Identification of sago land and its potential for development in the Coastal Area of North Luwu Regency

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Abstract. Indonesia is the largest sago producer in the world. The existence of sago as a source of food in Indonesia does not show an increased area of plant growing, instead, it tends to shrink from year to year. Only areas along the coast did not have significant land-use change due to limited soil characteristics for the cultivation of other types of plants, namely soil characteristics that are often waterlogged for months. The coastal area of North Luwu Regency is the area with the largest sago planting area in South Sulawesi. This makes sago a potential plant to be developed in the coastal area of North Luwu. This research aims to produce data on the characteristics of sago land and its development potential in the coastal area of the North Luwu Regency. The method was carried out in the form of collecting the list of coastal villages in North Luwu from Badan Pusat Statistik data and image data, then conducting field verification, analyzing the physical and chemical properties of soil and water, and conducting interviews to determine the potential for sago development based on the production of sago plants. The results of this research indicate that the land characteristics in the coastal area of North Luwu are very suitable for sago plants because they represented a high yield of wet sago starch production which reaches more than 250 kg/tree. It can be concluded that the characteristics of sago land in the coastal area of North Luwu Regency are very suitable for sago plants because they can grow and produce very well.

1. Introduction
The Southeast Asia region is the original habitat of sago plants. Indonesia become the largest sago planting area in the world and ranked first in the world's sago producer. Sago (Metroxylon spp.) as a food crop that used as a staple food in several regions in Indonesia is one of the potential carbohydrate-producing plants because the amount of carbohydrates is highest compared to other carbohydrate-producing plants that can be developed as food for the community. The management of sago in Indonesia a very promising prospect for national food security in the future [1]. By utilizing it in the food sector, it can help reduce the risk of food or carbohydrate crises due to crop failure of staple food crops.

The existence of sago as a source of food in Indonesia does not show an increase of area planted, instead it leans to decrease from year to year due to the conversion of sago land to other, harvesting patterns that tend to be extractive and the limitation of relatively wet land [2]. Likewise in the province of South Sulawesi, especially the North Luwu regency, although the area for sago planting still quite large, the problem of conversion sago land functions also continues. Only areas along the coast did not experience significant land use change due to limited soil characteristics for the cultivation of other types of plants, specifically soil characteristics that are often waterlogged for months.

The range of land characteristics for sago growth relatively wide, from flooded land to dry land [3]. The characteristics of coastal land overgrown with sago are classified as marginal land. Each condition of land overgrown with sago has characteristics that reflect their respective habitat types. Characteristic indicators are indicated by environmental characteristics which include soil properties, both physical and chemical, and climatic characteristics, especially microclimate. How the nature of the habitat of sago plants that grow and develop in a coastal area is an aspect that needs to be find out further considering the
potential of coastal sago for the community.

Therefore, this study aims to reveal the physical and chemical characteristics of various types of sago plant habitat, focused on the coastal area of Teluk Bone, North Luwu Regency as a coastal area with the largest sago area in South Sulawesi, providing an opportunity for the people of North Luwu to make sago as one of alternative livelihood. The results of this study can be used as a reference for the government and local communities in planning the development of sago in the coastal area of North Luwu Regency.

2. Methods
This research was carried out for six months, from October 2020 to March 2021 along the coastal village area in the sago forest area of North Luwu Regency. Soil and water sample analysis was carried out in the chemistry and soil fertility laboratory of Hasanuddin University. The tools used in this research were GPS (Global Position System), Arcgis 10.3, soil drill, refractometer, bar meter, camera, ring sample munsell soil colour chart. The materials used in this research were intact soil samples and disturbed soil samples, chemical materials used in analysis, BPS data, cutra image, North Luwu climate data, and work map of research location.

| Table 1. Observation Parameters and Methods of Soil Analysis in the Laboratory |
|---|
| Parameters | Method |
| Physical properties | |
| Texture | Hydrometer |
| Soil Color | Munsell Soil Color Chart |
| Chemical properties | |
| N-Total | Kjedahl |
| C-organic | Walkey and Black |
| pH | pH Meter |
| Soil Salinity | Conductivitometer |

Analysis of the potential for development of sago plants refers to the amount of core production produced from one sago in the last one year. This information was obtained from interviews with groups of farmer sago along the coast of North Luwu Regency.

