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Land priority determination for paddy field extensification in Subang Regency - Indonesia

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Abstract. Extensification efforts in agriculture to increase paddy production can be done through the selection of land for the development of paddy fields from available land. Every inch of land has different characteristics, which can be used for the selection of land suitable for a use, including for paddy fields. This study aims to delineate available land and set priorities for the development of paddy fields in Subang Regency. The main methodology used is a multicriteria-based land evaluation. The land attribute is weighted using the AHP technique from the assessment of 8 experts. Land availability was obtained from a combination of Weighted Linear Combination method and Geographic Information System. The results of the study found suitable land for paddy field extensification. Prioritization results showed that 76,115 hectares of land had high priority, 7,165 hectares had moderate priority, 55,280 hectares had low priority, and an area of 19,561 hectares is land that is not recommended for use. The land available for extensification of paddy fields from suitable land is 9,885 hectares with a composition of 73.24% (7,240 hectares) high priority, 21.20% (2,096 hectares) moderate priority, 3.36% (530 hectares) low priority, and 0.19% (19 hectares) are not recommended for paddy field extensification.

Keywords: GIS, Multicriteria, Priority of paddy fields

1. Introduction

Indonesia needs an increase in paddy production to offset rapid population growth. Increased production can be done by supplying inputs of specific location-based. The suitability of land is evaluated in the land mapping unit in Subang Regency, West Java Province, at a scale of 1: 25,000 [1]. The results of the study recommend local specific inputs for paddy fields in Subang Regency. The potential of the land in Subang Regency allows for the extensification of identified paddy fields outside of the actual paddy fields, which have the potential to develop paddy fields. As in the case of existing fields, such fields require local specific inputs according to characteristics that differ from place to place and can be spatially described.

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The shape of the Subang Regency extends from the coast to the hilly areas, which is considered to be more dynamic in the paddy field-alternation process [2]. Alternative land available has the hope to maintain the area of paddy fields in order to maintain the amount of paddy production needed. The increasing of paddy production can be done by intensification or extensification. Intensification is an effort to maximize available paddy fields by improving paddy production inputs. Extensification is an effort to expand paddy fields in other locations. This study tries to select the land for extensification that requires references for decision making in terms of determining the potential of paddy fields [1],[3],[4]. Decision making requires several alternatives to be chosen for subsequent implementation [3] and is an objective tool for the allocation of land use [5] including for the allocation of paddy fields.

The conceptualization of problems in the land suitability evaluation was the application of the MCDM (Multiple Criteria Decision Making) methodology which was chosen for unidimensional evaluation [6]. The MCDM method assists decision making processes involving policy priorities, trade-offs, and uncertainties [7]. The choice of location or allocation of land use for specific needs requires decision makers to involve several alternatives that are suitable to be evaluated based on multiple criteria [7],[8],[9]. All identified criteria have different levels of importance, so the decision-making process must consider the weight according to the relative importance of the results of alternative evaluations [8],[10].

Some alternative land allocation decisions require criteria from not only biophysical but also social and economic factors [2],[11],[12],[13]. The best alternative for paddy field LULC (land use/land cover) involves decision analysis that refers to several criteria (Multicriteria Decision Analysis) to determine subjective preferences between different criteria [10],[14]. Different weighted criteria have weight obtained from expert justification with the AHP (Analytical Hierarchy Process) technique. Priority of land is generated from spatial weighting using WLC (Weighted Linear Combination) in GIS (Geographic Information System).

Some researchers have previously integrated AHP with GIS for agricultural land suitability analysis [10],[15],[16],[17]. The study uses multi-criteria analysis for biophysical and socio-economic parameters. Multi-criteria techniques are also used for land suitability analysis [18], vegetation [17], agriculture [16], land evaluation [19]. Some researchers use GIS and multicriteria for the purpose of determining a location, for example: [20] determine suitable locations for gas power plants at Natanz City in Iran, [13] chose land suitability for pasture use and agriculture in northeastern Iran, [21] choose the location of the city park in Inskadar Malaysia.

The availability of land that can be converted into paddy fields is land that has a lower landrent value than paddy fields [22],[23], namely forest LULC, moor/fields, and bushes. This study uses the distance criteria for the land to-be to a place or object. Determining the alternative of weight of each land to-be utilizes criteria based on factors of land availability, land suitability, ease of work, and affordability. Each factor is used and based on the factors used. Specifically this research has the purpose of: (1) seeking priority land for paddy fields, (2) determining the availability of land for paddy fields. The results of this study provide information on the spatial location of the LULC paddy fields provided for land use planning, especially for LULC wetland purposes.

2. Materials and methods

2.1. Study Area

Subang Regency is located in a geographical position 107°31' - 107°54' East Longitude and 6°11' - 6°49' South Latitude (figure 1). Based on the topography, the Subang Regency region has mountainous regions in the South with altitudes between 500 - 1,500 meters above sea level (ASL), hilly areas and plains in the Middle with an altitude of 50-500 meters above sea level, and lowland areas in the North with height of 0-50 meters above sea level [24]. Most of the Subang Regency (80%) has a slope of 0° - 17°, 11% of the area has a slope of 18° - 45°, and 9% of the area has a slope of more than 45°. In general, the Subang Regency region has a tropical climate with an average rainfall of 2,352 mm per year with the number of rainy days of 100 days [24].

