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CLASSIFICATION ANALYSIS FOR LAND SUITABILITY USING LINKED OPEN DATA

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ABSTRACT

Land suitability is one of a solution to get alternative solutions to get maximum results. Land suitability is obtained by applying classification rules based on several factors, such as: nutrients, erosion hazard, temperature, flood hazard, and root media. The analysis will classify a land based on its order class into 2, such as: suitable (S) and non-suitable (N). Spatial analysis for land suitability usually put together all the required spatial data into one source first, and then analyzes it using land evaluation rules. However, the concept of linked open data can create structure that are connected between data from different sources, including applying classification rules to these data. Information related to the required attributes can be read using LOD concept. The formulation of the problem in this study is how to classify the suitability of a location for rice plants, if the data to be used as measuring variables are at different storage sources. This research used a coordinate of an area as an identity that is used as a linked between different sources. In addition, it will obtain the information that is needed for land suitability then classification rules are applied based on information obtained from that location.

Keywords: *Linked Open Data, Spatial Analysis, Information Intelligent, Precision Agriculture, Land Suitability*

1. INTRODUCTION

Food independence can be achieved when food self-sufficiency can survive according to predetermined targets for the amount of agricultural production. However, almost all crop productivity is still far from its potential, while on the other hand, the cost of goods produced is rising, so it is necessary to evaluate the land so that each land can be planted according to its characteristics.

The analysis is carried out to get alternative solutions to increase agricultural production yield [1]. The search for alternative solutions requires database subsystems, base subsystems and interactions between those sub systems [2]. Land suitability is one of a solution to get alternative solutions to get maximum results. Land suitability obtained from several factors, such as: (1) Nutrients; (2) Erosion hazard, (3) Temperature, (4) Flood Hazard, (5) Root Media. The analysis will classify a land based on its order class into 2, such as: Suitable (S) and Non-Suitable (N), which plant types is limited to rice crops.

The database subsystem in this study is spatial data related to land suitability. Where spatial data related to land evaluation is found in various sources. The thing that needs to be considered in finding information using data on the internet is that the data needed is in different sources [3] or different databases with differences in business processes, data structures and the design of distributed systems. Distributed system design is the architecture of a system that connects between data. Spatial data related for land evaluation are not interconnected, because the data sources are different from one data to another. Analysis using spatial data requires the process of collecting data into one source [4].

Analysis of land suitability requires analysis using some spatial data [5], the data are already available but are located in different sources. Tim Berners Lee has presented the development of a five-stars rating system on open data technology [6]. This allows the required farm-related spatial data to actually be available on the web portal and have the nature of open data. Where the nature of open data is free to access, modify and share with others for any purpose[7]. Even though it has the nature of open data, the spatial data on the open data portal is not interconnected. Linked Open Data (LOD) technology is a concept that connects data from various sources so that the data can be used by anyone [8], and can perform analysis using the connected data even though the data is different storage sources [9].

Spatial analysis for land suitability usually put together all the required spatial data into one source first, and then analyzes it using land evaluation rules. Novelty in this research is to analyze land suitability using spatial data that are located in different sources and applied land suitability rules to get a decision on the suitability of a land for rice crops.

2. LITERATURE REVIEW

Studies that have used standard levels (****) are [10], and [11]. Research [10] resulted in an application that provides information based on proximity to the user's location. This information is obtained by utilizing the location of the user's geographic coordinates and then connecting with data that has been stored from various sources and has been connected to each other using datasets from DBpedia. Meanwhile, research [11] uses the concept of Natural Language Programming to detect the relationship between drug names, indications and counter indications of a drug. The data of this research used standard level (*****), it means that the data not only have RDF (Resource Description Framework) but also have linked between the sources.

Some of the previous studies that have utilized spatial data in data sets are [10], and [12]. By reading a person's mobile location, data set information will be obtained around that person's location. The linked data set information is useful information for a city tour. However, in this research, the spatial data obtained from the LOD process is not only displayed as information but also used as an attribute for the application of land suitability classification rules.

In previous studies, interconnected data sets displayed information owned by the data set at each source. It can be seen that the data set that has been connected to each other has not been used for the analysis of a case. Meanwhile, this study uses spatial data that has been connected to each other for analysis of agricultural land suitability.

