Land Evaluation Suitability for Tobacco (*Nicotiana tabacum* L.) in Lombok Island Province of West Nusa Tenggara with Geographic Information System (GIS)

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Abstract. Land degradation consequence utilization of inappropriate causes depreciation watershed performance. The importance of using the land for conservation and cultivation requires wise handling. Tobacco gives good impact to conservation and beneficial to cultivate. Therefore, evaluation of land for tobacco is important. The purpose of this research is to determine land evaluation for tobacco plants at Lombok island with divider rainfall, land slope, temperature and soil depth with the geographic information system. The results of the land evaluation analysis show that 0% S1 (highly suitable), 32.2% S2 (moderately suitable), 66.4% S3 (marginally suitable) and 0.4% (not suitable). With that result, tobacco plants cultivation as land conservation can be developed in Lombok island.

1. Introduction
Tobacco is one of the main commodities of West Nusa Tenggara (NTB). The tobacco cultivation business reaches an area of 23,752.87 ha with production of more than 27,178.19 tons [1]. The high economic potential of tobacco will increase the demand to expand the cultivation area. Currently the tobacco cultivation is concentrated in two districts are Central Lombok Regency and East Lombok Regency. Opportunities to be extended to other districts are possible. Therefore, information about the potential for developing tobacco cultivation is required.

To reduce the conversion of forest into agricultural land is very difficult due to the dependence of the watershed community on the agricultural sector. Therefore, it is necessary to have an approach that benefits the watershed community. A possible approach is to direct land use as agroforestry. One commodity that has a good impact on conservation is tobacco plants. [2] reported that the size of the run of the area planted with coffee was 3%, slightly larger than the forest, which was 2.5%. Therefore, directing the watershed community to use the land planted with tobacco plants is very appropriate, in addition to the conservation side it also increases economic value.

2. Methodology
Land Evaluation is a process of assessing a land so that it is in accordance with its conditions for certain uses [3]. Factors evaluating tobacco plant land for this study are limited to rainfall, temperature, soil solum, slope and erosion hazard level.
Data processing begins with the formation of a land unit with an overlay of map data that is relevant to the objectives of processing data for tobacco: climate maps, topographic maps and soil type maps. Climate, topography and land data for each unit of land will be compared with the level of compliance with the requirements for tobacco plants. Several types of tobacco plants will be evaluated for their level of land suitability by comparing the quality of the land and the growing requirements of the plant. The land unit used is the same as what has been done for other tobacco plants.

Land suitability is the suitability of a plot of land for certain uses [4]. The land suitability classification structure uses the FAO system (Food and Agricultural Organization) as follows: highly suitable (S1), moderately suitable (S2), marginally suitable (S3), or not suitable (N) [5]. Based on these criteria, the usage requirements or land characteristics for tobacco plants are presented in the following table 1.