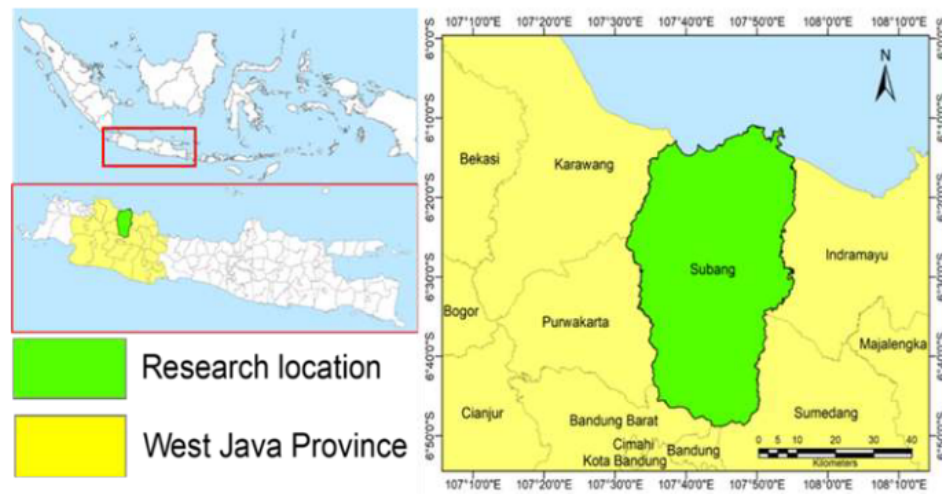


Figure 1. Research location to allocate land for paddy field, Subang Regency, West Java Province.

2.2. Requirements data

Attributes in the AHP hierarchy require spatial data generated from various existing data sources (table 1). This study uses GIS to produce all the attributes needed.

Table 1. Spatial data needs to determine the criteria weight of each factor, criteria, and alternative

Spatial Attributes	Data	Resolution / Scale / Accuracy	Source	Note
Land availability	Spot imagery 7	1.5 meter	[25]	Forest, bushland, moor / fields
Land suitability	Land suitability map	1:50,000	[1]	S1,S2,S3
Ease of work	Land Unit Map	1:50,000	[26]	Clay content <15%
Affordability	Road map	1:50,000	[27]	Collector road, path, farm road
Street	Road map 50k	1:50,000	[27]	Toll road, national road, provincial road, district road
Settlement	Spot imagery 7	1.5 meter	[25]	Settlement / place of activity
Paddy fields	Spot imagery 7	1.5 meter	[25]	Paddy Field
Water sources	Topographic Map	1:25,000	[26]	Water Body
Market	Topographic Map	1:25,000	[28]	The coordinates of the paddy market location
	Paddy Mill	1.5 meter	[29]	The coordinates of the paddy mill location
Industry	Regional Spatial Plan (RSP) 2011-2031	1:50,000	[30]	Industrial zone

2.3. Hierarchy

The hierarchy of land priority decision models for wetlands has a factor, criteria and alternative structure (figure 2). Biophysical attributes consider the biophysical availability of land, land suitability, ease of work, and affordability [3] which are used as factors in the multicriteria decision hierarchy. The criteria hierarchy selects the location of the land that takes into account the distance from the road, the distance from the settlement, the distance from the existing paddy field, the distance from the water source, the distance from the market, and the distance from the industry. Alternatives in the multicriteria hierarchy

choose LULC forests, fields / fields, and bushes. The third LULC is an alternative because the landrent value is lower than the LULC paddy field [22],[23].

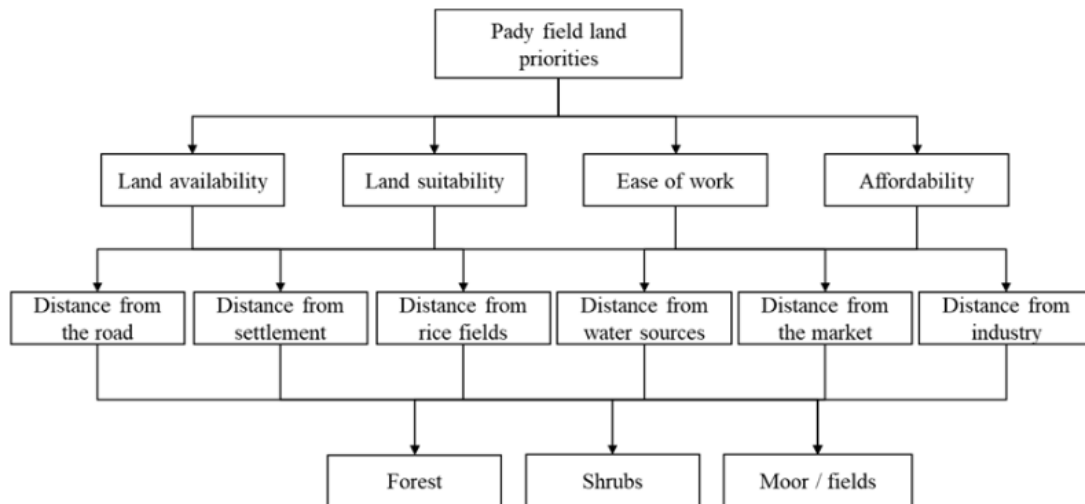


Figure 2. The hierarchy of land priority decision models for wetlands has a factor, criteria and alternative structure.