The formulation of the problem in this study is how to classify the suitability of a location for rice plants, if the data to be used as measuring variables are at different storage sources. In addition, the novelty of this paper is to make land suitability classification rules for a location for rice plants using the concept of linked open data.

Data began to be published on the internet openly, where everyone was free to access it [7]. However, to connect data that are in different sources and making the machine can read the web document, it is needed to add a semantic layer [13]. Interconnected data provides access to information in more depth because the information collected comes from various data sources that have been connected to each other using a bridge [14] including being able to analyze these data. In this study, the analysis that will be carried out is the evaluation of agricultural land using spatial data. Analysis of these interconnected data by taking information on criteria of land suitability in several sources and then applying the rule base related to evaluation land suitability uses information obtained from the data set.

The classification rules base used for land evaluation is decision tree, this method is a classification method in data mining using decision trees and produces if-then rules [14]. This method uses entropy to see the homogeneity of a data population [15]. Where the formula for entropy is as follows [16]:

$$Entropy\ (S) = \sum_{i}^{c} -p_i \log_2 p_i \quad (1)$$

pi = the number of samples pf each value c

The value of the target attribute is positive and the value of the target attribute is negative. After getting the entropy value for all attributes, the next step is to find the Gain value, the higher the Gain value, the higher the effectiveness value [17].

$$Gain\ (S, A) = Entropy(S) - \sum_{v \in Values(A)} \frac{|Sv|}{|S|} Entropy\ (S_v) \quad (2)$$

A = one of the attributes in S;
v = possible value for attribute A;

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Values(A)= the set of possible values for attribute A;
|Sv| = number of samples worth v;
|S| = the sum of the entire sample;
Entropy (Sv)= Entropy of each sample is worth v.

3. RESEARCH METHODOLOGY

The focus of this paper is the application of classification rules to land suitability data at a location. Where the resulting output is the decision whether a location is suitable or not for rice plants. This research will consist of several stages which can be seen in Figure 1.

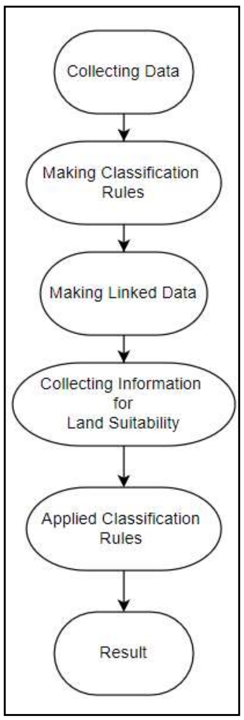

FIGURE 1. Stage of Research

The data collection process is carried out to obtain classification rules for land suitability. The data population in this study is Sleman Regency, Yogyakarta, Indonesia. The data population can be seen in Figure 2. While the data used to obtain the classification, rules comes from 2595 sample data. The data used comes from the Yogyakarta Agricultural Technology Assessment Center (BPTP). Which are in Sleman Regency, Yogyakarta, Indonesia. In addition, Table 1 is the description of the examples of data source and the attributes that will be used on the data source.

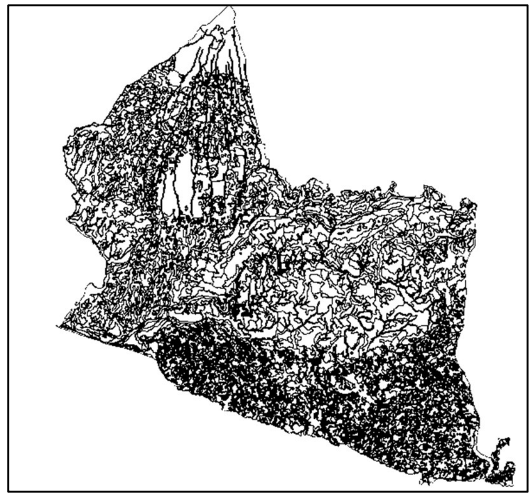

FIGURE 2. Area Population

TABLE 1. The Performance of Data for Land Suitability

Data Sources	Information	Attribute	Data Type
Region	Map of the area of a location	Longitude	Numeric
		Latitude	Numeric
Nutrient	Information related to data on the type of soil owned by a location, including the material contained in it and the texture of the soil.	Soil Texture	Character Character
		Andesite Material	Character
Erosion Hazard	Information related to the erosion rate of a location, which contains relief data of a location including land formation from the area.	Texture Relief Landform	Character Character Character
Temperature	Information related to the temperature of a location, which contains data on the slope of a location	Relief Minimal Slopes Maximum Slopes	Character Character Character
Land Preparation	Information related to the condition of the rocks	Andesite Material Stone	Character Character