Figure 1. Research Location Map
3. Results and discussion

3.1. Soil physical properties
Based on the results of soil physical properties including texture and soil color parameters from nineteen coastal villages in North Luwu Regency, the following results were obtained:

Table 2. Results of Analysis of Physical Properties of Soil Samples from Nine Coastal Villages, North Luwu Regency

| Name of Village | Subsoil  | Soil Texture  | Soil Color         |
|-----------------|----------|---------------|--------------------|
| Waelawi         | Wa - L1  | Silt Loam     | 5 Y 2.5/1 Black    |
|                 | Wa - L2  | Silt Clay Loam| 25 Y 4/2 Dark Grayish Brown |
| Pengkajoang     | Pe - L1  | Silt Loam     | 10 YR 4/2 Dark Grayish Brown |
|                 | Pe - L2  | Sandy Loam    | 10 YR 6/2 Light Brownish Gray |
| Waetuwo         | Wo - L1  | Sandy Clay Loam| 5 YR 4/3 Reddish Brown |
|                 | Wo - L2  | Silt Clay Loam| 5 YR 4/2 Dark Reddish Grey |
| Pao             | Pao - L1 | Silt Loam     | 2.5 Y 4/4 Olive Brown |
|                 | Pao - L2 | Silt Clay     | 2.5 Y 5/2 Grayish Brown |
|                 | Pao - L3 | Silt Clay     | 2.5 Y 6/2 Light Brownish Gray |
| Pattimang       | Pat - L1 | Silt Clay Loam| 2.5 Y 4/4 Olive Brown |
|                 | Pat - L2 | Silt Loam     | 2.5 Y 6/2 Light Brownish Gray |
|                 | Pat - L3 | Silt Loam     | 2.5 Y 5/2 Grayish Brown |
| Pince Pute      | Pin - L1 | Silt Clay Loam| 10 YR 4/3 Brown    |
|                 | Pin - L2 | Silt Clay Loam| 10 YR 3/3 Dark Brown |
| Tokke           | To - L1  | Silt Loam     | 5 Y 3/2 Dark Olive Gray |
|                 | To - L2  | Silt Clay Loam| 5 Y 4/2 Olive Gray  |
|                 | To - L3  | Silt Clay Loam| 5 Y 4/4 Olive      |
| Benteng         | Be - L1  | Silt Loam     | 5 Y 3/2 Dark Olive Gray |
|                 | Be - L2  | Silt Clay     | 5 Y 4/3 Olive      |
|                 | Be - L3  | Silt Clay Loam| 5 Y 4/2 Olive Gray  |
| Takkalala       | Ta - L1  | Silt Loam     | 5 Y 3/1 Very Dark Gray |
|                 | Ta - L2  | Clay Loam     | 5 Y 3/2 Dark Olive Gray |
|                 | Ta - L3  | Silt Clay Loam| 5 Y 4/2 Olive Gray  |
| Salakoe         | Sa - L1  | Clay Loam     | 10 YR 2/1 Black    |
|                 | Sa - L2  | Silt Clay Loam| 10 YR 3/1 Very Dark Gray |
| Ladongi         | La - L1  | Silt Loam     | 2.5 Y 3/2 Very Dark Grayish Brown |
|                 | La - L2  | Silt Clay Loam| 2.5 Y 4/2 Dark Grayish Brown |
| Pongko          | Pon - L1 | Silt Loam     | 5 Y 3/2 Dark Olive Gray |
|                 | Pon - L2 | Silt Loam     | 5 Y 4/2 Olive Gray  |
|                 | Pon - L3 | Silt Clay     | 5 Y 2.5/2 Black    |
| Batang Tongka   | Bt - L1  | Sandy Loam    | 5 Y 2.5/1 Black    |
|                 | Bt - L2  | Silt Clay     | 5 Y 2.5/2 Black    |
| Tamuku          | Ta - L1  | Silt Loam     | 2.5 Y 4/4 Olive Brown |
|                 | Ta - L2  | Silt Clay Loam| 2.5 Y 4/2 Dark Brayish Brown |


The nineteen villages in the coastal area of North Luwu Regency generally have soil with a texture of silt loam, silty clay loam, silty clay, clay loam, and sandy loam. The topsoil layer has a silt loam texture and the bottom layer is clay textured. These results indicate that in general the characteristics of sago land in coastal villages mostly grow in habitat types with a texture of silt loam and clay loam. Sago land that is flooded for less than six months has a smooth texture [3].

Soil samples totaling 49 samples consisted of several layers of soil, the number of layers varied because the water depth obtained was also different from all coastal villages of sago land. Soil colors obtained in the topsoil layer include dark and black. As the depth of the soil increases, the color of the soil will become lighter. The factors that affect the difference in soil color are due to the accumulation of organic matter based on the chemical properties of the soil, the value is higher in the topsoil layer and the underground layer is often flooded so that the iron content is higher. The dark color of the soil is generally caused by high organic matter content and is decomposed unless there is the influence of minerals such as iron oxide or accumulation of salts so that modifications of the soil color often occur [4].

