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Evaluation of Land Suitability of Horticultural Crops in Sembalun Sub-district, East Lombok Regency, Indonesia

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Abstract. This research aims to discover the data of land characteristic/quality, land suitability, limited factor, and improvement effort, directives of use and map of suitability for horticultural crops. The crops that are evaluated include red chili, onions, garlic, oranges, and apples. The selection of commodities is based on fluctuating production data, them are superior plant, and has a good market price. This research was conducted in November 2017 until January 2018 in Sembalun Lawang Village and Sembalun Bumbung Village, Sembalun Sub-district East Lombok Regency. Soil analysis was conducted in Soil Laboratory of Agriculture Faculty of Udayana Universit. It was analyzed using GIS modelling. Obtained six units homogeneous of land based on the result overlapped type of soil, land used and slopes, that is SBAISw, SBAIITg, SBAIVTg, SLHISw, SLHIITg, and SLHIVTg. The Land suitability assessment based on criteria requirements grew from Ritung et al., matchs with land characteristic/quality [1]. The result showed that the actual suitability class of land for horticultural crops was appropriate (S2) until they were not appropriate (N). Limited factors in the research area among others temperaturee (tc), rainfall (wa1), long dry months (wa), drainage (oa), textures (rc1), CEC (nr1), N-Total (na1), P2O5 (na2), slopes (eh1), and the dangers of erosion (eh2). Improvement of land suitability class can be done with improvement effort except temperaturee, long dry months and texture because they are permanent divider. Giving organic materials can improve soil physical and chemical properties. Slopes and the dangers of erosion can be improved by conservation tehcniques such as terracing. Class of potential land suitability was appropriate (S2) until they were marginal appropriate (S3). Land use of recommendations on SBAISw, SLHISw, and SBAIITg land are red chilli, garlic, and onion. SLHIITg, SBAIVTg, and SLHIVTg recommended for red chili, orange and apple crops based on agro-ecosystem, agroeconomic, and field observation.

Keywords: *Land suitability, Land evaluation, horticultural crops.*

1. Introduction

Land evaluation is one alternative that can be used in the effort of land resource utilization. Land evaluation is a process of estimating the potential of land resources for various uses by comparing the requirements required for a land use with the characteristics of existing resources on the land.Sembalun Sub-district is one of the biggest horticultural crops in East Lombok regency. The area of Sembalun sub-district is 21,708 ha with land use for 1155 ha of paddy field, 928 ha of fields, 411 ha of plantation, 565 ha of community forest and 18,649 ha of non-agricultural land [2]. Sembalun Lawang and Sembalun Bumbung villages are centers of horticultural crops production in Sembalun Subdistrict with a total area

of 60% of Sembalun District. Sembalun Lawang Village and Sembalun Bumbung Village are at an altitude of 1100 - 1300 mdpl, with an average rainfall of 2000-2500 mm / year.

Based on data from East Lombok Regency BPS, the production of horticulture crops such as red chili, garlic, onion fluctuated [2]. The production of citrus crops has continued to increase over the last five years. The type of citrus cultivated in Sembalun Sub District is Keprok Batu. Data for the production of apple crop in Kecamatan Sembalun not yet available, because it is still under development since last three years. Types of apples developed by the Department of Agriculture Food Crops and Horticulture NTB Province are varieties Anna and Manalagi.

Evaluation of land suitability for red chili, garlic, onion, orange, and apple commodities was conducted due to the unavailability of data on the characteristics and quality of the research area, as well as information on the suitability of the commodity land has not been evaluated. The selection of these commodities is based on fluctuating productivity, favorable economic value, and these commodities are some of the main commodities in Sembalun District. As for the apple commodity selected because it is a new type of plant developed in Sembalun District. In addition, the land suitability evaluation is conducted to determine the appropriate land use management and land use measures to improve the productivity of the land, especially in the villages of Sembalun Lawang and Sembalun Bumbung.

2. Methodology

2.1. Area of Study

The total area of the research area is 109.26 km^2, with total area of rice field 22.09 km^2 and total area of field 77.12 km^2. Land use for rice field and field in Sembalun Bumbung Village is 17.50 km^2 and 40.07 km^2 and in Sembalun Lawang Village is 4.59 km^2 and 37.05 km^2 [3]. Based on the result of overlay map of type of soil, land use, and slope is obtained six units of land. Characteristics of homogeneous land units and maps of research areas are presented in Table 1 and Figure 1.

