



*Research Paper*

**SPREAD OF AGRICULTURE OF CRITICAL LAND USING LAND  
EVALUATION FRAMEWORK APPROACH IN WELANG WATERSHEED,  
INDONESIA**

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**Abstract**

*Land degradation has become a global issue of the world, which leads to critical land conditions. If the distribution of critical land agriculture can be known, it will make it easier to formulate sustainable land use. This research was conducted in Welang Watershed, Pasuruan. The data attribute table of some combination of the results of the evaluation parameters of the land evaluation. In general, constraints on land criticality are identified as redox value and high number of microbes as the dominant parameter of land damage standard. In units of vegetable garden use for various uses such as for the cultivation of cabbage, potatoes and carrots, while mixed gardens on land criticality have a class of ability III for uncritical land and a critical potential to be somewhat critical of having an IV capability class, with annual crops for example coffee, cloves and durian. The classification of soil fertility capabilities in the vegetable garden land use unit as a whole has a high cation exchange capacity. Assessment of land suitability on the condition of vegetable garden and mixed garden land at various level of land criticality and adjusting to the desire of the farmer appears for vegetable crop only cabbage, potato and carrot for which farmers want while for plant mixture of coffee, clove and durian which appear in highland region . Farmer awareness and government intervention are expected to improve farmers' living standards from the agricultural sector while maintaining sustainable land for sustainable agriculture.*

Key words: Soil Damage, Soil Capability, Soil Fertility, Land Suitability and Agriculture's of Critical Land.

## INTRODUCTION

Land degradation has become a major issue in recent years, due to its impact on agricultural productivity decline, environmental degradation, quality of life and a decline in soil quality (Sklenicka, 2016). Land and agricultural activities should be an integral package, as increasing agricultural intensification will alter the soil condition of an agroecosystem, thereby causing the loss of biodiversity of soil organisms. This is due to the decrease in the number and diversity of organic input into its food chain, and the availability of chemicals and micro climate modification (Van Noordwijk and Hairiah 2006). Sklenicka (2016), adds the cause of land degradation has not been discussed comprehensively in terms of typology, relevance, or possible impact. In fact, the terminology is not realized, because in addition to the commonly used causes of the term (Stocking and Murnaghan, 2001; Nachtergaele et al., 2011; Nkonya et al., 2011), some researchers agree that even land degradation if periodic leads to conditions critical land.

Sitorus (2003) argues that critical land is a land that is not currently or less productive in terms of agricultural use, as its use does not or underestimate land conservation rules. At this critical land there are one or more factors that impede its utilization. Looking at data from the Indonesian Ministry of Environment and Forestry Statistics in 2015, this country is basically stated in the critical land hazard situation because in 2013 it is known that critical land critical with a critical level of 19,564,909 Ha, while at a very critical level is 4.631. 250 Ha. Critical land in watershed can be used as an indication that most of the land within the watershed is classified as critical, as a result of the carrying capacity of its land resources is no longer supported, such as its ability to store extremely low water, so that almost all rainfall falls over the surface of the ground into surface flows, and then goes into the river.

As is known by the high rainfall and intensity of land use, it has resulted in the loss of soil organic matter, soil structure damage, and increasing soil density. The soil's ability to dissolve the water (infiltration) into the soil section becomes diminished. When rain occurs in high frequencies, it can cause the soil to be saturated, so that all rainwater falling on the surface of the earth will be surface flow, and into the water or river (Amri, et.al, 2014). Similarly, in the dry season there is almost no rain falling on the watershed, or even if there is rain, rainwater falling over the ground does not penetrate into the soil due to dry soil, or evaporate back into the atmosphere (evaporation and transpiration). In addition, on critical land characterized by low or marginal soil fertility. These lands generally have marginal land suitability for various agricultural commodities, if these lands are used for agricultural cultivation including plantations, and carried out without proper and proper management, the fertility of the soil will continue to decline, and sooner the land become critical.

