Analysis of Ricefield Land Damage in Denpasar City, Bali, Indonesia

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Abstract. Soil as a natural resource, living area, environmental media, and factors of production including biomass production that supports human life and other living beings must be preserved, on the other hand, uncontrolled biomass production activities can cause soil damage, ultimately can threaten the survival of humans and other living things. Therefore, in order to control soil damage, first must inventories the soil condition data and its damage which then visualised in soil damage potential and soil damage status. The activities of the study are the preparation of a map of the initial soil conditions and the delineation of potentially land degradation distribution. Mapping results are used as work maps for verification on the field to take soil samples and create soil damage status. In general, Denpasar City have soil damage potential at very low, low until medium rate. Soil damage status in Denpasar City generally is low damage of bulk volume, total porosity, soil permeability and electrolyte conductivity which beyond limitation thresholds.

Keywords: Rice field land damage, Soil damage, GIS, Mapping

1. Introduction

Soil as a natural resource, living area, environmental media, and factors of production including biomass production that supports human life and other living beings must be preserved, on the other hand, uncontrolled biomass production activities can cause soil damage, ultimately can threaten the survival of humans and other living things. Government Regulation of the Republic of Indonesia No. 150 of 2000 on Control of Land Degradation for Biomass Production, Government Regulation No. 38 of 2007 on Governmental Administration of Government, Provincial Government and Regency / Municipality Government, clearly stipulates that Provinces and Regencies have the mandate, among others, to supervise the control of soil damage. This mandate is reinforced by the release of the No. 19 of 2008 on Minimum Service Standards (SPM) Environmental Area of Provinces and Regencies / Municipalities and Regulation of the Minister of Environment No. 20 of 2008 [1] on Technical Guidance SPM Environmental Area of Provinces and Regencies / Municipalities. It is therefore necessary to have a data containing soil conditions and soil damage status as stated in a minimum 1: 50,000 scale map for urban areas and a scale of 1: 100,000 for the district as a starting point for monitoring.

In the Government Regulation of the Republic of Indonesia No. 150 of 2000 standard criteria have been established for the destruction of land for the production of Biomass, including the parameters that must be established and measurement methodology. While the procedure of measuring the
standard criteria of land damage for biomass production has been established through the Regulation of the State Minister of Environment No. 07 of 2006. The products of this law and other research will be as reference in the preparation of Soil Status Map [2–4]. The current problem is the lack of data on the condition and status of soil damage both extent and spatial distribution in various regions. Therefore, in order to control soil damage, first must inventories the soil condition data and its damage which then visualised in soil damage potential and soil damage status

2. Methodology

2.1. Area of Study

Denpasar City is the capital city of Bali Province, Indonesia. Denpasar City located between 08° 35’ -08° 44’ South Latitude and 115° 10’ -115° 16” East Longitude, which is bordered by: North: Badung regency, East: Gianyar Regency, South: Badung Regency and Lombok Strait, West: Badung Regency. The total area of Denpasar City is 12.78 Ha, including addition of reclamation of 380 Ha seashore beach [5].

2.2. Materials and Tools

2.2.1. Materials

Materials for this study are:

1) Soil map

As a basic map material can use the map of Rupa Bumi Indonesia (RBI) production of the National Survey and Mapping Coordination Agency (Bakosurtanal) [6].

2) Spatial Plan Map (RTRW)

RTRW map used is map RTRW lingkat Regency or City. The function of the RTRW map in the preparation of the initial soil condition map is to filter the effective working area to be surveyed and to see the soil conditions in the field based on the status of the land.

3) Land map

Land maps are needed as materials for assessing the potential for soil damage. The type (classification) of land used may vary, generally using the Soil Taxonomy (USDA) classification system and sometimes also the equivalent of Puslitan and FAO classifications.

4) Slope Map

Slope map is processed from topographic map. The slope of the land is closely related to the potential of erosion as the main factor causing soil damage to be used as material for assessing the potential for soil damage. Slope maps that are easily obtained are sourced from land unit maps.

5) Rainfall Map

The availability of this data is necessary in determining the potential for soil damage. The rain map is usually composed of isohyet maps. BMKG (Meteorology Climatology Geophysics Agency) at the provincial level sometimes also arrange rain maps. Another source is a rain map compiled by Bappeda in each regency, city or province.

