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**Research Article**

# Land suitability evaluation for grass jelly (*Mesona palustris* BI.) and land conservation in Nawangan, Pacitan Regency

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**Abstract:** One of land degradation problems in Nawangan is surface erosion, throughout the years it widespread. Land conservation by planting plantations in the potential disturbed area is one way to solve this problem. Grass jelly or locally known as janggelan (*Mesona palustris BI.*) can be an alternative for this land conservation, Nawangan has suitable geographic location and grass jelly cultivation is profitable for the surroundings economically. Aim of this study was to evaluate land suitability for grass jelly to solve the land degradation problem in Nawangan. Purposive sampling methods were used to determine sample point, then soil sample analyzed in a laboratory, and overlay of type of soil map and land use map. After soil characteristic was obtained, then the matching process was used. Finally, from this study showed that land suitability classes in Nawangan for grass jelly are very suitable on (S1) land unit LaS and LaK, suitable (S2) on land unit Lil, LiH, LiS and LaH, and marginal suitable (S3) on land unit LaL and LiK.

***Keywords:*** *grass jelly, land evaluation, land suitability*

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## Introduction

Mainland degradation forms happening in Asia are soil erosion, (Firmansyah, 2003), land degradation in terms of soil chemistry such as soil organic matter degradation, and nutrient run-off. Soil and Agroclimate Research Centre (2005) mentioned that Pacitan Regency has 22.400 ha of critical land. One of sub-district in Pacitan Regency that has a high potential of soil erosion is Nawangan, the area itself has a variety of slopes from 8% -> 35%, this condition explained why soil erosion potential in the area is high. Vegetation has proven to help decrease erosion potential, Manik et al. (2003) also stated that the type of vegetation on the soil surface is one factor that can reduce erosion potential. Grass Jelly or Janggelan (*Mesona palustris* BL) is shrub plants with 30-60 cm height and grows on 75-2.300 meter above sea level (Widyaningsih et al., 2014). Grass Jelly has potential as cover crop plants, to protect soil from direct rain precipitation. On the previous study showed that Nawangan has suitable land for grass jelly plantation. The topography of Nawangan majority is hills or highlands, which slope play an important role in soil quality even more land suitability (Senawi, 1999). Djaenudin et al. (2003) found several land suitability standard to determine the level of plant suitability including grass jelly or janggelan. Several factors affecting land quality are humidity regime/ temperature, water and oxygen availability, rooting zone, nutrient retention, and nutrient availability also erosion potential. Harniati et al. (2000) mentioned that optimum soil pH for grass jelly is between 5,5 – 6,5, supporting the statement of AAK (1993) that aeration and drainage are also needed for grass jelly cultivation. Land suitability class information for grass jelly plantation are still limited in Nawangan, thus this study was aimed to evaluate land suitability in Nawangan for grass jelly cultivation. Hence the

land degradation problem in Nawangan, Pacitan Regency can be solved.

## Materials and Methods

### *Research design*

This study was conducted in Nawangan sub-district, Pacitan Regency located exactly in 8º00.695' SL and 111º09.840' EL in July-December 2018. Descriptive to give closure systematically, factual and precisely about the specific object (Hariwijaya, 2007). Data were obtained through soil samples, direct observation, laboratory analysis and document analysis. Data analysis done in this study was matching between soil characteristic to land suitability criteria for grass jelly plantation that has been determined by Ritung et al. (2011) with modifications.

### *Subject and Object*

The subject of the current study is the rice field, plantations, field, and forest in Nawangan, Pacitan Regency, East Java, Indonesia. The object of this study was the land unit gained from an *overlay* of land use map and type of soil map. Overlay map showed a land unit used as a guide for the current study's object selection. Purposive sampling methods were used in selecting soil sampling point. Matching result between overlay map and *purposive sampling* resulting 8 land unit such as LiL, LaL, LiK, LiH, LiS, LaS, LaH and LaK. Soil samples were taken from each land units, from soil 40 cm depth, suitable to Grass Jelly plantations.