2.4. *Weighting attribute criteria*

Weighting each attribute utilizes the calculation results from the AHP method which involves 8 experts as the resource person. The AHP method is used because it is one of the representative multicriteria decision analysis methods used in this study. The AHP method have three basic principles: decomposition, comparative assessment, and priority synthesis [31],[32],[33]. Decision problems are decomposed into hierarchies that capture important elements of the problem. Comparative assessment requires the assessment of pairwise comparisons of elements at the hierarchical structure level. Priority syntheses take each of the priority scale ratios derived at various levels of the hierarchy and build a set of priorities for the elements at the lowest level of hierarchy, the alternative [32].

Problem solving is formed in a hierarchical framework with a level of factors, criteria and alternatives [33]. The AHP procedure involves three main steps: (i) developing the AHP hierarchy, (ii) assigning important weights to each hierarchical structural element using pairwise comparison methods, and (iii) establishing overall priority rankings [32],[33],[34],[35]. This study involved eight experts with expertise specifications of planning experts, environmental experts, land morphologists, agronomists, economists, and socioeconomic experts.

2.5. *Pairwise Comparison*

The number of attributes in the hierarchy is 13 (4 attributes of the factor hierarchy, 6 attributes of the criteria hierarchy, and 3 attributes of the alternative hierarchy). Each attribute is carried out by pairwise comparisons based on the hierarchy and carried out 29 paired matrices. The factor hierarchy has 1 comparison matrix, the criteria hierarchy has 4 comparison matrices, and the alternative hierarchy has 24 comparison matrices.

If there are m attributes that are compared in each comparison, a $A_{m \times m}$ matrix will be formed with elements a_{ij} ($i, j=1, 2, \dots, m$). Element a_{ij} shows the level of importance the i attribute relatively to the j attribute. If $a_{ij} > 1$ then said that i attribute is more important than j attribute, and if $a_{ij} < 1$ then said that i attribute is less important than j attribute. If $a_{ij} = 1$ then i attribute is as important as j attribute. For all $i=j$ then the value of $a_{ij}=a_{jj} = 1$, and for each elements a_{ij} and a_{ji} fullfil the equation $a_{ij} \cdot a_{ji} =$

1, with $i, j = 1, 2, 3, \dots, m$. The relative importance between the two criteria is expressed by a numerical scale from 1 to 9 (table 2).

Table 2. Relative values for elements in paired matrices

Score Value (a_{ij})	Description
1	Equally important
3	A little more important
5	More important
7	Very important
9	Absolute very important
2,4,6,8	Middle value between two values

After the paired matrix $A_{m \times m}$ is formed, the next step to complete the $A_{m \times m}$ pairwise comparison matrix becomes normal, which makes the number of each column element equal to 1 using the equation:

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^m a_{kj}} \tag{1}$$

The average element values in each row of the matrix A_{normal} represent the weight vector \bar{w} obtained from equation (3).

$$\bar{w}_i = \frac{\sum_{k=1}^m \bar{a}_{ik}}{m} \tag{2}$$

There is a $S_{m \times m}$ matrix with each s_{ij} element value showing the i -selected value in the j^{th} attribute. After the weight vector \bar{w} and the S -score matrix have been obtained, a vector \bar{v} that is the total value is needed by multiplying the matrix S by vector \bar{w} , namely:

$$\bar{v} = S_{m \times m} \cdot \bar{w}_{m \times 1} \tag{3}$$

The i value in $\bar{v}(v_i)$ represents the overall value in the i -choice ($i=1, 2, \dots, m$). The choice rating is a descending order of the overall score. For paired matrices performed by several experts, each item for the last answer is used a geometric multiplication formula [36], with the formula:

$$\bar{b}_{ij} = \sqrt[e]{\prod_{g=1}^e (\bar{a}_{ij})_g} \tag{4}$$

With

- \bar{b}_{ij} : geometric mean
- e : the number of experts
- $(\bar{a}_{ij})_g$: assesment by g^{th} expert
- i, j : 1, 2, ..., m
- g : 1, 2, ..., e
- \prod : multiplication

2.6. Calculate Consistency

The Consistency Index (CI) is obtained by calculating the scalar value λ as the average j^{th} vector element which is the ratio of the j^{th} element of the $A \cdot \bar{w}$ vector to the corresponding vector element \bar{w} . So:

$$CI = \frac{\lambda - m}{m - 1} \tag{5}$$

$$CR = \frac{CI}{RI} \tag{6}$$

RI can be obtained from the consistency table (table 3) proposed by [31]. Consistent decision makers produce $CI = 0$, however the inconsistency value less than 10% ($CR < 0.1$) can be accepted.