Table 1. Characteristics of Homogeneous Land Unit

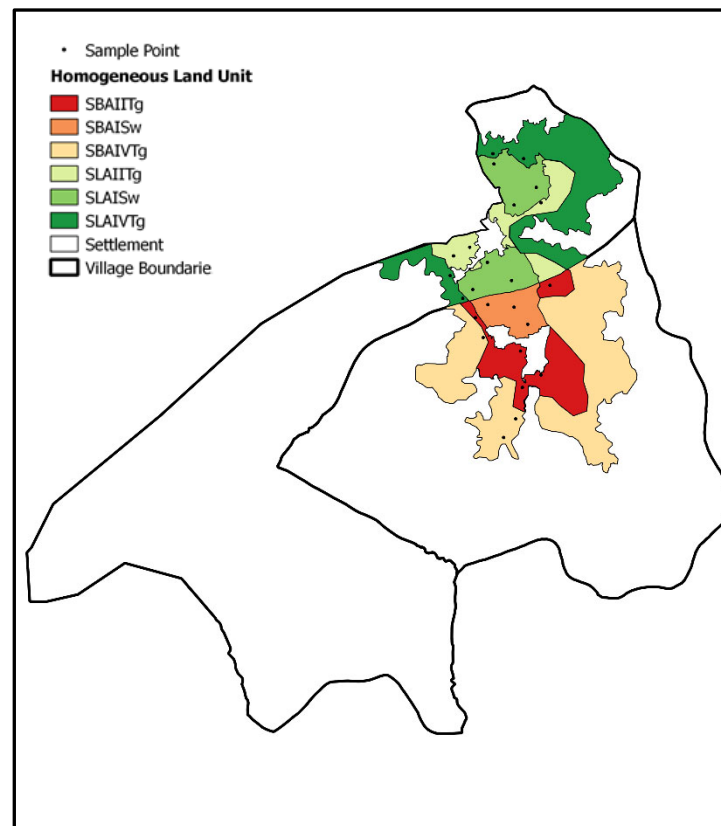| No.	SLH	Research Area	Type of Soil	Slope (%)	Landuse
1.	SBAISw	Sembalun Bumbung	Andosol	0 – 3 %	Rice Field
2.	SBAIITg	Sembalun Bumbung	Andosol	3 – 8 %	Field
3.	SBAIVTg	Sembalun Bumbung	Andosol	15 – 30 %	Field
4.	SLHISw	Sembalun Lawang	Andosol	0 – 3 %	Rice Field
5.	SLHIITg	Sembalun Lawang	Andosol	3 – 8 %	Field
6.	SLHIVTg	Sembalun Lawang	Andosol	15 – 30 %	Field

Figure 1. Research Area

2.2. Tools and Material

The material used in this research is the earth map of Sembalun Subdistrict 1: 50.000 [4], Map Administration of Sembalun Subdistrict 1: 50.000 [5], Slope Map 1: 50.000, Landuse Map 1: 25.000 [6], Type of Soil Map 1: 50,000 [7], Satellite Imagery from Google Maps, soil samples, and chemicals for analysis in the laboratory.

The tools used in this research are a set of computers with QGIS 2.18 software application tools, ground drill, sample ring, shovel, abney level, altimeter, field blade, pH stick, camera, pH meter, sieve, pipette, erlemayer and oven.

2.3. Method of Implementation Research

This research was conducted using survey method and soil analysis in laboratory. Survey method was conducted to determine land condition based on homogeneous land unit (SLH) from overlay map of type of soil, land use, and slope for determination of sample point. Determination of sample point was done by purposive sampling technique. Sampling in slope areas is taken by slope transect system, while on flat area with grid system. The composite sample was then analysed in the laboratory to obtain data physical and chemical of soil.

The method of land suitability classification is done by assessment system of land suitability based on criteria Ritung et al. by matching the data characteristics and quality of the land on the requirements of growing the evaluated crop [1]. This land evaluation is carried out to the sub-grade class to obtain limiting factor information and improvement efforts undertaken. Evaluation of suitability is also done in agroeconomics to determine the feasibility level of farming. The result of agroeconomic and agroecosystem evaluation is used as a reference in making land use directives.

