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Spatial Pattern Modeling Of Sustainable Mining Industrial Area In Routa Of Konawe Regency, Southeast Sulawesi Province

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Abstract

This study aims to describe a model of spatial dynamics of industrial estates in the Routa area of Konawe Regency, Southeast Sulawesi. The technique adopts purposive sampling techniques for determining the selected sample of a sample located in the area intended to be developed around 3500 ha area. The simulation results of changes in land use in 2040 in the Routa Region show that the development of the area of public facilities is around 89.05%, carrying capacity has increased by 74.99%, the industry by 50.39%, and settlements by 75.47%. Meanwhile, the reduced agricultural land is 15% farming. As a result, land use simulations are used to model land use change in the Routa Region from 2020 to 2040, assessing the model's validity by determining whether the number of cells for each land use in 2020 is appropriate.

Keywords: Land use, swamp, sustainable

Introduction

The concept's implementation was coordinated with the MDGs program until 2015, after which it was carried out in conjunction with the SDGs program for the 2015–2030 period. One of the themes of the SDGs program is that economic development must be in line with the management of the surrounding nature and social responsibility(Hariz, AR., Purwanto, 2015) As a result, all programs and activities in important development sectors

must commit to protecting the surrounding nature and reducing the amount of residue that gives an impression to the surrounding nature (Rahman, 2018).

A strategy to balance economic growth and the protection of natural resources and ecology, known as the notion of *"green industry*(Sharma, 2013). One of the basic concepts of EIP development and implementation adopted by many industrial estates in several developed countries is the concept formulated by Ernest Lowe (Lowe, 2015) in the *eco-industrial park handbook* based on the conception of industrial ecology, namely industrial estates that pay attention to several aspects; (1) integration of natural systems with the suitability of the carrying capacity of the environment; (2) sustainable use of energy and water; (3) integration of production and waste material streams; (4) effective management of industrial estates; (5) environmentally friendly infrastructure design; and (6) integration between industrial estates and community social communities and contributions to local economic development (Tessitore, Sara.T.D., dan Iraldo, 2015)

Routa Konawe Regency, Southeast Sulawesi Province, is a strategic industrial growth area currently increasing significantly. The Routa region has a lot of development potential where the natural environment of Routa, in general, has a relatively high level of diversity and vegetation density, as well as the diversity of wild fauna that lives in the wilderness of the Routa forest (Billé et al., 2012). Spatially, the growth of Routa industrial land has encouraged the conversion of other allotment land functions such as natural tourist destinations, educational tourism, industrial tourism, fertile agricultural land, and settlements. The trend of industrial development is linear with the policy of opening new industrial estates and deregulation of the industry by the government. The seriousness of the Konawe Regency Government makes the two sub-districts the center of industry, and mining is nothing but for the welfare of the Konawe community in particular.

Based on the description of the EIP study, Routa is very in line with the context of industrial estate development which is guided by the concept of EIP (*empirical problems*). The development of regions with the concept of EIP becomes an idea or breakthrough for the southeast region because Indonesia itself indicates that there are still few industrial estates that are able to match the basic requirement(Lowe, 2015). The development of this industrial area has been carried out by (Sandri & Rudiarto, 2017), Fleig (2010), Di Noi C. Ciroth (2018), and Fajarini et al.(2015), who examined the dynamics of land use change and regional development with the predicate of spatial planning 2005-2025(Fajarini et al., 2015)

Method

This study aims to describe a model of spatial dynamics of industrial estates in the Routa area of Konawe Regency, Southeast Sulawesi. The sampling techniques use *purposive sampling* techniques. According to (Sugiyono, 2013), *purposive sampling* is a technique for identifying the selected sample of a sample located in the region meant to be developed around a 3500 ha area.

Results And Discussion

Modeling the spatial dynamics of industrial estates in the Routa area of Konawe Regency, Southeast Sulawesi, is targeted at a priority scale, one of three indicators including the carrying capacity of environment, mining industry, and settlements. The results of calculating the priority scale using AHP show the first scale: the carrying capacity and

absorptive capacity of the environment in the local community economic sector, which is supported by the natural potential in the mining industry area.