Table 3. Random Index (RI) Values

<i>m</i>	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

2.7. Determination of Land Availability for Paddy Field Extensification

The determination of priority attributes is adjusted to the hierarchy of multicriteria decisions that have been formed. Spatial attribute priority calculation uses WLC technique which has two components, attribute weight (w_j) and value function ($f(r_{ij})$) [32]. In accordance with the hierarchy in AHP, the weight of each attribute in each hierarchy utilizes the results of pairwise comparisons in the corresponding AHP method. Value functions use spatial attributes that correspond to the decision hierarchy (figure 1). The relationship between value functions and attribute weights is expressed in equation (7) [37],[32].

$$V(x_i) = \sum_j^m w_j v_j(x_i) = \sum_j^m w_j r_{ij} \tag{7}$$

Where w_j is normal weight and $\sum_j^m w_j = 1$. Whereas $v_j(x_i)$ is a value function for the value of j -th attribute. Then x_i is $x_{i1}, x_{i2}, \dots, x_{im}$ are spatial value and r_{ij} are spatial attributes that are transformed into comparable scales.

Distance analysis (Euclidean Distance) utilizes the center distance attribute to the outer boundaries of the district administration which results in spatial distance attributes. Furthermore, normalized spatial distance attributes use a linear scale transformation method that generates standard attribute values with comparable units [37]. The function of nonlinear values standardizes criteria values ranging from 0 to 1, with 0 representing the lowest value and 1 represents the highest value (table 4) [7]. Standardization of values use the following equations (8) and (9) [38],[39].

$$v(x_{ij}) = \frac{x_{ij} - \min_j(x_{ij})}{\max_j - \min_j}, \text{ maximize the value of } j \text{ attribute} \tag{8}$$

$$v(x_{ij}) = \frac{\max_j(x_{ij}) - x_{ij}}{\max_j - \min_j}, \text{ minimize the value of } j \text{ attribute} \tag{9}$$

Table 4. Value of standardization of attributes at a comparable scale

Attribute	Value	Description
Land availability	1 – 0	Value 1 is suitability and 0 is not suitability
Land suitability	1 – 0	Value 1 is suitability and 0 is not suitability
Ease of work	1 – 0	Value 1 is suitability and 0 is not suitability
Affordability	1 – 0	Value 1 is suitability and 0 is not suitability
Distance from the road	1 – 0	Value 1 is not suitability and 0 is suitability
Distance from settlement	1 – 0	Value 1 is not suitability and 0 is suitability
Distance from paddy fields	1 – 0	Value 1 is suitability and 0 is not suitability
Distance from water sources	1 – 0	Value 1 is suitability and 0 is not suitability
Distance from the market	1 – 0	Value 1 is suitability and 0 is not suitability
Distance from industry	1 – 0	Value 1 is not suitability and 0 is suitability
Forest	1 – 0	Value 1 is suitability and 0 is not suitability
Shrubs	1 – 0	Value 1 is suitability and 0 is not suitability
Moor / fields	1 – 0	Value 1 is suitability and 0 is not suitability

The empirical conceptual model of WLC is used as the basis for the development and validation of the attributes of spatial data on land suitability for paddy field extensification. The involvement of

researchers who use the WLC method shows its strength to achieve acceptable results without reducing scientific standards [40]. For the purposes of technical spatial data analysis, all attributes of spatial data involved are converted to raster format with a cell size of 30mx30m with the system coordinate UTM 48S. Completion of the WLC technique uses ArcGis 10.31 software.

2.8. Stages to Obtain Land Availability

WLC method produces land suitability which is a linear combination between each attribute weight and value function. The suitability of land must be adjusted to the spatial pattern of Subang Regency to obtain land availability for the extension of paddy fields. The steps to obtain land availability for the extension of paddy fields are presented in figure 3.

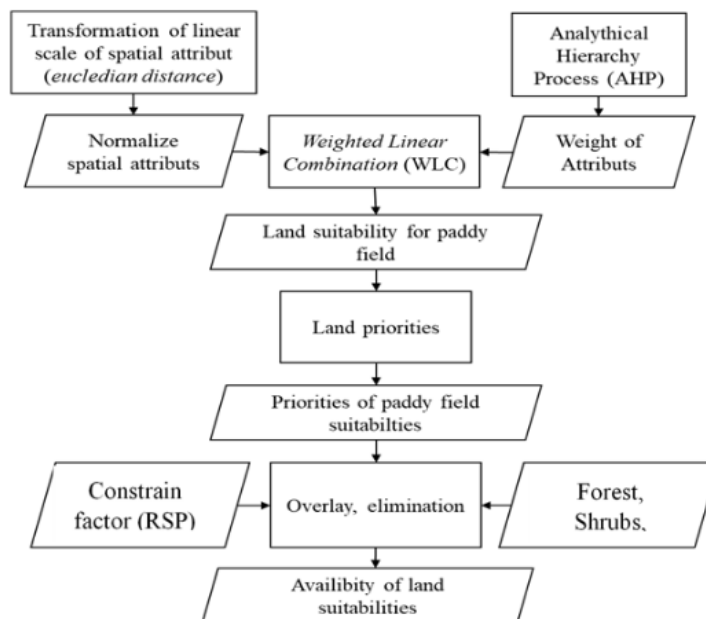


Figure 3. Stages to obtain land availability for extensification of paddy fields.