Where critical agricultural land distribution is known, it makes easier to determine natural protection and conservation measures for low carbon green development efforts, recovery efforts, and enhancing forest and land functions through the application of soil and water conservation can even formulate sustainable land use planning. Research questions that can be asked are *"How the mechanism of soil damage, soil capability, soil fertility and land suitability in describing the critical land agricultural in Welang watershed on comprehensive and interrelated point of view"*.

## MATERIALS AND METHODS

The research was conducted from July to November 2016 at Welang River Watershed, Pasuruan Regency. Materials used in this study include support maps (soil

type, rainfall, land use, terrain), and soil sample analysis materials in the laboratory. Tools used in this study include soil drill, sample ring, marker, scrup, field knife, label paper, and laboratory analysis tools. Implementation of the research is done with several steps are :

- a. **Preparation**, consisting of activities: Identification of the potential standard of damage, ability, fertility and land suitability from secondary data obtained from BPDAS Brantas, BAPPEDA Pasuruan Regency and Regional Spatial Plan (RTRW) of Pasuruan Regency 2010-2014; Determination of survey survey points taken at critical critical level to a rather critical and unit of land use of vegetable gardens and mixed orchards in the highland, and preparation of tools and materials required for field surveys.
- b. **Ground Check**, Checking in the field aims to observe the actual conditions of land use to support the validation and verification of the results of the analysis, especially in relation to the correction of agricultural in critical land. Sampling is done on the basis of consideration of limiting factors in land use.
- c. **Finishing**, Analytical samples of soil after drying are allowed in the laboratory to obtain quantitative quantities both physical, soil chemistry and soil biology. Physical properties of the soil analyzed include permeability, texture, porosity, volume weight. Chemical properties of soil analyzed include N, P, K, KTK, KB, BO, pH H<sub>2</sub>O, redox and electrical conductivity. The biological properties of the soil analyzed are the number of microbes for fungi and bacteria. The results of the data interpretation stage then the results of the results are presented systematically in the form of critical agricultural land distribution data from standard parameters of damage, capability, fertility and land suitability. In this stage, the attribute table data from some of the analysis results will be exported to Microsoft Excel 2013.

**Table 1. Critical Land Class Indexing (ILC)**

No.	Level of Critical	ILC
1.	Heavy Critical	120-180
2.	Critical	181-270
3.	Rather Critical	271-360
4.	Potential Critical	361-450
5.	Not Critical	451-500

Source: Ministry of Forest (2013).

## RESULT

### Existing condition of Welang Watershed

The Welang watershed is identified with an area of 518 km<sup>2</sup> and is one of the BPDAS working areas. Astronomically terrestrial watershed Welang are between 112°37'30 " - 112°52'30 " East Longitude and 7°37'20 " - 7°52'30 " South Latitude. BPDAS Sampean working area covers an area of 1,732,877.32 ha. Welang watershed is one of many watersheds that experience land degradation phenomenon to critical land. Welang watershed is part of the hydrological cycle precisely situated east of Pasuruan District, with the main rivers flowing from its southern highlands to the south, receiving streams from its tributaries in the central region and boiling in the Madura Strait which is the boundary north of Pasuruan district. Welang River is the largest river catchment area of 518 km<sup>2</sup>, as well as the longest 36 km and the width of 35 m, but the stream flow is still lower than the Rejoso River which has a smaller catchment area. This is due to the relatively short length of the Rejoso River, resulting in a short time of concentration and large flow discharge as well as rapidly to the finish. This can be seen

from the floods occurring in this estuary, which is larger than at the estuary of the Welang River.

### Soil Damage

Agricultural land's shifts many functions into non-farm land, as a result of farming activities shifting to critical land requiring high and expensive inputs to produce quality food products. Ground damage is the loss or decline of soil function, either as a source of plant nutrients and as a matrix where the root grows in anchor and where the water is stored. Codes for measuring land degradation because of human action in the areas of agriculture, plantations, forestry, and urban parks have been regulated in LH Reg. 07 of 2006. In Government Regulation No. 150 Year 2000, land degradation is the change in the nature of the soil that exceeds the standard criteria of soil damage in the soil condition at a certain place and time which is judged based on the standard criterion of soil damage. Criteria for ground damage are referred to the Government Regulation of the Republic of Indonesia No. 150 Year 2000.