### *Data collection*

Data obtained in this study were from laboratory analysis (texture, CEC, organic-C, pH, available P, available K and total N) and direct observation (land slope, altitude and oxygen availability). Secondary data gained from land-use map, type of soil maps, and rainfall maps.

## Results

Results from *overlay* maps of type of soil and land use map were 8 land unit also sample points, further description shown in Table 1.

Table 1. Land unit and soil sample description.

| Sample | Land Unit | Type of Soil | Land use | Location | Sub-district |
|---|---|---|---|---|---|
| Sample 1 | LiL | Litosol | Field | Penggung | Nawangan |
| Sample 2 | LaL | Latosol | Field | Joso | Nawangan |
| Sample 3 | LiK | Litosol | Plantations | Sengon | Penggung |
| Sample 4 | LiH | Litosol | Forest | Petunggeru atas | Penggung |
| Sample 5 | LiS | Litosol | Rice Field | Krajan | Ngromo |
| Sample 6 | LaS | Latosol | Rice field | Gumper | Mujing |
| Sample 7 | LaH | Latosol | Forest | Famar | Tokawi |
| Sample 8 | LaK | Latosol | Plantations | Palugeran | Sempu |

Source: Description: Li = Litosol; La = Latosol; L = Land; K = Plantation; S = PaddyField; H = Forest.

### *Land characteristic and classification of land suitability for grass jelly in Nawangan*

The characteristics of the land used in this study consisted of terrain (a), temperature (tc), water availability (wa), oxygen availability (oa), root zone (re), nutrient retention (nr) and nutrient availability (n). The level of land suitability classification for Janggelan plants in Nawangan can be seen after matching between soil characteristics in Nawangan and grass jelly plant requirement. The characteristics of soil in Nawangan can be seen through field observation, laboratory analysis, and documentation. The matching method was used to measure the probability of land classification based on the lowest value as the limiting factor in the evaluation of land (Rayes, 2006). The result then arranged sequentially from the best to the worst based on its limiting factors. The best land characteristic has low smallest limiting factors and the worst has the biggest limiting factors. Finally, the results of matching method will show land suitability for Janggelan / grass jelly plants. Land suitability in Nawangan, Pacitan Regency is very suitable in LaS and LaK Land Units, S2 (suitable) in Lil, LiH, LiS and LaH, S3 (marginal) in LaL and LiK Land Units. There are a number of limiting factors in the results of the evaluation of land ability in Nawangan District, which consists of slope, water availability, oxygen availability, soil texture, nutrient retention and nutrient availability. Details of the results of the evaluation of the land suitability of grass jelly in Nawangan are shown in Tables 2 and 3.

Table 2. Land suitability for grass jelly (janggelan) in Nawangan, Pacitan Regency.

