Utilization of suboptimal land for the sustainability of upland rice farming in Minahasa District

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Abstract. Increasing rice production is not only relied on from irrigated and rainfed rice fields, but also on dry land (upland rice). Development of upland rice on sub-optimal lands is one of the efforts to overcome the problem of vulnerability to rice availability, but until now its management is still not optimal. Minahasa District is one of the upland rice producing districts in North Sulawesi. This paper aims to identify matters related to sub-optimal land use for the sustainability of upland rice farming by farmers that can be developed in support of efforts to increase upland rice production in North Sulawesi, in addition to improving the existing technology used by farmers. This study was conducted in the Tombariri Subdistrict, Minahasa District, using a survey method. Data collection was carried out through field observations, surveys, documentation, in-depth interviews with key informants, and literature studies. The data obtained were then analyzed descriptively. Based on field identification and the results of the study, it was found that the existing local farmers’ technology was still very simple, especially in the aspects of seed supply, planting and maintenance. Farmers are increasingly pursuing development towards organic farming. There are still many sub-optimal land uses that can be optimized for upland rice cultivation accompanied by improvements to the existing limiting factors on each land.

1. Introduction

Agroecosystem on dry land is one of the great potentials of agricultural business to be cultivated both with food crops, horticulture (vegetables, ornamental plants and fruits) as well as annual crops and livestock business. Referring to the Atlas of Agricultural Spatial Planning of Indonesia with a scale of 1: 1,000,000 [1], Indonesia’s land area is about 188.20 million ha, consisting of 148 million ha of dry land (78%) and 40.20 million ha of wetlands (22%). In terms of area, the potential of dry land in Indonesia is high, but there are biophysical and socio-economic problems that must be overcome to increase productivity in a sustainable manner. Several actions to overcome the biophysical limiting factors of land include management of soil fertility, soil conservation and rehabilitation, and efficient management of water resources [2].

Upland rice cultivation is one of the right and effective alternatives to support food security. From the large dry land potential, there are about 59.3 million ha that have the potential to be used as productive land in various provinces, and only about 24.7 million ha are used as forestry and plantation land [3]. This means that the opportunity to develop upland rice in dry land is very large. Upland rice development areas or upland rice-based cropping patterns include (a) flat areas including riverbanks, (b) hilly watershed areas (DAS) and (c) as intercropping plants with plantation crops and young industrial forest plantations [4].
Although currently upland rice productivity is still relatively low (2.57 tons/ha) compared to upland rice productivity (4.75 tons/ha), however, with the intervention of technological innovation and optimizing the utilization of upland rice genetic resources spread across various regions including North Sulawesi, it is not impossible that upland rice productivity can be increased higher. Utilization of upland rice genetic resources to support optimistic food security can be done through the application of superior varieties. Germplasm-based breeding of upland rice which is widespread can be a key factor. This is because the low productivity of upland rice is partly due to the application of cultivation technology that has not been optimal, especially the use of superior varieties, fertilization and control of blast disease [4].

The Rice Research Center in Sukamandi, has produced several superior upland rice varieties with high productivity, including Situ Patenggang, Situ Bagendit, Tuwoti, Limboto, Inpago 4, Inpago 5, Inpago 6 and Inpago 7 [5]. Generally these varieties early maturity ranges from 105–125 days with a plant height of about 100–135 cm. The variety is tolerant to aluminum poisoning, drought tolerant, resistant to several races of blast disease. The yield potential of upland rice varieties is around 6–8 tons/ha. In addition, upland rice varieties are suitable for cultivation in low to moderate dry land <700 m above sea level [5]. Increasing rice production is highly dependent on the ability to combine various components of the best crop management for different varieties including a combination of varieties, fertilization and spacing [6,7]. Characteristics of plants that are adaptive to drought include good plant root systems, for example having a clumped distribution in the tillage layer and having deeper penetration capabilities [8–10]. The ability of root penetration in deeper soil layers allows plants to absorb water and nutrients in deeper layers.