The standard evaluation of land degradation in two land use units in the highlands has a difference, for every land use unit shows a high degree of land damage on a range of land criticalities with only one parameter but there are also more than one parameter of land damage, diverse. Vegetable gardens are based on (table 2.) Vegetable vegetable gardens show a critical overall with different constraints of parameters for a range of critical land. Redox that needs to be considered is 64.44. mv because redox indicates an indicator of the reduction process associated with poor soil conditions or when there is excess water. Ground redox conditions affect the stability of iron and manganese compounds, Eh values are the most important identifiers in evaluating the status of the element in the soil. Based on the relationship between soil properties and plant growth when the redox value is too low the plant in growth can be disturbed with a critical threshold value of less than 200 mv and for all critical land uses constraints in redox conditions.

The next constraint parameter for a unit of land use of vegetable garden in non critical areas is the number of microbes in particular bacteria and indicated that the area of vegetable garden area is often sprayed with inorganic pesticides as well as somewhat critical area of the microbial number of mushrooms is also indicated as the non critical area with the use of excess pesticides.

The solution is to reduce the critical threshold for redox conditions by creating good drainage systems and the addition of organic materials by reducing intensive soil treatment and to reduce the use of inorganic pesticides by making natural or organic pesticides by utilizing local wisdom.

**Tabel 2. Recapitulation of Soil Damage in Highland**

No.	Land Use Unit	Level of Critical	Soil Damage Result	Detail Assesment
1.	Vegetable Garden	a. Not Critical b. Potential Critical c. Rather Critical	Critical Critical Critical	Redox dan Amount of microbes (bacteria) Redox Redox dan Amount of microbes (mushrooms)
2.	Mixed Garden	a. Not Critical b. Potential Critical c. Rather Critical	Critical Critical Critical	Redox Redox dan Amount of microbes (mushrooms) Redox

Source : Data Analyzed (2017).

Mixed gardens on a wide range of land criticality indicate critical land. Based on the condition of the land from the results of the laboratory analysis of the redox parameter is also a limiting indicator keritisan land, except for the critical potential number of microbes, especially mushrooms are also a constraint. The solution to fix the land is almost the same as the vegetable garden land use unit in addition to the organic material supply, drainage system improvement, land management must be in accordance with the efforts of land conservation including the making of terraces, planting annual crops in all the boundaries of the terrace, planting the crops in agroforestry , and reforesting land with a slope of more than 450 and providing extension to the public how important the source of springs and fertile soil for human life because it influences from upstream to downstream and reduces inorganic pesticides by utilizing local wisdom.

### Soil Capability

Classification of land capability is a classification of land potential for the use of various agricultural systems in general without explaining the designation for certain plant species or management measures. Atalay (2016) argued that the result of land capability evaluation is the grouping of land into classes determined by the biggest inhibiting factor of the land. Based on Table 2., it shows that the Land Utilization Unit of vegetable gardens of each land criticality has different categories of land capability. Class III for non critical and class IV for critical and somewhat critical potential. Land with classes of ability III and IV has a large fixed restriction of land in land use units This vegetable garden can still be planted with seasonal crops but very limited choice and must be accompanied by intensive soil conservation efforts and should be cultivated in a closed, It has a moderate to ugly drainage characteristic of a redox reaction having a deep effective depth but very easy surface erosion. Soils in grades III to IV at well-managed research sites are capable of producing and suitable for various uses such as for cultivation of common crops such as cabbage, potatoes and carrots according to land conditions corresponding to altitude.

Land in mixed garden land use units on land criticality has a class of ability III for uncritical land and a critical potential to be somewhat critical of having an IV capability class. Soils in mixed garden land use units are almost the same as vegetable garden land use units but are less erosive due to the many lands covered by many annual crops such as coffee, cloves and durian.

Alternatives to maintaining land tenure classes for both land use units on land criticality such as slopes, drainage and effective depth with terracing, irrigation and drainage systems appropriate to conservation of land for effective depth with minimal land management.

