

## Evaluation of Land Capability for Agriculture in the Upstream of Jeneberang Watershed, South Sulawesi

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**Abstract:** Land utilization especially sloping land should be based on land capability. Land capability should be classified based on their potential for general agricultural utilization without causing damage in the long term. Land utilization in the upstream of Jeneberang watershed should be based on its land capability. Soil types found in the upstream of Jeneberang watershed were Inceptisol, Ultisol, Alfisol and Oxisol, with the slope of ramp too steep. Classifications of land capability in this location were grade II (27.39%), III (33.16%), IV (30.55%), VI (8.45%) and VII (0.45%), with dominant limiting factors were erosion hazard (e), barriers of rooting zone (s) and drainage (w).

**Key words:** Land capability • Limiting factors • Sloping land

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### INTRODUCTION

Land basically has different abilities to support a specific use. To determine the ability of an area it is necessary to conduct land capability classification. Land capability classification is land valuation with systematic component and grouping into categories based on nature of which is the potential and constraints in its use of sustainable [1, 2]. The ability here is seen as the capacity of land to a kind or level of common usage.

Land with high capability expected great potential for a variety of uses, making it possible to effectively use a wide range of activities. To maintain the productivity of the land what is needed is a way of appropriate management in order to achieve optimal productivity and not cause damage to the land [3]. In accordance with the nature and the limiting factor, the land has usability different from one another [4, 5]. On determining land capability class, the nature and the limiting factor are used that determines whether or not the soil is easily processed if the land is used as an agricultural business [6]. Nature

of the land and limiting factors that influence the ability of land in one place can be influenced by rock, climate, soil, land form, length and slope and processes at work in the land [4].

Upstream Jeneberang watershed condition with the potential existing land, either already utilized or not utilized is the basis for the development of Gowa district, especially for agriculture. Potential of existing land when there is no special attention will forever be a potential output, that is, not important and beneficial product. One of the potentials of Gowa district is potential agricultural land located in the upper Jeneberang watershed.

But now that potential has not been optimally arranged, therefore there is no outstanding contribution. Therefore, for the expectation to be realized, it requires an effort in order to know for certain about the potential of land upstream that is Jeneberang watershed. This is a way to determine the ability of land as well as how land suitability can be modified so as to produce the maximum production [7]. Evaluation of the ability of upstream land needs to be done so that Jeneberang watershed land use

can be adapted to land capability. Thus, land degradation can be minimized and land use is sustained.

## MATERIALS AND METHODS

The study was conducted in upstream Jeneberang watershed, Gowa district, South Sulawesi Province, Indonesia. The study of characterization, delineation and analysis of land units in the study carried out in several stages are as follows: The maps used include soil type maps, elevation maps and topographic maps at a scale of 1:50.000 upstream of Jeneberang watershed. Differentiation regions based on temperature and precipitation divided and bounded by the lower altitude of 700 m above sea level and higher than 700 m above sea level, For topographic maps, delineation of regions based on the slope can be divided into >40%, 25-40%, 15-25%, 8-15% and <8%.

To map soil type, soil unit using soil map units on the type of soil in the study site. The overlay on the type of soil maps, topography maps and elevation maps obtained land unit map at a scale of 1:50.000. With the scale of 1:50.000 the smallest unit of land on the map is equivalent to 25 ha on the field. Administrative maps with a scale 1:50.000 are obtained from the local government of Gowa district. They are used to delineate the boundaries for local government as well as integrating biophysical information with information about the social, economic, cultural and institutional aspects.

Observations and data retrieval on soil properties and land for the purpose of land evaluation are performed on each unit of land. Soil properties and land use in the field evaluate the physical and morphological properties that include land and land properties that can be directly observed in the field. Land capability class is based on its potential for general farm without causing any damage in the long term [4]. Soil physical properties and morphology were observed for grade level, including slope, erosion sensitivity, depth of solum, soil structure, the state water logging, drainage, presence of rock on the surface and salinity. For sub-division classes, those observed include erosion, waterlogging, inhibitor of the plant roots and climate [1].

The system of land capability classification used the USDA system, which is expressed in the Agricultural Handbook No. 210 [8]. Land capability classification is done through a sub-class category based on intensity of inhibiting factor. Land is classified into eight classes, namely Classes I to VIII, threat of damage or increased resistance in a row of Classes I to VIII [9]. Land in grades

I to IV, with good management are able to generate suitable variety of uses. Land in grades V, VI and VII correspond to pasture, plant trees or native vegetation respectively. Class VIII of land should be left in its natural state.