	contained in the soil.		
Flood Hazard	Information related to the level of flood hazard of a location, contains data on drainage and soil depth.	Drainage Depth Surface	Character Character Character
Root Absorption	Information related to the rate of water absorption by the roots at a site.	Texture Surface Consistency	Character Character Character

The attributes in Table 1 will be used as consideration criteria when applying the rules base, where each attribute has a value. Each polygon in Figure 1 has a specific value of attributes drawn from each data source, meaning that each polygon has only 1 value on each of its attributes. The details of the values on each attribute can be seen in Table 2.

TABLE 2. The Value of Land Suitability's Criteria

Criteria	Value
Soil	Andic Hapludolls, Typic Hapludands,Andic Dystropepts, Typic Troporthents, Typic Endoaquents, Typic Fragiaquents, Andic Eutropepts, Typic Eutropepts, Typic Tropaquepts, Lithic Ustropepts, Typic Fluvaquents, Vertic Tropaquepts, Lithic Ustorthents, Aeric Tropaquepts, Typic Hapluderts, Typic Ustropepts, Lithic Haplustols, Vertic Eutropepts, Fluventic Eutropepts, Oxic Eutropepts, Typic Haplustalfs, Typic Ustorthents, Typic Tropopsamments, Typic Hydraquents, Aquic Eutropepts, Typic Ustipsamments
Landform	Backswam, Covered basin, Former river flow (Bed River), Beach sand shoal, Monoclinal hill, Eroded hills, Alluvial plain, Army plains, Floodplain, Karst plains, Colluvial plain, Volcanic plains, Eskarpment, River flow path, Foot of the hills force, Karst hump, Karst cones, Complex of folds/fault hills, Downslopes between karst cones, The mountain slopes of the force, Volcanic slopes, Folded mountains, The valley between the hills, Karst valley (Dead Valley), Force hills, karst hills, Folded hills, Plate, Point bars, Field, Sand dunes, syncline, River embankment
Indesit Material	Coluvial material, volcanic material, Volcanic sedimentary rock, Limestone, Limestone and clay deposits, Dasitan limestone, Limestone, siltstone, Palmstone, Sandstone, Breach, Coal, gravel and sand deposits, Clay deposits, Clay and sand deposits, Clay deposits, sand and organic matter, Sand deposit, Eolin gravel sand deposit, Beach sand deposits, Sand/gravel/crust/chunk deposits, Sandstone and siltstone complex, Breccia and volcanic tuff complex, Breccia and dacite tuff complex, Volcanic tuff and sandstone complex, Limestone and limestone complex, Clay and limestone sediment complex, Complex of clay and marlstone deposits, Dasit tufa, Napalan tufa, Volcanic tuff
Min Slope	0, 1, 3, 5, 8, 15, 25, 46, 61
Max Slope	0, 3, 5, 8, 15, 25, 30, 45, 60, 90
Texture	Clayey sand, Sandy loam, Loam, Dusty clay, Clay, Dusty clay, Clayey sand, Clay loam, Sandy clay loam, Dusty look, Fine sand
Relief	Very steep, A bit steep, slightly flat, Sloping, slightly sloping, Hilly, Flat, Steep, Steep, Wavy, choppy, Mountainous, Little hills, Huddle
Rock	Zero/ little, Moderate
Drainage	1, 2, 3
Depth	1, 2, 3, 4, 5, 6
Surface	Pretty fast, A bit slow, Almost, Slow, very slow, Medium
Consistency	Slightly sticky/slightly plastic, Loose, Sticky/plastic, Free, Firm

Second stage of the research is making classification rules. Based on formulas (1) and (2), Entropy(S) search was carried out on 2595 data sets, of which 590 datasets were N (Non-Suitable) for rice plants and 2005 were S (Appropriate) for rice plants. The last result after several Gain search processes against the criteria, a decision tree was obtained which is the basis for the rules base for evaluating rice crop land. Rules used to classify land suitability are stored on a separate server, separate from the data used as data attributes.

