The dynamics of agricultural crop production development on land cover changes in Tinggimoncong District

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Abstract. Agricultural activities can lead to land cover changes in a watershed region such as in Tinggimoncong District, Gowa Regency that located in the upper stream of the Jeneberang watershed. Gradually, there has been a development in agricultural activities in the area, marked by an increase in agricultural area as well as agricultural production that led to a change in land cover in the region. A descriptive study was conducted with aim to determine the relationship between the development of agricultural activities and the increase in agricultural production with land cover changes in the upstream Jeneberang watershed. This understanding is expected to help create a more environmentally friendly agricultural environment so that it can be more sustainable. This research shows that the development of plantation crops had contributed to land cover change, due to expansion of human activities in agriculture into the forest area, thus the primary forest then turned into secondary forest. The development of agricultural activities was partly attributed to the higher selling price of agricultural products. It makes farmers excited to increase their production, including by expanding the area for planting crops that have high selling value.

1. Introduction

Agriculture are activities that have been carried out for a long time by human ancestors. Smallholder agriculture is not only a source of food but also a driver of economic development, especially for people in rural areas [1]. This farming activity develops in accordance with the natural conditions of the surrounding environment. In addition, its development also depends on the activeness of the farming community in that place.

Crops planted by farmers are agricultural plants that has adapted well under local natural conditions and needed by local and surrounding communities. From the natural conditions perspective, it is possible to plant several types of crops in one area. Crop choices also can be affected by the
relations between regions. A good interconnectivity between regions means it is possible that the plants cultivated by local farmers are not only based on the needs of the local community, but are carried out to meet the needs of people in other places for these crop products. This is especially true if the benefits that can be obtained for farmers from these crop products are good enough. However, the management of the agricultural sector potential has tended to pursue an increase in productivity and quality of agricultural products, but has paid less attention to stability and sustainability [2].

The Jeneberang watershed is one of the watersheds in South Sulawesi which is categorized as priority watershed. Many conditions around the watershed have changed the function of land from forest functions to agricultural and residential cultivation functions [3,4]. A common problem in agricultural areas in the upstream watershed is the occurrence of disturbances and damage from natural resources and the surrounding environment because farmers mainly pay attention to their agricultural production, but do not pay attention to their impact on the environment [5].

Tinggimoncong District which is located in the upstream of the Jeneberang watershed is one of the districts in Gowa Regency the highlands. This district is one of the areas that has active agricultural activities. The residents of Tinggimoncong district generally work as farmers, especially vegetable and plantation farmers, while community activities in the non-agricultural sector are mainly engaged in large and retail trading business fields. According to Anwar [6], there are several superior agricultural commodities located in Tinggimoncong District both from the food crop, horticulture, and plantation sectors, including: rice, sweet potatoes, cocoa, Robusta coffee, Arabica coffee, cloves, potatoes, chinese cabbage, and several others.

To avoid high plant maintenance costs, it is better to develop types of agricultural crops in an area by selecting the types of plants that are naturally suitable for the growing conditions in the area, both in terms of soil types, climatic conditions, rainfall, hydrological conditions or water availability. In addition, in selecting crops to be cultivated, farmers will usually consider the habits of the local community (socio-culture) and the economic value of the plants. Thus in fact, agricultural activities are activities that are influenced by natural, social, and economic conditions.

On the other hand, agricultural activities can have impact on the changes in these three circumstances *vice versa*. To increase agricultural production, farmers carry out agricultural intensification programs, which have helped to increase agricultural production through the use of high-yielding crop varieties, fertilizers, pesticides, and irrigation [7]. Nevertheless, these activities can result in several things that do not support sustainable agriculture, such as reduced biodiversity, reduced ecological functions, and critical ecosystems in agricultural landscapes [8]. Farmers also do imply an agricultural extensification by expanding agricultural areas, to encroaching forest areas for example. Extensification of agriculture causes changes in forest land, loss of natural habitat for some animals, and can even cause erosion of critical land that is still planted [9].