Upland rice varieties that are adaptive to marginal land environments can be obtained through plant breeding. Plant breeding programs require a source of genes that carry adaptive traits on marginal land, especially upland rice germplasm originating from various regions that have adapted to their environment. Wild rice germplasm groupings based on plant quantitative characters have been produced [11]. The problem is, how to optimize the use of suboptimal land resources with upland rice in a sustainable manner, so that upland rice can contribute to efforts to develop food security? This study aims to identify matters related to suboptimal land use for upland rice farming by farmers that can be developed to support efforts to increase upland rice production in North Sulawesi, in addition to improving the existing technology used by farmers.

2. Materials and methods
This research was conducted in July 2017 in Tombariri Subdistrict, Minahasa District using a survey method. Data was collected through field observations, surveys, documentation, interviews with 60 farmers who were trying to grow upland rice using a questionnaire and through literature study. Data on mastery of upland rice farming technology is based on twelve components of integrated crop management technology (PTT) from soil processing tillage to post-harvest. The data obtained were then analyzed descriptively.

3. Results and discussion
3.1. The proportion of dry land area
Dry land in North Sulawesi is spread throughout the district and city areas in North Sulawesi Province. District areas with relatively large dry land are concentrated in three districts, namely Bolaang Mongondow, South Minahasa, and Minahasa. The amount of dry land in the three districts reaches about 42% of all dry land in North Sulawesi Province. The proportion of dry land area in other districts is in the range of 1.54 to 9.56%. The lowest dry land area is in Kotamobagu City (Table 1).
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Table 1. Average area of non-paddy agricultural land by use in North Sulawesi, (2008-2015) (hectares).

| District/City                   | Garden (ha) | Field (%) | Total (ha) | (%) |
|--------------------------------|-------------|-----------|------------|-----|
| Kotamobagu City                | 367.75      | 0.18      | 4,565.9    | 3.82| 4,933.6    | 1.54|
| Tomohon City                   | 1,982.1     | 0.99      | 4,496.6    | 3.76| 6,478.7    | 2.02|
| Bitung City                    | 3,544       | 1.76      | 2,173.1    | 1.82| 5,717.1    | 1.78|
| Manado City                    | 4,102.3     | 2.04      | 1,565.3    | 1.31| 5,667.6    | 1.77|
| East Bolaang Mongondow         | 12,898      | 6.42      | 7,801.3    | 6.53| 20,699     | 6.46|
| South Bolaang Mongondow        | 14,423      | 7.17      | 4,793.5    | 4.01| 19,216     | 6.00|
| South East Minahasa            | 7,524.3     | 3.74      | 5,463.4    | 4.57| 12,988     | 4.05|
| Sitaro Islands                 | 7,416.4     | 3.69      | 3,486      | 2.92| 10,902     | 3.40|
| North Bolaang Mongondow        | 9,745.4     | 4.85      | 12,523     | 10.48| 22,269     | 6.95|
| North Minahasa                 | 22,716      | 11.30     | 3,372.5    | 2.82| 26,089     | 8.14|
| South Minahasa                 | 25,575      | 12.72     | 18,607     | 15.57| 44,181     | 13.78|
| Talaud Islands                 | 22,054      | 10.97     | 8,598      | 7.20| 30,652     | 9.56|
| Sangihe Islands                | 7,229       | 3.60      | 7,208.9    | 6.03| 14,438     | 4.50|
| Minahasa                       | 26,500      | 13.18     | 14,736     | 12.33| 41,237     | 12.86|
| Bolaang Mongondow              | 34,978      | 17.40     | 20,089     | 16.81| 55,067     | 17.18|
| Jumlah                         | 201,055     | 100.00    | 119,479    | 100.00| 320,534    | 100.00|

If we look at the development of dry area in North Sulawesi, in a period of 6 years (2008 – 2014), there is a sharp tendency to decrease land area, as shown in Figure 1. The downward trend is explained in an equation that has a negative coefficient, i.e., y = -844, 14X + 321740.

![Figure 1](https://example.com/image1.png)

**Figure 1.** Development of upland and field in North Sulawesi period 2008–2014.

3.2. Rice production system in rainfed upland

Upland rice production systems in rainfed dry land by farmers are planted during high rainfall with a subsistence cropping pattern by farmers everywhere, including Indonesia. The habit of farmers growing food which is also carried out with annual crops is a strategy in maintaining life that is carried out by the community which is also carried out for the sustainability of land in production. The combination of crops cultivated on dry land is in the form of mixed crops with sweet potatoes, corn, and bananas.
The productivity per unit area of upland rice at the farmer level is an average of 2,424 tons/ha where this production is still very low and there is still a chance to increase it by about two times. The low yield at the farm level is due to the fact that farmers generally grow local varieties with long maintenance life and high agronomic growth and are easy to fall.