**Table 1. Land Suitability Classes for Tobacco Plants Following Are Land Characteristics Requirements.**

| Land characteristics requirements                  | Land suitability class |
|----------------------------------------------------|-----------------------|
| **S1**                                             | **S2**                | **S3**        | **N** |
| Temperature at growth times (ºC)                   | 22-28                 | 20-22;        | 15-20; | <15  |
|                                                     | 28-30                 | 30-34         | >34   |
| Water availability                                 |                       |
| Rainfall (mm)                                       | 600-1200              | 1200-1400     | >1400  | <1400 |
|                                                     | 500-600               | 400-500       | <400  |
| Humidity (%)                                       | 24-75                 | 20-24         | <20   |
|                                                     | 75-90                 | >90           |       |
| Drainage                                           | Good, medium          | Obstructed, slightly fast | Very obstructed, fast |
| Rooting Media                                       | medium, rather smooth, smooth | slightly rough, very smooth | rough | rough |
| Coarse material (%)                                | <15                   | 15-35         | 35-55  | >55  |
| Soil depth (cm)                                     | >75                   | 50-75         | 30-50  | <30  |
| Peat                                               |                       |
| Thickness (cm)                                      | < 100                 | 100-200       | 200-300 | >300 |
|                                                     | < 140                 | 140-200       | 200-400 | >400 |
| Thickness (cm), if there is a mineral inserts       |                       |
| Maturity                                           | saprik+               | saprik, hemik+ | hemik, fibrik+ | Fibrik |
| Nutrient Retention                                  |                       |
| CEC (cmol)                                         | > 16                  | 5-16          | <5    |     |
| Alkali Saturation (%)                              | > 35                  | 20-35         | <20   |     |
| pH H2O                                             | 5.5 - 6.2             | 5.2 - 5.5     | < 5.2 |     |
|                                                    | 6.2 - 6.8             | > 6.8         |       |     |
| C-organic (%)                                      | > 1.2                 | 0.8 - 1.2     | < 0.8 |     |
| Toxicity                                           |                       |
| Salinity (dS / m)                                   | < 2                   | 2 - 4         | 4 - 6  | > 6  |
| Alkalinity/ESP (%)                                  | < 10                  | 10 - 15       | 15 - 20 | > 20 |
| Sulfidic (cm)                                       | > 100                 | 75 - 100      | 40 - 75 | < 40 |
| Erosion                                            | < 3                   | 3-8           | 8-15   | > 15 |
| Danger of erosion                                   | Very light            | Light-medium  | Heavy-very heavy |
| Flood                                              |                       |
| Puddle                                             | F0                    | -             | -      | > F0 |
| Land Setup                                         |                       |
| Rock surface (%)                                    | < 5                   | 5 - 15        | 15 - 40 | > 40 |


Land characteristics requirements | Land suitability class
---|---|---|---|---
Rock outcrop (%) | S1 | S2 | S3 | N
< 5 | 5 - 15 | 15 - 25 | > 25

Source: [4]

Land characteristics that are closely related to land evaluation needs can be grouped into 3 main factors, are topography, soil and climate. The characteristics of the land (especially topography and land) are the constituent elements of the land map unit.

Analysis of land suitability using GIS is carried out in the following stages:
1. Process reclassification of land suitability based on rainfall, soil solum, temperature and land slope based on the requirements stated by [6].
2. Overlay all four limiting factor maps with arithmetic methods, so that maps of land suitability for tobacco plants are obtained.
3. To find out the land area of each land suitability is using xtool.

3. Result and Discussion
Current land use can be used as an indicator of potential land to be developed according to needs. The results of the delineation of the Indonesian earth map show that there are 31.66% of the land is dry land agriculture mixed with shrubs and 21.98% shrubs. More than 50% of Lombok Island's land can be optimized if the land suitability is met for the development of certain commodities.

The results of delineation of land use on the island of Lombok in NTB province are show in table 2.

| No | Land Use | Area (ha) | % |
|----|----------|-----------|---|
| 1  | Primary Dryland Forest | 80,473.73 | 20.52% |
| 2  | Secondary Dryland Forest | 29,648.31 | 7.56% |
| 3  | Primary Mangrove Forest | 1,142.52 | 0.29% |
| 4  | Secondary Mangrove Forest | 3,178.59 | 0.81% |
| 5  | Industrial Plantation Forest | 1,616.74 | 0.41% |
| 6  | Plantation | 3,144.27 | 0.80% |
| 7  | Settlement | 6,674.97 | 1.70% |
| 8  | Dryland Agriculture combine with Shrubs | 124,172.36 | 31.66% |
| 9  | Savana | 1,683.43 | 0.43% |
| 10 | Field | 21,439.58 | 5.47% |
| 11 | Shrub | 86,185.63 | 21.98% |
| 12 | Fishponds | 1,039.73 | 0.27% |
| 13 | Open Land | 3,075.61 | 0.78% |
| 14 | Transmigration | 32.89 | 0.01% |
| 15 | Cloud Cover Land | 26,327.98 | 6.71% |
| 16 | Body of Water | 2,327.03 | 0.59% |

Source: delineation RBI map

The results of the area of each land use in table 2 are the results of drainage from figure 1 based on the land use, it can be determined which ones can be transferred to other commodities and which areas should be conserved.
Figure 1. Land Use Map.

In the analysis of land suitability for tobacco plants, the data sources are derived from land system analysis maps which is conducted by the Ministry of Forestry's Planology Agency. The maps used include soil type, drainage, soil texture, solum depth, rainfall. Whereas the altitude and slope uses maps from the Shuttle Radar Topography Mission and the temperature is analyzed by the Braak equation [7].