2.4. Research Stage

Stage of this research flow is divided into six stages, namely:

1. Preparation Phase

 a. Literature Study

   Stages of literature study is done by collecting of information and data related to the area of research and commodities to be evaluated. At this stage information about the growing requirements of plants to be evaluated, the condition of the research area in the form of climate data, production data, geography data, land use and maps.

 b. Determination of Homogeneous Land Units (SLH)

   Determination of homogeneous land units (SLH) is done to delineate land units that have the same properties hose. SLH is obtained by overlay and intersection of slope, soil type map, and land use map, then based on similarity of properties.

2. Preliminary survey

   The preliminary survey was conducted to check the accuracy of SLH that has been made, whether in accordance with the conditions in the field. If there are differences between SLH that has been established with the actual situation, then it can be done improvements.

3. Field Survey And Soil Sampling

   Field surveys conducted to determine the physical conditions in the field such as; land conservation management measures, effective depth, slope gradient, surface rock, rock outcrop, and drainage. Soil sampling at each SLH is three to five points. Soil samples were then composite for analysis in the laboratory. Sampling is taken up to a depth of 60 cm.

4. Soil Analysis Stage

   Soil samples obtained were then analysed in the laboratory to determine the quality and characteristics of the soil. Parameters analysed were C-organic by Walky and Black, N-total method by Kjeldahl method, soil surface texture by pipette method, soil pH using electrometric pH, P and K were available by Bray-1 method, salinity using EC meter, CEC and Saturation bases with NH4OAc extractor, erosion hazard using Universal Soil Loss Equation (USLE) equation.

5. Data Analysis Stage

   Data analysis at this stage is divided into two, namely analysis of agroecosystem and agroeconomic data tabulated into the form of tables to facilitate the evaluation. The tabulated agroecosystem data is the result of observation of physical condition of field and data of laboratory test result. Agroeconomic data were obtained from secondary data of farming feasibility and interview result with farmer in research area which cultivated some predetermined horticultural commodities.

 6. Evaluation of Suitability

   Evaluation of suitability of agro ecosystem in this research using matching method that is matching land characteristic with land use requirement or plant growth requirement [1]. Evaluation is done up to sub-grade level to get limiting factor information and improvement effort will be done.

   Evaluation of agroeconomic suitability is assessed based on the feasibility of farming by calculating B / C Ratio (Benefit Cost Ratio), ie comparison between income (Benefit = B) with total production cost (Cost = C). Within the limits of the value of B / C can be known whether a business is profitable or unprofitable [8] with the formula shows at Equation 1

   B / C ratio = Total Revenue (TB): Total Production Cost (TC)   (**Equation 1**)

    If B / C ratio> 1, business worth cultivating

    If B / C ratio <1, business is not feasible or loss

   7. Determination of Land Use Directives

Land use directives are based on the suitability of agroecosystem land (actual and potential land suitability) and agroeconomics as well as field observations as a reference for the development of horticultural crops in order to obtain optimal and sustainable land use benefits.

3. Result and Discussion

3.1. Characteristics and Land Quality

The average temperaturee regime in the study area was 21.22 ° C [8]. The study area has an average annual rainfall of 2.332,1 mm / year, 5 months dry months and an average humidity of 85% [9]. The drainage conditions are good on SLH SBAIITg, SLHIITg, SBAIVTg, and SLHIVTg with homogeneous soil color characteristics without spotting or rust and / or manganese as well as gley color (reduction) in layers up to ≥ 100 cm. In SLH SBAISw and SLHISw the drainage condition is somewhat retarded due to the presence of spots or rust and / or manganese as well as the color of the gley (reduction) in the ≥ 25 cm layer. All SLH in the study area had a total of 0% crude material, and a soil depth >100 cm. Soil texture on SLH SBAISw, SLHISw, SBAIVTg, and SLHIVTg is Sandy Loam (SL) / medium-sized sandy clay. SBAIITg and SLHIITg are Loam Sandy (LS) / Sand is somewhat coarse-grained sand.