3. Results and discussion

3.1. Weight and standardization attributes

Factor, criteria and alternative assessments involved eight experts with their respective expertise in land morphology, environmentalists, planning experts, economists, geodesists, social experts, agricultural socio-economic experts, and agronomists. Each element of the combined pairing matrix is produced from equation (4) which is presented in table 5 for factor pairwise comparisons, table 6 for pairwise criteria comparisons, and table 7 for alternative paired comparisons.

Table 5. Pairwise comparisons in the factor hierarchy involving 8 experts using the AHP method in Subang Regency

Factor	Land availability	Land suitability	Ease of work	Affordability
Land availability	1.00	2.00	6.00	3.00
Land suitability	0.50	1.00	2.00	2.00
Ease of work	0.17	0.50	1.00	1.00
Affordability	0.33	0.50	1.00	1.00

Table 6. Pairwise comparisons in the criteria hierarchy involving 8 experts using the AHP method in Subang Regency

Factor Criteria	DFTR	DFS	DFRF	DFWS	DFTM	DFI
Land Availability						
Distance from the road (DFTR)	1.00	3.00	1.00	1.00	3.00	4.00
Distance from settlement (DFS)	0.33	1.00	1.00	1.00	1.00	2.00
Distance from rice fields (DFRF)	1.00	1.00	1.00	1.00	4.00	4.00
Distance from water sources (DFWS)	1.00	1.00	1.00	1.00	4.00	6.00
Distance from the market (DFTM)	0.33	1.00	0.25	0.25	1.00	2.00
Distance from industry (DFI)	0.25	0.50	0.25	0.17	0.50	1.00
Land suitability						
Distance from the road (DFTR)	1.00	3.00	1.00	1.00	3.00	4.00
Distance from settlement (DFS)	0.33	1.00	1.00	1.00	1.00	2.00
Distance from rice fields (DFRF)	1.00	1.00	1.00	1.00	3.00	3.00
Distance from water sources (DFWS)	1.00	1.00	1.00	1.00	5.00	6.00
Distance from the market (DFTM)	0.33	1.00	0.33	0.33	1.00	3.00
Distance from industry (DFI)	0.25	0.50	0.33	0.17	0.33	1.00
Ease of work						
Distance from the road (DFTR)	1.00	1.00	1.00	1.00	3.00	5.00
Distance from settlement (DFS)	1.00	1.00	1.00	1.00	2.00	4.00
Distance from rice fields (DFRF)	1.00	1.00	1.00	1.00	3.00	4.00
Distance from water sources (DFWS)	1.00	1.00	1.00	1.00	4.00	6.00
Distance from the market (DFTM)	0.33	0.50	0.33	0.33	1.00	2.00
Distance from industry (DFI)	0.20	0.25	0.25	0.17	0.50	.00
Affordability						
Distance from the road (DFTR)	1.00	2.00	2.00	1.00	3.00	4.00
Distance from settlement (DFS)	0.50	1.00	1.00	1.00	2.00	2.00
Distance from rice fields (DFRF)	0.50	0.50	1.00	1.00	2.00	3.00
Distance from water sources (DFWS)	1.00	1.00	1.00	1.00	3.00	3.00
Distance from the market (DFTM)	0.33	0.50	0.50	0.50	1.00	2.00
Distance from industry (DFI)	0.25	0.50	0.33	0.33	0.50	1.00

The AHP method approach produces the weight of each attribute on the hierarchy of factors, criteria, and alternatives. The weight of each attribute is obtained from pairwise comparisons of geometric mean result matrices from 8 experts. The results of pairwise comparisons in the factor hierarchy produce the value of the weight of land availability, land suitability, ease of work, and affordability. The attribute weight in the criteria hierarchy is the multiplication of paired comparisons in the criteria hierarchy with the factor weight that produces the overall value on the criteria attribute. The overall value of the attributes in the alternative hierarchy is obtained from doubling the weight of the alternative attribute with the weight of the criteria; the end result of the overall value of the alternative hierarchy is the average of the overall value of each alternative produced. The final value of each alternative is the average of each weight value from the contribution of each criterion. All paired comparisons yield a consistency value of less than 10% which indicates that the decision was not given by chance [31]. All results of calculations based on hierarchy are presented in **table 8**.

The result of weighting attributes shows that in the hierarchy of factors, "land availability" has the highest role in determining the priority of land for extensification of paddy fields. The "land suitability" factor has a second weight after "land availability". This shows that after the land is available, it must be considered the suitability of the land for paddy commodities. Furthermore the affordability factor has a third weight in the factor hierarchy. This shows that after land is available and has land suitability for wetland; planners must pay attention to how easy the priority location of the land can be reached. The

lowest in the hierarchy of factors, the "ease of work" factor has the lowest weight, this shows that in determining the priority of land for extensification of paddy fields, the ease of working factor is the last factor in considering the priority location of land for extensification of paddy fields.

