Spatial Plans Suitability Detection using Remote Sensing and GIS based on Land's Potentional Indices
Case Study: Parepare City, Indonesia

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ABSTRACT : Spatial plans (Rencana Tata Ruang Wilayah) are the result of spatial planning in some regions. The spatial plan was made because basically, space has limitations. Therefore, it needs some regulations to manage and plan the space, so it can be effectively used and prevent conflict among the process of space management. Spatial plans in Indonesia still have many problems. One of them is the mismatch between spatial plans and the potential of the land. The land's potential has an important role in the creation of a comfortable, safe, productive condition, and sustained. The use and management of a region can be said productive and sustain if the spatial plans already match with the land's potential. Every region has diverse potential, like in Parepare, so we need to search the land's potential of Parepare. Land's potential can be known by Land's Potential Index (Indeks Potensi Lahan/IPL) approach that every variable is extracted from remote sensing data such as SPOT imagery and DEMNAS and then processed by GIS. The variable that used to get the Land's Potential consists of slope, relief, groundwater condition, soil texture and it's depth, lithology, and the limitation variable is a disaster. Land's Potential Index in Parepare known by giving a score in each class and overlay every variable. Land's potential index Map of Parepare was overlaid to detect the suitability between Land's potential index and the spatial plans of Parepare. The suitability of spatial plans based on land's potential index was judged based on the suitability matrix. The result of this research show that 59.812 km2 or it is 71.99% of the total research area is already suitable for the land's potential and 23.265 km2 or 28.01% of the total area is not suitable with the land's potential.

KEY WORDS : remote sensing, GIS, spatial plans, Land's Potential Index (IPL)

I. Introduction

The regional spatial planning or RTRW is the result of spatial planning in an area. The region can be interpreted as a geographical entity along with all related elements whose boundaries and systems are determined based on administrative aspects (Regulation of the Minister of Public Works Number 16 of 2009). Spatial plans are made because basically space has limitations. Therefore, regulations are needed to regulate and plan space so that it can be used effectively and prevent conflicts between functions in the process of spatial use. The drafting of the spatial planning is conducted by examining various aspects, including physical, social and economic aspects (Regulation of the Minister of Agrarian and Spatial Planning Number 1 of 2018).

Awareness of a plan has begun long ago. The development of regional and city planning is closely related to the development of civilization, culture, and science and technology. The development of civilization in addition to having a positive impact also gives a negative impact related to spatial planning that can be grouped into environmental problems and spatial management (Lutfi, 2013). Environmental problems include: a decrease in the quality of the environment, a decrease in the area of tropical forests, a decrease in the function of water catchment areas, an increase in the phenomenon of disasters, degradation of environmental quality, the threat of the effects of global warming, and increasing urbanization. Meanwhile, for the problems of spatial management, including the low quality of spatial planning, the spatial planning law is still not fully used, and support for regional development is not optimal. Problems in spatial planning often occur in various regions in Indonesia.

Management of spatial planning in the city of Parepare is based on the Regional Regulation of the City of Parepare Number 10 of 2011 about the Spatial Planning for the Municipality of Parepare in 2011 - 2031. An evaluation of the RTRW needs to be done to determine whether the existing spatial plan can still be used for the next period. One method for evaluating the spatial plan is to use the Land's Potential Index (IPL). IPL is used for spatial plan evaluation because it has many parameters that can be used to measure the suitability of the spatial planning. The Land's Potential Index (IPL) parameters that can be derived from remote sensing images include slope, soil texture, groundwater, lithology and erosion. The image used for extracting information related to IPL parameters is Sentinel 2A imagery which has a spatial resolution of 10 meters. Furthermore, information that has been obtained from remote sensing images will be processed using a Geographic Information System (GIS). The purpose of this study is to find out the potential of land in Parepare City based on the Land's Potential Index through remote sensing technology and GIS and to determine the suitability of the Parepare City spatial planning based on the Land's Potential Index.