The CEC value of the soil is low at intervals of 9.743 - 13.528 cmol. The basic saturation at all SLHs is very high, with intervals of 123.639% - 206.178%. In the study area the degree of soil acidity (pH) was between 6.45 (slightly acid) to 7.84 (slightly alkaline). The amount of C-organic in the study area was 2.50% - 5.17% including moderate to very high. Availability of N-total in the study area is very low to moderate, with intervals of 0.082% - 0.225%. The value of P2O5 (P-available) ranged from 2.518 mg / 100 g - 239,190 mg / 100 g including very low - very high. K-available at all SLH ranges between 170.353 mg / 100 g – 495.092 mg / 100 g including very high.

Salinity in the study area is very low. The dangers of erosion in the area are very light, and there is no puddle and long puddles. Rock outcrop and surface rock for five SLH is 0%, while SLHIITg SLH has rock and surface outcrop ranges of 3% and 2%. Based on field observations and analysis of soil samples in the laboratory, land characteristic and land quality can be seen in **Appendix 1**.

3.2. Evaluation of Land Suitability

3.2.1. Land Suitability for Red Chili Plants

The actual land suitability class for red chili plants in SLH SBAISw is S3wa1 (rainfall), SBAIITg is S3wa1.rc1.na1 (rainfall, texture, N-total), SLAISw is S3wa1.na2 (rainfall, P2O5), SLHIITg is S3wa1.rc1.na1.na2 (rainfall, texture, N-total, P2O5), SBAIVTg and SLAIVTg are Neh1 (slopes). Potential land suitability classes on SLH SBAISw and SLAISw are S2wa1 (rainfall), SBAIITg and SLHIITg are S3rc1 (texture), SBAIVTg and SLAIVTg are S3eh1 (slopes).

3.2.2. Land Suitability for Garlic Plants

The actual land suitability class for the garlic crop on SLH SBAISw, SLAISw, SBAIITg and SLAIITg is Nwa1 (rainfall), whereas in SBAIVTg and SLAIVTg is Nwa1.eh1 (rainfall, slope). Potential land suitability classes on SBAISw and SLHISw are S3tc.wa1 (temperaturee, rainfall), SBAIITg and SLAIITg are S3tc.wa1.rc1 (temperaturee, rainfall, texture), SBAIVTg and SLAIVTg are S3tc.wa1.eh1 (temperaturee, rain, slopes).

3.2.3. Land Suitability for Onion Plants

The results of land suitability evaluation for onion crops obtained the actual land suitability class on SLH SBAISw, SLAISw, SBAIITg and SLAIITg are Nwa1 (rainfall), whereas in SBAIVTg and SLAIVTg is Nwa1.eh1 (rainfall, slope). Potential land suitability classes on SBAISw and SLHISw are S3wa1 (rainfall), SBAIITg and SLAIITg are S3wa1.rc1 (rainfall, texture), SBAIVTg and SLAIVTg are S3wa1.eh1 (rainfall, slope).

3.2.4. Land Suitability for Citrus Plants

The actual land suitability for citrus trees in SLH SBAISw is S2wa2.oa.nr1.nr3.na1.eh2 (long dry month, drainse, CEC, pH, N-total, erosion hazard), SBAIITg is S3na1, (N-total), SLAISw is

S3na1.na2 (N-total, P2O5), SLAIITg is S3na2 (P2O5), SBAIVTg and SLAIVTg are S3eh1 (slopes). Potential land suitability classes in SLH SBAISw and SLAISw are S2wa2 (long dry months), SBAIITg and SLAIITg are S2wa2.rc1 (long dry month, texture), SBAIVTg and SLAIVTg are S2wa2 (long dry months).

3.2.5. Land Suitability for Apple Crops

The actual land suitability class for the apple plant on the SBAISw is S2tc.oa.rc1.nr1.nr3.na1.eh2 (temperature, drainage, texture, CEC, pH, N-total, erosion hazard), SBAIITg is S3rc1.na1 (texture (N-total, P2O5), SLAIITg is S3rc1.na2 (texture, P2O5), SBAIVTg and SLAIVTg are S3eh1 (slopes). SLAISw, SBAIVTg and SLAIVTg are S2tc.rc1 (temperature, texture) grade, SBAIITg and SLAIITg are S3rc1 (texture).

