Analysis of Soil Types on Flood Hazard Potential in Gorontalo City

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Abstract: The purpose of this research study is to determine the influence of soil type on the conditions of flood inundation heights that occurred in the city of Gorontalo through a grit-based approach to the study of spatial hydrogemorphology. Analysis technique using land units approach as mapping units. Based on the results of the study concluded that the city of Gorontalo, (1) Type of land located in the city of Gorontalo consists of two types of soil and soil alluvial soil hydromorphic grumosol. type of soil in the alluvial plains of the city of Gorontalo area of 3492.31 ha (98.55% of the plains town of Gorontalo) or 52.3% of the total area of the city of Gorontalo, (2) the results of the regression analysis (Chi Square Tests) mapping hydrogeomorphological units of Gorontalo, it is known that the characteristics of the potential danger of flooding is influenced by soil type, while to test directional measures have no effect because the real-lying city of Gorontalo is already a flood plain, (3) the infiltration rate is very slow in some areas of 0.0003 mm / sec according to Tsukamoto minimum of 2mm / sec. (4) high ground water level during the rainy season ranges from 0.5 m to 1.5 m.

***Keywords**: Type of Soil, Flood, Gorontalo City.*

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I. INTRODUCTION

Flood is a land that was previously dry but becomes inundated (Seyhan, 1977). The causes of flooding include overflowing rivers or blocked surface flow towards rivers. Flood disasters have a major impact on society. The impact is in the form of loss of life or material losses including damage to buildings, damage to infrastructure networks such as roads and bridges, in the agricultural sector such as crop failure due to damaged rice fields, disruption of trade and services, causing various health problems both during and after the flood, disrupting government services.

Floods are closely related to the physical properties of the soil, such as infiltration rate, aquiver rate and groundwater level. The infiltration rate depends on the condition of the vegetation cover or land use above it, while the aquiver rate depends on the structure of the forming rocks in the soil. The land drainage conditions are as stated in Table 1.

Table 1 Soil Type Values

No	Class	Soil Type	Description	Score
1	T0	Mediterranean	Loam to clay, good water absorption capacity	1
2	T1	Alluvial	Clay, sufficient water absorption capacity	2
3	T2	Grumosol	Heavy clay, less water absorption capacity	3

Source: Adaptation Sutanto, R. (2005)

Looking at the theory put forward by Tsukamoto and Sutanto, it is also necessary to know the composition of rocks and soil formations in Gorontalo City. Igneous rocks and volcanic formations stretch from Gorontalo City to Batudaa District and Bongomeme District, Gorontalo Regency, while further west coral limestone will be found. The central part of the Gorontalo area is a lowland formed from thick lake deposits. A number of lagoons can be found along the south coast formed from coral reefs.

CIDA (1999), sedimentary rocks are the oldest rocks, while volcanic rocks come from the Oligocene-Eocene era, and further up are young and old volcanics, Molasa Celebes, limestone and young alluvium. Tertiary rocks in some places have experienced intrusion as granite and granodiorite rocks. Rocks from the Tertiary era can be distinguished into, Dulukapa Formation (in the northwest of Gorontalo City), Tinombu Formation (southwest of Gorontalo City), Bilungala Formation (south) and Massive Limestone in the central part of Gorontalo Province.

Specifically for Gorontalo City based on the geological map from the Forestry, Mining and Energy Service of Gorontalo Province conducted by the Bandung Geological

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Research and Development Center (1977), the distribution of geological rock conditions consists of 4 (four rock formations, namely the Lake Deposit formation (Qpl), the Reef Limestone formation (Ql), the Pinogu Volcanic Rock formation (TQpv), and the Bone Diorite formation (Tmb). Table 2 and Figure 1 show the distribution of geological conditions of rocks in Gorontalo City.

The Lake Sediment Formation (Qpl) is made of sedimentary rock and surface deposits are rocks resulting from the decay of gray claystone as fine to coarse grained sandstone and gravel. This formation is spread almost throughout the plains of Gorontalo City with locations in 50 sub-districts covering an area of 3791.639 Ha or 37.9 km2 or around 56.8% of the total area of Gorontalo City.