The first root is the first rule, which is seen from the Landform criteria. There are several types of

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landforms that produce other nodes, namely: Plains, Flood Plains, Karst Plains, Volcan Plains, River Flow ways, and Volcan Slopes. Details decision tree for first root can be seen in Figure 3.

Plains node is in node 2.1 and it can be seen in Figure 4. Flood Plains nodes is in node 2.2 and it can be seen in Figure 5. Karst Plains node is in node 2.3 and it can be seen in Figure 6. Volcan Plains nodes is in node 2.4 and it can be seen in Figure 7. River Flow ways node is in node 2.5 and it can be seen in Figure 8. Volcan Slopes node is in node 2.6 and it can be seen in Figure 9.

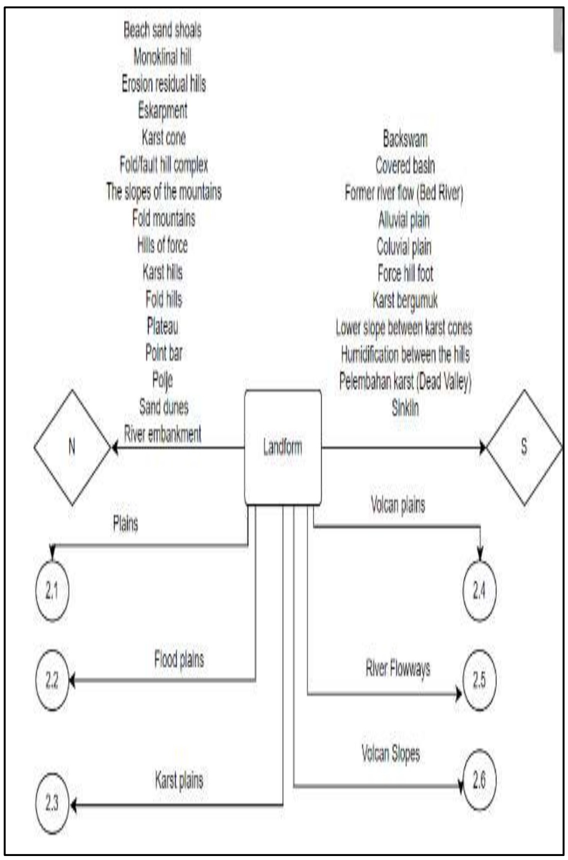

