Soil classification for sustainable agriculture

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Abstract. Agriculture is one of the people’s livelihoods in Baebunta Sub-District. High activity rainfall in Luwu area could cause soil degradation and decrease nutrient in the soil. Soil type gives us information about morphological, physical and chemical characteristic and mineral content. As a medium for growing plants, the soil becomes one of the important factors in assessing the sustainability of agriculture. This study aims to classify and provide management recommendations of soil from Baebunta Sub-District in North Luwu District, South Sulawesi for sustainable agriculture. The sampling method uses catena transect, and soil analysis for physical and chemical properties, and soil minerals, as the parameter in classifying soil types from the Order to the Family Category using the USDA Soil Taxonomy system. The land uses dominant was a paddy field. The results showed that soil formed are Biotite-Quartz-Sandy Typic Endoaquepts, Orthoclase-Quartz-Loamy Skeletal Lithic Dystrudepts, Biotite-Quartz-Fine-Silt Typic Endoaquepts, Coarse-Silt Lithic Typic Endoaquepts. The soil family categories have nutrient-carrying minerals like biotite but the dominance of quartz mineral showed the need for improving management like adding the organic material for stabilizing the soil aggregates, reduce toxic mineral and nutrient leaching so that the soil can be sustainable for agriculture.

1. Introduction
Agriculture is one of the people’s livelihoods in Baebunta Sub-District. According to BPS [1], Paddy production in Baebunta District reached 35,791.11 tons / 6,035.60 ha (average 5.9 tons / ha), maize commodity reached 13,851.39 tons / 2,787.00 ha (average 4.97 tons / ha), and cocoa commodity reached 6,996.45 tons / 9,380 ha (average 0.7 tons / ha). High activity rainfall in Luwu area could cause soil degradation and decrease nutrient in soil [1,2], this situation will impact to agriculture productivity [3]. One way to assess soil fertility by indicating the characteristic of soil type [4,5]. Soil type gives us information about morphological, physical and chemical characteristic and mineral content. As a medium for growing plants, the soil becomes one of the important factors in assessing the sustainability of agriculture.

Different types of soil have an impact on the different management improvements that can be given [6–8] from Inceptisol with high resistant mineral content [9,10]. So, this study aims to classify and provide management recommendations of soil from Baebunta Sub-District in North Luwu District, South Sulawesi for sustainable agriculture.
2. Material and methods

The study site was located in the North Luwu District of South Sulawesi province with the location coordinate is 2°21’55”S-2°49’29”S and 120°5’39”E-120°20’42”E (Figure 1). Determination of the location of soil sampling locations using the catena transect method with eight soil profiles (Table 1). The parameters were; texture (Hydrometer method [11]), Cation Exchange Capacity (CEC) (NH₄OAc Extraction), C-org (organic) (Walkley and Black method), pH, Base Saturation (BS) (NH₄OAc of pH 7 Extraction), Grain Size, and Mineral (with binocular microscope identification of sand fraction). Soil classification with USDA 2014 [12] Method: Orde, Sub-Orde, Great Group, Sub-Group, and Family.

Figure 1. Location of the study area

Table 1. Soil profile characteristic

| Profile | Coordinate          | Elevation (m asl) | Slope (%) | Drainage | Rock Formation | Vegetation                  |
|---------|---------------------|-------------------|-----------|-----------|----------------|----------------------------|
| T1      | 2°34’3,137” LS 120°16’13,938” BT | 120 | 15-25 | good      | Tpgk           | palm and grass             |
| T2      | 2°35’36,590° LS 120°15’16,107” BT | 41  | 0-8   | good      | Tplv           | palm and shrub             |
| T3      | 02°37’03,3° LS 120°17’54,1” BT | 62  | 0-8   | bad       | Qa             | paddy field and cocoa      |
| T4      | 2°47’3,575° LS 120°14’30,586” BT | 12  | 0-8   | good      | Qa             | cocoa, banana, corn, and durian |
| T5      | 02°31’46,3° LS 120°14’59,6” | 40  | 25-45 | good      | Tpgk           | palm                      |
| T6      | 02°33’14,09° LS 120°16’32,09” | 100 | 0-8   | good      | Tmpb           | shrub and palm             |
| T7      | 02°37’03,3° LS 120°17’54,1” BT | 40  | 0-8   | bad       | Qa             | paddy field and cocoa      |
| T8      | 02°40’06,8° LS 120°20’06,2” BT | 30  | 0-8   | good      | Qa             | shrub and palm             |
3. Results and discussion

Based on rainfall data in the last ten years (2008-2018) (Meteorology, Climatology and Geophysics Region IV Makassar), the climate type of Baebunta District according to Oldeman climate classification is classified as type B climate with 9 wet months (figure 2).