Table 2 Distribution of Geological Conditions (Rocks) in Gorontalo City

No	**Parent Material**	**Formation**	**Area (ha)**	**(%)**
(1)	(2)	(3)	(4)	(5)
1	Sedimentary Rocks and Surface Deposits	Qpl	3,791,693	56.8
2	Sedimentary Rocks	Ql	1,052,588	15.8
3	Volcanic Rocks	TQpv	1,266,117	19.0
4	Breakthrough Rock	Tmb	565,177	8.4

Source: Analysis of the Geological Map of Gorontalo City 2010

The Reef Limestone Formation (Ql) is made of sedimentary rock parent material which is the decay of uplifted reef limestone and clastic limestone covering an area of 1052.588 Ha or 10.52 km2 or 15.8%. spread across 9 (nine) sub-districts located at the foot of the hill, south to west of Gorontalo City, namely Dembe I, Lekobalo, Pilolodaa, Buliide, Tenilo, Donggala, Siendeng, Pohe and Tanjung Keramat sub-districts.

The next formation is the Pinogu volcanic rock formation (TQpv) made of volcanic rock parent material is the decay of tuff, lapilli tuff, breccia and lava covering an area of 1266.117 Ha / 12.6 km2 or 19% of the total area of Gorontalo City. Spread to the south west such as Tenilo, Donggala, Siendeng, Tenda Pohe, Tanjung Keramat and south of Gorontalo City to the east such as South Leato, North Leato and Botu sub-districts.

Bone diorite formation (Tmb) is made of intrusive rock and is a decay of diorite, quartz diorite, granodiorite, adamellite rocks covering an area of 565.177 Ha/5.6 km2 or 8.4% of the area of Gorontalo City. This intrusive rock formation is often used by the Gorontalo community as a C Quarry material as backfill sand. Also spread in Donggala, Siendeng, Tenda, South Leato, North Leato and Botu.

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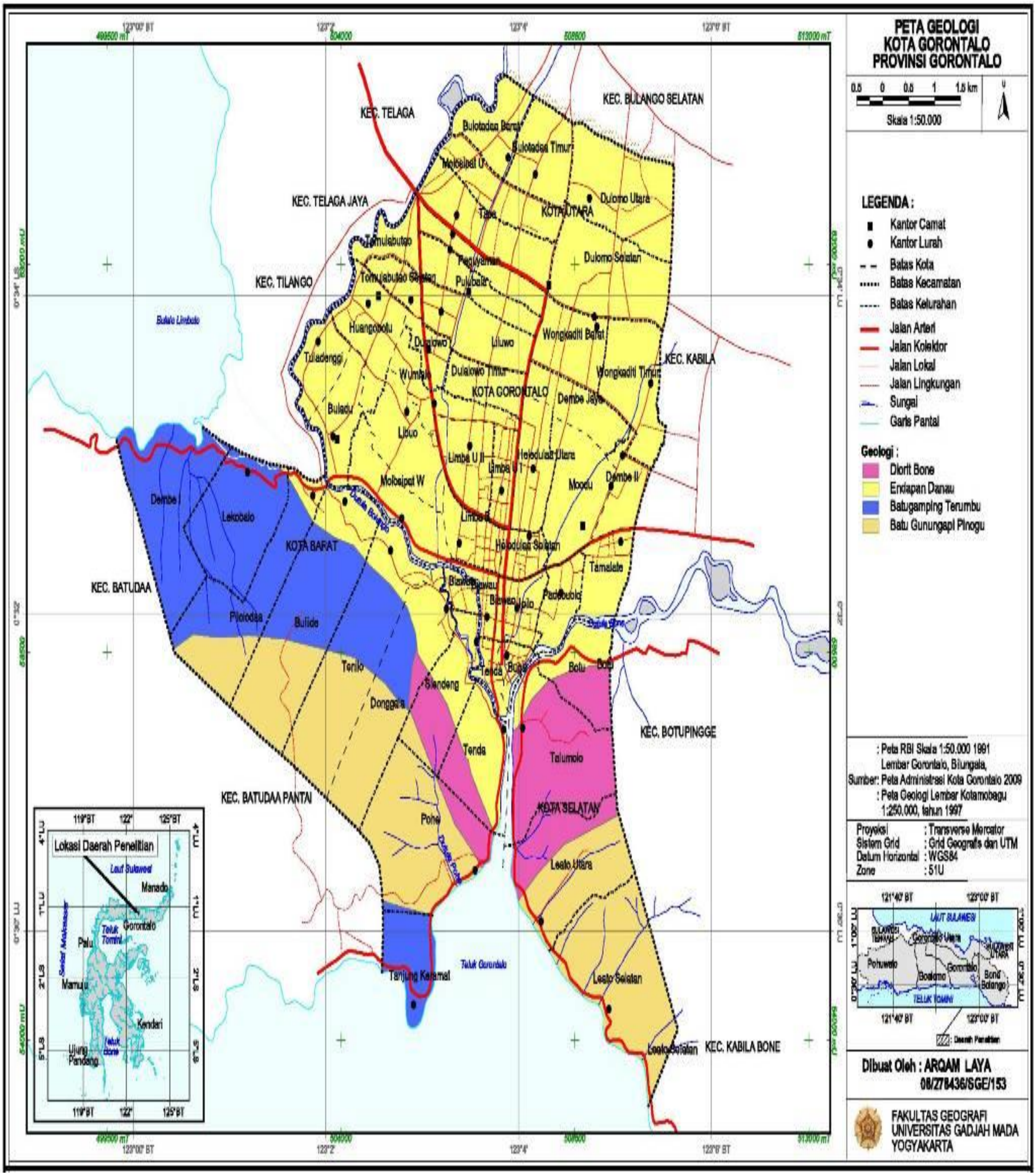