II. Study Area

The study area is located in Parepare city of Indonesia with $3^0$57 ’39" - 4^0 04 "49" South Latitude and 119^0 36 "24" - 119^0 43 "40" East Longitude (Figure 1). Parepare city is a city in South Sulawesi with an area of 99.33 km2 which has a strategic position because it is located on land and sea transportation crossings, both North-South and East-West directions, making Parepare City a National Strategic Area for Integrated Economic Development is based on Parepare city spatial plan (Bappenas, 2009).

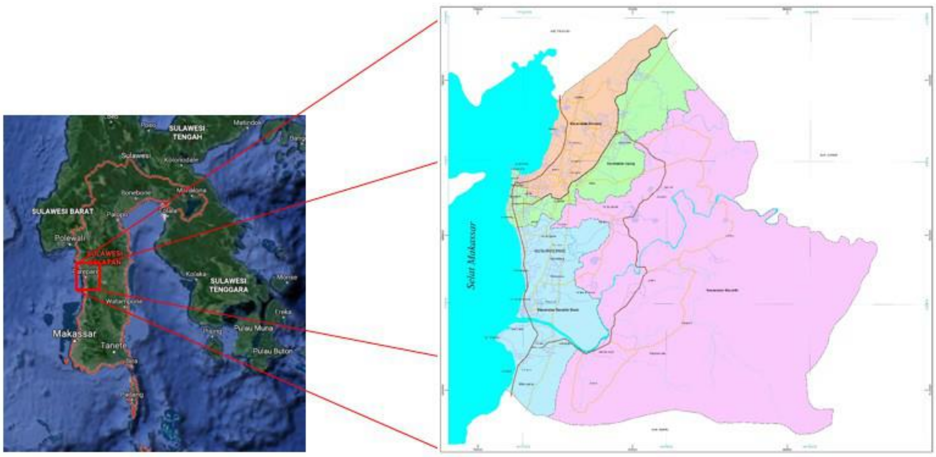

Figure 1. Location of the study area in Parepare

III. Materials and Methodology

3.1 Land's Potential Index (IPL)

The potential of a land for certain land use needs to be known because with the potential of the land, land use and management can be carried out optimally and accordingly. Land use that is in accordance with land potential has a small chance of land degradation and environmental damage (Andini, 2017).

The method used for RTRW evaluation is the Land's Potential Index (IPL). There are two Land's Potential Index (IPL) parameters that is supporting parameters and limiting. Supporting parameters include slope and relief maps, soil depth maps, lithology maps, soil texture maps, surface potential maps and groundwater hydrological maps, while limiting parameters are disaster maps. These parameters have a value which will be calculated using the formula Potential Index (IPL):

$$IPL = (R+L+T+H)*B$$

R= Relief
L=Lithology
T=Soil
H=Hidrology
B=Disaster or Hazard

Tabel 1 : Assesment of IPL parameters

Assesment of relief factor

Class	Relief	Value
R1	Flat- Sloping	5
R2	Wavy - Choppy	4
R3	Low hilly	3
R4	Hilly	2
R5	mountainous	1

Assesment of slope factor

Class	Slope	Value
I	0-5%	5
II	6-15%	4
III	16-25%	3
IV	26-45%	2
V	>45%	1

Assesment of Lithology factor

Code	Rock type	Value
Lb	Massive igneous rock	5
Lp	pyroclastic rocks	8
Lk	Coarse grained sedimentary clastic	5
Lh	Fine-grained sedimentary clastic	2
Lg	Limestone sediment / metamorphic rocks	3
Ll	Limestone	5
La	Alluvium	10

Assesment of soil depth factor

Code	Class	Soil type	Value
S1	Very deep (>100 cm)	Aluvial, latosol, mediteran, podsolik, grumusol	5
S2	Deep (75-100 cm)	Andosol, podsol	4
S3	Medium depth (50-75 cm)	Rensina, planosol	3
S4	Shallow (30-50 cm)	Gley humus, hidromorf	2
S5	Very Shallow (< 30 cm)	Regosol, litosol	1