6) Landcover and Land Use Map

In general, soil degradation in Indonesia occurs as an influence of human activities (land use), such as agriculture, forestry, mining, industry and so on. In estimating the potential for soil damage, the land use / cover map used is the most recent map that is still relevant to describe the condition

7) Maps and Other Data

Maps and other data such as critical land maps or direct reports from the public or relevant agencies on the existence of soil damage to certain areas, such information can be accommodated in the initial condition map if the position and distribution are known.
2.2.2. Methodology

The activities of the study were the preparation of a map of the initial soil conditions and the delineation of potentially land degradation distribution [7,8]. Mapping results were used as work maps for verification on the field. In principle, the initial conditions map (work map) presents alleged information of potential soil degradation based on analysis of maps and secondary data. The potential for soil damage is assumed by two approaches, namely overlay of thematic maps and scoring of factors considered to have an effect on soil damage.

The process of preparing this work map consists of several steps, namely (1) screening of effective working area, (2) Storing potential land damage on thematic maps (3) overlay some of the thematic maps required to create the potential land damage, (4) field verification, (5) Preparation of Land Condition Map, (6) Creation of Land Damage Map. Figure 1 shows the methodology diagram.

**Figure 1. Methodology Diagram**

1) **Intersect Process**

The intersect process will produce new polygons with attributes of land conditions in accordance with thematic constituent maps. In this polygon will be assessed potential land damage by considering the weighted score of potential damage to the land of its constituent maps.

2) **Matching and Scoring**

Scoring scores or weighting scores of potential damage to the soil obtained from the multiplication of the rating value with the weight value of each thematic map of soil maps, slope maps, rainfall maps and landuse maps. The rating value is set to range from 1 to 5. While the weight value for land use maps and soil maps are weighted by two (2) and the slope and rainfall maps are weighted by three (3).

The higher scoring scores obtained, the higher the potential the soil is damaged. The rating and scoring values of soil factor presented in Table 1, the rating and scoring values of slope factor...
presented in Table 2, the rating and scoring values of rainfall presented in Table 3 and the rating and scoring values of landuse presented in Table 4.

### Table 1. Assessment of Potential Land Damage Based on Soil Type

| Soil Type                  | Class    | Symbol | Rating | Score*Weight |
|----------------------------|----------|--------|--------|--------------|
| Vertisol, a quick humidity | Very low | T1     | 1      | 2            |
| Oxisol                     | Low      | T2     | 2      | 4            |
| Alfisol, Mollisol, Ultisol | Moderate | T3     | 3      | 6            |
| Inceptisols, Entisols,     | High     | T4     | 4      | 8            |
| Histosols                 | Very high| T5     | 5      | 10           |

Description: * Aquents, Aquepts, Aquults, Aquoxs, etc. With the exception of Sulfaquept and Sulfaquent considered potentially high damage.

### Table 2. Assessment of Potential Land Damage Based on Slope

| Slope (%) | Soil Damage Class | Symbol | Rating | Score |
|-----------|-------------------|--------|--------|-------|
| 0 – 8     | Very low          | L1     | 1      | 3     |
| 9 – 15    | Low               | L2     | 2      | 6     |
| 16 – 25   | Moderate          | L3     | 3      | 9     |
| 26 – 40   | High              | L4     | 4      | 12    |
| > 40      | Very high         | L5     | 5      | 15    |

### Table 3. Assessment of Potential Land Damage Based on Rainfall Intensity

| Rainfall (mm) | Soil Damage Class | Symbol | Rating | Score |
|---------------|-------------------|--------|--------|-------|
| < 100         | Very low          | H1     | 1      | 3     |
| 1000 – 2000   | Low               | H2     | 2      | 6     |
| 2000 – 3000   | Moderate          | H3     | 3      | 9     |
| 3000 – 4000   | High              | H4     | 4      | 12    |
| > 4000        | Very high         | H5     | 5      | 15    |

### Table 4. Assessment of Potential Land Damage Based on landuse (a)

| Rainfall (mm) | Soil Damage Class | Symbol | Rating | Score |
|---------------|-------------------|--------|--------|-------|
| Forest        | Very low          | T1     | 1      | 2     |
| Rice field    |                   |        |        |       |
| Reed          |                   |        |        |       |
| Mixed garden  | Low               | T2     | 2      | 4     |
| Shrub/ bush   |                   |        |        |       |
| Meadow        |                   |        |        |       |
| Production forest | Moderate       | T3     | 3      | 6     |
| Cultivation   |                   |        |        |       |
| Moor (annual crop) | High        | T4     | 4      | 8     |
| Open ground/ clearing | Very high  | T5     | 5      | 10    |