The transformation of the mining-based economic structure to local renewable resources (agriculture and tourism) is located in the mining area. The existing condition of the economic structure of the Routa area of Konawe Regency, Southeast Sulawesi, is based on an output-input table strongly dominated by mining, agriculture, and ecotourism.

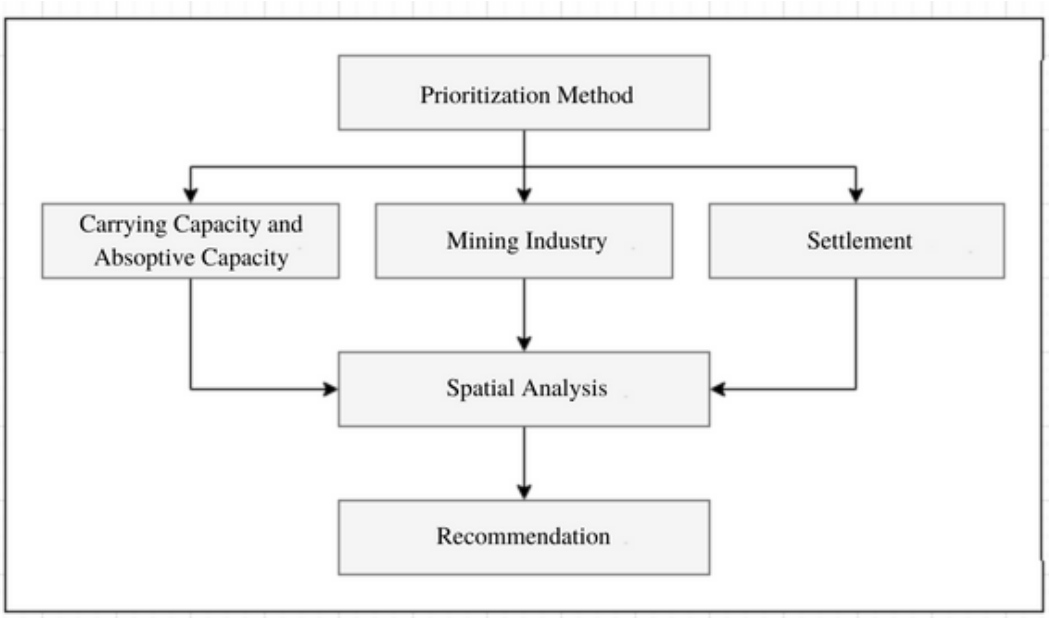

Figure 1. *RTH Prioritization Method*
Source: *Humaida, 2016*

The details of the data are presented as follows:

Table 1. *Existing Land Use of Villages in Routa District*

No.	Villages / Subdistrict	Land Use Zoning (Ha)				
		KR	P	T	KPIs	R
1	Walandawe	328.17	1.787.74	6.960.14	1.72	7.08
2	Routa	154.69	842.65	3280.67	0.81	3.34
3	Tirawonua	220.99	1.203.84	4.686.89	1.16	4.77
4	Parudongka	555.79	3,027.68	11,787.56	2.92	11.99
5	Puuwiwirano	88.88	484.15	1.884.92	0.47	1.92
6	Lalomerui	425.49	2.317.84	9.023.99	2.23	9.18
7	Tanggola	132.56	722.1	2.811.33	0.7	2.86
Routa District		1906.57	5076.58	15068.23	10.01	41.14

Source: *GIS analysis results, 2022.*

Based on table above we can discuss first about *Carrying Capacity and Absorptive Capacity of the Environment.* We can divided into plantation; agricultural potential;farm; and forestry. Based on the percentage of land use in Routa District in community plantations and agriculture, plantation commodities cultivated by the community in Routa District include Lada, Kaka, Coffee, Sago, Cashew, and Coconut. Based on information from the previous two years, it is known that plantation crops covered 1,016 ha in 2020 and 1,078 ha in 2021. However, the amount of crop production and productivity decreased in 2022 compared to

2021. The types of plantation crops that are widely cultivated are pepper (564 ha) and cocoa (406 ha).

Next, discussion about agricultural potential. Routa District in 2021 has a rice field area of 472 ha, consisting of irrigated rice fields (248 ha) and non-irrigated rice fields (224 ha). In addition, based on this data, 1,135 ha of non-agricultural land use of rice fields and 802 ha of non-agricultural land were also identified. Other plantation crops such as cocoa, coffee, sago, cashew, and cloves show that farmers' production and maintenance processes were relatively low compared to pepper and oil palm plants that are managed independently by the community. One of the plantation commodity products that were relatively recently developed by the community is the tobacco plant business found in UPT Parudongka, which is starting to be widely cultivated by the community. There is even one household industry business that produces cigarettes for the needs of the local community.