Productive agricultural activities cause agricultural landscapes to be the result of reciprocal formation between nature and society, because they cause changes in land cover such as changes in the area of bush and grassland cover into areas of agricultural cultivation, decreasing biodiversity due to uniform agricultural patterns [10]. Socio-economic aspects, environmental factors, and policy factors are various factors that can influence the process of land use change [11], which in turn has an impact on environmental changes and land cover [12]. This study aims to determine the relationship between the development of agricultural activities and the increase in agricultural production and changes in land cover in the upstream of Jeneberang watershed.
2. Methodology
This study was conducted in Tinggimoncong District, Gowa Regency, South Sulawesi Province. The research is a descriptive-analysis study, using an interview approach, distributing questionnaires, field surveys, and mapping. The data used consisted of primary and secondary data. Primary data is the result of interviews and questionnaires to respondent farmers, as well as field surveys. Meanwhile, secondary data comes from literature studies and data from various related agencies.

In this study, data collected including data on the production of several superior agricultural crops in Tinggimoncong District in several years, the area of the superior agricultural crops in Tinggimoncong District for several years, and the prices of some agricultural crop products in Gowa Regency. This data was collected from the Central Bureau of Statistics for data from Gowa Regency in Figures for 2007, 2011, and 2018. Other data collected for the purposes of this research is data from farmer respondents regarding the types of agricultural activities carried out at the beginning of the farmer. The respondent started farming activities and the types of agricultural activities carried out by the respondent farmers at this time. Meanwhile, to see changes in land cover in Tinggimoncong District at different times, a GIS approach was used. For this reason, the study employed land cover maps for years of 1990, 2000, 2011 and 2018, for the area currently located in Tinggimoncong District. The use of GIS helps identify land cover changes at the study site. Geospatial data for land cover is obtained from the GIS website of the Ministry of Environment and Forestry, as well as the Center for Research and Development of Spatial Planning and Spatial Information (witaris), Hasanuddin University Makassar.

The land cover change analysis was carried out by creating a land cover change matrix based on the results of GIS analysis from 1990, 2000, 2011 and 2018. Based on the land cover change matrix, it can be seen that the changes occurred from each land cover and the extent of the changes.

3. Results and discussion

3.1. Production dynamics and area of agricultural crops
Agricultural products from Tinggimoncong District are varied from horticultural crops, food crops, and plantation crops. The development of the production of several plantation crops in Tinggimoncong District is shown in figure 1.
Figure 1. Production of several plantation crops in Tinggimoncong District
Source: Central Board of Statistics of Gowa Regency.

The overall production of seven main plantation crops in Tinggimoncong District has continued to increase from 2007 to 2018, although with the dominance of different crop production, which is ultimately dominated by the production of Arabica coffee, followed by Robusta coffee, cloves, and cocoa (figure 1). The biggest increase in production for plantation crops is the production of Arabica coffee. In contrast to the production of Robusta coffee, there was higher production of the Arabica coffee in 2007, but in subsequent years the production continued to decline. Meanwhile, clove crop production is relatively stable with an increasing trend of production. Other plantation crops have a relatively small percentage of production, with relatively unstable development of production, except for the production of coconut plants whose production results were not recorded in 2018.

Planted area for plantation crops has also continued to increase from 2007 to 2018 (figure 2). Along with the development of increasingly large production, the planting area for Arabica coffee plants also experienced the largest increase from 2007 to 2018. Finally in 2018 the area of planting for plantation crops in Tinggimoncong District was dominated by Arabica coffee plants, followed by cloves. On the other hand, the planted area for Robusta coffee, recorded dominated the planting area for plantation crops in Tinggimoncong District in 2007, decreased quite significantly, especially from 2012 to 2018. Likewise, the planted area of cocoa has decreased slightly during the years. Meanwhile, the area of other plantation crops is relatively stable.

Figure 2. Development of Plantation Plant Area in Tinggimoncong District.
Source: Central Board of Statistics of Gowa Regency.

The development of the planting area and the increase in the production of plantation crops, apart from being influenced by weather conditions, may also be influenced by the interest of the community to plant or cultivate certain plantation crops due to the high price of the crops. Figure 3 shows the development of estate crop prices in Gowa Regency, which is the benchmark price for plantation crops in Tinggimoncong District, which, if analyzed, may also influence the development of both production and planting area of the plantation crops in Tinggimoncong District.
Figure 3. Prices of product for several plantation crops in Gowa Regency
Source: Central Board of Statistics of Gowa Regency

Plantation crops that had the highest price from 2008 to 2010 in Gowa Regency were cloves, followed by pepper, Arabica coffee, vanilla, cocoa, and Robusta coffee (figure 3). In 2011, the price of pepper plants showed the highest price, followed by cloves and Arabica coffee. Meanwhile, the price for cocoa and vanilla decreased in 2011. The increase in production and area of Arabica coffee plantations may have been triggered by the increase in the price of Arabica coffee products, which was higher than the price of the Robusta coffee plant. Meanwhile, the Robusta coffee plant, which was originally higher in production and planted area, then decreased in production and planted area. In addition, for the highland areas the Arabica coffee plant is more suitable for growing requirements than the Robusta coffee plant.