| **Parameter** | **Land Unit** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | | | | **2** | | | | **3** | | | | **4** | | | |
| | **Score** | **KA** | **TP** | **KP** | **score** | **KA** | **TP** | **KP** | **Score** | **KA** | **TP** | **KP** | **Score** | **KA** | **TP** | **KP** |
| **Location (a)** | 8-15 | **S1** | √ | **S1** | 25-35 | **S2** | + | **S1** | 8-15 | **S1** | √ | **S1** | 25-35 | **S2** | + | **S1** |
| Land slope | | S1 | | S1 | | S2 | | S1 | | S1 | | S1 | | S2 | | S1 |
| Altitude (mdpl) | 800 | S1 | √ | S1 | 590 | S1 | √ | S1 | 709 | S1 | √ | S1 | 629 | S1 | √ | S1 |
| **Temperature (tc)** | 21.47 | **S1** | √ | **S1** | 22.76 | **S1** | √ | **S1** | 22.04 | **S1** | √ | **S1** | 22.52 | **S1** | √ | **S1** |
| Range Temperature (ºC) | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 |
| **Water Availability (wa)** | | **S2** | + | **S1** | 2056.3 | **S2** | + | **S1** | 2056.3 | **S2** | + | **S1** | 2056.3 | **S2** | + | **S1** |
| Precipitation (mm) | 2056.3 | S2 | | S1 | | S2 | | S1 | | S2 | | S1 | | S2 | | S1 |
| **Oxygen Availability (oa)** | | **S1** | √ | **S1** | Medium | **S2** | + | **S1** | Medium | **S2** | + | **S1** | Good | **S1** | √ | **S1** |
| Drainage | Good | S1 | | S1 | | S2 | | S1 | | S2 | | S1 | | S1 | | S1 |
| **Rooting zone (re)** | *Clay loam* | **S2** | - | **S2** | *Clay* | **S3** | - | **S3** | *Clay* | **S3** | - | **S3** | *Clay loam* | **S2** | - | **S2** |
| Texture | | S2 | | S2 | | S3 | | S3 | | S3 | | S3 | | S2 | | S2 |
| **Nutrient Retention (f)** | 6.42 | **S1** | √ | **S1** | 7.00 | **S2** | + | **S1** | 6.22 | **S1** | √ | **S1** | 6.75 | **S2** | + | **S1** |
| Soil reaction (pH) | | S1 | | S1 | | S2 | | S1 | | S1 | | S1 | | S2 | | S1 |
| C Organic (%) | 1.1 | S1 | √ | S1 | 1.9 | S1 | √ | S1 | 1.4 | S1 | √ | S1 | 0.8 | S1 | √ | S1 |
| CEC (cmol/kg) | 10.4 | S1 | √ | S1 | 24.8 | S1 | √ | S1 | 18.8 | S1 | √ | S1 | 21.4 | S1 | √ | S1 |
| **Nutrient Availability (n)** | 0.74 | **S2** | + | **S1** | 0.37 | **S2** | + | **S1** | 0.50 | **S1** | √ | **S1** | 0.65 | **S2** | + | **S1** |
| Available K (cmol/kg) | | S1 | | S1 | | S2 | | S1 | | S1 | | S1 | | S1 | | S1 |
| Available P (ppm) | 7.2 | S2 | + | S1 | 10.5 | S1 | √ | S1 | 11.1 | S1 | √ | S1 | 7.5 | S2 | + | S1 |
| N Total (%) | 0.22 | S1 | √ | S1 | 0.19 | S2 | + | S1 | 0.24 | S1 | √ | S1 | 0.15 | S2 | + | S1 |
| **Subclass land suitability** | | **S2** | | **S2** | | **S3** | | **S3** | | **S3** | | **S3** | | **S2** | | **S2** |

Source: Matching Analysis Result

Description:

| | | | | | |
|---|---|---|---|---|---|
| KA | : Actual suitability | S1 | : Very suitable | - | : irreparable |
| KP | : Potential Suitability | S2 | : Suitable | + | : reparable (S3 menjadi S2) |
| TP | : Management level | S3 | : Marginal | ++ | : very reparable (S3 menjadi S1) |
| | | N | : Not suitable | √ | : No repair needed |

Table 3. Land suitability for grass jelly in Nawangan, Pacitan Regency.