Third, The farm types of livestock cultivated by the community in Routa District are cows, buffaloes, goats, free-range chickens, ducks, and manila. Based on 2021 data, it is known that the total livestock population is 39,522 heads. The most cultivated livestock was free-range chickens with 33,740 heads (85.37%), and the lowest was buffalo livestock with 25 heads (0.06%). The livestock business is underdeveloped in Routa District, and this is due to the limited grazing land that the community can utilize. Considering that there is open land overgrown with reeds, it has the potential to be a grazing field. However, the location is far from community settlements and partly located in a forest area.

Forestry, the potential for tree stands in the forest area in Routa is an average of 286 trees per hectare with a volume of 260.40 cubic meters per hectare. The most numerous tree stands are the class 2 commercial group of 227.28 trees per hectare with a volume of 200.63 cubic meters per hectare. Furthermore, the meranti class 1 commercial group consisted of 421 trees per hectare with a volume of 34.39 cubic meters per hectare, and the gorgeous wood group consisted of 24.34 trees per hectare with a volume of 22.21 cubic meters per hectare (Wibisono, 2020)

The division of forest areas according to their functions mentioned above does not indicate the actual situation in the field. For residents in Routa, all forests are the same, which is white. There is no green, yellow, light green, or purple. This indicates that citizens' desire to open a forest area is neither constrained nor hindered by the government's segmentation of forest areas according to their functions, as mentioned above. This situation is especially true for logging companies, migrants, and shifting cultivators.

Currently, HPT is a wood processing area, a community and company plantation area, and a shifting cultivation area. Practically, almost all of HP has changed its function to become a nickel ore mining area of PT. SCM (Sulawesi Mineral Light Company). Most of the HPK has been opened by the Mopute and Tundundete people. Likewise, the current HL has changed a lot into logging areas, people's plantation areas, and shifting cultivation areas.

The carrying capacity of Industry dividing into mining excavations; tourism and industry it self. *Mining Excavations* in Routa District is one of the areas that has mining and excavation potential. Based on the Spatial Pattern Plan in the Konawe Regency RTRW for 2019-2039, it is known that in Routa District, there are plans for mineral and rock mining areas: (1) Radioactive mineral mining areas (Uranium), (2) nickel mining areas, (3) cobalt mining areas, (4) iron mining areas, (5) asbestos mining areas, talk stones, ocer stones, flint, (6) phosphate deposit mining areas, (7) limestone mining areas.

Based on data from the Ministry of Energy and Mineral Resources, until 2022, there are 9 Mineral Mining Business Permits (IUP) in Routa District with a total area of IUP (44,501.20 ha).(Yoesgiantoro et al., 2022) The nine IUPs referred to are Modern Cahaya Makmur; Prospek Bumindo Sejahtera; Andalan Energi Nusantara; Modern Sinar Energi; Sulawesi Cahaya Mineral; Andalan Energi Nusantara; Alvindo Mining Resources; and Nikelindo Suryakencana Agung. The largest IUP area is PT. Sulawesi Cahaya Mineral (21,100 ha) and its mining location across districts (Morowali Regency and Konawe Regency). Meanwhile, the lowest IUP area is PT. Andalan Energi Nusantara (403.20 ha). A complete overview of IUP data in the Routa District.

Given the distribution and location of the IUP areas in the Routa District, it is known that: (a) there are parts of the IUP area that overlap with existing residential areas, business land, and infrastructure; (b) the proportion of mining area of (26.01%) of the total area of Routa District (171,054.94 ha); (c) the IUP area is partly within the forest area so that when all IUPs have been operational, it has the potential to cause environmental ecosystems and services. Therefore, in the preparation of the conception of RDTR Routa District, it is necessary to zone the area clearly between various forms of land use that considers all aspects of both economic, social, and environmental interests.