Fig 1 Geological Map of Gorontalo City

II. METHOD

Gorontalo City was the location of the research, conducted for 10 months (December 2009 to October 2010). The data collection technique used secondary and primary data. Secondary data in the form of a Soil Type Map of Gorontalo City which was used bySoil and Agroclimate Research Center, Bogor (1992). The primary data are in the form of measurements of inundation height, groundwater level and aquiver rate and infiltration rate in an area in Gorontalo City that has been gridded with a size of 200 mx 200 m. The number of samples obtained for each parameter is 108 samples consisting of 46 samples in the lowlands while the remaining 62 samples are located in the hilly area.

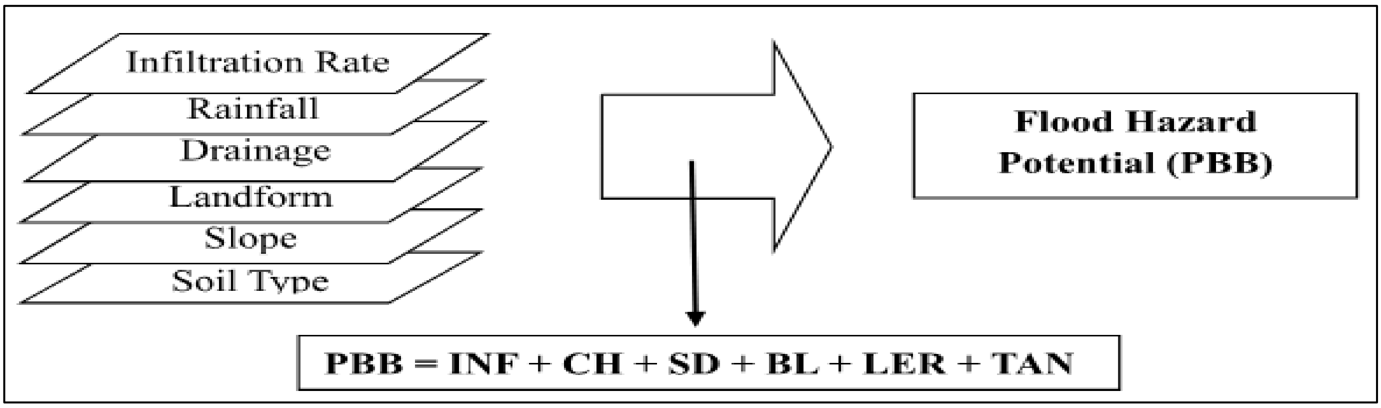

Fig 2 Overlay Engineering Diagram of Potential Flood Hazards

Data analysis uses the overlay method where decision making is based on the index method (rating technique) (Table 3). Validation uses measurements of the height of the inundation on each grid.

