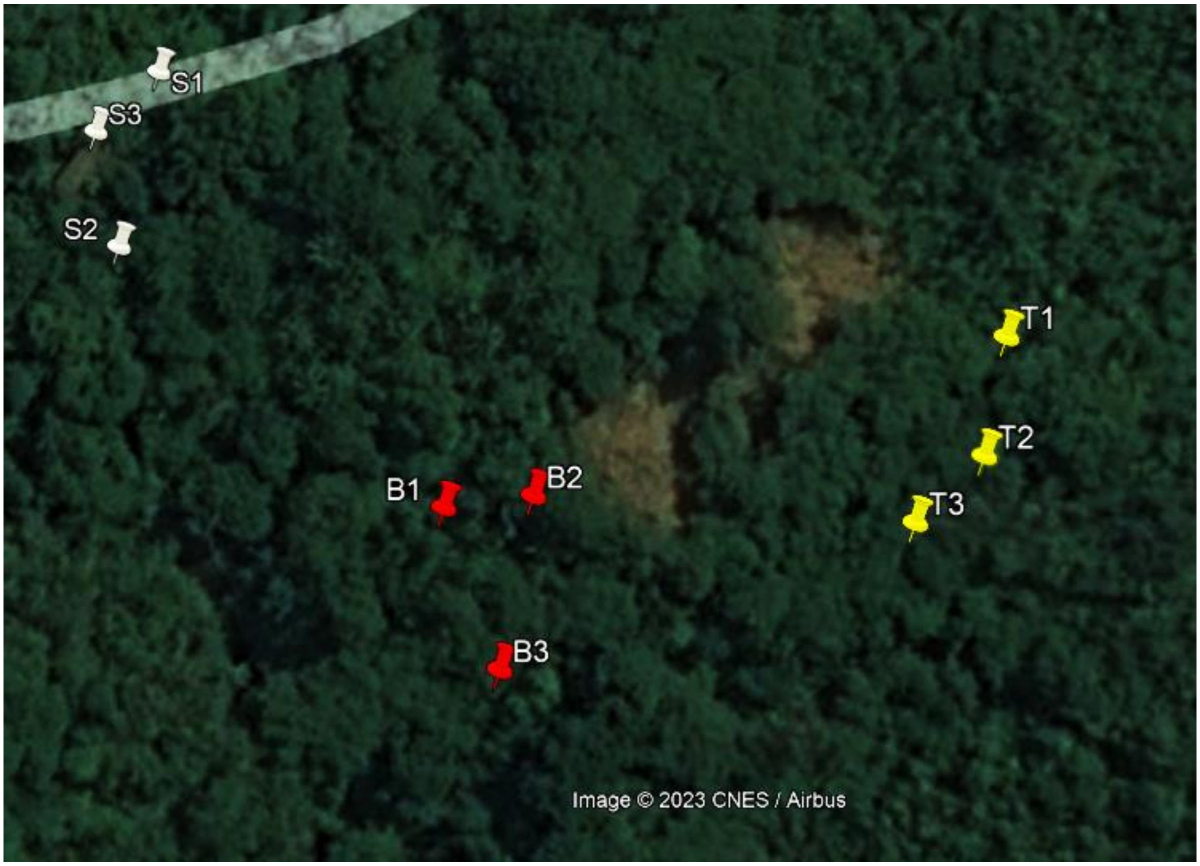


**Fig. 3 Infiltration Rate Test Point in Datar Ajab Village**

The coordinates of the research location are as follows:

1. Point B1 at coordinates 2º39'52.50" S, 115º32'13.50" E.
2. Point B2 at coordinates 2º39'52.50" S, 115º32'13.70" E.
3. Point B3 at coordinates 2º39'53.40" S, 115º32'13.40" E.
4. Point T1 at coordinates 2º39'52.00" S, 115º32'16.30" E.
5. Point T2 at coordinates 2º39'52.60" S, 115º32'16.10" E.
6. Point T3 at coordinates 2º39'52.90" S, 115º32'15.70" E.
7. Point S1 at coordinates 2º39'49.80" S, 115º32'11.80" E.
8. Point S2 at coordinates 2º39'50.80" S, 115º32'11.50" E.
9. Point S3 at coordinates 2º39'50.10" S, 115º32'11.40" E.