3.3. Limiting Factors and Assumptions of Effort Improvement

Based on the evaluation of land suitability of the research area, obtained the actual of land suitability and limiting factors for each SLH for each commodity are evaluated. This limiting factor can be improved, so the class of suitability can increase from N to S3 to S1. The limiting factor of temperature, texture and the duration of dry months cannot be improved because it is a permanent limiting factor. The rainfall factor can be improved by irrigation and planting time adjustment according to the plant growth phase. Improved retention and nutrient availability can be improved by the provision of organic and fertilizers such as NPK, urea, and TSP / SP-36. Slopes can be repaired by making terraces and reinforcing plants. Classes of actual and potential land suitability, limiting factors and improvement efforts are presented in Table 2.

Table 2. Limiting Factors and Improvement Efforts

No	Land Unit	Crops	Class Actual	Limiting Factor	Improvement Efforts	Class Potential
1.	SBAISw	Red chili	S3wa1	Rainfall	Planting time settings	S2wa1
		Garlic	Nwa1			S3tc.wa1
		Onion				S3wa1
		Citrus	S2wa2.oa.nr1.nr3.na1	Long dry months, drainage, CEC, pH, N-total		S2wa2
		Apple	S2tc.oa.rc1.nr1.nr3.na1	Temperature, , CEC, pH, N-total,	Drainage, Organic and fertilizer application	S2tc.rc1
2.	SBAIITg	Red chili	S3wa1.rc1.na1	Rainfall, Texture, N-total,	Planting time settings, fertilizer,	S3rc1
		Garlic	Nwa1	Rainfall	Planting time settings	S3tc.wa1.rc1
		Onion				S3wa1.rc1
		Citrus	S3na1	N-total	Fertilizer	S2rc1
		Apple	S3rc1.na1	Texture, N-total		S3rc1
3.	SBAIVTg	Red chili	Neh1	Slope	Conservation tehniques	S3eh1
		Garlic			Planting time settings,	S3tc.wa1.eh1
		Onion	Nwa1.eh1	Rainfall, Slope	Conservation tehniques	S3wa1.eh1
		Citrus	S3na1.eh1	N-total, Slope	Fertilizer, Conservation tehniques	S2wa2.eh1
		Apple	S3rc1.na1	Tekrtur, N-total	Fertilizer	S2tc.rc1.eh1
4.	SLHISw	Red chili	S3wa1.na2	Rainfall, P_2O_5	Planting time settings, fertilizer	S2wa1

		Garlic Onion	Nwa1	Rainfall	Planting time settings	S3tc.wa1 S3wa1
		Citrus	S3na2	P_2O_5	Fertilizer	S2wa2
		Apple	S3na2			S2tc.rc1
5.	SLHIITg	Red chili	S3wa1.rc1.na1.na2.eh2	Rainfall, Texture, N-total, P_2O_5, Bahaya erosi	Planting time settings, fertilizer, Conservation tehniques	S3rc1
		Garlic Onion	Nwa1	Rainfall	Planting time settings	S3tc.wa1.rc1 S3wa1.rc1
		Citrus	S3na1.na2	N-total, P_2O_5		S2wa2.rc1
		Apple	S3rc1.na1. na2	N-total, P_2O_5	Fertilizer	S3rc1
6.	SLHIVTg	Red chili	Neh1	Slope	Conservation tehniques	S3eh1
		Garlic			Planting time settings,	S3tc.wa1.eh1
		Onion	Nwa1.eh1	Rainfall, Slope	Conservation tehniques	S3wa1.eh1
		Citrus	S3eh1	Slope	Conservation tehniques	S2wa2.eh1
		Apple	S3eh1			S3rc1

3.4. Feasibility Analysis of Farming

The evaluation of agroeconomic suitability was assessed based on the feasibility of farming, using B / C ratio analysis. Based on the value of B / C ratio according to Pusdiklathut, horticultural crops evaluated can provide benefits to farmers with B / C ratio >1 [10]. If the B / C ratio <1, then the business is not feasible to cultivate. Agro-economic feasibility of each crop based on B / C ratio is presented in Table 3.