Grouping into sub-classes are based on the types of constraint. There are four main types of barrier erosion threats, the threats of excess water, limiting root development and climate constraints [1, 7]. Other obstacles or threats are caused by erosion, excess water as well as limiting root development (shallow soil, surface rocks, low water holding capacity, salinity or salt content). These threats can be changed or partially mitigated and they limit the precedence of the climate which in turn will determine the subclass which is given signs such as e, w or s. Lands with no barrier but having climatic condition are characterized as subclass c.

## RESULTS AND DISCUSSION

**Determination of Land Unit:** Land unit is a unit of lands that has similar characteristics. The unit was formed based on common land slope, soil type and altitude. Results overlay (overlap right) map soil type, slope maps and elevation maps in upper watershed areas of Jeneberang acquired 55 units of land maps. There are 28 units of land in the upper watershed areas of Jeneberang used as a horticultural crop of fruits and vegetables and 20 units of land under cultivation of horticultural crops including vegetables located in upland (> 700 m asl), while 8 SLH horticultural crops planted have fruit plants located in lowland (<700 m asl). Soil type, slope, altitude and area of each land unit are presented in Table 1.

The land area which is categorized as lowland (altitude <700 m asl) is 14,842.00 ha and is divided into 8 units of land. While the land area which is classified as upland (elevation > 700 m asl) is 16,177.60 ha and is divided into 20 units of land. The total area of land which is expected to be used for horticultural crop farms is 31,019.60 ha. The soil types that are found in the study site are Inceptisol, Ultisol, Alfisol and Oksisol, of which the slope of the ramps is too steep (Table 1).

**Physical Characteristics of the Land in the Watershed Upstream of Jeneberang:** Physical characteristics of the land in the watershed upstream of Jeneberang include slope, erosion sensitivity, effective soil depth, soil texture, permeability, drainage, water supply, land surface rocks and exposed rocks. Existing information is used to derive

Table 1: Number and area of land unit in the upstream watershed of Jeneberang based on soil type, slope and altitude classes

No. Land Unit	Smpl Code	Soil Type	Slope Class (%)	Altitude (m asl)	Area (ha)
17	PL1	Dystropepts	<8	< 700	2,232.33
18	PL2	Dystropepts	8 - 15	< 700	396.04
19	PL3	Dystropepts	15 - 25	< 700	106.94
30	PL4	Tropohumults	<8	< 700	4,044.18
32	PL5	Tropohumults	8 - 15	< 700	3,563.59
34	PL6	Tropohumults	15 - 25	< 700	4,295.81
36	PL7	Tropohumults	25 - 40	< 700	149.96
44	PL8	Tropudults	25 - 40	< 700	53.15
6	SP1	Tropudalfs	<8	= 700	934.86
7	SP2	Tropudalfs	8 - 15	= 700	1,532.61
9	SP3	Tropudalfs	15 - 25	= 700	397.10
11	SP4	Tropudalfs	25 - 40	= 700	72.05
12	SP5	Dystrandepts	<8	= 700	323.55
13	SP6	Dystrandepts	8 - 15	= 700	1,438.33
14	SP7	Dystrandepts	15 - 25	= 700	1,713.96
15	SP8	Dystrandepts	25 - 40	= 700	1,311.41
16	SP9	Dystrandepts	> 40	= 700	138.94
23	SP10	Humitropepts	8 - 15	= 700	2,030.35
25	SP11	Humitropepts	15 - 25	= 700	2,102.28
27	SP12	Humitropepts	25 - 40	= 700	429.35
39	SP13	Tropudults	<8	= 700	501.34
41	SP14	Tropudults	8 - 15	= 700	1,128.17
43	SP15	Tropudults	15 - 25	= 700	602.25
45	SP16	Tropudults	25 - 40	= 700	425.08
49	SP17	Haplorthoxs	<8	= 700	459.16
51	SP18	Haplorthoxs	8 - 15	= 700	197.26
53	SP19	Haplorthoxs	15 - 25	= 700	260.65
55	SP20	Haplorthoxs	25 - 40	= 700	178.90
Total					31,019.60

Table 2: Physical and morphological characteristics of land in upstream Jeneberang watershed