### *4.2. Infiltration Capacity*

Testing the infiltration rate in the field is intended to determine the speed and amount of water entering or seeping into the soil [23]. The infiltration process is an important part of the hydrological cycle, especially in the process of converting rain into river flow [24][25].

**Table 2. Infiltration Capacity Calculation Results with the Horton Method Testing 1**

| TESTING 1 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Point Name** | **t (hour)** | $f_0$ **(cm/hour)** | $f_c$ **(cm/hour)** | $(f_0 - f_c)$ **(cm/hour)** | **m** | **k** | **e** | **-k.t** | **f (cm/hour)** |
| 1 | B1 | 0,250 | 5,52 | 1,20 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 4,835 |
| 2 | B2 | 0,083 | 3,60 | 3,60 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 3 | B3 | 0,250 | 7,92 | 3,60 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 7,235 |
| 4 | T1 | 0,250 | 16,32 | 12,00 | 4,32 | -3,338 | 0,690 | 2,718 | -0,680 | 15,635 |
| 5 | T2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 6 | T3 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 7 | S1 | 0,167 | 6,30 | 8,40 | -2,10 | -7,541 | 0,306 | 2,718 | -0,453 | 6,047 |
| 8 | S2 | 0,167 | 8,70 | 0,00 | 8,70 | -4,226 | 0,000 | 2,718 | -0,453 | 8,465 |
| 9 | S3 | 0,083 | 18,00 | 18,00 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |

**Table 3. Infiltration Capacity Calculation Results with the Horton Method Testing 2**

| TESTING 2 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Point Name | t (hour) | $f_0$ (cm/hour) | $f_c$ (cm/hour) | $(f_0 - f_c)$ (cm/hour) | m | k | e | -k.t | f (cm/hour) |
| 1 | B1 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 2 | B2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 3 | B3 | 0,167 | 23,40 | 18,00 | 5,40 | -11,594 | 0,199 | 2,718 | -0,453 | 22,677 |
| 4 | T1 | 0,167 | 20,70 | 18,00 | 2,70 | -14,530 | 0,159 | 2,718 | -0,453 | 20,191 |
| 5 | T2 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 6 | T3 | 0,083 | 1,20 | 1,20 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |
| 7 | S1 | 0,083 | 6,30 | 3,60 | 2,70 | -7,541 | 0,306 | 2,718 | -0,227 | 6,047 |
| 8 | S2 | 0,250 | 19,68 | 13,20 | 6,48 | -7,125 | 0,323 | 2,718 | -0,680 | 18,245 |
| 9 | S3 | 0,083 | 6,00 | 6,00 | 0,00 | 0,000 | 0,000 | 2,718 | -0,227 | 0,000 |

Based on Table 2, four points out of nine did not decrease in the first test, namely, B2, T2, T3, and S3. As for the infiltration capacity in the second test, there were five points did not decrease from nine points, namely, B1, B2, T2, T3, and S3.