3.3. Application of upland rice technology

From the results of interviews with farmers and field extension workers, in general, farmers have applied the existing technology. The twelve components of upland rice technology based on Integrated Technology Management (PTT) which are used as a reference (Table 2). Soil cultivation or processing tillage has been well controlled by farmers. For the Seed aspect, the selection of varieties as well as pest control and aspects of the harvest are still not properly controlled and need assistance. Farmers should use labeled seeds. Then the varieties used should be superior varieties because many have been produced by agricultural R&D agencies.

The seeds used are generally from their own harvest obtained from the provision of the local government (Local Authority of Agriculture Services) and the varieties used have been used for generations in the last five years. Farmers mostly use inorganic fertilizers (artificial fertilizers) and it is still very rare to find farmers using organic fertilizers for upland rice cultivation. Inorganic fertilizers used by farmers in each location are relatively similar, namely using Phonska's trademark fertilizer, Urea. The average use of fertilizer for upland rice is Urea, and Phonska 50 kg and 100 kg/ha, respectively. The use of this fertilizer dose is thought to be far from the recommendation. The use of Urea fertilizer 135 kg + 200 kg SP-36 + 100 kg KCl/ha for upland rice in dry land is good enough to increase the yield per unit area [12].

Table 2. Mastery of upland rice technology knowledge component.

| No. | Knowledge component            | High (%) | Midle (%) | Low (%) |
|-----|--------------------------------|----------|-----------|---------|
| 1.  | Processing tillage             | 52       | 7         | 1       |
| 2.  | Seed                           | 10       | 35        | 15      |
| 3.  | Varieties                      | 15       | 20        | 25      |
| 4.  | Cultivation system             | 44       | 13        | 3       |
| 5.  | Number of seeds per hole       | 35       | 23        | 2       |
| 6.  | Dosage of organic fertilizer   | 59       | 1         | 0       |
| 7.  | Dosage of inorganic fertilizer | 50       | 4         | 6       |
| 8.  | Weeds weeding                  | 50       | 4         | 6       |
| 9.  | How to fertilize               | 50       | 4         | 6       |
| 10. | Pest control                   | 15       | 30        | 15      |
| 11. | Harvest                        | 20       | 22        | 18      |
| 12. | Post-harvest                   | 49       | 5         | 6       |

The planting system used by farmers is random, but the spacing used by farmers is 20x20 cm or 20x25 cm. The cropping system used by farmers is more difficult in weeding and fertilizing. The low use of fertilizers by farmers is due to limited capital in the form of cash. Besides that, farmers use inorganic fertilizers sufficiently and lack of availability of fertilizers at the location, so that fertilization is not in accordance with the actual needs of upland rice plants, as a result the productivity of upland rice is not optimal. Farmers use far more seeds than recommended. When viewed from the high level of use of seeds from the use of recommended seeds (30–40 kg/ha), farmers are not sure that the seeds used for upland rice are broadly integrated. However, farmers have their own reasons, namely to keep some of the seeds planted from becoming seedlings due to pest attacks, especially ants and birds. More farmers use seeds for upland rice cultivation because the seeds used are not labeled (because the seeds are produced by themselves) [13], so the quality and growth power of the seeds are not good.
Farmers generally cultivate the land after harvest, leaving the land for about a month. Farmers spray herbicides with the trademarks DMA, Gramaxone, and Round Up. DMA is used for broadleaf weeds, while Gramaxone and Round Up are used for pre-growing plants. Rahman et al. [12] stated that the introduction of chemical/herbicide technology as an effort to reduce the use of labor, especially in land preparation and weeding so as to overcome labor shortages.

4. Conclusions
The existing local farmers' technology was still very simple, especially in the aspects of seed supply, planting and maintenance. Farmers are increasingly pursuing development towards organic farming. There are still many sub-optimal land uses that can be optimized for upland rice cultivation accompanied by improvements to the existing limiting factors on each land.

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