### 3.2. Soil chemical properties

Based on the results of soil physical properties including texture and soil color parameters from nineteen coastal villages in North Luwu Regency, the following results were obtained

#### Table 3. Results of Analysis of Chemical Properties of Soil Samples from Nine Coastal Villages, North Luwu Regency

| Name of Village | Layers | pH (H2O) | C-Organik (%) | Salinity (mS cm⁻¹) | N-total (%) |
|----------------|--------|----------|---------------|-------------------|-------------|
| Waelawi        | Wa-L1  | 6.25     | 2.04          | 0.071             | 0.26        |
|                | Wa-L2  | 6.23     | 1.11          | 0.019             | 0.21        |
| Pengkajoang    | Pe-L1  | 6.34     | 2.24          | 0.081             | 0.23        |
|                | Pe-L2  | 6.21     | 1.85          | 0.030             | 0.22        |
| Waetuwo        | Wo-L1  | 6.23     | 2.78          | 0.072             | 0.24        |
|                | Wo-L2  | 6.23     | 1.95          | 0.170             | 0.25        |
| Pao            | Pao-L1 | 6.31     | 2.44          | 0.066             | 0.41        |
|                | Pao-L2 | 6.30     | 1.75          | 0.048             | 0.25        |
|                | Pao-L3 | 6.13     | 0.15          | 0.032             | 0.33        |
| Location     | Reference | Value1 | Value2 | Value3 | Value4 |
|--------------|-----------|--------|--------|--------|--------|
| Pattimang    | Pat - L1  | 6.98   | 3.09   | 0.036  | 0.41   |
|              | Pat - L2  | 6.32   | 2.48   | 0.076  | 0.23   |
|              | Pat - L3  | 5.68   | 1.75   | 0.036  | 0.21   |
| Fince Pute   | Pin - L1  | 6.18   | 2.14   | 0.124  | 0.25   |
|              | Pin - L2  | 6.46   | 1.20   | 0.149  | 0.21   |
| Tokke        | To - L1   | 6.61   | 2.49   | 0.176  | 0.19   |
|              | To - L2   | 6.37   | 1.40   | 0.076  | 0.21   |
|              | To - L3   | 6.36   | 0.85   | 0.071  | 0.11   |
| Benteng      | Be - L1   | 6.34   | 2.44   | 0.067  | 0.32   |
|              | Be - L2   | 6.23   | 2.40   | 0.012  | 0.25   |
|              | Be - L3   | 6.05   | 1.15   | 0.035  | 0.21   |
| Takkalala    | Ta - L1   | 6.16   | 1.30   | 0.007  | 0.25   |
|              | Ta - L2   | 6.05   | 1.01   | 0.019  | 0.12   |
|              | Ta - L3   | 5.86   | 0.35   | 0.026  | 0.11   |
| Salakoe      | Sa - L1   | 5.89   | 3.54   | 0.360  | 0.28   |
|              | Sa - L2   | 5.08   | 2.94   | 0.298  | 0.21   |
| Ladongi      | La - L1   | 6.57   | 2.79   | 0.118  | 0.23   |
|              | La - L2   | 5.93   | 2.34   | 0.079  | 0.32   |
| Pongko       | Pon - L1  | 6.32   | 3.49   | 0.068  | 0.23   |
|              | Pon - L2  | 6.11   | 1.35   | 0.021  | 0.22   |
|              | Pon - L3  | 5.92   | 0.55   | 0.019  | 0.14   |
| Batang Tongka| Bt - L1   | 6.46   | 3.69   | 0.226  | 0.41   |
|              | Bt - L2   | 6.65   | 0.95   | 0.200  | 0.21   |
| Tamuku       | Ta - L1   | 6.35   | 3.74   | 0.235  | 0.44   |
|              | Ta - L2   | 6.32   | 3.02   | 0.067  | 0.42   |
|              | Ta - L3   | 5.77   | 2.92   | 0.190  | 0.32   |
| Rampoang     | Ra - L1   | 5.89   | 3.89   | 0.073  | 0.25   |
|              | Ra - L2   | 5.87   | 2.89   | 0.077  | 0.22   |
|              | Ra - L3   | 5.59   | 1.75   | 0.012  | 0.17   |
| Karondang    | Ka - L1   | 6.58   | 3.94   | 0.036  | 0.12   |
|              | Ka - L2   | 5.80   | 2.84   | 0.067  | 0.12   |
|              | Ka - L3   | 5.38   | 1.28   | 0.034  | 0.11   |
|              | Ka - L4   | 5.30   | 0.75   | 0.071  | 0.08   |
| Munte        | Mu - L1   | 5.88   | 3.54   | 0.014  | 0.21   |
|              | Mu - L2   | 5.71   | 3.69   | 0.129  | 0.22   |
| Poreang      | Por - L1  | 6.12   | 3.19   | 0.070  | 0.19   |
|              | Por - L2  | 6.02   | 2.14   | 0.032  | 0.12   |
|              | Por - L3  | 5.94   | 1.30   | 0.034  | 0.11   |
| Bungadidi    | Bu - L1   | 6.16   | 2.79   | 0.121  | 0.27   |
|              | Bu - L2   | 5.90   | 0.70   | 0.055  | 0.21   |