Table 7. Pairwise comparisons in the alternative hierarchy involving 8 experts using the AHP method in Subang Regency

Land availability									
	a. DFTR			b. DFS			c. DFRF		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.74	0.72	1.00	0.48	0.45	1.00	0.70	0.43
Shrubs	1.35	1.00	0.94	2.09	1.00	1.17	1.42	1.00	0.89
Moor	1.39	1.06	1.00	2.22	0.85	1.00	2.31	1.13	1.00
	d. DFWS			e. DFTM			f. DFI		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.63	0.42	1.00	0.66	0.47	1.00	0.73	0.98
Shrubs	1.59	1.00	0.94	1.51	1.00	0.92	1.38	1.00	1.77
Moor	2.37	1.06	1.00	2.15	1.08	1.00	1.02	0.57	1.00
Land suitability									
	a. DFTR			b. DFS			c. DFRF		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.74	0.69	1.00	0.76	0.66	1.00	0.76	0.72
Shrubs	1.35	1.00	1.35	1.32	1.00	1.22	1.32	1.00	1.29
Moor	1.45	0.74	1.00	1.52	0.82	1.00	1.38	0.77	1.00
	d. DFWS			e. DFTM			f. DFI		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.74	0.69	1.00	0.72	0.69	1.00	1.05	0.98
Shrubs	1.36	1.00	1.29	1.39	1.00	1.35	0.95	1.00	1.35
Moor	1.44	0.77	1.00	1.45	0.74	1.00	1.03	0.74	1.00
Ease of work									
	a. DFTR			b. DFS			c. DFRF		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.77	0.88	1.00	0.81	0.84	1.00	0.76	0.76
Shrubs	1.29	1.00	1.49	1.23	1.00	1.35	1.32	1.00	1.22
Moor	1.13	0.67	1.00	1.19	0.74	1.00	1.32	0.82	1.00
	d. DFWS			e. DFTM			f. DFI		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.72	0.62	1.00	0.76	0.84	1.00	0.76	0.84
Shrubs	1.39	1.00	1.00	1.32	1.00	1.29	1.32	1.00	1.29
Moor	1.63	1.00	1.00	1.19	0.77	1.00	1.19	0.77	1.00
Affordability									
	a. DFTR			b. DFS			c. DFRF		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	0.31	0.77	0.65	1.00	0.95	0.84	1.00	0.76	0.67
Shrubs	0.36	1.00	1.10	1.05	1.00	1.22	1.32	1.00	1.22
Moor	0.33	0.91	1.00	1.19	0.82	1.00	1.49	0.82	1.00
	d. DFWS			e. DFTM			f. DFI		
	Forest	Shrubs	Moor	Forest	Shrubs	Moor	Forest	Shrubs	Moor
Forest	1.00	0.72	0.62	1.00	0.98	1.01	1.00	1.08	1.01
Shrubs	1.39	1.00	1.10	1.02	1.00	1.22	0.92	1.00	1.35
Moor	1.63	0.91	1.00	0.99	0.82	1.00	0.99	0.74	1.00

Table 8. The value of the weight of each attribute from the calculation aggregation results involving 8 experts using the AHP method in Subang Regency

Hierarchy	Attribute	Weight
Aim	Priority of land for paddy fields	1
Factor	Land availability	0.46
	Land suitability	0.25
	Ease of work	0.11
Criteria	Affordability	0.18
	Distance from the road	0.17
	Distance from settlement	0.09
	Distance from rice fields	0.19
	Distance from water sources	0.39
	Distance from the market	0.09
	Distance from industry	0.07
Alternative	Forest	0.28
	Shrubs	0.36
	Moor/fields	0.36

Attribute weight in the criteria hierarchy, the attribute weight of the proximity of the water source has the highest weight. This is very reasonable considering that water is the main input in paddy production. The second weight after criteria for proximity to water sources, proximity to existing paddy fields provides convenience in the extension of paddy fields in terms of infrastructure such as irrigation networks and road access to locations. Next is weighting criteria for distance from the road, priority of land for extensification of paddy fields adjacent to the road (Toll, National, Province, and Regency) vulnerable to conversion [1]. In planning, the distance from the road criteria has a low weight. It is followed by weighting criteria for distance from residential and market. This fact shows that the priority of land approaching settlements is also vulnerable to conversion even though the rate of conversion of paddy fields to settlements tends to be slow. The market chosen in this study is the paddy market and paddy mills. The criteria for proximity to this market are used to consider the costs incurred due to transportation from paddy fields to the market. Based on alternative land that can be converted into paddy fields, LULC shrubs and field moorings have the same weight, while forest LULC has the lowest weight of the three alternatives.

The standardization of each spatial attribute has an ideal limit in the preparation of land suitability for paddy field extensification (figure 4). These standard attributes are basic data for determining priorities of land suitability for paddy field extensification. Conformity limits of each attribute are divided into 4 priorities, namely: priority 1, priority 2, priority 3, and priority 4. Determination of the limits of each priority using quartile values that produce 4 parts (table 9). Suitability levels were also divided into 4 priorities based on the equal intervals by [41].