Table 3 Classification of Potential Flood Hazard Levels in Gorontalo City

No.	UN Value Interval	Code	Criteria
1	6 – 9	f0	Without danger
2	10 – 13	f1	Minor danger
3	14 – 17	f2	Medium Danger
4	18 – 21	f3	Danger is quite severe
5	22 – 26	f4	Serious Danger

Source: Widiatmaka and Hardjowigeno, S., (2007)

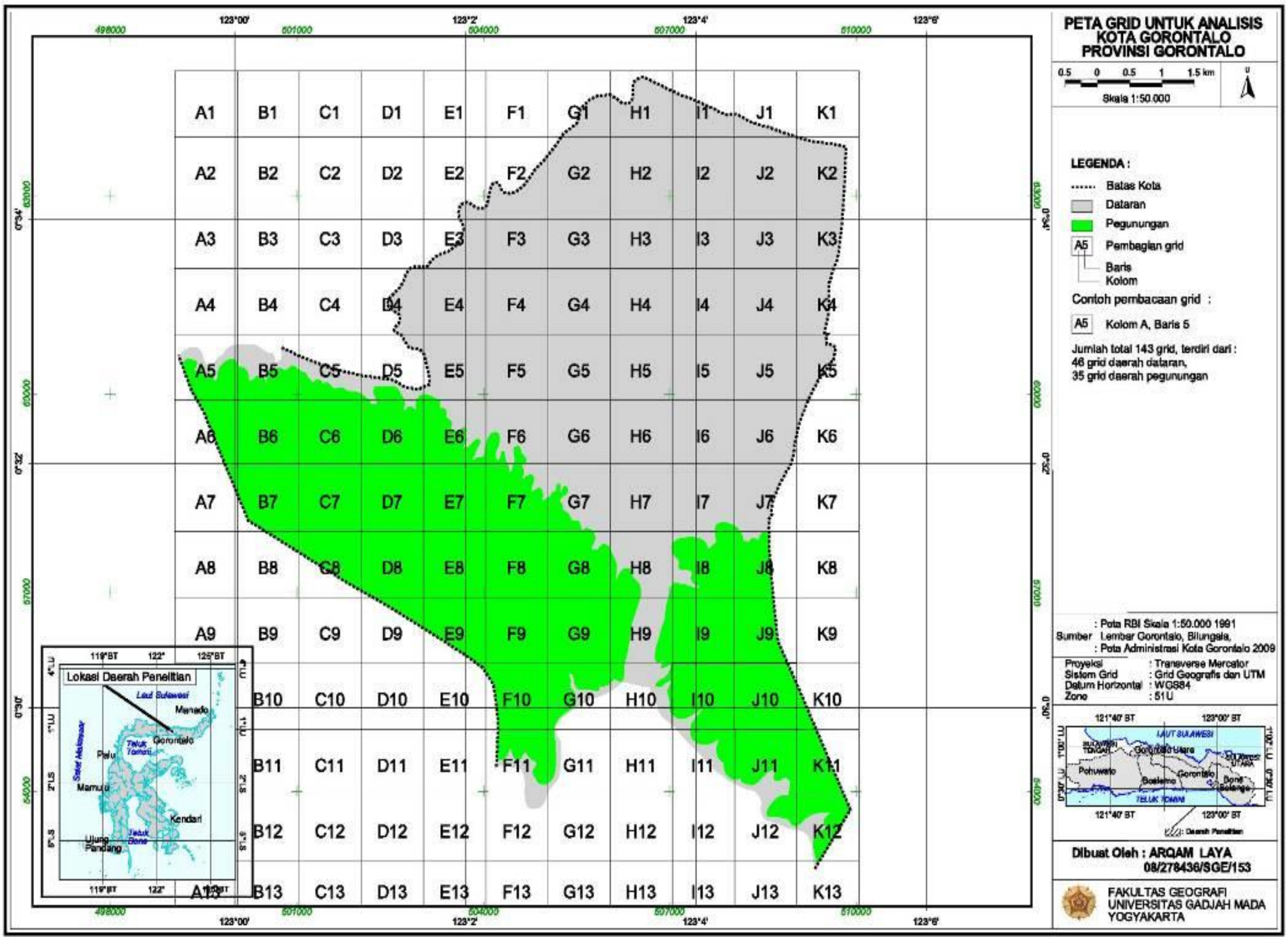

Fig 3 Grid Division Map of Research Locations for Analysis Needs

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III. RESULTS AND DISCUSSION

Alluvial soil types are spread throughout the research area except in Dembe 1 and Lekobalo Villages. Of the 46 grids that were sampled in the study, only 2 grids were grumosol soil types, the other 44 grids were alluvial soil types. The distribution of alluvial soil types is 95.7% of the plain area of Gorontalo City. Alluvial soil types seen from the classification of flood vulnerability levels are included in the fairly vulnerable and vulnerable classifications for all grids that were sampled. This means that an increase in the vulnerability level from the fairly vulnerable classification to the vulnerable classification, due to differences in soil types, is unlikely to occur. So based on the direct measures test, the ordinal value of soil types is no longer related to the level of vulnerability, which can be accepted.

IV. RESULTS

Cross tabulation method in testing *Chi Square Test* and directional measures, as shown in Table 4

Table 4 Relationship between Flood Hazard Potential and Soil Type According to the Chi-Square Test and Directional Measures

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.145a	2	.000
Likelihood Ratio	9,724	2	.008
Linear-by-Linear Association	8,882	1	.003
N of Valid Cases	46		

a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .22.

Directional Measures

			Value	Asymp. Std.Error	Approx. Tb	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	-.234	.075	-1.512	.131
		P. Danger B. Dependent	-.932	.038	-1.512	.131
		Dependent Land Type	-.134	.085	-1.512	.131

Source: Cross Tabulation Analysis Results

Table 4 shows that the type of soil has an association or relationship with the potential for flood hazards. Based on the Asymp. Sig. (2-sided) value, the value *Pearson Chi-Square*, *Likelihood Ratio*and the Linear-by-Linear Associationof 0%, 0.8%, and 0.3% or less than 1%. Thus the test*Chi-Square*reject the hypothesis H0 and accept H1. This means that according to *Chi-Square* soil type has a significant effect