3) **Soil Damage Potential**

Potential damage calculated by grouping to the weighted score accumulation, the result of scoring value with the weight of each thematic map. This potential assessment is performed on the polygons produced by the intersect process. The value of the accumulated score ranges from 10 to 50. The maximum value occurs if all attribute values of each thematic map used are potentially very high against the soil damage. Based on the accumulation of the score, all the land to be assessed is classified into 5 classes of potential damage, ie very low, low, medium, high, and very high damage.
4) Field Check

Field verification is to prove whether or not the indication or potential damage to the land has been properly corrected. This activity is carried out in a priority order based on the potential for soil damage. The main priority is on land with the highest potential damage. In the field survey, there are several methods of land observation and sampling. Commonly used soil sampling methods are random sampling. This system is usually applied to fairly diverse land conditions where the land is divided into several relatively homogeneous land units through the overlay process of some thematic maps as previously mentioned and then in each random sampling unit.

Several standard parameters of ground damage criteria were measured directly in the field, while others were measured through laboratory analysis. For this purpose, soil sampling is required at each observation point. The verification and identification of soil damage parameters also allow for the change of polygons in the potential soil damage map. Location of soil sampling are focused on ricefield with assumption that ricefield will represent higher value to sustainable crops and agriculture development in general.

5) Soil Damage Map

The Soil Damage Map contains the values of ground damage criteria. The value included in the map legend is the range value of each parameter. The criteria for classifying the soil damage are presented in Table 5.

| Parameter          | Symbol | Soil Damage Potential | Score |
|--------------------|--------|-----------------------|-------|
| PR.I               | Very low | < 15                  |
| PR.II              | Low    | 15 – 24               |
| PR.III             | Moderate | 25 – 34              |
| PR.IV              | High   | 35 – 44               |
| PR.V               | Very high | 45 - 50             |

Data taken from the location of the activity to determine the criteria of the degree of soil damage consist of slopes, rainfall, erosion / sedimentation, thickness of solum, surface unity, soil fraction composition, degree of water grinding, fill weight, total porosity, pH (H₂O), electrolyte conductivity, redox and microbial quantities. These criteria are the minimum standard criteria set by the Environmental Ministry of Indonesia. The raw criteria are factors that may affect the quality of the soil for biomass production. Table 6 indicates the criteria for soil damage [1].

| No | Parameter          | Symbol | B | BPAR | AR | ARPR | R   |
|----|--------------------|--------|---|------|----|------|-----|
| 1  | Slopes (%)         |        | 0 – 8 | 8 – 15 | 15 – 25 | 25 – 45 | > 45 |
| 2  | rainfall (mm/ht)   | < 1500 | 1500 - 2000 | 2000 - 2500 | 2500 - 2000 | > 2500 |
| 3  | Solum thickness (cm) | > 150 | 150 – 100 | 100 – 50 | 50 – 20 | < 20 |
| 4  | Surface Unity (%)  | < 10 | 10 – 20 | 20 – 30 | 30 – 40 | > 40 |
| 5  | Composition of Soil Fraction sand | Koloid (%) | > 33 | < 33 – 28 | < 28 – 23 | < 23 – 18 | < 18 |
|    |                    | sand (%) | < 20 | > 20 – 40 | > 40 – 60 | > 60 – 80 | > 80 |
| 6  | Water Smoothing Degree (cm/jam) | 4.0 - 5.0 | 4.0 - 3.0 | 3.0 - 2.0 | 2.0 - 0.7 | < 0.7 |
|    |                    |        | 5.0 - 6.0 | 6.0 - 7.0 | 7.0 - 8.0 | > 8.0 |
| 7  | Content Weight (g/cm³) | < 0.8 | > 0.8 – 1.0 | > 1.0 – 1.2 | > 1.2 – 1.4 | > 1.4 |
| 8  | pH (H₂O) : 2.5     | 6.0 – 5.5 | 5.5 – 5.0 | 5.0 – 4.5 | 4.5 – 4.0 | < 4.0 |
|    |                    | 6.0 – 6.5 | 6.5 – 7.0 | 7.0 – 7.5 | 7.5 – 8.0 | > 8.0 |
| 9  | Power Conductivity (mS/cm) | < 1.0 | > 1.0 – 2.0 | > 2.0 – 3.0 | > 3.0 – 4.0 | > 4.0 |
| 10 | Number of Microbes (cfu/g) | > 10⁶ | < 10⁶ - 10⁷ | < 10⁵ - 10⁶ | < 10⁵ - 10⁷ | < 10⁵ |
3. Result and Discussion