Figure 3. Decision Tree For First Root

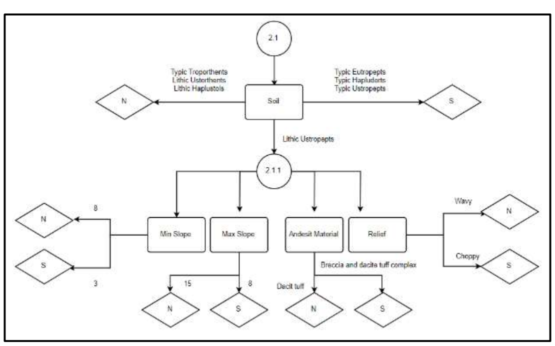

Figure 4. Decision Tree For Plains

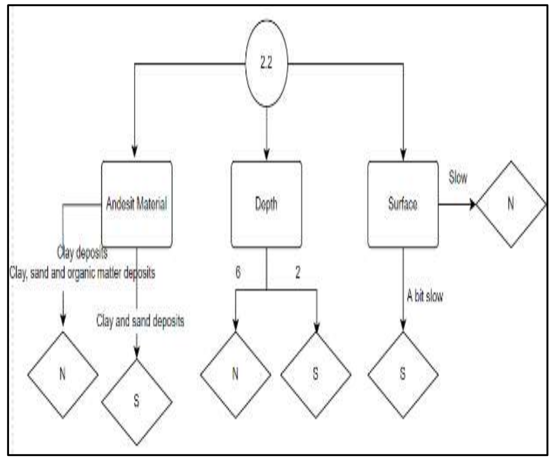

Figure 5. Decision Tree For Flood Plains

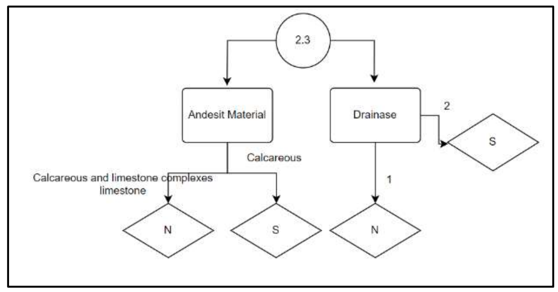

Figure 6. Decision Tree For Karst Plains

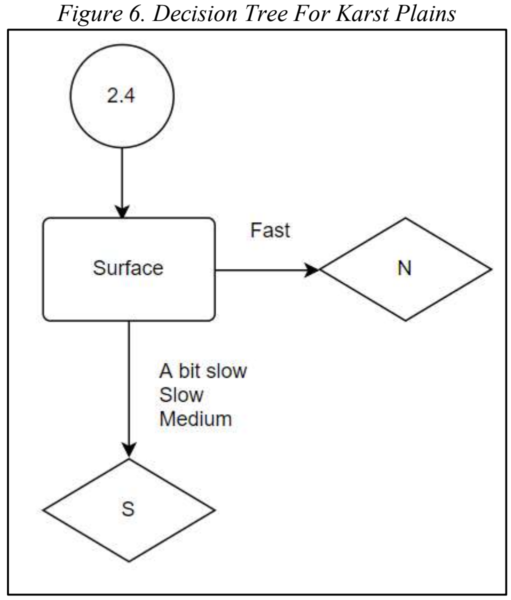

Figure 7. Decision Tree For Volcan Plains

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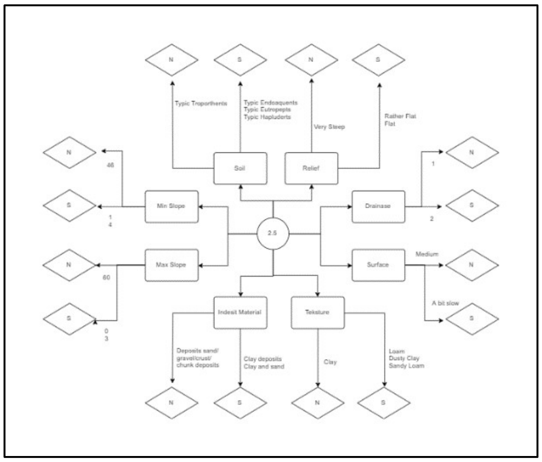

FIGURE 8. Decision Tree for River Flow ways

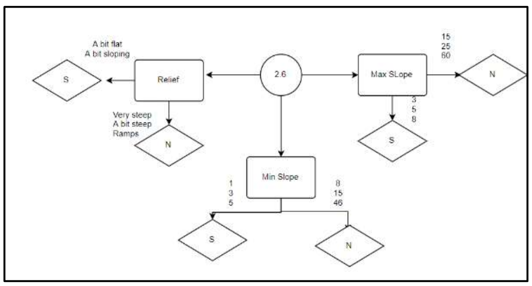

FIGURE 9. Decision Tree for Volcan Slope

Based on Figure 3 until Figure 9, it can be seen 46 classification rules for land suitability for rice plants. The details of the rules can be seen in Table 3.