Table 3. Agroeconomic Feasibility

No	Crops	Value B/C	Feasibility of Farming
1.	Red chili	4.17	Feasible
2.	Garlic	1.69	Feasible
3.	Onion	2.89	Feasible
4.	Citrus	2.36	Feasible
5.	Apple	2.40	Feasible

3.5. Landuse Directives

Landuse directives are based on agro-ecosystem and agroeconomic suitability and field observations on each SLH. Land use directives are presented in Table 4 and Figure 3.

Table 4. Landuse Directives

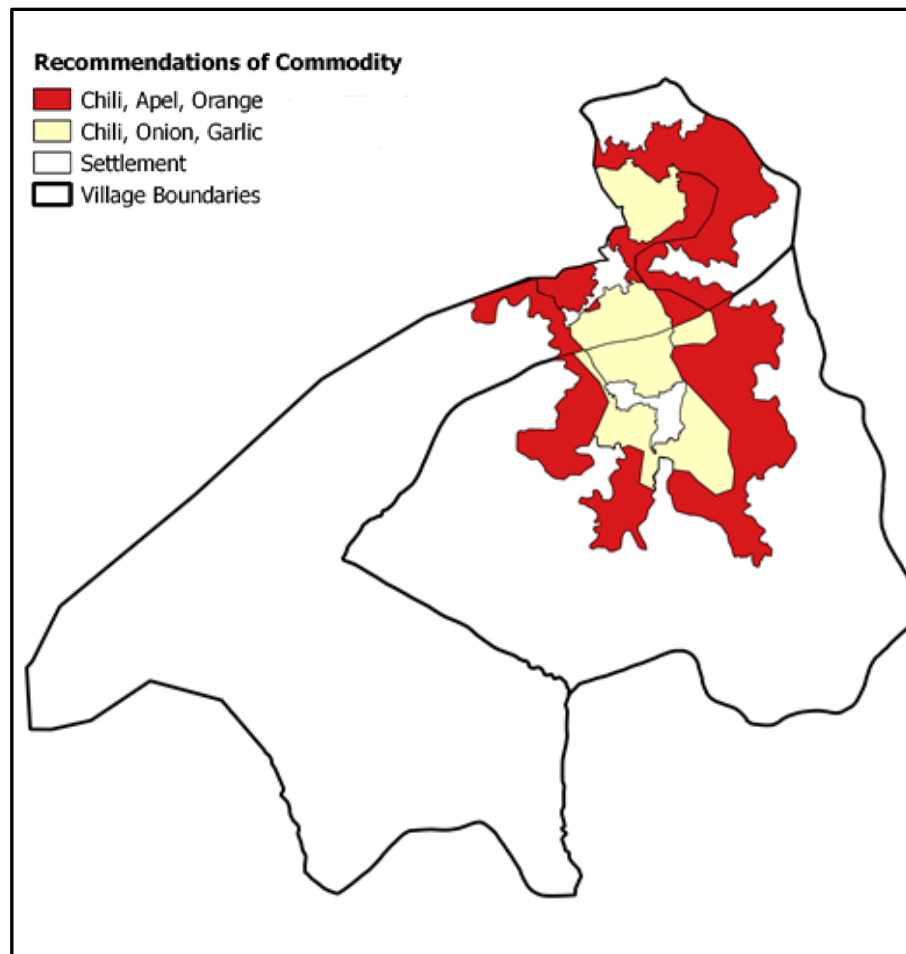| No	SLH	Suitability of Agroecosystem	Feasibility of Agroeconomy	Crops
1.	SBAISw, SLHISw and SBAIITg	S1	Feasible	Red chili, Garlic, Onion
2.	SLHIITg, SBAIVTg, and SLHIVTg	S1 S1	Feasible Feasible	Citrus dan Apple Red chili

Figure 3. Landuse Directive

4. Conclusions

The results of land suitability evaluation for horticultural crops in Sembalun District, as follows:

1. The actual suitability class for each unit of land for evaluated commodities is included in the S2 class (reasonably appropriate) to N (not appropriate), with limiting factors including temperature, rainfall, long dry months, drainage, soil texture, CEC, pH, N- total, P2O5, and slope. Some limiting factors such as temperaturee, long dry months, and soil texture are permanent limiting factors and can not be repaired. The assumption of improvement effort on rainfall limiting factor can be done by arranging the time of planting and irrigation aid, giving organic matter and fertilizer for nutrient retention limit factor (CEC and pH) and nutrient availability (N and P). The assumption of improvement effort on 15-30% slope can be done with conservation techniques such as terrace and reinforcement plants. Potential land suitability classes are included in the S2 class (reasonably appropriate) to S3 (corresponding marginally) with temperaturee limiting factors, rainfall, long dry months, soil textures, and slopes.