3.1. Soil Damage Potential

The condition of agricultural land is indicated by the condition of existing land use and available facilities such as irrigation conditions. Ricefield conditions in subdistrict of West and North Denpasar are ricefield / plantation land area of 256ha and 754 ha respectively from 24.13 km² and 31.12 km² area respectively. The area of ricefield in East Denpasar District is 694 ha and in South Denpasar is 896 ha, while the area of tegalan land in both subdistricts is 144 ha and 183 ha [9]. Mapping results are used as work maps for verification of the field. In principle, the initial conditions map (work map) presents information on potential soil damage based on analysis of maps and secondary data. Work maps were made by using overlay method between isohyet map, soil type map with slope map and landuse map. Spatial overlay process is done using QGIS device.

The analysis shows that the potential of soil damage in North Denpasar District and West Denpasar District has only two classes, which are low potency and medium potential. Soil that has the lowest damage potential has the highest area that reaches 1,769.55 ha or 96.69% from the research area. While the soil that has the potential for damage is only 60.64 ha or 3.31% of the area of North Denpasar District and South Denpasar District. Based on the location of the administration, North District has a potentially larger area of moderate damage compared to West Denpasar District. Potential land of moderate damage in North Denpasar District has an area of 57.12 ha while in West Denpasar District is only 3.53 ha. The common cause of the potential for low soil damage is due to the soil use and steep slope conditions. Types of land use of moor affected much of the potential for soil damage in the West District (Padang Sambian Kaja), while in sub district of North Denpasar, besides being caused by land use type (Ubung Kaja), it is also caused by steep slopes condition or has slopes exceeding 25% as happened in Peguyangan Kangin, Peguyangan Kaja and Tonja Villages.

South Denpasar Sub district and East Denpasar Sub district have only two classes that are low potency and medium potency. Soil that has the lowest damage potential has the highest area that reaches 1,769.55 ha or 96.69% from the research area. While the Soil that has the potential for damage is only 60.64 ha or 3.31% of the area of South Denpasar District. Based on the location of the administration, Southern Sub district has a land that has the potential of damage is more extensive when compared with the District of East Denpasar. Potential land of moderate damage in South Denpasar District has an area of 57.12 ha while in East Denpasar District is only 3.53 ha. Map of class potential distribution of soil damage in South Denpasar Sub district and East Denpasar Sub district shows that potentially moderate soil damage only reach 60.64 ha or 3.31% from study area. The common cause of the potential for low soil damage is due to the soil use and steep slope conditions. Types of land use moor affect much of the potential damage to land in Eastern District (Padang Sambian Kaja). While in sub district of South Denpasar, besides being caused by land use type of moor (Ubung Kaja), it is also caused by steep slopes condition or has slopes exceeding 25% as happened in Peguyangan Kangin, Peguyangan Kaja and Tonja Villages. Table 7 listed the area of soil damage potential for ricefield in Denpasar City. Meanwhile Figure 2 shows the soil damage potential in Denpasar City.

Table 7. Area of Soil Damage Potential for Ricefield in Denpasar City

| Landuse | Sub-district | Village/ Kelurahan | Class | Area (Ha) |
|---------|--------------|--------------------|-------|----------|
| Ricefield | West | Padang Sambian, Padang Sambian Kaja, Padang Sambian Klod, Daun | Low | 158.51 |
| Ricefield | West | Padang Sambian Klod | Medium | 35.18 |
| Ricefield | North | Ubung Kaja, Ubung, Tonja, Peguyangan Kangin, Peguyangan Kaja | Low | 503.41 |
| Ricefield | North | Peguyangan Kaja, Peguyangan Kangin, Tonja | Low | 10.87 |
| Ricefield | East | Daging Puri Klod, Sumerta, Kesiman Kertalangu, Sumerta Klod | Medium | 577.72 |


4.2. Soil Damage Status

The result of analysis shows that in West Denpasar Sub-district there are 4 (four) parameters which have percentage value of relative frequency of soil over 10% ie Bulk Volume, Soil pH, Electrolite Conductivity, and Total Soil Microbe. The situation shows that in West Denpasar Sub-district, the weight of the soil is relatively damaged. In addition, soil pH, soil DHL, and soil microbes also bring a relative frequency of soil damage of 20%, 40% and 60% respectively. Conditions in North Denpasar District have better condition than West Denpasar District. Bulk Volume is the only parameter that has a percentage value of the relative frequency of soil damage exceeding 10%. In North Denpasar District the relative frequency value of soil damage from soil contents weight is 100%.