TABLE 3. The Rules of Land Suitability

No	Rules	Fig
1	**IF Landform** is Beach sand shoals or Monoklinal hills or Erosion residual hills or Eskarpment or Karst cone or Fold/fault hill complex or The slopes of the army mountains or Folding mountains or Force hills or Karst hills or Folding hills or Plate or Point bar or Field or Sand dunes or River embankment, **THEN** the decision for the location is **Not Suitable** for rice plants.	3
2	**IF Landform** is Backswam or Closed basin or Former River (Bed River) or Alluvial plain or Colluvial plain or The foothills of the force or Karst bergumuk or Lower slopes between karst cones or Inter-hilly splintering or Pelembahan karst (Dead Valley) or Sinklin, **THEN** the decision for the location is **Suitable** for rice plants.	3
3	**IF Landform** is Plain **AND Soil** is Typic Troporthents or Lithic Ustorthents or Lithic Haplustols **THEN** the decision for the location is **Not Suitable** for rice plants.	4
4	**IF Landform** is Plain **AND Soil** is Typic Eutropepts or Typic Hapluderts or Typic Ustropepts **THEN** the decision for the location is **Suitable** for rice plants.	4
5	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Min Slope** is 8 **THEN** the decision for the location is **Not Suitable** for rice plants.	4
6	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Min Slope** is 3 **THEN** the decision for the location is **Suitable** for rice plants.	4
7	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Max Slope** is 15 **THEN** the decision for the location is **Not Suitable** for rice plants.	4
8	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Max Slope** is 8 **THEN** the decision for the location is **Suitable** for rice plants.	4
9	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Andesite Material** is Dacit tuff **THEN** the decision for the location is **Not Suitable** for rice plants.	4
10	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Andesite Material** is Breccia & dacite tuff complex **THEN** the decision for the location is **Suitable** for rice plants.	4
11	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Relief** is Coppy **THEN** the decision for the location is **Suitable** for rice plants.	4
12	**IF Landform** is Plain **AND Soil** is Lithic Ustropepts **AND Relief** is Waxy **THEN** the decision for the location is **Not Suitable** for rice plants.	4
13	**IF Landform** is Flood plains **AND Andesite Material** is Clay deposits or Clay, sand & organic matter deposits **THEN** the decision for the location is **Not Suitable** for rice plants.	5
14	**IF Landform** is Flood plains **AND Andesite Material** is Clay & sand deposits **THEN** the decision for the location is **Suitable** for rice plants.	5
15	**IF Landform** is Flood plains **AND Depth** is 6 **THEN** the decision for the location is **Not Suitable** for rice plants.	5
16	**IF Landform** is Flood plains **AND Depth** is 2 **THEN** the decision for the location is **Suitable** for rice plants.	5
17	**IF Landform** is Flood plains **AND Surface** is Slow **THEN** the decision for the location is **Not Suitable** for rice plants.	5
18	**IF Landform** is Flood plains **AND Surface** is A bit slow **THEN** the	5