| **Parameter** | **Land Unit** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5** | | | | **6** | | | | **7** | | | | **8** | | | |
| | **Score** | **KA** | **TP** | **KP** | **Score** | **KA** | **TP** | **KP** | **Score** | **KA** | **TP** | **KP** | **Score** | **KA** | **TP** | **KP** |
| **Location (a)** | 25-35 | **S2** | + | **S1** | 8-15 | **S1** | √ | **S1** | 25-35 | **S2** | + | **S1** | 15-25 | **S1** | √ | **S1** |
| Landslope | | S2 | | S1 | | S1 | | S1 | | S2 | | S1 | | S1 | | S1 |
| Altitude (mdpl) | 700 | S1 | √ | S1 | 470 | S1 | √ | S1 | 750 | S1 | √ | S1 | 700 | S1 | √ | S1 |
| **Temperatur (tc)** | 22.1 | **S1** | √ | **S1** | 23.48 | **S1** | √ | **S1** | 21.8 | **S1** | √ | **S1** | 22.1 | **S1** | √ | **S1** |
| Average Temperature (ºC) | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 |
| **Water Availability (wa)** | 2056.3 | **S2** | √ | **S1** | 2056.3 | **S2** | + | **S1** | 2056.3 | **S2** | + | **S1** | 2056.3 | **S2** | + | **S1** |
| Precipitation (mm) | | S2 | | S1 | | S2 | | S1 | | S2 | | S1 | | S2 | | S1 |
| **Oxygen Availability (oa)** | Medium | **S2** | + | **S1** | Good | **S1** | √ | **S1** | Good | **S1** | √ | **S1** | Good | **S1** | √ | **S1** |
| Drainage | | S2 | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 | | S1 |
| **Root zone(re)** | *Sand clay* | **S2** | - | **S2** | *Sandy* | **S1** | √ | **S1** | *Clay* | **S2** | - | **S2** | *Sandy* | **S1** | √ | **S1** |
| Texture | *loam* | S2 | | S2 | *loam* | S1 | | S1 | *loam* | S2 | | S2 | *loam* | S1 | | S1 |
| **Nutrient Retention (f)** | | **S2** | + | **S1** | 6.81 | **S2** | + | **S1** | 6.39 | **S2** | + | **S1** | 6.62 | **S2** | + | **S1** |
| pH) | 6.66 | S2 | | S1 | | S2 | | S1 | | S1 | | S1 | | S2 | | S1 |
| C Organik (%) | 0.4 | S2 | + | S1 | 0.4 | S2 | + | S1 | 1.8 | S1 | √ | S1 | 0.9 | S1 | √ | S1 |
| CEC (cmol/kg) | 19.0 | S1 | √ | S1 | 20.2 | S1 | √ | S1 | 7.3 | S2 | | S1 | 7.0 | S2 | + | S1 |
| **Nutrient Availability (n)** | 0.25 | **S2** | + | **S1** | 0.3 | **S2** | + | **S1** | 0.08 | **S3** | ++ | **S1** | 0.6 | **S2** | + | **S1** |
| Available K (cmol/kg) | | S2 | | S1 | | S2 | | S1 | | S3 | | S1 | | S1 | | S1 |
| Available P (ppm) | 12.1 | S1 | √ | S1 | 8.5 | S1 | √ | S1 | 12.5 | S1 | √ | S1 | 8.2 | S2 | + | S1 |
| N Total (%) | 0.42 | S2 | + | S1 | 0.2 | S2 | + | S1 | 0.09 | S3 | ++ | S1 | 0.14 | S2 | + | S1 |
| **Subclass land suitability** | | **S2** | | **S2** | | **S2** | | **S1** | | **S3** | | **S2** | | **S2** | | **S1** |

Source: Matching Analysis Result

Description:

| | | | | | |
|---|---|---|---|---|---|
| KA | : Actual suitability | S1 | : Very suitable | - | : irreparable |
| KP | : Potential Suitability | S2 | : Suitable | + | : reparable (S3 menjadi S2) |
| TP | : Management level | S3 | : Marginal | ++ | : very reparable (S3 menjadi S1) |
| | | N | : Not suitable | √ | : No repair needed |

## Discussion

Results of this study indicated that Nawangan on the terrain conditions, has slope ranging from 8% to 25% or sloping to rather steep and has an altitude ranging from 470-800 meters above sea level. The Nawangan District region has average temperatures ranging from 22Cº-28ºC and has rainfall of 2056.3 mm/year. Drainage conditions (oxygen availability) have medium to good values. Soil texture consisting of clay, clay loam, sand clay loam and sandy loam. Nutrient retention such as soil pH ranging from 6.22-7.00 or slightly acidic to neutral, then the C-organic content has a value of ≤1.9% or low and the Cation Exchange Capacity has a value ranging from 7.00-24.8 cmol/kg or low to medium. The availability of nutrients such as K available has a value of 0.74 cmol/kg or high, the available P has a value of ≤12.5 ppm or medium and the total N has a value of ≤0.42% or medium. Land suitability for grass jelly cultivation in Nawangan has several classifications as follows:

a. S1 (very suitable)
   Land Unit 6 LaS with minimum factors of water availability, nutrient retention (pH and C Organic), nutrient availability (available K and N Total).
   Land Unit 8 LaK with minimum factors of water availability, nutrient retention (pH and CEC), nutrient availability (available P and N total).
b. S2 (Suitable)
   Land Unit 1 LiL with minimum factors of land slope, water availability, root zone (soil texture), nutrient availability (available P).
   Land Unit 4 LiH with minimum factors of land slope, water availability, root (soil texture), nutrient retention (soil pH) nutrient availability (available P and N total)
   Land Unit 5 LiS with minimum factors of land slope, water availability, oxygen availability (drainage), root zone (soil texture), nutrient retention (pH and C Organic), nutrient availability (available K and N total).
   Land Unit 7 LaH with minimum factors of water availability, root zone (soil texture), nutrient retention (CEC), nutrient availability (available K and N total).
c. S3 (Marginal)
   Land Unit 2 LaL with minimum factor water availability, oxygen availability (drainage), root zone (soil texture), nutrient retention (pH), nutrient availability (available K and N total).
   Land Unit 3 LiK with minimum factor land slope, water availability, oxygen availability (drainage), root zone (soil texture).

Based on the brief explanation above obtained that minimum or limiting factor for grass jelly cultivation in Nawangan are: temperature and soil texture. Both of the mentioned factors are irreparable for grass jelly cultivation. Non-permanent minimum factors are; land slope, water availability, oxygen availability, nutrient retention, and nutrient availability. The mentioned factors can be improved by management practices and fertilization. Further discussion on reparable minimum factors needed in Nawangan, Pacitan Regency as follows:

1) Slope
   Arsyad (2000) found the highest of land slope percentage, it induced bigger surface flow (erosion) will be even greater. Hence, high organic material content will also be transported and carried to a lower place. Slope conditions in regional studies that still require improvement are Unit 2 LaL, 4 LiH, 5 LiS, and 7 LaH. Land slope can be improved by making terraces to minimize surface erosion.
2) Rainfall/ Precipitation
   The amount of rainfall in a region cannot be changed, because the rainfall of a region is affected by its geographical location on the surface of the earth. High amount of rainfall will exceed plant requirement, thus it can be overcome by making proper drainage on the farm. Low amount of precipitation can be overcome by irrigation techniques.Suppor ting this study Nasiyev (2013) found manure, straw and green manure gave positive influence to soil physical properties, it promoted water absorption during the rainy season into the soil, increased productive moisture reservoir, and increased precipitation efficiency. Rainfall in Nawangan, Pacitan Regency classified as suitable (S2) with a value of 2056.3 mm/year, this can be interpreted that the water requirements for Grass Jelly cultivation are less than required and this can be improved through irrigation. Irrigation in Nawangan can be done with water sources found on the soil surface, such as rivers.
3) Drainage
   Aeration in soil has large influence on nitrogen availability (Van Schilfgaarde 1974). Soil aeration gained from a good drainage system. According to Hardjowigeno (2010) soil porosity caused by the composition of organic matter, soil structure, and soil texture. Drainage conditions in the study area that still need improvement are in Lan unit 2 LaL, 3 LiK and 5 LiS. In this case,