Based on the criteria of soil degradation, relative frequency of soil degradation, and relative frequency score in North Denpasar Sub-district and West Denpasar Sub-district, the status of soil damage in both sub-districts can be calculated. The scores of soil damage for ricefield shows that the level of soil damage in North Denpasar District has a better total score of 4 with the status of low damage, whereas the total score of soil damage in West Denpasar District is 10 with the same status of low damage. The area of soil that has a score of 4 in North Denpasar District is 1,118, 47 ha, while the soil that has a score of 10 in West Denpasar District is 711,72 ha. Relative frequency data of soil degradation and relative frequency scores for each standard of soil damage and total score for West Denpasar Sub-district and North Denpasar Sub-district are presented in Table 8.

Although the study area has a low degree of soil damage, the mitigation and recovery measures need to be considered, especially for the area of West Denpasar. Measures to address parameters that indicate damage or potential damage need to be considered based on the type of planted commodity. The parameter indicates potential damage to some locations but the range of values is still at a scale that allows the growth of plant roots. However, countermeasures are needed to improve the weight of the soil content so that plant growth becomes better. One way that can be done is to cultivate the land for moor land in accordance with the rules of soil conservation or when the paddyfield is not planted with rice paddy. Control measures that need to be done is the addition of organic materials. An increase in soil pH towards a slightly alkaline direction (> 6.5) needs to be controlled. Organic materials can be used because organic materials have a high buffer capacity to change soil pH.
Figure 2. Map of Soil Damage Potential for Ricefield in Denpasar City

Table 8. Soil Damage Score for West Denpasar Sub-district and North Denpasar Sub-district

| No | Criteria for Soil Damage | West Denpasar | | North Denpasar |
|----|---------------------------|---------------|------------------|------------------|
| 1  | Slope (%)                 | 0%            | 0                | 0%              | 0                |
| 2  | Rainfall (mm/th)          | 0%            | 0                | 0%              | 0                |
| 3  | Solum width (cm)          | 0%            | 0                | 0%              | 0                |
| 4  | Surface rock (%)          | 0%            | 0                | 0%              | 0                |
| 5  | Sand (%)                  | 0%            | 0                | 0%              | 0                |
| 6  | Permeability (cm/minutes) | 0%            | 0                | 0%              | 0                |
| 7  | Bulk Volume (g/cm³)       | 100%          | 4                | 100%            | 4                |
| 8  | pH (H₂O) 1 : 2.5          | 20%           | 1                | 0%              | 0                |
| 9  | electrical conductivity (mS/cm) | 40%       | 2                | 0%              | 0                |
| 10 | Number of Microbes (cfu/g) | 60%          | 3                | 0%              | 0                |
|    | Total Score               | 10            | 4                |                  |                  |
Increasing the value of soil electrolyte conductivity indicates the occurrence of salinization process which at $> 4 \text{ mS / cm}$ can inhibit plant growth. The increasing value of soil electrolyte conductivity indicates an increase in the concentration of dissolved salt in the soil that may be caused by excessive water volume or increased solute salt concentration due to the fertilization or intrusion of seawater on coastal soils. When it is compared to the soil fertility status, soil in the study area still have a low DHL value so that specific control or recovery measures is not necessary unless there is a drastic increase in soil electrolyte conductivity value over a short period of time. However, organic materials can also be used because of the ability of organic materials to bind organic or inorganic ions in the soil environment thus preventing the process of salinization.

The improvement of the total microbial population of the soil is necessary to restore the soil biological fertility status because microbes are the key agents of biochemical processes in the soil. Microbial activity greatly determines the chemical, physical and biological properties of the soil. To restore the number of microbial populations the soil can be done by adding microbes among others with compost applications or regulating environmental conditions to be more suitable for microbial growth and development. One step that can be done is to use organic materials that have diverse qualities.