Table 9. Land priority classification based on quartile

Priorities	Description	Interval values
P1	Land has a high priority for paddy field extensification	0.75 - 1
P2	Land has a moderate priority for paddy field extensification	0.50 - 0.75
P3	Land has a low priority for paddy field extensification	0.25 - 0.5
P4	Available land is not recommended for paddy field extensification	0 - 0.25

Normalization of spatial attribute values using equation 8 and equation 9 using GIS tools. Normal spatial attributes are classified according to four priority classes (table 7) which produce priority spatial attributes (figure 4). The spatial factor attribute has four formers, namely land availability, land suitability, easyness, and affordability.

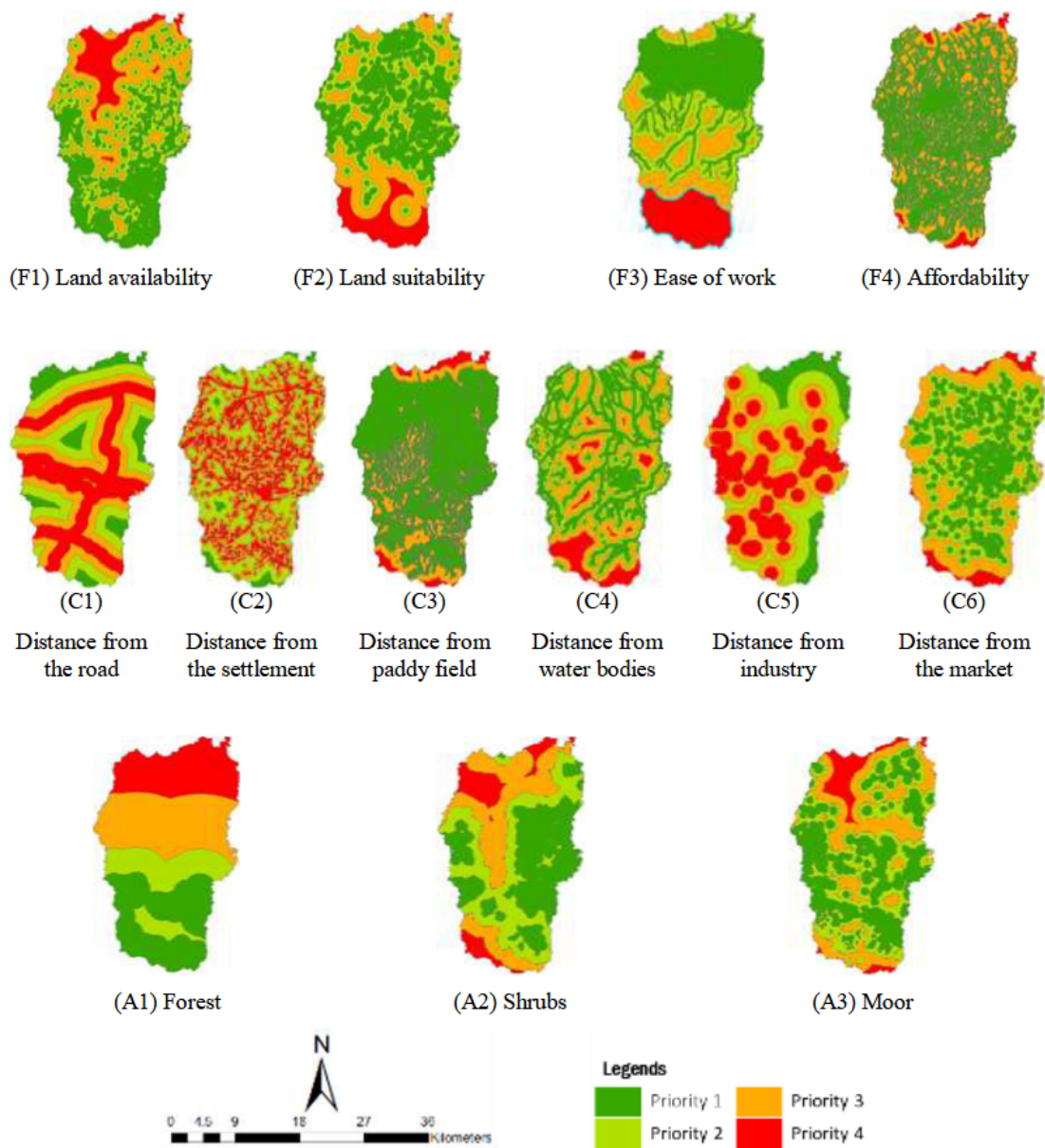


Figure 4. The suitability of the location of each attribute for paddy field extension.

P1 is a land that is prioritized for the development of paddy fields that have high land suitability. P2 is an area of land that can be used for the development of paddy fields that have several constraints or distance limiting factors. P3 is the location of land that can be cultivated for paddy fields with the consequence that the land has a larger limiting factor. P4 is a land that has a very large limiting factor, so it is not recommended to develop paddy fields.

3.2. Availability of land for extensification of paddy fields

WLC aggregation on each spatial attribute with the weight of the AHP calculation results in spatial distribution for paddy field extensification. The results of the calculation resulted in

34.90% (76,115 hectares) of areas with high priority for paddy field extensification, 30.79% (67,165 hectares) of moderate priority for paddy field extensification, 25.34% (55,280 hectares) had low priority for paddy field extensification, and 8.97% (19,561 hectares) are not recommended for paddy field extensification. This shows that Subang Regency has potential land for paddy fields which are not yet used for paddy fields [1]. Visually, delineation of land suitability for paddy field extensification is presented in figure 5a.