	decision for the location is **Suitable** for rice plants.	
19	**IF Landform** is Karst plains **AND Andesite Material** is Calcareous & limestone complexes or limestone **THEN** the decision for the location is **Not Suitable** for rice plants.	6
20	**IF Landform** is Karst plains **AND Andesite Material** is Calcareous **THEN** the decision for the location is **Suitable** for rice plants.	6
21	**IF Landform** is Karst plains **AND Drainage** is 2 **THEN** the decision for the location is **Suitable** for rice plants.	6
22	**IF Landform** is Karst plains **AND Drainage** is 1 **THEN** the decision for the location is **Not Suitable** for rice plants.	6
23	**IF Landform** is Volcan plains **AND Surface** is Fast **THEN** the decision for the location is **Not Suitable** for rice plants.	7
24	**IF Landform** is Flood plains **AND Surface** is A bit slow or Slow or Medium **THEN** the decision for the location is **Suitable** for rice plants.	7
25	**IF Landform** is River flow ways **AND Soil** is Typic Troporthents **THEN** the decision for the location is **Not Suitable** for rice plants.	8
26	**IF Landform** is River flow ways **AND Soil** is Typic Endoaquents or Typic Eutropepts or Typic Hapludent **THEN** the decision for the location is **Suitable** for rice plants.	8
27	**IF Landform** is River flow ways **AND Relief** is Very steep **THEN** the decision for the location is **Not Suitable** for rice plants.	8
28	**IF Landform** is River flow ways **AND Relief** is Rather flat or Flat **THEN** the decision for the location is **Suitable** for rice plants.	8
29	**IF Landform** is River flow ways **AND Min Slope** is 46 **THEN** the decision for the location is **Not Suitable** for rice plants.	8
30	**IF Landform** is River flow ways **AND Min Slope** is 1 or 4 **THEN** the decision for the location is **Suitable** for rice plants.	8
31	**IF Landform** is River flow ways **AND Max Slope** is 60 **THEN** the decision for the location is **Not Suitable** for rice plants.	8
32	**IF Landform** is River flow ways **AND Max Slope** is 0 or 3 **THEN** the decision for the location is **Suitable** for rice plants.	8
33	**IF Landform** is River flow ways **AND Drainage** is 1 **THEN** the decision for the location is **Not Suitable** for rice plants.	8
34	**IF Landform** is River flowways **AND Drainage** is 2 **THEN** the decision for the location is **Suitable** for rice plants.	8
35	**IF Landform** is River flowways **AND Surface** is Medium **THEN** the decision for the location is **Not Suitable** for rice plants.	8
36	**IF Landform** is River flow ways **AND Surface** is A bit slow **THEN** the decision for the location is **Suitable** for rice plants.	8
37	**IF Landform** is River flow ways **AND Andesite Material** is deposited sand/gravel/curst/ chunk deposits **THEN** the decision for the location is **Not Suitable** for rice plants.	8
38	**IF Landform** is River flow ways **AND Andesite Material** is Clay deposited or clay & sand **THEN** the decision for the location is **Suitable** for rice plants.	8
39	**IF Landform** is River flow ways **AND Texture** is Clay **THEN** the decision for the location is **Not Suitable** for rice plants.	8
40	**IF Landform** is River flow ways **AND Texture** is Loam or Dusty clay or Sandy loam **THEN** the decision for the location is **Suitable** for rice plants.	8
41	**IF Landform** is Volcan slope **AND Relief** is Very steep or A bit steep or Ramps **THEN** the decision for the location is **Not Suitable** for rice plants.	9
42	**IF Landform** is Volcan slope **AND Relief** is A bit flat or A bit sloping **THEN** the decision for the location is **Suitable** for rice plants.	9
43	**IF Landform** is Volcan slope **AND Max Slope** is 15 or 25 or 60 **THEN** the decision for the location is **Not Suitable** for rice plants.	9
44	**IF Landform** is Volcan slope **AND Max Slope** is 3 or 5 or 8 **THEN** the decision for the location is **Suitable** for rice plants.	9
45	**IF Landform** is Volcan slope **AND Min Slope** is 8 or 15 or 46 **THEN** the decision for the location is **Not Suitable** for rice plants.	9
46	**IF Landform** is Volcan slope **AND Min Slope** is 1 or 3 or 5 **THEN** the decision for the location is **Suitable** for rice plants.	9

Third stage of the research is making linked between the attribute data. Land suitability linked data architecture that connects attribute data from various sources using the references in the previous paper [18]. The linked data architecture can be seen in Figure 10.

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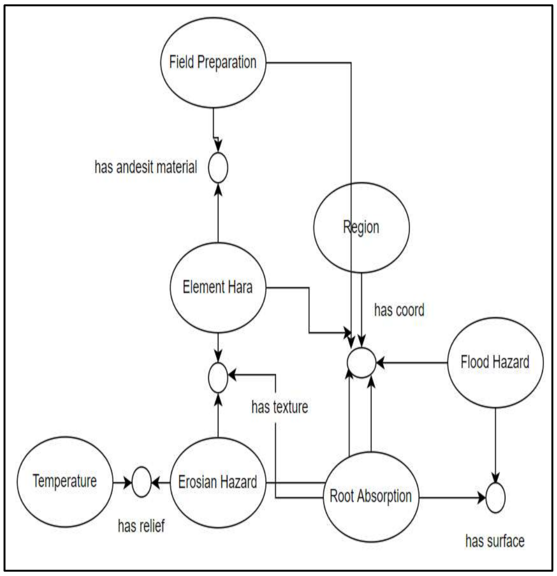

Figure 10. The Linked Data Architecture For Land Suitability (Charitas,2023)

4. RESULT AND DISCUSSION

The next process after linking the required data sources is collecting the required information as land suitability attributes. The examples of data obtained from various sources by utilizing linked data can be seen in Figure 11.