Code Land Unit	Slope	Erosion	Depth Soil	Textur	Permeability	Drainage	Availability of Water	Rock Surface	Rock Exposed
PL1	Declivous	Slihgt	Medium	Fine	Medium	Passable	Medium	Slightly	No
PL2	Rather Tilt	Medium	Medium	Few fine	Slow	Passable	Medium	Slightly	No
PL3	Tilt	Few Heavy	Medium	Fine	Few slow	Passable	Medium	Slightly	Slightly
PL4	Declivous	Slihgt	Medium	Fine	Few slow	Passable	Medium	Slightly	No
PL5	Rather Tilt	Medium	Medium	Fine	Medium	Passable	Medium	Slightly	No
PL6	Tilt	Few Heavy	Medium	Few fine	Medium	Passable	Medium	Slightly	Slightly
PL7	Rather steep	Heavy	Shallow	Fine	Few slow	Passable	Medium	Slightly	Slightly
PL8	Rather steep	Heavy	Shallow	Fine	Slow	Passable	Medium	Slightly	Slightly
SP1	Declivous	Slihgt	Medium	Fine	Few fast	Good	Good	Slightly	No
SP2	Rather Tilt	Medium	Medium	Fine	Medium	Good	Good	Medium	No
SP3	Tilt	Few Heavy	Medium	Fine	Medium	Good	Good	Medium	No
SP4	Rather steep	Heavy	Shallow	Fine	Medium	Good	Good	Medium	No
SP5	Declivous	Slihgt	Medium	Medium	Few slow	Good	Good	Slightly	No
SP6	Rather Tilt	Medium	Medium	Medium	Medium	Good	Good	Slightly	No
SP7	Tilt	Few Heavy	Medium	Medium	Medium	Good	Good	Medium	No
SP8	Rather steep	Heavy	Shallow	Few fine	Medium	Good	Good	Medium	No
SP9	Curam	Very Heavy	Medium	Medium	Few fast	Good	Medium	Medium	No

Table 2: Continue

Code Land Unit	Slope	Erosion	Depth Soil	Textur	Permeability	Drainage	Availability of Water	Rock Surface	Rock Exposed
SP10	Rather Tilt	Medium	Medium	Medium	Few slow	Good	Medium	Medium	No
SP11	Tilt	Few Heavy	Medium	Medium	Medium	Good	Medium	Medium	No
SP12	Rather steep	Heavy	Shallow	Medium	Medium	Good	Good	Medium	No
SP13	Declivous	Slihgt	Medium	Few fine	Few slow	Good	Good	Slightly	No
SP14	Rather Tilt	Medium	Medium	Few fine	Medium	Good	Good	Medium	Slightly
SP15	Tilt	Few Heavy	Medium	Fine	Slow	Passable	Good	Medium	Slightly
SP16	Rather steep	Heavy	Shallow	Few fine	Slow	Passable	Good	Medium	Slightly
SP17	Declivous	Slihgt	Medium	Medium	Slow	Passable	Good	Medium	No
SP18	Rather Tilt	Medium	Medium	Fine	Slow	Passable	Good	Medium	Slightly
SP19	Tilt	Few Heavy	Medium	Fine	Medium	Good	Good	Medium	Slightly
SP20	Rather steep	Heavy	Shallow	Fine	Few fast	Good	Good	Medium	Slightly

a capability value for each land characteristic, whose influence upon the overall capability is included by user-defined weighting values [10,11]. Field observations and laboratory analysis are presented in Table 2.

Slope on the upstream watershed area between the ramps are Jeneberang, angled, sloping and extremely steep. The slope of the land affects the erosion that occurs. The more oblique the slope, the greater the erosion is. [12]. This can be seen in the parameter sensitivity of erosion. Erosions in the upper watershed of Jeneberang range from mild, moderate, somewhat heavy, heavy and very heavy. Land with a gentle slope, the erosion in the mild category, moderate erosion somewhat oblique, slanting slope erosion extremely heavy erosion is rather steep and the steep slope of the erosion is very severe.

Effective soil depth is a depth of good soil for the growth of plant roots, that is, until the layers that cannot be penetrated by plant roots. Effective soil depth on sloping land in the upper watershed of Jeneberang is from medium (50-90 cm) to shallow (25-50 cm). Soil depth greatly influenced the development of plant roots. The development of plant roots is crucial for plants productivity.

Soil texture is the relative comparison between the fractions of sand, silt and clay. Soil texture on sloping land in the upper watershed of Jeneberang is somewhat varied in smoothness and subtle. Fine-textured soils include sandy clay texture, dusty clay and clay. Rather fine-textured soils include texture sandy clay loam, tough clay and dusty clay loam. Meanwhile the medium-textured soils include texture loam, clay dust and dust.