Assesment of soil texture factor

Code	Class	Soil type	Value
I1	rough	Regosol, litosol, organosol	1
I2	rhater rough	Podsolik, andosol	4
I3	medium	Aluvial coklat, andosol, mediteran	5
I4	rather smooth	Gley humus, rensina, podsol	3
I5	smooth	Grumusol, latosol, aluvial kelabu	2

Assesment of hydrology factor (Groundwater and surface water)

Code	Surface Water	Value	Code	Groundwater	Value
P1	The potential and possibility of irrigation is huge	5	A1	High productivity, wide spread	5
P2	The potential and possibility of irrigation is large	4	A2	Medium productivity , widely spread	4
P3	Medium potential, possibility of local irrigation	3	A3	Medium productivity - high local spread (local)	3
P4	Small / local potentia	2	A4	Small-medium productivity, local spread (local)	2
P5	Rare surface water	0	A5	Rare groundwater	0

Assesment of flood disaster factor

Flood		Erosion		Mass motion		Rock		Value
B1	Very often inundated	E1	Very heavy	G1	Very heavy	R1	Very much	0.5
B2	Often inundated	E2	Medium	G2	Heavy	R2	A lot	0.6
B3	Sometimes inundated	E3	Medium	G3	Medium	R3	Medium	0.7
B4	Rarely inundated	E4	Mild	G4	Mild	R4	A little rock	0.8
B5	Without	E5	Without	G5	Without	R5	Without	1

Source : Faculty Geography Team, 1994

The land potential index will produce five land's potential classes (Table 2)

Class	**Class of Land's Potential Index (IPL)**	**Value of Land's Potential Index (IPL)**
I	Very high	32 – 40
II	High	24 – 31,9
III	Medium	16 – 23,9
IV	Low	8 – 15,9
V	Very Low	0 – 7,9

Table 2 : Class of Land's Potential Index

Determination of Land's Potential Index using a tiered quantitative method by overlaying all parameters that is slopes and relief, lithology, soil types, hydrology, and disaster used as limiting factors. Each parameter is given value according to the level of influence on the potential of the land. The results of the Land's Potential Index classification will be matched with the map of the Parepare City spatial plannning to find out which classes are appropriate and not appropriate for protected area class; buffer zone; annual crop cultivation area and crop cultivation area; and settlement.

3.2 Data

The data used in this study are primary data and secondary data. Primary data consist of ground drilling to take soil samples and find out the depth of the soil, as well as interviews conducted in relation to the existing groundwater potential. Secondary data consist of Sentinel 2A satellite imagery of the 2018 recording year, DEMNAS and administrative maps obtained from the InaGeoportal website, hydrogeological maps, geological maps, and Parepare City spatial planning. Sentinel-2A satellite imagery is a multispectral optical image that has 13 bands, which are divided into several spectra of visible light, near infrared and shortwave infrared. Sentinel-2A satellite imagery consists of 4 bands with a resolution of 10 m, 6 bands with a resolution of 20 m and 3 other bands with a resolution of 60 m (European Space Agency, 2019). Digital Elevation Model (DEM) is a spatial data that represents the surface relief by interpolating elevation data. DEMNAS was built from several data sources including IFSAR data (5m resolution), TERRASAR-X (5m resolution) and ALOS PALSAR (11.25m resolution), with additional stereo-plotting Masspoint data. The DEMNAS spatial resolution is 0.27-arcsecond, using the EGM2008 vertical datum (Badan Informasi Geospasial, 2018).