Apart from plantation products, Tinggimoncong District also produces food crop and horticultural crop products. Figure 4 shows the area of rice that has not changed from 2007 to 2018. But even though the area of the rice fields has not changed, there is a slight increase in the area of harvested, which may be due to the fact that there are rice fields that can be planted more than once in the observed year, which has a little impact on the increase in production.
Figure 4. Area of paddy fields, harvested area and rice production in Tinggimoncong District. Source: Central Board of Statistics of Gowa Regency.

Figure 5. Harvested area and production of several food crops in Tinggimoncong District. Source: Central Board of Statistics of Gowa Regency.

Rice is a food plant that has the largest harvest area and provides the highest production yield in Tinggimoncong District compared to other food crops recorded in this study (figure 5). This shows that the rice plant is still the main food crop that is most in demand for the people of Tinggimoncong District to cultivate.

3.2. Development of community farming activities in Tinggimoncong District

Communities in the upstream Jeneberang watershed, especially in Tinggimoncong District, generally work as farmers in food crop agriculture, horticulture or plantation crops. Meanwhile, community activities in the non-agricultural sector are mainly engaged in wholesale and retail trade. However, as reported by Dungga [13], agricultural activities that occur in the upstream of the Jeneberang watershed are activities that have been going on for a long time, but have become more active starting with the arrival of immigrant farmers from outside Sulawesi to Kanreapia and Buluballea villages in Pattapang, Tinggimoncong, in the middle of the 1980s which became the pioneer farmers mainly for vegetable crops. The success of these migrant farmers motivated the local community to also work on horticultural agriculture, especially supported by its location in the highlands and the cool temperature of the area. This is what causes horticultural crops to become a spine of Tinggimoncong District [14], especially in the Pattapang environment.

The comparison of the types of initial agricultural activities carried out by the respondent farmers in Tinggimoncong Subdistrict also changed slightly when compared to the current types of farming activities. As can be seen in figure 5 and figure 6, it appears that most of the respondent farmers in Tinggimoncong District started their type of farming activities by farming (66%). The next form of agriculture that was mostly practiced by respondent farmers at the beginning of their farming activities was horticulture farming (24%), and other farming activities were plantation crop farming and agrotourism activities. But over time, the respondent farmers began to develop their farming activities, so
that at the beginning of their farming activities they only carried out rice farming activities, now they are also developing plantation farming activities. This is what causes the percentage of plantation farming activities to increase compared to before (to 25%). Apart from that, to increase farmers’ income, there are other activities carried out by respondent farmers, which at the beginning of their farming activities no one had done them, namely raising livestock.

Figure 6. Respondent farmer’s first farming activity in Tinggimoncong District.

Figure 7. Current farming activities of respondent farmers in Tinggimoncong District

3.3. The dynamics of the land cover of Tinggimoncong District
Varied agricultural products also determine variations in the types of land cover in Tinggimoncong District. There is mixed dryland agricultural land cover, paddy field cover, primary forest land cover, and other land cover.

Figure 8 shows an overview of the dynamics of land cover in Tinggimoncong District in 1990, 2000, 2011 and 2018. In 1990, land cover was still dominated by bush cover, followed by primary forest land cover. However, from year to year, the cover of bush land as well as primary forest land cover is decreasing and replaced by land cover in the form of mixed dry land agriculture and secondary forest. Even primary forest land cover has almost completely disappeared, replaced by secondary forest land. The land cover that barely changes in area is the cover of paddy fields.

The change in land cover in Tinggimoncong District is inseparable from the activities of the farming community in this district. Secondary forest land cover is becoming more extensive, replacing the area of primary forest land cover. This is possible because the community uses primary forest to carry out agroforestry activities by planting plantation crops between forestry plants to get better income due to the better price of plantation products. This causes primary forest to change its land cover to become secondary forest. This is as expressed by Ruspendi, Hadi and Rusdiana [15] that in the same area of land, if there is a change in land cover by the land owner, then usually the land cover that provides higher economic value for the land owner will replace the previous land cover.