The permeability of the soil in the upper watershed land slope of Jeneberang includes the ranges of slow, a little slow, medium and rather quickly. The rates are: slow category, the permeability is of less than 0.5 cm /

hour, rather slow: 0.5 to 2.0 cm/hour, moderate: 2.0 to 6.25 cm/hour and rather quickly, specifically 6.25 to 12.5 cm / hour.

Soil drainage in the upstream watershed land slope of Jeneberang is good and rather good. Good drainage means the soil has good air circulation. All the land from the top to the bottom is of light-colored uniformity and there are no patches of yellow, brown or gray. Rather good drainage means soil has good air circulation in the root zone. There are no patches of yellow, brown or gray on the top layer and the top of the bottom layer (up to about 60 cm from the ground).

Availability of ground water indicates the amount of water that can be used by plants to support its growth. Availability of water in the upstream watershed area of Jeneberang is moderate to good, meaning that sufficient water is available to plants. However, in the long dry season, the water available is not sufficient to cater for the needs of the plant.

Rock surface is rough material or small rocks diameter of 7.5 cm to 25 cm if round, or axis length measuring 15 cm to 40 cm if the form is sprawling [13]. Many small rocks on the ground surface in the study area ranges from slight to moderate. Rocks at the surface means that the number of categories is a bit of rock ranging 0 to 15% by volume of the soil, while the middle category means the amount of rock on the surface is ranging from 15 to 50% of the soil volume. In the medium category, the rock surface can affect the processing of soil and hence, the plant growth is rather disturbed.

Exposed rocks are rocks that appear on the surface and small proportions are mostly found in the soil [14]. Rocks exposed in the upper watershed area of Jeneberang are from none to a few. Category is nothing less than 2% of the land surface which is covered by rocks that appear on the surface of the soil. Meanwhile the category of little

Table 3: Land capability class and land use guidance in upstream Jeneberang watershed

Land Unit	Class	Limiting Factor	Area (ha)	Direction of land use [16]
PL1, PL4, SP1, SP5, SP13, SP17	II	s,w	8,496.23	Plant annuals and perennials
PL2, PL5, SP2, SP6, SP10, SP14, SP18	III	w,e,s	10,286.35	Plant annuals and perennials, grassland, forest production, forest protection
PL3, PL6, SP3, SP7, SP11, SP15, SP19	IV	e	9,478.99	Perennial plant, annual plant with a good cover crop, grassland, forest production, forest protection
PL7, PL8, SP4, SP8, SP12, SP16, SP20	VI	e	2,619.90	Perennial plant, annual plant with a good cover crop, grassland not intensif, forest production, forest protection
SP9	VII	VIIe	138.94	Not suitable for annual crops, pasture, production forests with the prevention of erosion, forest protection

Table 4: Land capability class, subclass and area of land in upstream Jeneberang watershed

Class	Subclass	Area (ha)	Percentage (%)
II	IIw	6,263.09	20.19
	IIs	2,232.33	7.20
III	IIIw	593.30	1.91
	IIIs	1,532.61	4.94
	IIIe	8,160.44	26.31
IV	IVe	9,478.99	30.55
VI	VIe	2,619.90	8.45
VII	VIIe	139.94	0.45

value is from 2% to 10% of land surface covered by rocks are exposed, so it is somewhat disturbing for tillage and planting.

**Land Capability Classification of the Upstream Watershed of Jeneberang:** Based on the physical and morphological characteristics of the land presented in Table 2 and the matrix of land capability classification criteria of the modified USDA [1], the land in the watershed upstream of Jeneberang are included in the category of classes II, III, IV, VI and VII, with limiting factor inhibiting the root (s), the threat of excess water (w) and the threat of erosion (e). Land capability classifications for each land unit are presented in Table 3. It provides a brief assessment of the state of scientific knowledge on the analysis of land use change, combined with a consideration of some of the possible advances promised by the new land use science [15].

Land capability class II is a land with a slope ramps up to choppy (3-8%) and /or has undergone minor erosion (<25% upper layer has been lost), moderate depth (50-90 cm). Land capability class II according to a variety of uses, including use for annual crops, perennial crops, pasture, forest production and so on [17]. Therefore, when used for agricultural crops, in order that the land is not damaged, it requires light soil conservation measures such as crop rotation, mulching and mounds ducts. Class II land area in the watershed upstream of Jeneberang is 8,495.42 ha (27.39%). Class II land with drainage limiting

factor (w) (subclass IIw) area of 6,263.09 ha (20.19%) and land with obstacles limiting factor of the root zone (subclass IIs) is 2,232.33 ha (7.20%) (Table 3).