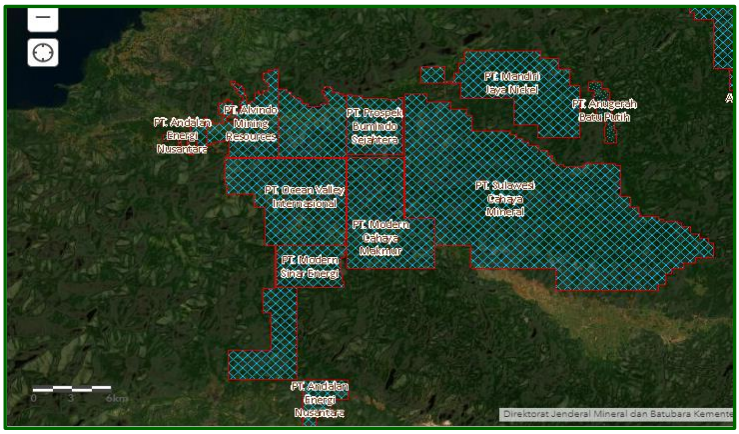

Figure 2. *Overview of IUP Location in Routa District*
(source: https://geoportal.esdm.go.id/minerba/)

Tourism Aspect, the potential tourist areas in Routa District that can be developed in Routa District are natural and mountain tourism, such as natural tourism of the Lasampala and Hiuka mountain complex, Lalomerui waterfall, and lakes in Walandawe and Lalomerui Villages. In addition to the natural tourism places, other tourism potentials are cultural reserves or relics for cultural tourism and local wisdom, such as Kampung Tua Routa in Wawo Polihe, Old pre-Islamic cemetery in Matambolihe; Polihe Fort or O'ou Fortress; Paruponti and Batubarang Caves in Tirawonua and Damar Tree Area.

Figure 3. *Location of Baths in Walandawe Village*

Industry aspect in Routa District has the potential for the development of large industries as well as small industries. The potential of the existing large industry is the mining industry. Referring to the spatial pattern plan in the Konawe Regency RTRW, 2019-2039, Routa District is one of the areas within the scope of the Konawe Industrial Estate (KIK), in addition to Morosi, Kapoiala, and Bondoala Districts. The area of designation for the mining industry of Routa District is 3. 500 acres.

The number of industries in Routa District is 17 industrial units, including Rumbia Roofs, Nonmetallic Excavated Goods (Roof Tiles, Bricks, Ceramics, etc.), Wood Products, bamboo and the like, and Rice Milling. The most cultivated industries are Wood Products, bamboo, and the like (7 units), and the lowest is the non-Metal Excavated Goods industry (Roof Tiles, Bricks, Ceramics, etc.) with 2 units. The results of surveys and field observations identified that the dominance of the wood processing industry was influenced by: the history of granting permits for the use of wood forest products (IPPKH) which was the forerunner of the entry of the wood processing industry in Routa District.

The existence of the wood processing industry currently seems to be somewhat reduced in intensity. However, in practice, the source of raw wood materials used comes from other use areas (APL) and forest areas, so there is a potential for forest area encroachment practices. The field survey results show that a patchouli oil refining industry business has begun to be developed by the community, namely: in Tirwanonua Village (1) and Routa Village (2 units).

The last discussion is about the carrying capacity of Settlement, the intensity of buildings in Routa District is generally very low. The characteristics of the building pattern are generally located along axis roads or village roads, with KDB varying between 20%-100%. KDB calculation is the result of processed GIS because there is no building parcel data available as in the data issued by the Land Agency Office of an area. From all areas in Routa District, it is known that the average building density is still less than one building per hectare. The area that is a bit high in terms of buildings is Routa Village (0.013), although it is still below one. In contrast to places far from the primary collector shaft road, such as rural areas with poor road access, which have a low level of building density, it is situated along the primary collector road, which has the potential to have a greater KDB in the long run.

Based on the results of field surveys and GIS processing, it is known that the number of house buildings in the district is 914 house units with an area of around 13.71 ha or 0.01% of the total area (171,054.94 ha). The number of building houses will affect the building area of the house.