on the potential for flood hazard in Gorontalo City. The results of the Chi Square Tests show a value of 17.145 with a significance probability of 0.000 and an expected value of 66.7%. This means that the results of the Chi Square test state that the correlation between the potential for flood hazard is greatly influenced by soil type with a test confidence level of 66.7% in each grid. The minimum expected value in this grid analysis is 0.22.

Other analysis in cross tabulation is directional measures, states that the symmetric value is-0.284,the relationship or association between flood hazard potential and soil type is negatively correlated. This means that an increase in soil type will be followed by a decrease in flood potential. So the very significant relationship that has been described previously in the Chi-Square test states the opposite relationship. Therefore, according to the directional measures test (*Somers'd*) the nominal value of the soil type is not related to the value of the potential flood hazard with a probability of approximation of significance of 13.1% or more than 5%. The condition of the soil type that is not related to the potential flood hazard, because the type of soil in the plains of Gorontalo City is almost uniform. The directional measures test shows that differences in soil types will be related to the classification of potential flood hazards. This is indicated by the large value of the soil type of -13.4% as a dependent variable which is smaller than the value of the potential flood hazard of -93.2%. The symmetric value of -23.4% states that the relationship between the two variables is equal or free.

Other analysis, namely the "t" test analysis and the scatter diagram test, showed that the type of soil as a variable assumed to be able to affect the height of the inundation, the results showed no significant effect (99.2% > 5%). The distribution of frequency values also states the same thing as shown in the scatter diagram image (Figure 4). The scatter diagram image shows that of the 46 grids studied, it turns out that the 46 grids are only represented by 4 groups, namely Group A consisting of 24 grids, group B = 17 grids, group C = 3 grids and group D = 2 grids. As the name implies, namely a scatter diagram, the points to show their influence should also be scattered. So looking at the condition of this diagram, it can be concluded that the type of soil has no significant effect on flood hazards.