Land capability class III is located on land that slopes slightly sloping or undulating (8-15%) and shallow soil depth (25-50 cm). These are vulnerable to erosion or have been eroded somewhat heavy. Land capability class III is suitable for agricultural crops, perennial crops, pasture, forest production and protection of forests. If used for agricultural crops, so as not to damage and loss of function of hydrology, it takes pretty severe conservation measures such as creating mounds ducts, based on the wide porch, or a combination of several methods of vegetative. The data in Table 4 shows the class III land area in the watershed upstream of the widest Jeneberang is 10,286.35 ha (33.16%). Class III land with drainage limiting factor (w) (subclass IIIw) covering 593.30 ha (1.91%), with a land area of root barriers limiting factor (subclass IIIs) is 1,532.61 ha (4.94%) and soil erosion limiting factor (subclass IIIe) covering 8,160.44 ha (26.31%).

Land capability class IV land is located on sloping or hilly slopes (15-30%) and shallow soil depth (25-50 cm) and has been eroded somewhat heavy (more than 75% upper layer has been lost). Land capability class IV is used for annual crops, perennial crops with good ground cover plants, prairie, forest production and protection of forests. If used for annual crops, to avoid damage and loss of soil functions, the necessary conservation measures such as terracing heavier bench, rorak and a combination of several methods of vegetative. Class IV land area in the watershed upstream of Jeneberang is 9,478.99 ha (30.55%), with the limiting factor is the erosion (subclass IVe).

Land capability class VI is located on the land which has rather steep slopes (30-45%) and very shallow soil depths (<25 cm), has undergone a rather severe erosion (more than 25% lower layers have been lost). Land capability of class VI is not suitable for crops. However, annual p lant with good cover crop has no intensive

grassland render for forest production as well as protection of forests. If solum in soil can be used for the production of annual crops and perennial crops, severe erosion prevention methods can be applied, such as bench terracing and vegetative combination of several methods. Class VI land area in the watershed upstream of Jeneberang covers 2,619.90 ha (8.45%), with the limiting factor is the erosion (subclass VIe).

Land with land capability class VII is located on steep slopes (45-65%) and soil depth is very shallow (<25 cm). It has experienced severe erosion (erosion ditch). Logging and shifting cultivation have degraded forest quality but commercial estate agriculture, especially oil palm, is now the major cause of forest loss [18]. Land capability class VII is not suitable for crops, but can be used for pasture / grazing, limited production forest with erosion prevention and the best allotment is protected forests or nature reserves. Class VII land area in the watershed upstream of Jeneberang is 139.94 ha, with the limiting factor is the erosion (subclass VIIe).

### CONCLUSION

Land in the upper Jeneberang watershed consists of 55 land units, of which 28 land units with an area of 31,019.60 ha were used for cultivation of horticulture. There are 20 land units with an area of 16,177.60 ha located on the plateau (> 700 m asl) and used for horticulture cultivation of vegetables and 8 land units with an area of 14,842 ha of land located on the lowlands (<700 m asl) and used for the cultivation of horticultural fruits.

Physical characteristics of the land in the upper Jeneberang watershed ramps up the steep slope conditions, mild to severe erosion, soil effective depth shallow to moderate, fine to medium soil texture, soil permeability is slow to moderately fast, rather good to excellent drainage, moderate to good water availability, slight to moderate surface rocks and rocks exposure is to a minimum.

Classes in the upstream watershed land capability is class II of Jeneberang (8,495.42 ha) with drainage limiting factor (subclass IIw) area of 6,263.09 ha and the root zone barriers limiting factor (subclass IIs) covering an area of 2,232.33 ha. Class III capability (10,286.35 ha) with drainage limiting factor (subclass IIIw) covering an area of 593.30 ha, root zone barriers limiting factor (subclass IIIs) is 1,532.61 ha and limiting factors of erosion (subclass IIIE) covering an area of 8,160.44 ha. Class IV by factor limiting the ability of erosion (subclass IVe) has the extent of 9,478.99 ha. Class VI by factor limiting the ability

of erosion (subclass VIe) has an area of 2,619.90 ha. Finally, class VII to factor limiting the ability of erosion (subclass VIIe) has an area of 139.94 ha.

### ACKNOWLEDGEMENTS

This study has been supported and hence submitted to the Higher Education Ministry of Education and Culture, which has funded this research through the National Strategic Research Grant.

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