**Table 2. Soil Capability Recapitulation in Highland**

No.	Land Use Unit	Level of Critical	Soil Capabilities Result	Detailed Assessment
1.	Vegetable Garden	a. Not Critical	III	t1,i1,d1,k1,e1,b0,o0
		b. Potential Critical	IV	t2,i3,d1,k1,e2,b0,o0
		c. Rather Critical	IV	t1,i4,d2,k1,e2,b0,o0
2.	Mixed Garden	a. Not Critical	III	t3,i1,d1,k1,e1,b0,o0
		b. Potential Critical	III	t1,i1,d1,k1,e1,b1,o0
		c. Rather Critical	IV	t1,i3,d2,k2,e2,b1,o0

Source : Data Analyzed (2017).



Explanation :

t	: Texture	e	: Erosion
l	: Slope	b	: Pebble
d	: Drainage	o	: Flood Hazards
k	: Effective Depth		

### Soil Fertility

Soil fertility is a soil condition where the water, air, and nutrients are adequately balanced and available as needed by plants, both physical, chemical and biological soil. The soil has different fertility depending on the number of soil-forming factors that dominate the site: the parent material, the climate, the relief, the organism, or the time. The classification of soil fertility capability in the vegetable garden land use unit for different land criteria is different ie not critical critical, high critical potential and moderately critical. Overall it has a high cation exchange capacity because the cation exchange capacity (CEC) shows the size of the soil's ability to absorb and exchange cations. The higher the CEC, the more cations it can draw. The low soil CEC is determined by the content of clay and organic matter in the soil affecting soil fertility (Corwin and Lesch, 2005). For the overall saturation of the soil is low so it is always connected as a clue to the fertility of a soil. The ease in releasing entangled ions for crops depends on the degree of saturation of the base. The soil is very fertile if saturation of base > 80%, moderate fertility if saturation of base between 50-80% and infertile if saturation of base < 50%, overall saturation base between 20 to 35%.

The organic material varies from medium to low with a range of 1 to 3%. The role of organic matter can improve soil fertility, improve soil structure, improve soil holding capacity, increase soil pores, and improve soil microbial development media so that the soil plays an important role for plant growth. Phosphorus (P) element in all units of land use ranges from 3 to 30 ppm P<sub>2</sub>O<sub>5</sub> is car in plant, Phosphorus is macro nutrient and is essential for plant growth and component of every living cell, and tends to be more on seed and growing point, soil type factor also contributed to the high availability of elements, the type of soil andisol that exist on high land greatly affect by tying the elements in the soil becomes unavailable.

**Table 3. Soil Fertility Assessment in the Highlands**

No.	Land Condition based on Criticality	Soil Fertility Assessment of Vegetable Garden Plants				Result
		Parameters				
		KTK	KB	BO	P Available	
1.	KSTK	T	R	S	SR	Medium
2.	KSPK	T	R	R	T	High
3.	KSAK	T	R	R	S	Medium
No.	Land Condition based on Criticality	Soil Fertility Assessment of Mixed Garden Plant				Result
		Parameter				
		KTK	KB	BO	P Available	
1.	KCTK	T	R	R	SR	Low
2.	KCPK	T	SR	S	SR	Low
3.	KCAK	T	R	S	SR	Medium

Source : Data Analyzed (2017).

Explanation :

- KSTK : Not Critical Vegetables Garden
- KSPK : Potential Critical Vegetables Garden
- KSAK : Rather Critical Vegetables Garden
- KCTK : Not Critical Mixed Garden
- KCPK : Potential Critical Vegetables Garden
- KCAK : Rather Critical Vegetables Garden

Land use unit for mixed garden of low to moderate fertility level, for uncritical criticality and critical potency has low fertility rate while for moderately moderate problem with saturation problem in the range of 18 to 21% and P is available from low to very low with range 1.58 to 2.43 ppm P2O5.

Based on the overall land use unit (vegetable garden and mixed garden), the most dominant factors to be improved are basic saturation (KB) and P available element which have low element content so that to continuously increase the element by giving organic fertilizer and land utilization in accordance with the conditions and the ability of the soil to provide elements for the cultivated plants in a sustainable manner so that the productivity of the land can be maintained and the critical lands will increase as a percentage becomes uncritical.