![Figure 2. The climate type of Baebunta District](image)

There is three soil order that has been formed in Baebunta Sub-District, namely; Inceptisol, Oxisol, and Ultisol. The Characteristics and type of soil are presented in Table 2.

| Soil Profile and Land Use | Soil Characteristic | Soil Classification |
|--------------------------|--------------------|---------------------|
| **Profile T1:** Soil depth 0-80 cm, good drainage, the texture of sandy clay loam, CEC ≤ 15cmol/kg, Base Saturation ≥ 35%, C-organic content 1.85%, pH 5, dominant minerals: biotite and quartz | Order: Inceptisol with the cambic horizon, Sub-Order: Udepts, Great Group: Dystrudepts, Sub-Group: Typic Dystrudepts, Family: Biotite-Quartz Skeletal Medial Sandy Typic Dystrudepts | |
| **Profile T2:** Soil depth 0-180 cm, good drainage, the texture of sandy clay loam, CEC ≤ 15cmol/kg, Base Saturation ≤ 35%, C-organic content of 1.6%, pH 4.2, dominant minerals: quartz and oxide | Order: Oxisol with the oxic horizon, Sub-Order: Haploperox, Great Group: Typic Haploperox, Family: Quartz-Oxide Sandy Typic Haploperox | |
| **Profile T3:** soil depth 0-65 cm, good drainage, the texture of sandy clay loam CEC value ≥ 15cmol / kg, base saturation ≤ 35%, C-organic C 1.72%, pH 4.6, dominant minerals: biotite and quartz | Order: Inceptisol with Umbric horizon, Sub-Order: Aquepts, Great Group: Endoaquepts, Sub-Group: Typic Endoaquepts | |

Table 2. Characteristics and classification of soil in Baebunta Sub-District
Profile T4: soil depth 0-65 cm, good drainage, the texture of sandy clay loam CEC value $\geq 15$ cmol / kg, base saturation $\leq 35\%$, C-organic C 1.72%, pH 4.6, dominant minerals: orthoclase and quartz

Order: Inceptisol with the cambic horizon, Sub-Order: Uderts, Great Group: Dystrudepts, Sub-Group: Lithic Dystrudepts, Family: Orthoclase-Quartz Sceletal Loamy Lithic Dystrudepts

Profile T5: Soil depth 0-120 cm, good drainage, the texture of sandy clay loam, CEC $\leq 15$ cmol / kg, Base Saturation 35%-38%, C-organic content 1.93%, pH 4.2, dominant minerals: quartz

Order: Ultisol with Argilic horizon, Sub-Order: Udults, Great Group: Hapludults, Sub-Group: Inceptic Hapludults, Family: Quartz Fine Inceptic Hapludults

Profile T6: Soil depth 0-80 cm, good drainage, the texture of sandy clay loam, CEC $\leq 15$ cmol / kg, Base Saturation $\geq 35\%$, C-organic content 1.27%, pH 4.6, dominant minerals: muscovite and quartz

Profile T7: Soil depth 0-70 cm poor drainage, the texture of sandy clay loam CEC value $\geq 15$ cmol/kg, base saturation $\leq 35\%$, C-organic content 1.6%, pH 4.6, dominant minerals: biotite and quartz

Profile T8: Soil depth 0-90 cm poor drainage, silty clay texture, CEC value $\leq 15$ cmol/kg, Base saturation $\geq 35\%$, C-organic content 1.66%, pH 5.2, dominant minerals: biotite and quartz

Order: Inceptisol with the cambic horizon, Sub-Order: Aquents, Great Group: Endoaquepts, Sub-Group: Typic Endoaquepts, Family: Biotite-Quartz Silty Fine Typic Endoaquepts

Paddy field land use in Baebunta Sub-District is classified into land suitability evaluation that is a highly suitable class to the moderately suitable class [13] with soil types were Biotite-Quartz Sandy Typic Endoaquepts and Biotite-Quartz Silty Fine Typic Endoaquepts. The content of biotite minerals as nutrient-carrying minerals for plants [14] shows that the soil is still quite potent in developing paddy fields, but the presence of quartz mineral content indicates that the soil has undergone an intensive leaching process [15] that requires fertilization management, especially liming to raise soil pH, and the addition of solid organic matter to increase the weathering of biotite minerals so that nutrients become available to the plants, and can improve soil aggregate, and chelate a toxic cations in the soil [16].
Palm land use in Baebunta Sub-District has a moderately suitable class for land suitability evaluation [13]. For soil types, Biotite-Quartz Skeletal Medial Sandy Typic Dystrudepts and Biotite-Quartz Silty Coarse Lithic Typic Endoaquepts, require management liming to increase pH and the addition of solid organic matter to increase the weathering of biotite minerals [17], improve soil aggregate and reduce nutrient leaching processes [18]. The soil type Quartz-Oxide Sandy Typic Haploperox, Quartz Fine Inceptic Hapludults, and Mucovite-Quartz Sandy Ruptic Ulthic Dystrudepts, require the addition of solid and liquid organic matter to be able to chelate iron and aluminum cations of mineral oxide in the soil that can toxic the plants [16], increasing the charge negative soil because the soil with dominant mineral oxide has more positive charge, as well as the addition of chemical fertilizers because the soil is dominant with resistant minerals. Soils in area that have >15% slope need cover crops management to decrease soil erosion.

Cocoa plant land use in Baebunta Sub-District has land suitability evaluation in a marginally suitable class [13], with the soil type is Othoclase-Quartz Sceletal Loamy Lithic Dystrudepts that require liming management to increase soil pH, the addition of solid organic matter to improve soil aggregate [18], to reduce nutrient leaching, to increase the negative charge of the soil in order to maintain nutrients in the soil [19], and the addition of chemical fertilizers because the soil does not contain nutrient-carrying minerals. The soil type of Biotite-Quarzt Silty Fine Typic Endoaquepts requires liming management to increase soil pH, and the addition of solid organic matter to increase weathering of biotite minerals in the soil, and to improve soil aggregate so that the soil drainage become good condition and can increase the production.

4. Conclusions
Soil family categories still contain biotite mineral as nutrient-carrying minerals, but the high content of quartz minerals in the soil requires management in the form of adding organic material and liming to maintain soil fertility, increase aggregate stability and reduce nutrient leaching, so that the soil can be sustainable for agriculture.

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