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V. DISCUSSION

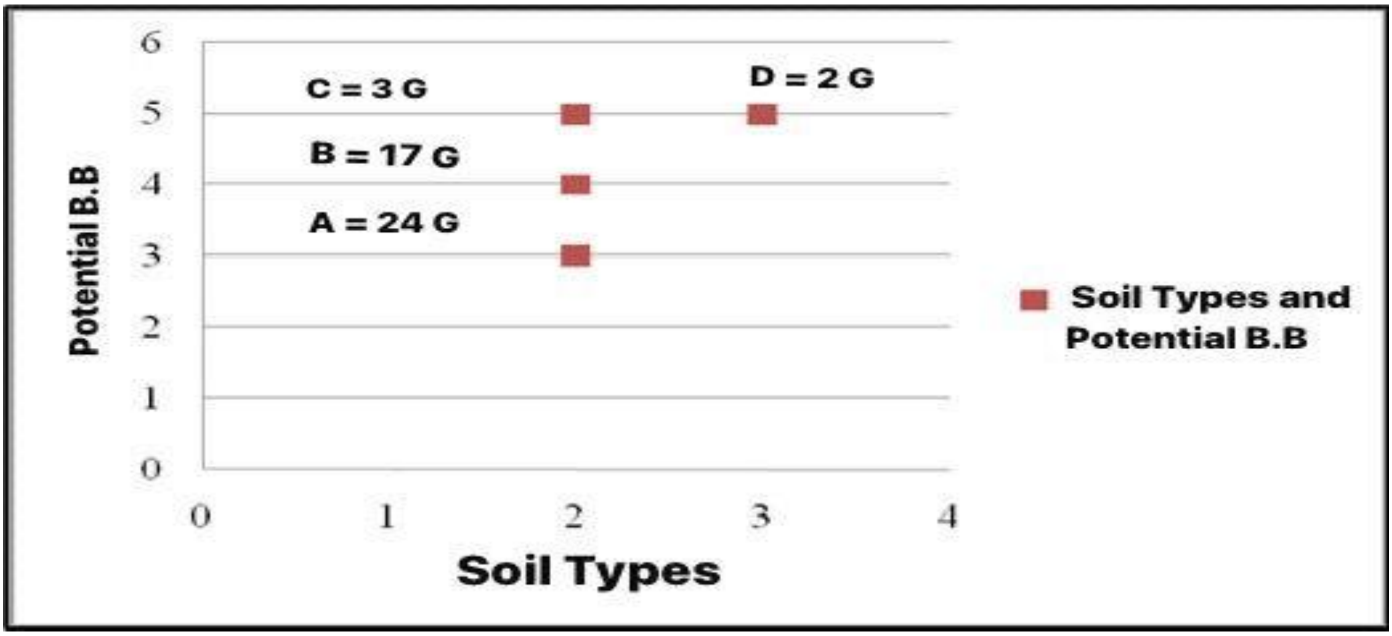

Fig 4 Frequency Distribution of Potential Flood Hazards and Soil Types
Source: Results of Frequency Value Distribution Analysis

Figure 4 is a scatter diagram of the relationship between flood hazard potential and soil type. This correlation consists of 46 grids represented by four groups, namely group A, group B, group C, and group D. Group A is the correlation value between flood hazard potential classified as moderate hazard and alluvial soil type (class T1). Group A represents 24 (twenty four) grids, namely grids G1, H1, I1, J1, H2, I2, J2, G3, H3, I3, F4, G4, H4, I4, J4, D5, H5, I5, J5, K5, F6, J6 and G7. Group B is the correlation value between flood hazard potential classified as moderate hazard and alluvial soil type (class T1). Group B represents 17 (seventeen) grids, namely grid J1, F2, K2, E3, F3, J3, K3, E4, K4, C5, E5, F5, G6, H6, I6, I7 and J7. Group C is the correlation value between the potential flood hazard classification of severe hazard and the type of alluvial soil (class T1). Group C represents three grids, namely grid D4, H7 and H8. Group D is the correlation value between the potential flood hazard classification of severe hazard and the type of grumosol soil (class T2). Group D represents two grids, namely grid A5 and B5. This is indicated by a decrease in the soil type class followed by an increase in the classification of potential flood hazard as shown by the decreasing linear line.