### Land Suitability

Land suitability is a description of the level of suitability of a plot of land for a particular use. The level of suitability of a land based on the classification system with a category that is declining. First the order indicates a suitable land (S) or Inappropriate (N) for the development of a particular agricultural commodity. Both classes indicate the suitability of the land of each order, S1 (Very Suitable), S2 (Fairly Suitable), S3 (Marginal Suitable), N1 (Not Current) and N2 (Not Permanent). Assessment of land suitability on the condition of vegetable garden and mixed garden land at various level of land criticality and adjusting to the desire of the farmer appears for vegetable crop only cabbage, potato and carrot for which farmers want while for plant mixture of coffee, clove and durian which appear in highland region .

The cabbage plants that most farmers plant have an actual land suitability suit marginal (S3wa, nr) for uncritical land with constraints on water availability (rainfall) and nutrient retention (basic saturation), marginal critical potentials (S3wa, nr, eh) with constraints on water availability, nutrient retention and erosion hazards whereas somewhat critically, there is an inappropriate class (Neh) with a limitation on erosion hazard with a slope of more than 30%.

**Tabel 4. Land Suitability Assessment in the Highlands**

Land Conditio ns	Land Suitability for Vegetable Crops					
	Cabbage		Potatoes		Carrot	
	Actual	Potential	Actual	Potential	Actual	Potential
KSTK	S3wa,nr	S3wa	S3tc	S3tc	S3tc	S3tc
KSPK	S3wa,nr,eh	S3wa	S3tc,eh	S3tc	S3tc,eh	S3tc
KSAK	Neh	S3wa,eh	Neh	S3tc, eh	Neh	S3tc, eh

Land Conditio ns	Land Suitability for Mixed Garden Plant					
	Coffee		Clove		Durian	
	Actual	Potential	Actual	Potential	Actual	Potential
KCTK	S3wa,nr	S3wa	S3tc,nr	S3tc	S3wa	S3wa

KCPK	S3wa,nr,lp	S3wa,lp	Nnr	S3tc,rc,nr, lp	S3wa,nr,lp	S3wa,lp
KCAK	S3wa,rc,nr, eh,lp	S3wa,rc,lp	S3tc,rc,nr,e h,lp	S3tc,rc,lp	S3wa,rc,eh,l p	S3wa,rc,l p

Source : Data Analyzed (2017).

Explanation :

KSTK : Not Critical Vegetables Garden      tc : Temperature      nr : nutrients Retention  
 KSPK : Potential Critical Vegetables Garden      wa : Water Availability      eh : Flood Hazards  
 KSAK : Rather Critical Vegetables Garden      rc : rooting media      lp : Land preparation  
 KCTK : Not Critical Mixed Garden  
 KCPK : Potential Critical Vegetables Garden  
 KCAK : Rather Critical Vegetables Garden

Coffee plant is a plant that is often found in the highlands so that the main plant for the mixed garden, each land differentiation differences have different characteristics class that is not critical to have a suitability class according to marginal (S3 wa, nr) with limiting factors on the availability of water in particular rainfall (2000-3000 mm / yr) and nutrient retention, especially basic saturation (<35%), the critical potential is obtained marginally (S3wa, nr, lp) with limiting factors on water availability, nutrient retention and land preparation for somewhat critical grade suitability according to marginal (S3wa, rc, nr, eh, lp) with limiting factors on water availability, rooting media, nutrient retention, erosion hazard and land preparation.

Actual conditions obtained are limiting factors described among which there are factors that can be fixed or limiting factors that can not be fixed / permanent. The limiting factors that can be fixed in various land use units on various land criticalities are nutrient retention (nr) and erosion hazard (eh) whereas irreversible or permanent limiting factors are water availability (wa), rooting medium (rc), and preparation (lp) whereas if they have been repaired for the future there will be a potential class of land suitability.