The condition of soil damage in South Denpasar Sub-district and East Denpasar sub-district indicates that the soil damage status in both Sub-districts can be calculated. The compilation result of the relative frequency score of soil damage levels indicates that the level of soil damage to in both Sub-districts has a total score of 2 to 8 with the status of low damaged soil.

Inceptisol is the largest land order in the city of Denpasar and also dominates the District of East Denpasar and South Denpasar. Inceptisol land in both sub-districts is used for mooring / gardens, ricefields, grasslands or associations between types of land use. In this study, Inceptisol soil is classified into land which is an association of ricefields. Inceptisol soil damage is low damaged by a score of 4 for inceptisol of ricefield association.

Alfisol, Entisol, and Mollisol are three types of minor land in Denpasar City. Alfisol and Molisolsoil are in the middle and north of Denpasar City. While the Entisolsoil located in the southern city of Denpasar. Usually these three types of soil are also associated with the dominant species of Inceptisol soil. In this study, the Inceptisol soil associations with the three minor soil types are grouped into 3 groups: Alfisol-Inceptisol, Entisol-Inceptisol, and Mollisol-Inceptisol.

The three associations of Inceptisol land with Alfisol, Entisol and land have a slightly damaged soil category with a score of 4 for the Alfisol-Inceptisol association, a score of 8 for the Entisol-Inceptisol association, and a score of 6 for the Mollisol-Inceptisol association. In general, the types of parameters that indicate the damage are total porosity, soil permeability and electrical conductivity beyond the critical threshold. The Entisol-Inceptisol Association has the highest level of damage with the highest score. The condition is due to the condition of Entisol soil that is still developing and its presence near the beach. Land entisol is located near the coast has a high electrical conductivity (DHL) and fast up to very fast soil permeability. The high electrical conductivity condition is a manifestation of high salt content and leads to a base pH of the soil. In total, extent of damaged soil with minor damage category is 2,586, 96 Ha from agricultural land area of 3,430.76 Ha or 75.404% of agricultural land suffered low damage. Table 9 listed the soil damage for Alfisol – Inceptisol soil. Table 10 listed the soil damage for Entisol – Inceptisol soil and Table 11 listed the soil damage for Mollisol – Inceptisol soil. Figure 3 shows the soil damage status in Denpasar City.
### Table 9. Soil Damage for Alfisol – Inceptisol soil in South Denpasar and East Denpasar

| No | Parameter | Limitation threshold | Samples/ Land unit | % | Score |
|----|-----------|----------------------|--------------------|---|-------|
| 1  | Solum depth | <20 cm | >20 | >20 | >20 | >20 | 0 | 0 |
| 2  | Surface rocks | >40 % | <40 | <40 | <40 | <40 | 0 | 0 |
| 3  | Fraksi: Koloid sand Fraction | <18 % koloid; >80 % sand | 14,97 | 3,52 | 3,47 | 5,64 | 6,91 | 0 | 0 |
| 4  | Bulk Volume | >1,4 g/cm³ | 0,87 | 1,06 | 1,24 | 1,06 | 0,86 | 0 | 0 |
| 5  | Total Porosity | <30 %; >70% | 65,06 | 57,11 | 50,44 | 57,09 | 62,41 | 0 | 0 |
| 6  | Permeability | <0,7 cm/jam; >8,0 cm/jam | 54,89 | 5,41 | 0,48 | 0,37 | 29,43 | 100 | 4 |
| 7  | pH (H₂O) 1 : 2,5 | <4,5 ; >8,5 | 6,82 | 7,00 | 6,55 | 6,86 | 6,98 | 0 | 0 |
| 8  | Electrolyte conductivity | >4,0 mS/cm | 1,18 | 1,05 | 0,16 | 0,95 | 0,97 | 0 | 0 |
| 9  | Redoks | <200 mV | - | - | - | - | - | - | - |
| 10 | Microbe total | <10²cfu/g soil | 3 x 10⁹ | 125x10⁷ | 116x10⁷ | 125x10⁷ | 3x10⁹ | 0 | 0 |