Cross tabulation analysis when compared with the reading method based on Table 4will obtain a soil type value of 98.55%. This percentage result is obtained from the total soil type value divided by the alluvial soil type classification value of 3 and multiplied by the number of grids of 46 units or 136/(3*46). This means that the type of soil in the plains of Gorontalo City that is related to the potential for flooding is the alluvial soil type of 98.55% and 1.45% is a type of soil other than alluvial. This indication states that the soil in the plains of Gorontalo City is a young soil type formed from dried puddles. In other words, the entire land in Gorontalo City is an area that was once flooded, or an area in the form of a lake or swamp that has dried up. This fact can occur if you look at the area around Gorontalo City such as the Limboto Lake area which has recently changed definitely into land.

Referring to the theory put forward by Sutanto (2005) where the soil absorption capacity is determined by the height of the groundwater level, the measurement of the water level is also carried out on each grid. The maximum groundwater level in Gorontalo City, in the dry season, its depth is around 2.5 meters from the ground surface. The height of the groundwater level in the rainy season, its maximum depth is around 1.5 meters from the ground surface. In some areas, the level reaches 0.5 meters from the ground surface. If the groundwater level is 0.5 meters deep, then the waterproof layer above the groundwater level is only a few centimeters from the ground surface. As a result of this condition, the infiltration rate in the soil becomes very slow. From the results of measurements of field infiltration in the plains of Gorontalo City, there are indeed areas where infiltration is very slow, some even have negative infiltration values. This negative value was obtained from the results of research on the infiltration rate in the soil after 3 days of testing, the water level decreased by 1 cm, some even 0.5 cm. The spatial distribution of soil conditions like this is found in Dembe I Village (grid A5, B5), Limba U II (grid G5), Limba U 1 (grid H5), Moodu (grid I5) and Tenda Village (grid I7). The spatial distribution of very slow infiltration results from field measurements include Wongkaditi Village (grid I4), Wongkaditi Timur (grid K4), Lekobalo (C5), Limba B (grid H6) and Moodu (grid I6). The very slow infiltration rate influenced by the height of the groundwater level and the impermeable layer above the groundwater level, is further exacerbated by the reclamation of the compacted land surface.

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This maximum infiltration rate when referring to Tsukamoto's statement (1975) is very small (which occurs 1cm/3 days, while Tsukamoto 2mm/second, good soil type 60mm/second). The impact of this small infiltration, if there is a large enough rainfall, then the surface flow that occurs is also quite large. The greater the surface flow, the greater the possibility of puddles. So the results of the cross-tabulation analysis stating that there is a real relationship between soil type and vulnerability level can be accepted. Furthermore, the cross-tabulation analysis on the direct measures test states that the ordinal value of soil type no longer affects the level of vulnerability can also be accepted. This is possible because almost all plains in Gorontalo City have alluvial soil types as explained previously (as much as 98% of the plains of Gorontalo City).

VI. CONCLUSION

The conclusion that can be drawn from this research is:

- The types of soil that can be found in Gorontalo City consist of 2 types of soil, namely alluvial hydromorphic soil and grumosol soil. The type of alluvial soil in the plains of Gorontalo City covers an area of 3492.31 Ha (98.55% of the plains of Gorontalo City) or 52.3% of the total area of Gorontalo City.
- Analysis resultsregression (*Chi Square Test*) of hydrogeomorphological mapping units of Gorontalo City, it is known that the characteristics of potential flood hazards are greatly influenced by the type of soil, while for the test directional measures has no effect because in fact the plains of Gorontalo City are already flood plains.
- The infiltration rate in some areas is very slow at 0.0003 mm/second, according to Tsukamoto, a minimum of 2 mm/second.
- The groundwater level during the rainy season ranges from 0.5 m to 1.5 m.

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