Based on the results of the analysis shows the increasing criticality of the land from uncritical to critical potential and somewhat critical It seems the limiting factor is so increasing that the land is more critical it is very necessary once handlers repair and maintenance of land in an integrated by looking at all aspects of land constraints problems so that the land is kept awake fertility, ability, and productivity.

### Interrelation of Critical Land Evaluation Parameters on Agricultural Land's Spread

Based on the result of the observation, the overall assessment on table 5 of vegetable garden land use is not critical of the condition of the land is still better to be cultivated cabbage plants although the land is in critical condition and the ability of medium grade III fertility land and although actual land suitability there are still obstacles on the level of water availability on the rainfall is high enough and the availability of nutrients is somewhat less, so if still cultivated cabbage plants it is still very need very improvement of a comprehensive and integrated.

Coffee plants are the main crops for mixed crops are not critical and seen from the overall assessment table can still be utilized to be developed almost the same as cabbage plants although the level of compliance is still appropriate marginal (S3) but when compared with the level of criticality others fewer obstacles and land improvement, economically the cost is also less and automatic income increases.



**Tabel 5. Evaluation Results of Land Evaluation Parameters**

No.	Land Condition	Evaluation Results					Plant
		Soil Damage	Soil Capabilities	Soil Fertility	Land Suitability		
					Actual	Potential	
1.	KSTK	Critical	III	Medium	S3wa,nr	S3wa	Cabbage
2.	KSPK	Critical	IV	High	S3wa,nr,eh	S3wa	
3.	KSAK	Critical	IV	Medium	Neh	S3wa,eh	
4.	KCTK	Critical	III	Low	S3wa,nr	S3wa	Coffee
5.	KCPK	Critical	III	Low	S3wa,nr,lp	S3wa,lp	
6.	KCAK	Critical	IV	Medium	S3wa,rc,nr,eh,lp	S3wa,rc,lp	

Source : Data Analyzed (2017).

Explanation :

- KSTK : Not Critical Vegetables Garden
- KSPK : Potential Critical Vegetables Garden
- KSAK : Rather Critical Vegetables Garden
- KCTK : Not Critical Mixed Garden
- KCPK : Potential Critical Vegetables Garden
- KCAK : Rather Critical Vegetables Garden

Land conditions that have hilly topography with proper land management with land conservation rules, continuous nutrient administration and more organic pesticide use are expected for all land criticisms. It is expected that the process of decomposition and supply of nutrients by beneficial bacteria and fungi can work properly and social economic factors also become a problem so that the awareness of farmers and government intervention is expected to improve the living standards of farmers from the state deficit agricultural sector while maintaining the sustainability of land to sustainable agriculture.

## CONCLUSION

1. Vegetable gardens show a critical overall with different parameter constraints for various land criticalities, among all redox values and high number of microbes is the dominant parameter of land critical indicators. Whereas, in mixed garden from laboratory analysis the redox parameter also becomes limiting land keritisan indicator, except for critical potency of microbial quantity especially mushroom as constraint.
2. Vegetation garden land every land criticality has different categories of land capability. Class III for non critical and class IV for critical and somewhat critical potential. Ground in class III to IV at the study site for various uses such as for planting cabbage, potatoes and carrots because appropriate land conditions in accordance with the height of the area. Similarly with mixed garden land use units on a wide range of land criteria have a third ability class for uncritical land and a critical potential to be somewhat critical of having an IV capability class, with fewer erosion traits because of the many lands covered by the number of annual crops such as coffee, cloves and durian.
3. The classification of soil fertility capability in the vegetable garden field use unit as a whole has a high cation exchange capacity because the cation exchange

capacity (KTK) shows the measure of the soil's ability to absorb and exchange cations. Land use unit for mixed garden of low to moderate fertility level, for uncritical criticality level and critical potential have low fertility level while to moderately moderate with problems of basic saturation.

4. Assessment of land suitability on the condition of vegetable garden and mixed garden land at various level of land criticality and adjusting to the desire of the farmer appears for vegetable crop only cabbage, potato and carrot for the desired farmers while for plant mixture of coffee, cloves and durian that appear in the region highland.

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