3.3 Data Processing

Slope and relief maps are derived through DEMNAS, with percent units to fit the classification in the Land's Potential Index. A groundwater potential map is created using hydrogeological maps and data from interviews with the community. Hydrogeological maps are used for the purposes of observing the distribution of aquifers and the presence of groundwater basins. Interview data are used to detail secondary data. Soil texture maps and soil depth maps are made using the soil type approach and soil drilling data. Data taken from soil drilling are texture and depth. Flood hazard map is made through variables that influence it, rainfall, slope, soil type, and land use. Flood disaster vulnerability is a limiting factor for land potential in an area (Suharsono, 1988).

The making of suitability matrix is based on the Land's Potential Index and was slightly modified to adjust to the planned land use by the government in spatial planning. The matrix is made with various considerations regarding terrain conditions with associated land use. Land uses such as built land, agriculture, livestock, and protected areas have different matrices. Each land use class can be considered suitable for several classes of land's potential index.

IV. RESULT AND DISCUSION

From the data that has been collected shows that in Parepare dominated with 16-25% slope for about 30%, and 0-5% slope for about 27%. This condition affects the IPL because they are many class of land use that can not be located at land with high slope. Besides slope, the geological condition in Parepare shows that about 85% of the of the area is made up from pyroclastic materials, 11% alluvium, and 4% limestone. It can be said that in Parepare has high score in lithology because alluvium and pyroclastic materials is one of geological condition that makes the land fertile and potential to almost all of the land use.

Parepare dominated with rough and rather rough soil texture and shallow and medium soil depth. From this soil condition, Parepare has a low score of IPL. The deeper the soil depth, the higher the IPL score. Parepare crossed by one big river and reservoirs are rarely found. So, the surface water in Parepare is less potential. Besides that, the ground water in Parepare also hard to get because they need to make the wells so deep. This condition makes the IPL score of water potential is low. From the boundary variable, Parepare dominated with rarely inundated land, about 35%, especially in the land with high relief likes in Bacukiki. But there are 25% area that classified as often inundated so it has a low score.

The class of land's potential index found in the city of Parepare is very low, low, medium, and high (Table 3). The most dominant class is medium class with a percentage of 61.88%. Classes are being spread evenly throughout the city of Pare-pare. The high-class in Bacukiki sub-district is near the river with a rather rough soil texture, medium soil depth and good surface water potential.

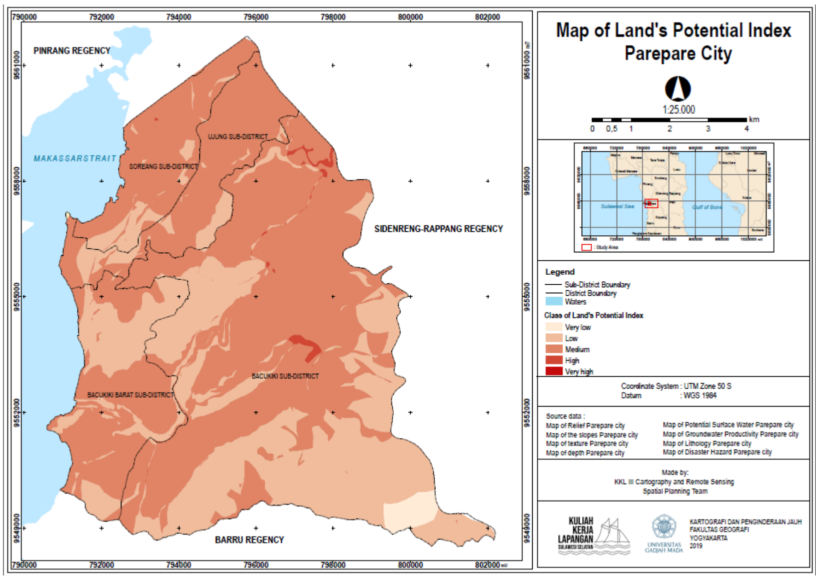

Figure 2 : Maps of Land's Potential Index

Land's Potential Index	Large (km)	Percentage (%)
Very Low	1.045325	1.180187918
Low	32.28628	36.45170407
Medium	54.807197	61.87816392
High	0.433957	0.489944092
Very High	0	0