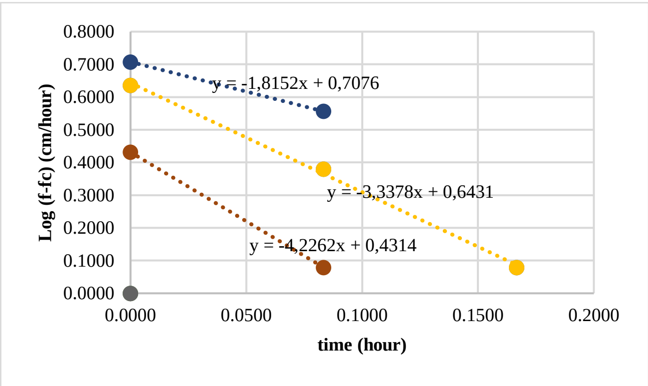


**Fig. 4 Graph of Relationship Between Time (hours) and Log (f-f_c) (cm/hour) in Test 1**

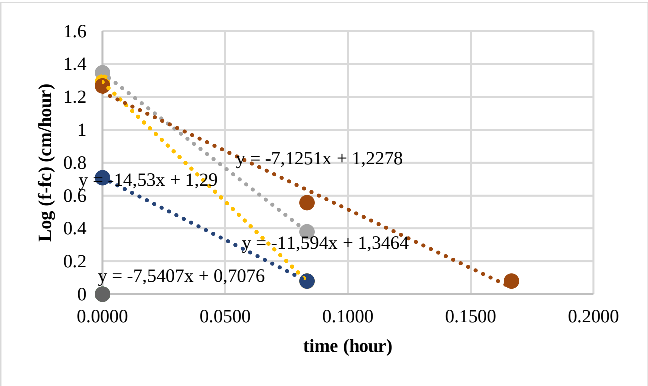


**Fig. 5 Graph of Relationship Between Time (hours) and Log (f-f_c) (cm/hour) in Test 2**

### *4.3. Infiltration Rate*

The findings of the infiltration rate analysis utilizing the Horton technique and classification based on Uhlan and O'Neal are presented in Table 4.

**Table 4. Classification of Infiltration Rate Testing 1**

| TESTING 1 | | | |
|---|---|---|---|
| No. | Point Name | f (cm/hour) | Classification |
| 1 | B1 | 4,835 | Currently |
| 2 | B2 | 0,00 | Very Slow |
| 3 | B3 | 7,235 | Kinda Fast |
| 4 | T1 | 15,635 | Fast |
| 5 | T2 | 0,00 | Very Slow |
| 6 | T3 | 0,00 | Very Slow |
| 7 | S1 | 6,047 | Currently |
| 8 | S2 | 8,465 | Kinda Fast |
| 9 | S3 | 0,00 | Very Slow |

Based on Table 4 from test 1, at nine points, there were four points with very slow classification, namely, B2, T2, T3, and S3 of 0.00 cm/hour. Then there are two points with moderate classification, namely B1 of 4.835 cm/hour, S1 of 6.047 cm/hour, two points with a rather fast classification, namely B3 of 7.235 cm/hour, S2 of 8.465 cm/hour, and one with fast classification namely T1 15.635 cm/hour.

**Table 5. Classification of Infiltration Rate Testing 2**

| TESTING 2 | | | |
|---|---|---|---|
| No. | Point Name | f (cm/hour) | Classification |
| 1 | B1 | 0,00 | Very Slow |
| 2 | B2 | 0,00 | Very Slow |
| 3 | B3 | 22,677 | Fast |
| 4 | T1 | 20,191 | Fast |
| 5 | T2 | 0,00 | Very Slow |
| 6 | T3 | 0,00 | Very Slow |
| 7 | S1 | 6,047 | Currently |
| 8 | S2 | 18,245 | Fast |
| 9 | S3 | 0,00 | Very Slow |

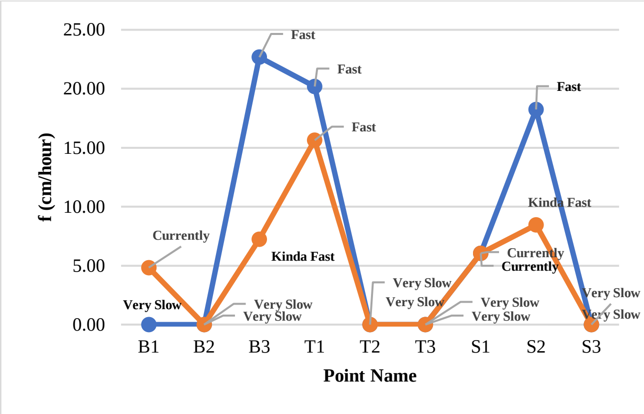


**Fig. 6 Graph Comparison of Classification in Test 1 and Test 2**

Based on Table 5 from test 2, at nine points, there were five points with very slow classification, namely, B1, B2, T2, T3, and S3 of 0.00 cm/hour. Then there is one point with moderate classification, namely S1 at 6.047 cm/hour, and three points with fast classification, namely, B3 at 22.677 cm/hour, T1 at 20.191 cm/hour, and S2 at 18.245 cm/hour.

## 5. Conclusion

According to the test result and analysis of calculations made using the Horton Method, out of a total of nine points, four of them in test 1 had extremely slow classifications; two were moderate, two were quite fast, and one was rapid. Whereas in test 2, there were five points whose infiltration capacity was classified as very slow, one point classified as medium, and three points classified as fast. Based on this, the research location area is prone to flooding if it rains with high intensity. This is because the soil cannot absorb water properly due to changes in land use, so it takes quite a long time or does not absorb at all.

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