Description:
- **Red**: Highest Value
- **Green**: The Lowest Value
The results of pH analysis showed the lowest pH value was 5.08 in the Sa - L2 layer and the highest was 6.98 in the Pat - L1 layer. From all sample analysis results, the average pH was >5 or close to neutral. Factors that affect soil pH can also be seen from the high rainfall in North Luwu Regency in the last 10 years, all of which are classified as wet months so that especially in coastal areas the land often experiences flooding for months. One of the factors that affect the pH value is the process of flooding so that the soil pH becomes neutral [4]. The result of the analysis which is also related to pH is soil salinity. All soil sample points show a very low salinity value, which is <0 based on the criteria for soil chemical properties [5]. This parameter value is in line with the soil pH value which is close to neutral. Although it is a coastal area, high rainfall and months of flooding are also factors that affect the level of soil salinity.

The C-organic content shows the highest value in Karondang village in the topsoil layer and the lowest value in Pao village (Pao-L3) or the lowest layer. Based on the soil chemistry criteria from BPT Bogor and looking at the overall results of the analysis, it can be said that the c-organic content of the soil in layer 1 is high (> 3.01) [5]. In layer 2, it is classified as low (1.0-2.0) to moderate (2.01-3.0). The lowest layer, namely layer 3 and layer 4 is classified as very low (<1) to low (2.01-3.0). The low C-organic content is an indicator of the low amount of soil organic matter available in the soil [6]. As the soil depth increases, the amount of c-organic in the soil decreases because the organic matter in the lower layers has been transported from the topsoil. The content of organic matter can also be influenced by land conditions that are often flooded, the subsoil is more often affected by inundation.

The research table related to the total N content of the soil shows that the nitrogen content of the soil is more in the topsoil. If viewed from the table of chemical characteristics of soil BPT Bogor (2005), the nitrogen content with a value of 0.1% is classified as very low, 0.1-0.2% low, 0.21-0.5% moderate, 0.5 -0.75% high, and above 0.75% very high. In Luwu Regency, the coastal area contains nitrogen which is in the range of 0.1-0.2% or low. In this case, it can be concluded that the availability of nitrogen in the soil will decrease with increasing soil depth. This is because the topsoil contains more organic matter due to the decomposition process. In addition, considering that the location of this study is in a coastal area, the nitrogen content of the soil is not too high when compared to non-coastal areas, this is due to the fact that coastal areas are often flooded so that the nitrogen content is decreasing due to being washed out by water [7].

### 3.3. Soil water

| Name of Village | Salinity (dS m⁻¹) | pH  |
|-----------------|------------------|-----|
| Waelawi         | 0.31             | 6.25|
| Pengkajoang     | 0.29             | 6.23|
| Waetuwo         | 0.42             | 6.52|
| Pao             | 0.14             | 6.34|
| Pattimang       | 1.27             | **6.81**|
| Pince Pute      | 1.19             | 6.38|
| Tokke           | 0.33             | 6.34|
| Benteng         | 0.65             | 6.24|
| Takkalala       | 1.03             | 5.53|
| Salakoe         | 1.41             | **5.5**|
| Ladongi         | 0.63             | 5.72|
| Pongko          | 0.68             | 6.43|
| Batang Tongka   | **0.19**         | 5.68|
| Tamuku          | 1.09             | 5.63|
| Rampoang        | 0.56             | 6.42|
| Karondang       | -                | -    |
The salinity of the water is the level of saltiness or levels of salt dissolved in water. Salinity is influenced by several factors such as tides, evaporation, rainfall, and water topography. From the research data in the coastal area of North Luwu Regency, the salinity value of the water is in the number 0.19 – 1.41, mS cm⁻¹, and these values are low for the level of water salinity based on the chemical properties [1].