Likewise with the increasing area of mixed dryland agricultural land cover. This is due to the activities of the community who use scrub land to carry out agricultural activities of secondary crops and horticultural crops, so that this land has turned into mixed dry land agricultural land. For farming communities, of course, mixed dryland agricultural land cover provides more economic benefits compared to scrubland cover.

![Figure 8](image_url)

**Figure 8.** The dynamic of land cover change in Tinggimoncong District.

**Table 1.** Area of various land cover classes in the study area over several years of observation.

| No. | Land cover               | 1990 | 2000 | 2011 | 2018 |
|-----|--------------------------|------|------|------|------|
|     | Waterbody                |      |      |      |      |
|     | Primary forest           |      |      |      |      |
|     | Dry land agriculture     |      |      |      |      |
|     | Rice Fields              |      |      |      |      |
|     | Open field               |      |      |      |      |
|     | Clouds                   |      |      |      |      |
|     | Secondary forest         |      |      |      |      |
|     | Mixed dry land agriculture|     |      |      |      |
|     | Shrub 1                   |      |      |      |      |
|     | Industrial forest plantations |   |      |      |      |
|     | Plantations              |      |      |      |      |
|     | Savana                   |      |      |      |      |
|     | Quarry                   |      |      |      |      |
|   | Waterbody (W) | Clouds (C) | Industrial forest plantations (IFP) | Primary forest (PF) | Secondary forest (SF) | Plantations (P) | Dry land agriculture (DLA) | Mixed dry land agriculture (MDLA) | Savana (S) | Rice Fields (RF) | Shrub (S) | Quarry (Q) | Open Field (OF) | Total |
|---|---------------|------------|-----------------------------------|---------------------|----------------------|------------------|-----------------------------|---------------------------------|-----------|----------------|-----------|-----------|----------------|-------|
| 1 | 178.55        | 178.55     | 178.55                            | 178.55              | 178.55               | 178.55           | 178.55                      | 178.55                          | 178.55    | 2185.70        | 7844.02  | 0.00      | 0.00          | 18462.84|
| 2 | 2630.63       | 0.00       | 187.10                            | 1311.25             | 3910.95              | 173.89           | 0.00                        | 6842.01                         | 144.37    | 2277.64        | 3437.10  | 0.00      | 0.00          | 18462.84|
| 3 | 80.53         | 0.00       | 187.10                            | 38.45               | 4973.84              | 173.89           | 0.00                        | 8508.22                         | 144.37    | 2277.64        | 1674.36  | 2.33      | 304.10        | 18462.84|
| 4 | 5263.05       | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.84|
| 5 | 27.46         | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 120.27                          | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.84|
| 6 | 80.53         | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 7 | 5263.05       | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 8 | 27.46         | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 9 | 80.53         | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 10| 5263.05       | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 11| 27.46         | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 12| 80.53         | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|
| 13| 5263.05       | 0.00       | 187.10                            | 38.45               | 4915.85              | 173.89           | 0.00                        | 8728.45                         | 144.37    | 2277.64        | 1585.99  | 0.00      | 304.10        | 18462.48|

According to Verburg et al. [16] cited in Ren et al. [17], human activities have an impact on the environment, and changes in land use / cover have been identified as the main driving force for local, regional, and global environmental change. Understanding the dynamics of community farming activities, the area of harvest and crop production, as well as the economic influence on the dynamics of land cover change, is expected to help understand natural and human (social, economic, cultural) influences so that sustainable agricultural landscape planning can be realized. As also stated by Vallejo Cabrera [18] that in order to foster sustainable agriculture, it is necessary to consider the social, cultural and political contributions of communities in related rural areas. Agricultural production results will influence community decisions in using their land, which in turn will have an impact on environmental changes and land cover.

4. Conclusions
The development of plantation crops had contributed to land cover change, due to expansion of human activities in agriculture into the forest area, thus the primary forest then turned into secondary forest. The development of agricultural activities was partly attributed to the higher selling price of agricultural products. It makes farmers excited to increase their production, including by expanding the area for planting crops that have high selling value.

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