Score total: 4 (Low Damage)

| Area | 71,63 ha |

### Table 10. Soil Damage for Entisol – Inceptisol soil in South Denpasar and East Denpasar

| No | Parameter | Critical Threshold | Sample/ Land unit | % | Score |
|----|-----------|-------------------|-------------------|---|-------|
| 1  | Solum depth | <20 cm | >20 | >20 | >20 | >20 | 0 | 0 |
| 2  | Surface rocks | >40 % | <40 | <40 | <40 | <40 | 0 | 0 |
| 3  | Fraksi: Koloid sand Fraction | <18 % koloid; >80 % pasir Kuarsitik | 14,87 | 11,48 | 8,00 | 2,91 | 4,37 | 0 | 0 |
| 4  | Bulk Volume | >1,4 g/cm³ | 1,21 | 0,27 | 0,99 | 0,72 | 0,66 | 0 | 0 |
| 5  | Total Porosity | <30 %; >70% | 56,05 | 87,53 | 61,55 | 69,96 | 69,12 | 20 | 1 |
| 6  | Permeability | <0,7 cm/jam; >8,0 cm/jam | 56,48 | 21,95 | 0,53 | 0,96 | 11,37 | 80 | 4 |
| 7  | pH (H₂O) 1 : 2,5 | <4,5 ; >8,5 | 6,90 | 7,65 | 7,54 | 7,35 | 7,35 | 0 | 0 |
| 8  | Electrolyte conductivity | >4,0 mS/cm | 1,41 | 8,18 | 8,79 | 4,97 | 3,55 | 60 | 3 |
| 9  | Redoks | <200 mV | - | - | - | - | - | - |
| 10 | Microbe total | <10²cfu/g Tanah | 117x10⁷ | 21X10⁷ | 44x10⁷ | 135x10⁷ | 73x10⁷ | 0 | 0 |

Score total: 8 (Low damage)

| Area | 160,67 ha |

### Table 11. Soil Damage for Mollisol – Inceptisol soil in South Denpasar and East Denpasar

| No | Parameter | Critical Threshold | Sample/ Land unit | % | Score |
|----|-----------|-------------------|-------------------|---|-------|
| 1  | Solum thickness | <20 cm | >20 | >20 | >20 | >20 | 0 | 0 |
| 2  | Surface rocks | >40 % | <40 | <40 | <40 | <40 | 0 | 0 |
| 3  | Composition of Fraction: Koloid Sand | <18 % koloid; >80 % Sand Kuarsitik | 5,49 | 4,53 | 5,66 | 7,70 | 0 | 0 |
| 4  | Content Weight | >1,4 g/cm³ | 0,83 | 0,83 | 0,77 | 1,01 | 0 | 0 |
| 5  | Total Porosity | <30 %; >70% | 67,06 | 67,62 | 69,57 | 60,08 | 0 | 0 |
| 6  | Water Smoothing Degree | <0,7 cm/jam; >8,0 cm/jam | 5,57 | 0,53 | 0,48 | 2,86 | 50 | 2 |
|   | (permeabilitas) |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|
|   | pH (H₂O) 1 : 2.5 | <4.5 ; >8.5 | 6.70 | 6.76 | 7.11 | 6.90 | 0 | 0 |
|   | electrical conductivity | >4.0 mS/cm | 0.81 | 1.65 | 2.33 | 0.10 | 0 | 0 |
| 9 | Redoks | <200 mV | - | - | - | - | - | - |
| 10 | Number of Microbes Tanah | <10⁶ cfu/g | 7x10⁸ | 67x10⁷ | 3x10⁸ | 12x10⁷ | 0 | 0 |

| Score total | 2 (Low damage) |
|---|---|
| Area | 55.11 |

Figure 3. Soil Damage Status in Denpasar City

4. Conclusions

In general, Denpasar City have soil damage potential at very low, low until medium rate. Physical condition of ricefields in study area is relatively homogenous, ie soil condition, soil physical condition, soil chemical condition and soil biological condition. The result of analysis shows that in West Denpasar Sub-district there are 4 (four) parameters which have percentage value of relative frequency of soil over 10% ie Bulk Volume, Soil pH, Electrolyte Conductivity, and Total Soil Microbe. Bulk Volume is the only parameter that has a percentage value of the relative frequency of soil damage exceeding 10%. In North Denpasar District the relative frequency value of soil damage from soil contents weight is 100%. The condition of soil damage in South Denpasar Sub-district and East
Denpasar Sub-district, indicates score of soil damage levels indicates that the level of soil damage to in both Sub-districts has a total score of 2 to 8 with the status of low damaged soil. Soil damage status in Denpasar City generally is low damage of bulk volume, total porosity, soil permeability and electrolyte conductivity which beyond limitation thresholds.

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