Table 3 : Land's Potential Index in Parepare City

Suitability matrix spasial pattern map based on Land's Potential Index

Land's Potential Index value is used to determine the most ideal land use. There are four land uses classified, that is protected areas (kawasan lindung), agriculture, livestock and built land. (Table 4). Other land use are not used because Land's Potential Index (IPL) does not represent land use such as mining and tourism. The parameters used by the Land's Potential Index (IPL) point to the agricultural sector so that only land use can be evaluated that leads to agriculture

IPL (Land's Potential Index)	Spatial Pattern Map			
	Protected Areas	Cultivation Area		
		Agriculture	Livestock	Built Land
I (32-40)				
II (24-31,9)				
III (16-23,9)				
IV (8-15,9)				
V (0-7,9)				

Table 4 : Suitability matrix Spasial Pattern and Land's Potential Index

Conditions:

1. Built land according to the low Land's Potential Index when the slope class is less than 8% and the relief is flat-sloping.
2. Livestock is in accordance with low and very low Land's Potential Index when flood classes are rarely flooded or without flooding.
3. Agriculture is in accordance with medium Land's Potential Index when the slope class is not more than 30%. (Regulation of the Minister of Agriculture Number 79 / Permentan / OT.140 / 8/2013).

Protected areas can be suitable for all Land's Potential Index values because although how low the value of Land's Potential Index can still be used for protected areas even the low IPL value should be used as a protected area so that natural disasters do not occur. Agriculture can be carried out in very high, high and medium class IPL with the condition that the slope should not exceed 30%. But agriculture with slope less than 30% has a very large risk of erosion. Agriculture must have a high IPL value to produce optimal results. Agriculture carried out in the low-class is at risk of failure because of the potential for poor land. It could be that the land has rough or rather rough soil, difficult water and steep terrain.

Built land can be done in all IPL classes except for very low classes with slope requirements of no more than 8%. So that buildings are not at risk of being hit by landslides. Water problems can be done by making drill wells that can reach more than 90 meters deep. Livestock can be suitable for all Land's Potential Index with conditions to avoid floods. Livestock is not too affected by soil conditions, lithology and water. Rare water can be engineered by extracting water from other places or making boreholes. Livestock is quite affected by the temperature so that livestock do not get sick.

Suitability spatial pattern map based on Land's Potential Index

The suitability evaluation of Parepare city spatial planning based on the Land's Potential Index (IPL) was carried out with a subjective matching approach, using subjective considerations in determining suitability classes. Spatial Pattern Map is divided into two categories, protected areas and cultivation areas. Protected areas include protected forest areas, local protected areas, areas that provide protection under it and open green areas. While the cultivation area includes the area of agriculture, livestock and built land. Determination of conformity is carried out by reference to the Land's Potential Index class. The IPL class consists of very low, low, medium, high and very high classes. The results of the evaluation of the spatial planning for the IPL obtained percentage of 71, 99 for the appropriate class and 28.01% for the inappropriate class (Table 5).

Suitability	Large (km^2)	Percentage (%)
Appropriate	59,812395	71,99595341
Inappropriate	23,265045	28,00404659

Table 5 : Suitability Spatial Paterrn Parepare City based Land's Potential Index

V. CONCLUSION

Based on the research that has been done, it can be concluded that: Land's Potential Index in Parepare city included in the very low (IPL 0 - 7.9), low (IPL 8 - 15.9), medium (IPL 16 - 23.9), and high (IPL 24 - 31) , 9) with a medium class dominated by 61.878% of the total area of Parepare City. The Parepare City Spatial Planning (RTRW) for 2011 - 2031 is in appropriate with the land's potential index with a percentage of 71.99% and an inappropriate area of 28.01%.

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