The type of soil on the island of Lombok is dominated by Humitropept (23.78%), Pellustert (22.58%), Ustorthent (20.64%) and Vitrandept (13.98%). Overall the type of soil on the island of Lombok in NTB province is presented in table 3 and figure 2.

Table 3. The Type of Soil on the Lombok island in NTB Province.

| Soil Type          | Area (ha) | %    |
|--------------------|-----------|------|
| Calciorthids       | 10,500    | 2.31%|
| Dystropept         | 16,754    | 3.69%|
| Haplustalf         | 18,054    | 3.97%|
| Humitropept        | 108,079   | 23.78%|
| Hydraulquent       | 2,851     | 0.63%|
| Pellustert         | 102,592   | 22.58%|
| nothing            | 13,803    | 3.04%|
| Tropaquaquept      | 20,651    | 4.54%|
| Tropopsamment      | 275       | 0.06%|
| Ustifluvent        | 3,355     | 0.74%|
| Ustipsamment       | 201       | 0.04%|
| Ustorthent         | 93,788    | 20.64%|
| Vitrandept         | 63,536    | 13.98%|
Climate is one of the factors that greatly determines the success of tobacco cultivation. Climate element that is important in determining the suitability of plants is rainfall and air temperature. The results of the class delineation of climate suitability on the island of Lombok in the province of NTB are showed in table 4 and figure 3.

**Table 4. Climate Classes for Suitability of Tobacco Plant.**

| Climate Classes       | Area       | %    |
|-----------------------|------------|------|
| Highly Suitable (S1)  | 345983.04  | 76.53% |
| Moderately Suitable (S2) | 52968.59  | 11.72% |
| Marginally Suitable (S3) | 37599.87  | 8.32%  |
| Not Suitable (N)      | 15523.05   | 3.43%  |

Tobacco plants are plants that not resistant to water immersion. Therefore, the ability of the land to be drained is one of the determinants for the suitability of the area planted with tobacco. The results of class analysis of soil drainage on the island of Lombok in the NTB province are presented in table 5 and figure 4.

The slope of land is one of the important limiting factors in determining regional suitability for a commodity including tobacco. The greater of land slope value, the erosion hazard level will also be greater so that the layer of tillage will eventually disappear due to erosion. The results of the analysis of the land slope class are showed in table 6 and figure 5.
Figure 3. Map of Climate Classes for Suitability of Tobacco Plants.

Table 5. Class of Soil Drainage.

| Drainage | Soil Class              | Area (ha)     | %    |
|----------|-------------------------|---------------|------|
| S1       | Good, Medium            | 29,558.53     | 6.50%|
| S2       | Slightly Obstructed     | 288,384.57    | 63.46%|
| S3       | Obstructed, Slightly fast | -             | 0%   |
| N        | Very obstructed, fast   | 136,496.41    | 30.04%|

Table 6. Land Slope Class.

| Land Slope Class         | Value | Area (ha)     | %    |
|--------------------------|-------|---------------|------|
| Highly Suitable (S1)     | < 3%  | 20301.584     | 4.49%|
| Moderately Suitable (S2) | 3-8%  | 231027.647    | 51.10%|
| Marginally Suitable (S3) | 8-15% | 129846.888    | 28.72%|
| Not Suitable (N)         | >15%  | 70898.442     | 15.68%|
Figure 4. Map of Drainage for Suitability of Tobacco Plants.

Figure 5. Map of Slope for Suitable of tobacco plants.

Soil texture greatly affects the ability of the soil to store and pass water. Therefore, the soil texture class condition of an area will also affect the suitability of the region to a type of commodity. The results of the analysis of soil texture classes on the island of Lombok are showed in table 7 and figure 6.
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| Table 7. Soil Texture Class. |
|-------------------------------|
| Soil Texture Class | Area (ha) | % |
|----------------------|-----------|---|
| Smooth (S1)          | 209801.254| 46.41% |
| Slightly smooth (S1) | 228670.324| 50.58% |
| Medium (S1)          | 2859.177  | 0.63% |
| Slightly rough (S1)  | 10719.375 | 2.37% |
| Rough (S3)           | 24.431    | 0.01% |

Figure 6. Map of Texture for Suitability of Tobacco Plants.