Land suitability (figure 5a) is a land location that has not considered the Urban Planning in Subang Regency and the type of land use can be converted into paddy fields. Therefore, the availability of existing land is chosen in the direction of the pattern of space for wet agriculture in the RTRW (regional spatial plan) and selecting land from forest use (production that can be converted, limited production), shrubs, and moor/fields (figure 5b).

The fact shows that from the 76,115 hectares of land suitability which has a high priority is only 9.51% (7,240 hectares) which can be used for paddy field extensification. Available land with moderate priority is obtained from land suitability with moderate priority of 3.12% (2,096 hectares) of 67,165 hectares. Land suitability of 55,280 hectares with low priority can be obtained 0.96% or 530 hectares which is the availability of land with low priority and the availability of land that is not recommended only 0.10% (19 hectares) of 19,561 hectares of land suitability that is not recommended. The total available land for extensification of paddy fields is 9,885 hectares, with a composition of 73.24% (7,240 hectares) of available land with high priority, 21.20% (2,096 hectares) of available land with moderate priority, 3.36% (530 hectares) land is available with low priority, and 0.19% (19 hectares) of land that is not recommended for paddy field extensification.

The availability of land obtained shows the results of the calculation of the normalized WLC method for determining land suitability priorities. Land availability shows the entire area of Subang Regency that has not considered the Spatial Plan and land cover that can be converted into paddy fields, namely forests, shrubs, and fields. Multicriteria evaluation results based on GIS are visualized in figures 5(a) and figure 5(b). Figure 5(a) shows the availability of land suitable for paddy fields. Figure 5(b) shows the availability of land suitable for paddy fields that choose LULC (land use/land cover) in the forest, shrubs, and moor / fields.

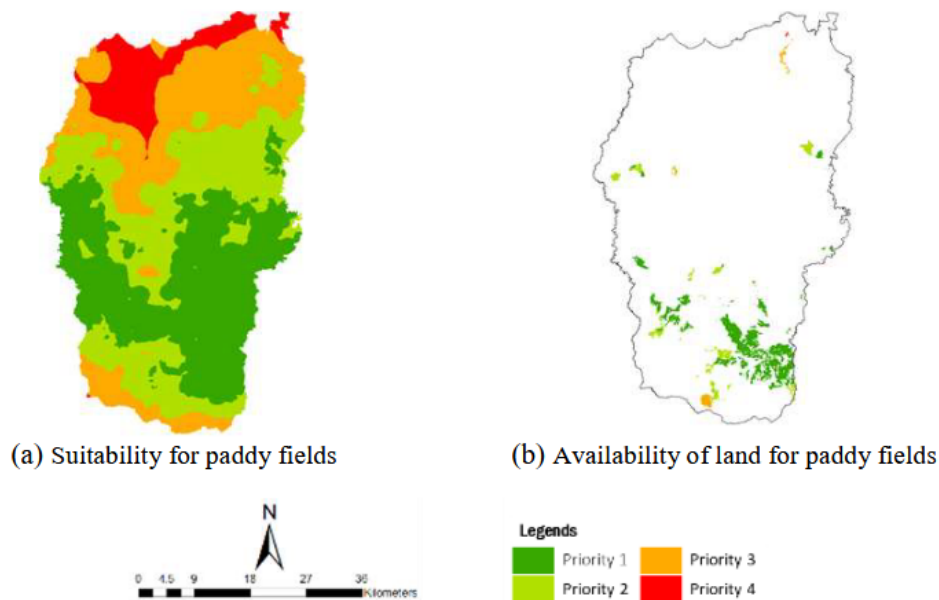


Figure 5. Land suitability and availability of land that can be used for the extension of paddy fields.

4. Conclusion

Land suitability evaluation for paddy fields in the Subang regency found 158,121 hectares of land suitable for paddy fields. The land area suitable for paddy fields is divided into 4 priorities, namely 76,115 hectares of high priority land (48.14%), moderate priority 7,165 hectares (4.53%), low priority 55,280 hectares (34.96%), and an area of 19,561 hectares of land (12.37%) which is not recommended. The available land is then stacked with the Urban Planning. The results of elimination using the Spatial Plan show that the land suitable for paddy fields covering 9,885 hectares, with a composition of 73.24% (7,240 hectares) of available land with high priority, 21.20% (2,096 hectares) of available land with moderate priority, 3.36% (530 hectares) of land available with low priority, and 0.19% (19 hectares) of land that is not recommended for paddy field extensification. There is an area of 9,885 hectares which is not the actual paddy field that has the potential to be developed into paddy fields. From the available land, an area of 9,336 hectares is high and moderate priority land. Subang Regency has the potential to increase paddy production from the addition of paddy fields from the availability of land acquired.

The results of land suitability analysis for paddy fields reflect the potential for expanding agricultural land use. In general, land evaluation based on multicriteria and GIS shows high potential to use in land use planning.

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