The pH value of the water is in the range of 5.5 – 6.81 which shows that the pH of the water is slightly acidic. Coastal areas usually have high water salinity, not the case with coastal areas where sago plants grow, the water pH is <7, but some areas show near-neutral pH values and low water salinity conditions in the entire study area. Several factors affect this condition, namely the high rainfall in the North Luwu district which is classified as a wet month in 2010 - 2020 and causes the soil to be inundated for months.

3.4. analysis of sago development potential
Based on the results of interviews with sago farmers in the North Luwu Regency, the following information was obtained.

Table 5. Interview Results of the Sago Farmer Group in the Coastal Region of North Luwu Regency in 2020

| Respondent (Name of Village) | Number of Sago Trees Cut/Year | Production (Kg) |
|------------------------------|-------------------------------|----------------|
| Ridwan (Tokke)               | 18                            | 14.850         |
| Nasrih (Pengkajoang)         | 98                            | 88.200         |
| Israil (Waelawi)             | 135                           | 76.950         |
| Haeruddin (Pince Pute)       | 100                           | 42.000         |
| Tasrifanto (Poreang)         | 50                            | 12.500         |
| Farhan (Rampoang)            | 12                            | 4.992          |
| Lomo (Bungadidi)             | 30                            | 7.500          |
| Dahir (Karondang)            | 20                            | 15.000         |
| Anton (Salakoe)              | 17                            | 10.200         |
|                              | 53.3                          | 30.243,5       |

Description :
- The Highest Value
- The Lowest Value
Of the 19 coastal villages that still have sago clumps, there are only 9 groups of sago farmers who are still actively processing sago stems. Several groups of sago farmers no longer operate because they do not get sago stems ready to be harvested for processing.

Based on the results of interviews from 9 coastal villages that have sago farmers groups in September 2020, the data described in table 4. The whole stem of sago that has been processed produces > 250 kg of wet starch, and in Pengkajoang village as the highest sago starch production, from one stem of sago, the average production of wet starch is > 400 kg, even reaching > 1 ton with total production in 2020 is 88,200 kg. Sago farmers group from Waelawi village can cut 135 sago stems as the village with the second highest sago starch production in the coastal area of North Luwu, which is 76,950 kg. The lowest production of wet sago starch from the sago farmer group in Rampoang village, which was 4,992 kg from 12 harvested sago stems. Based on interviews with the group of sago farmers, this low income is due to the lack of ready-to-harvest sago that can be processed. The work of processing sago is not the main job of each member of the sago farmer group, because it will only process when there are sago stems ready to harvest.

4. Conclusions
The characteristics of sago land in the coastal area of North Luwu Regency as described are very suitable for sago plants because they can grow and produce very well, with an average production reaching > 250 kg/sago stem and even reaching > 1 ton/sago stalk. For plants in general, the limitations of coastal land do not support their growth, but for sago plants it is very suitable and has the potential to be developed.

References
[1] Hayati N, R. P and A. K 2014 Preferensi Masyarakat Terhadap Makanan Berbahan Baku Sagu (Metroxylon sagu Rottb) Sebagai Alternatif Sumber Karbohidrat di Kabupaten Luwu dan Luwu Utara Sulawesi Selatan. Penelit. Sos. dan Ekon. Kehutanan. 11
[2] Muhidin, Leomo and Arma S 2012 Pengaruh Perbedaan Karakteristik Iklim terhadap Produksi Sagu (Kendari: fakultas pertanian UHO)
[3] Louhenapessy. 1996 Evaluasi dan Klasifikasi Keseuaian Lahan bagi Sagu (Metroxylon spp). (Yogkakarta)
[4] N. H, M.Y.Nyakpa. S G L, M.R.Nugaha., M.ASaul., G.B.ong. and H.H.Bailey 1986 Dasar-dasar Ilmu Tanah. ed U Lampung (Bandar Lampung.)
[5] BPT 2005 Petunjuk Teknis Analisis Kimia Tanah, Tanaman, Air dan Pupuk. (Bogor: Badan Penelitian dan Pengembangan Pertanian)
[6] Gerson 2007 Kondisi Tanah Pada Sistem Kalivu dan Mawar Info hutan 5 45–52
[7] Izzudin 2012 Perubahan Sifat Kimia dan Biologi Tanah Pasca Kegiatan Perambahan di Areal Hutan Pinus Reboisasi Kabupaten Humbang Hasunduta Provinsi Sumatera Utara (Sumatera Utara)