2. Land use directives on SBAISw (Sembalun Bumbung, 0-3% Rice field), SLHISw (Sembalun Lawang, 0-3% Rice Fields) and SBAIITg (Sembalun Bumbung, 3-8% crane slopes) for red chili, red onion , and garlic with a suitability agroekosistem S1 (very appropriate). The intercropped orange, apple and chilli pods are recommended on SLHIITg (Sembalun Lawang, 3-8% Calamity) with

suitable S1 agroecosystem, SBAIVTg (Sembalun Bumbung keSlopean 15-30% Tegalan) and SLHIVTg (Sembalun Lawang slope 15-30% Tegalan) with suitability of agroecosystem S2 (quite appropriate).

5. Acknowledgments

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Appendix 1. Land Characteristic and Land Quality of the Research Area

Land Characteristics / Land Suitability Classification (I)

No	Homogen Land Unit	Temperature (tc) (°C)	Water Availability (wa)			Drainage (oa)	Root Media (rc)			Hara Retention (nr)	
			Rainfall (wa1) (mm/thn)	Dry Month (wa2) (month)	Moisture (wa3) (%)		Texture (rc1)	Rough Material (rc2) (%)	Soil Depth (rc3) (cm)	Cation Exchange Capacity (nr1) (cmol)	Base Saturation (nr2) (%)
1	SBAISw	21,22	2.332,1	5	85	Somewhat Hampered	SL (s)	0	105	13.528 (R)	185,602 (ST)
2	SBAIITg	21,22	2.332,1	5	85	Good	LS (ak)	0	110	9.743 (R)	202,198 (ST)
3	SBAIVTg	21,22	2.332,1	5	85	Good	SL (s)	0	115	10.323 (R)	175,978 (ST)
4	SLAISw	21,22	2.332,1	5	85	Somewhat Hampered	SL (s)	0	105	12.168 (R)	123,637 (ST)
5	SLAIITg	21,22	2.332,1	5	85	Good	LS (ak)	0	110	9.862 (R)	141,938 (ST)
6	SLAIVTg	21,22	2.332,1	5	85	Good	SL (s)	0	120	9.246 (R)	206,178 (ST)

Land Characteristics / Land Suitability Classification (II)

No	Homogen Land Unit	Hara Retention (nr)		Available Hara (na)			Toxicity (xc)	Erosion Hazard (eh)		Flood Hazard (fh)		Land Preparation (lp)	
		pH H2O (nr3)	C-organic (nr4) (%)	N Total (na1) (%)	P2O5 (na2) (mg/100 g)	K2O (na3) (mg/100 g)	Salinity (xc) (dS/m)	Slope (eh1) (%)	Erosion Hazard (eh2)	Inundation Height (fh1) (cm)	Inundation Length (fh2) (day)	Surface Rock (lp1) (%)	Rock Outcroop (lp2) (%)

1	SBAISw	7,84 (AA)	4,22	0,129 (R)	33.35 (T)	330.086 (ST)	0.32	0-3 %	0.0001 (SR)	-	-	0	0
2	SBAIITg	7,67 (AA)	2,50	0,082 (SR)	50.906 (ST)	198.072 (ST)	0.05	3-8%	0.0490 (SR)	-	-	0	0
3	SBAIVTg	6.63 (N)	2,87	0.129 (R)	136.536 (ST)	357.101 (ST)	0.17	15-30%	0.2295 (R)	-	-	0	0
4	SLAISw	6,45 (AM)	5,17	0,097 (SR)	2.518 (SR)	274.657 (ST)	0.08	0-3%	0.0002 (SR)	-	-	0	0
5	SLAIITg	7,78 (AA)	3,31	0,225 (S)	4.477 (SR)	170.353 (ST)	0.08	3-8%	0.0041 (SR)	-	3	2
6	SLAIVTg	7.58 (N)	3.55	0.131 (R)	37.021 (ST)	326.162 (ST)	0.06	15-30%	0.2219 (R)	-	-	0	0