Oxygen availability can be improved by making a drainage channel in each field

4) Soil Reaction (pH)
According to Triharto (2013) explained that acidity soil is important, suitable soil pH for Grass Jelly cultivation range from 5.5 - 6.5 (Harniati et al., 2000). pH soil in this study several land units (2 LaL unit, 4 LiH, 5 LiS, 6 LaS, and 8 LaK) still need improvement. In this case, alkaline soil pH can be improved by fertilization in order to reduce pH close to the ideal limit for the grass jelly requirements. Calcification (also fertilization) must be done with 4 rights, namely right dosage, right way, on time, and right conditions (Hanafiah, 2007).
5) Organic-C
Total soil organic carbon is important for sustainability because it affects soil quality. The C-organic analysis showed a significant correlation with all soil physical properties, C-organic has an important role in infiltration, and water retention and water availability (Supriyadi et al., 2014). Organic material is generally found on the surface of soil or topsoil. The amount of organic matter ranges from 3-5% but plays an important role in determining soil properties, and in agriculture, especially for plant growth. Carbon Organic content in this study still needs repairs in several Land Unit (5 LiS and 6 LaS units), which can be repaired by manure, compost or green manure fertilization. Organic carbon content can also be improved by returning the remains of plants into the soil, this also supported by Fahriansyah's research (2015).
6) CEC
Suitable Cation Exchange Capacity (CEC) for Janggelan cultivation is > 16 cmol/kg. CEC in obtained study area still needs repairs, in land units; 7 LaH unit and 8 LaK units. CEC can be improved by adding organic material to soil with less suitable classification for grass jelly cultivation. This statement is supported by several studies (Uehara and Gillman, 1981; Sufardi, 1999), the presence of organic matter besides functioning to maintain soil quality, can also function to reduce the zero charge point (PZC) hence the organic material content increases and increase soil CEC.
7) Available K
Potassium (K) able to make plants resistant to diseases, prevent symptoms of ammonium poisoning (Jones et al. 1991), making plants not easy to fall down (Razzaque et al. 1990). The available K suitable for Grass Jelly cultivation is 0.4-0.5 cmol/kg. Available K in the obtained study still needs improvement in the Land Units; 2 LaL unit, 5 LiS, 6 LaS and 7 LaH units. In this case, the grass jelly plant only requires a medium available K. Therefore, to overcome the low or very low Land Unit, efforts can be made to improve the addition of fertilizers containing K and compound fertilizers containing P and K elements, this is linear to Setyorini et al. (2005).
8) Available P
Phosphorus (P) is found in the most important nutrient for plants, in the nucleo-protein (protein core). Phosphor is needed in developing roots (AAK, 2002: 162-163). The available P content suitable for Janggelan cultivation range from 11-15 ppm. The P content available in the study area that still needs repairs is Land Units; 1 LiL, 4 LiH and 8 LaK units. Supported by Djajadi and Murdiyati (2000), availability of P elements in soil is low to very low, therefore for Land Units that are still unsuitable with the grass jelly growth requirements can be improved by adding fertilizer containing phosphor and inorganic fertilizers containing P and K. The increase in P and K available is due to the application of long-term fertilizers (organic and inorganic fertilizers) (Supriyadi et al., 2014).
9) Total N
Nitrogen (N) is an essential element for plants, and needed in large quantities (Hanafiah et al. 2010). N in soil and plants are very mobile, as the presence of N in soil quickly changes or even disappears. N losses can be through denitrification, volatilization, plant biomass or runoff and soil erosion of soil. N loss through runoff generally occurs in coarse-textured soils, with low organic matter content and low cation exchange capacity (CEC). The low content of N elements and other nutrients can occur in soil that has a high level of acidity (pH 5.5). This is common in soil with cultivation activity, such as in Entisol, Inceptisol and Ultisol (Hardjowigeno, 2010). Nitrogen (N) content needed for Grass Jelly (Janggelan) cultivation range from 0.21-0.5%. The previous study by Santoso et al. (2014) mentioned that altitude affects the N total availability. The higher the altitude, the lower the concentration of N. In Cookson et al (2005), the ability of soil to provide N is largely determined by the amount of soil organic matter. The total N content in the current study area that still needs improvement is Land Units; 2 LaL unit,

4 LiH, 5 LiS, 6 LaS, 7 LaH and 8 LaK. In this case, the addition of N-containing fertilizers, as well as compound fertilizers containing N, P and K, can be used to increase N total in soil. Supporting the study's find Wiyantoko et al. (2017) found that nitrogen elements in NPK inorganic fertilizers are needed by plants but at a suitable dosage.

## Conclusion

Land unit LaS and LaK was found as S1 (very suitable) for grass jelly cultivation. Land Unit Lil, LiH, LiS and LaH are suitable (s2), Land Unit LaL and LiK included in marginal (S3) suitability. Land improvement such as terrace needed in Nawangan to decrease erosion potential in terms of land slope, increase water availability, fertilization and stabilize soil pH, drainage improvement can be done through soil management practice such as tillage, the addition of animal manure or compost, to increase organic carbon and CEC. Nutrient availability can be improved through fertilization suitable to soil minimum factor.

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