Criteria	Value						
ID	58	66	80	71	117	76	19
Region	Margodadi	Wotgaleh	Terbah	Tlogo	Serut	Terbah	Ginggang
Soil	Typic Tropaquepts	Lithic Ustropepts	Typic Ustropepts	Lithic Ustropepts	Typic Hapluderts	Typic Ustropepts	Lithic Ustorthents
Indesit Material	Clay and sand deposits	Dacit tough	Siltstone	Siltstone	Clay and sand deposits	Sandstone and siltstone complex	Breccia and dacite tuff complex
Texture	Clay	Loam	Loam	Dusty clay	Loam	Loam	Clay
Relief	Rather flat	Hilly	Steep	Steep	Rather flat	Hilly	Steep
Drainage	2	2	1	1	2	1	1
Landform	Volcanic plains	Monoclinal hill	Army mountain slopes	Army mountain slopes	Alluvial plain	Fold hills	Eskarpment
Min Slope	1	15	25	25	1	15	61
Max Slope	3	25	45	45	3	25	90
Rock	Zero or little	Medium or a lot	Medium or a lot	Medium or a lot	Zero or little	Zero or little	Medium or a lot
Depth	1	3	3	2	3	3	3
Surface	Slow	Medium	Medium	Medium	A bit slow	Medium	Pretty fast
Consistency	Loose	Firm	Firm	Firm	Firm	Firm	Loose

Figure 11. The Examples Of Data Obtained

Based on the classification rules in Table 3. The rules are applied to the sample data in Figure 11. In addition, the results of applying the rules base can be seen in Table 4. Pseudocode to display the results of applying the rules to the attributes of a location obtained can be seen in Figure 12. Figure 13 shows the view of map for specific region based on click mouse, in this case is "Serut" region. Based in the available information, Serut is suitable for rice crops.

Table 4. The Result Of Classification Rules

ID	Region	Decision
58	MARGODADI	Not Suitable
66	WOTGALEH	Not Suitable
80	TERBAH	Not Suitable
71	TLOGO	Not Suitable
117	SERUT	Suitable
76	TERBAH	Not Suitable
19	GLINGGANG	Not Suitable

```
Program Classification Result
begin
	num x
	char a,b,c,d,e,f,g,h,i,j,k,l,m
{
	x=[long,lat]
	a=[region,"value"]
	b=[soil,"value"]
	c=[indesit material,"value"]
	d=[texture,"value"]
	e=[relief,"value"]
	f=[drainage,"value"]
	g=[landform,"value"]
	h=[min dlope,"value"]
	i=[max slope,"value"]
	j=[rock,"value"]
	k=[depth,"value"]
	l=[surface,"value"]
	m=[consistency,"value"]
	id=collectdata(x,a,b,c,d,r,f,g,h,i,j,k,l,m);
	$class

	if(id["value']==Non Suitable Rules) $class="Not Suitable";
	else if(id["value']==Suitable Rules) $class="Suitable";
}
```

Figure 12. Pseudocode To Applying The Rules

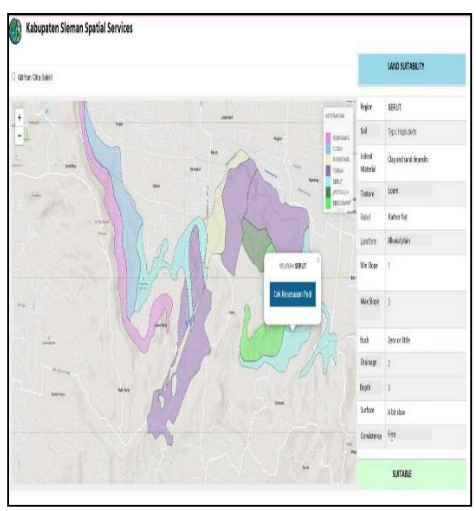

Figure 13. The Result For "Serut" Region

5. CONCLUSIONS

Rules used to classify land suitability are stored on a separate server, separate from the data used as data attributes. This is one of the solutions that can be used to perform spatial analysis of data that come from different sources. Data on different sources does not need to be collected in one place to apply the land suitability rules. The concept of linked open data used to read the values of the attributes needed for the suitability of the land is then matched with the rules that have been stored, which will then provide a conclusion whether the value of the area is suitable or not suitable for planting rice.

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