The depth of the soil solum will determine the depth of the soil that can be reached by the roots. The more shallow the solum of the soil, the rooting of the plant will be shallower so that it will be more difficult for a plant to develop. The results of the analysis of the depth of the soil solum on the island of Lombok are showed in table 8 and figure 7.

| Table 8. Depth of soil solum. |
|-------------------------------|
| Soil Class               | Depth of soil solum (cm) | Area (ha) | % |
|--------------------------|--------------------------|-----------|---|
| Highly Suitable (S1)    | > 75 cm                  | 29,558.53 | 6.50% |
| Moderately Suitable (S2)| 50 – 75 cm               | 288,384.57| 63.46% |
| Marginally Suitable (S3)| 30 – 50 cm               | -         | 0% |
| Not Suitable (N)        | < 30 cm                  | 136,496.41| 30.04% |
Figure 7. Map of Soil Solum for Suitability of Tobacco Plant.

By combining the limiting factors that will affect the suitability of the area for a commodity, an overlay is carried out so that the land is suitable for planting tobacco. The results of overlaying land suitability for tobacco commodities are showed in table 9 and figure 8.

Table 9. Suitability of Biophysical Land for Tobacco Plants.

| Districts       | Protected Area | N       | S3     | S2       | S1       |
|-----------------|----------------|---------|--------|----------|----------|
| West Lombok     | 33870.37       | 27309.65| 22494.70| 761.24   | 1826.03  |
| Central Lombok  | 30809.22       | 7691.62 | 46498.65| 35840.50 | 0.00     |
| East Lombok     | 59649.14       | 24757.35| 64610.70| 4249.61  | 7288.20  |
| North Lombok    | 27338.65       | 7838.69 | 41203.58| 1244.08  | 0.00     |
| Mataram         | 0              | 6130.00 | 0.00   | 0.00     | 0.00     |

in percent

| Districts       | Protected Area | N       | S3     | S2       | S1       |
|-----------------|----------------|---------|--------|----------|----------|
| West Lombok     | 39.26%         | 31.66%  | 26.08% | 0.88%    | 2.12%    |
| Central Lombok  | 25.50%         | 6.37%   | 38.48% | 29.66%   | 0.00%    |
| East Lombok     | 37.15%         | 15.42%  | 40.24% | 2.65%    | 4.54%    |
| North Lombok    | 35.22%         | 10.10%  | 53.08% | 1.60%    | 0.00%    |
| Mataram         | 0.00%          | 100.00% | 0.00%  | 0.00%    | 0.00%    |
Figure 8. Map of Suitability of Tobacco Plants.

Table 9 and figure 8 illustrate the existing biophysical conditions for the suitability of tobacco plants, that for the highly suitable (S1) only in two regencies, East Lombok regency 4.54% with an area of 7288.20 ha, and West Lombok 2.12% with an area of 1826.03 ha while the other districts are 0%. For the moderately suitable (S2) in each district, namely Central Lombok regency of 29.66%, East Lombok 2.65%, North Lombok 1.60% and West Lombok 0.88%. For the marginally suitable (S3) of each district, namely North Lombok Regency 53.08%, East Lombok 40.24%, Central Lombok 38.48% and West Lombok 26.08%. For the not suitable (N), West Lombok regency with the largest area is 31.66% and Central Lombok district with the smallest area of 6.37%. From the biophysical aspects, it is shown that tobacco plants still have the potential to be developed in each district on the island of Lombok, West Nusa Tenggara province.

4. Conclusion
Land suitability for tobacco plants on Lombok Island in West Nusa Tenggara province that for the highly suitable (S1) only in two districts, East Lombok regency at 4.54% with an area of 7288.20 ha, and West Lombok at 2.12% with an area of 1826.03 ha, while districts that another 0%. The moderately suitable (S2) in each district, namely Central Lombok regency of 29.66%, East Lombok 2.65%, North Lombok 1.60% and West Lombok 0.88%. The marginally suitable (S3) of each district are North Lombok Regency 53.08%, East Lombok 40.24%, Central Lombok 38.48% and West Lombok 26.08%. For the not suitable (N), West Lombok regency with the largest area is 31.66% and Central Lombok district with the smallest area of 6.37%.

5. References
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