Table 2. *Building Intensity in Routa District and Supporting Facilities*

No	Village/ Subdistrict	Percentage of Building Area	Facility			
			Education	Health	Religion	Institutional
1	Walandawe	7	1	0	2	3
2	Routa	20.46	2	0	3	7
3	Tirawonua	20.46	4	1	2	3
4	Parudongka	28.12	4	4	3	4
5	Puuwiwirano	8.42	1	0	1	4
6	Lalomerui	5.69	2	1	3	3
7	Tanggola	9.85	2	0	1	3
	Total/Average	100	16	6	15	27

Source: *Routa District In Numbers, 2022 and Village IDM Data, 2022*

The potential for opening settlements in the Routa District area can be done with the support of educational, health, religious, and community facilities. Based on the Land Closure Map of Routa District in 2022, there is a land cover class of Settlements and Activity Places with an area of 152.72 ha. The map shows that the pattern of population settlements is linearly following the road and is scattered in groups at the centers of socio-economic activity in each village/subdistrict.

The diversity of population settlement patterns is influenced by the number and density of the population, the carrying capacity of the land for settlements, the availability of road infrastructure (regency and province), as well as the direction of development of socio-economic activities of the community and investment in the Routa District area.

The results of the survey and field observations in 2022 identified 914 housing units in Routa District, with the highest number in Parudongka Village: 257 houses (28.12%) and the lowest in Lalomerui Village: 52 house buildings (5.69%). The average building area of the house is 150 m2, with the distance of the house from the road ± 7 – 12 meters. However, not all married residents have houses that can be seen from the average of one housing unit inhabited by 4-5 heads of families.

Based on data, it is known that there is a need for a program to provide housing assistance for residents who do not have a home, and it is prioritized for those who have lived for a long time (at least 5 years). In addition, it is necessary to arrange the boundary of the road boundary with residents' houses so that there is a wide road space (minimum 10-20 meters) and its borders that match the class of roads in Routa District.

Spatial planning for residential areas is critical, considering that population growth increases every year, which will be followed by the provision of space for the needs of supporting infrastructure for settlements. Meanwhile, the carrying capacity of land and living space for those that can be intended for residents is only 10,182.28 ha in the form of other use areas (APL) or about 6-7% of the area of Routa District. At the same time, the rest is intended as forest areas (HPT, HP, HPK, and HL) which take a portion of the area of around 96-97%.

Based on the data presented, spatial modeling for sustainable mining industrial areas in Routa from AHP results is: the first *Carrying Capacity and Carrying Capacity of the Environment.* In simulating the carrying capacity and tamping capacity of the environment, the factors and weights used are: (a) plantation (weight: 0.342); (b) agriculture (weight: 0.035); (c) animal husbandry (weight: 0.075); and forestry (weight: 0.033).

Second, In industrial land use simulations, the factors and weights used are: (a) mining excavation (weight: 0.245); (b) tourism (weight: 0.1850); and (c) industrial (weight: 0.058). The last is about Settlements. In the simulation of residential land, the factors and weights used are: (a) educational facilities (weight: 0.063); (b) health (weight: 0.144); (c) religious (weight: 0.234); and (d) institutional (weight: 0.065)

Furthermore, the land use simulation process is carried out by simulating land use from 2020 projecting 2040, then comparing the simulation results to the existing 2020 land use map for model validation purposes. The neighborhood filter used in this study is a 3x3 neighborhood filter so that 1 pixel will only affect 8 surrounding pixels with the sum filter operation. It is obtained:

Table 3. *Land Use Change Matrix*

General Facilities	Existing 2020			
	General Facilities	Carrying Capacity	Industry	Settlement
General Facilities	1065.04			
Carrying Capacity		16599.8515		
Industry			1065.04	
Settlement				2258
Total	1065.04	16599.8515	1065.04	2258
Accuracy	89.05	74.99	50.39	75.47

The simulation results of changes in land use in 2040 in the Routa Region show that the area development in public facilities is around 89.05%, carrying capacity has increased by 74.99%, the industry by 50.39%, and settlements by 75.47%. Meanwhile, the reduced agricultural land is 15% agriculture. As a result, land use simulations are used to model land use change in the Routa Region from 2020 to 2040, assessing the model's validity by determining whether the number of cells for each land use in 2020 is appropriate.

Conclusion

Land use change modeling in the Routa Region was carried out through land use simulations from 2020 to 2040 by testing model validation with the matching of the number of cells per land use in 2020.

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