
Research Article

Agricultural landscape management strategies in watersheds towards resilient agroecosystems

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Abstract

A resilient and sustainable agriculture must be able to meet the needs of food for people while taking into account the state of the ecosystem. Aims of this study is to develop a suitable management strategy to be applied to the agricultural landscape in the upstream of Jeneberang watershed in order to form a resilient agroecosystem. This research is a descriptive-analysis research. In this study, information was collected regarding the development of agricultural and agroecosystem activities in the upstream of the Jeneberang watershed. The data used were derived from primary data and secondary data. Primary data obtained from interviews and distributing questionnaires to respondent farmers, as well as field surveys. Meanwhile, secondary data retrieved from literature studies and data from various related agencies. Several strategies for managing agricultural landscapes towards resilient agroecosystems in the upstream Jeneberang watershed are as follows: diversify agricultural crops and agricultural activities in the upstream Jeneberang watershed; combine the use of environmentally friendly technology to make it suitable for the land; build good communication among the community; and develops agrotourism or ecotourism activities.

Introduction

Agricultural activities have a significant impact on the surface of the planet. This is because of an increasing agricultural production, agricultural extensification and intensification are generally carried out (Gibbs et al., 2010). Agricultural extensification causes changes in forest land cover to agricultural land, loss of natural habitat for some animals, it can even cause erosion on critical lands that are still

planted (Wilson & Lovell, 2016). Meanwhile, the intensification of agriculture, which has helped increase in agricultural production through the use of high yield crop varieties, fertilizers, pesticides, and irrigation (Koohafkan et al., 2012), resulted in some things that do not support sustainable agriculture such as reduced biodiversity, declined ecological function, and critical ecosystems in the agricultural landscape (Landis, 2017). These things can

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cause problems for agricultural sustainability in the future.

Agricultural areas are expanding every year. Invasion of this area even had spread into forest areas, especially areas that have water sources, such as in watersheds (Charnsungnern & Tantanasarit, 2017). The upstream area of a watershed is usually located at a sloped elevation. Sloped land, especially one with steep slopes, has many limitations in its use and utilization. This area was originally had a forest land function, which later, due to the increasing of human population and limited available fertile land, was usually converted into an agricultural cultivation function area. Various impacts that follow these changes, including erosion and landslides, particularly if this land is cleared and processed without paying attention to environmental sustainability (Ruspendi et al., 2013; Solle & Ahmad, 2016; Surni et al., 2015).

The upstream Jeneberang watershed is located at an altitude ranging from 400 m - 1750 m above sea level. The agricultural landscape in the upstream area of the Jeneberang watershed is a horticultural farming area. Horticultural farming is carried out by the community with consideration of broad market needs, so that it can provide faster and more competitive profits, compared to other commodities (Nuraeni et al., 2013). In this area several communities have also started doing agro-tourism businesses. Apart from horticultural crops, the community in the upstream area of the Jeneberang watershed also cultivates food crops and plantation crops which are planted using intercropping or agroforestry patterns (Arsyad & Sainuddin, 2007; Purwanti, 2007).

A common problem in agricultural areas in the upstream watershed is the occurrence of disturbances and damage to natural resources and the surrounding environment because farmers mainly pay attention to agricultural production, but do not pay attention to the impact on the environment (Charnsungnern & Tantanasarit, 2017). To obtain adaptive and resilient agriculture, an innovative approach is needed, which can provide various solutions to agricultural development while reducing the adverse impacts of agriculture on biodiversity,

water resources and quality, hazardous contaminants, and the climate (Bennet et al., 2014).

According to (Bachrein, 2006) there are several factors that influence the development of farming system. The factors are: the powerlessness of small farmers in adopting technology due to limited resources; efforts to reduce farming risks through a diversification approach; increase productivity; develop job availability and strengthen farm income; preserve the environment in a sustainable manner. The problems that occur in a farming family are interrelated from one problem to another, so that solutions to them must be considered thoroughly.

Sustainable agriculture and a resilient environment can support each other, by still paying attention to the welfare of the community, and maintaining the physical environment of the land, such as water, soil, and vegetation on agricultural land (Suyana, 2008). The main objective of assessing resilience is to identify vulnerabilities in the socio-ecological system so that action can be taken to create a more sustainable future for people and land (Knickel et al., 2018). The path to resilient and sustainable agriculture must meet food and development needs on a local to global scale without disturbing ecosystems. The use of technology and the establishment of appropriate policies to increase food production, along with attention to environmental conservation are things that need to be a priority in developing sustainable agriculture (Laurance et al., 2014).

Therefore, this study aims to develop a suitable management strategy to be applied to the agricultural landscape in the upstream of the Jeneberang watershed in order to form a resilient agroecosystem.

Materials and methods

This research was conducted in the upstream of the Jeneberang watershed, precisely in Tinggimoncong and Parigi Districts, Gowa Regency, South Sulawesi Province. The topography of research area is in the highlands with an altitude ranging from 400 - 1750 meters above sea level. Average annual rainfall is 2420 mm (1,500 - 3,000 mm/year). According to

(Danial et al., 2020), the widest distribution of soil types in the upstream area of the Jeneberang watershed is Dystropepts.

The research is a descriptive-analysis research. The data were derived from primary data and secondary data. Primary data obtained from interviews and distributing questionnaires to 70 respondent farmers, as well as from field survey. The questionnaires were used to gain information of farmers' considerations in choosing their farming activities and plants to be planted on their land. The questionnaires also used to know prioritize farming activities, and the most sub system farming done by farmers in Jeneberang watershed.

Meanwhile, secondary data retrieved from literature studies and data from various related agencies. Information about plantation crop production and its wide area were collected using data from the Central Bureau Statistics of Gowa Regency for 2007, 2011 and 2018. Likewise, information on prices for several plantation crops in Gowa Regency was taken from the same source.

Meanwhile, to study the changes in land cover in the upper stream of the Jeneberang watershed, especially in Tinggimoncong and Parigi Districts at different times, it was carried out using a GIS approach. For this purpose, land cover maps of Tinggimoncong and Parigi Districts in 2000 (as a starting point of this research) and 2018 (as a finish point of this

research) are used. The use of GIS helps to identify changes in land cover in the research location. 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.

To develop an appropriate management strategy, it is necessary to pay attention to the various activities and conditions of the area to be managed. The analysis is based on logic that can maximize strengths and opportunities, but at the same time minimize weaknesses and threats (Rangkuti, 2008). To develop strategic factors, the SWOT matrix was used. This matrix can clearly describe the external opportunities and threats faced, which can be adjusted to the internal strengths and weaknesses of a location or situation. This matrix can generate four sets of possible strategic alternatives

Results

Inventory of agroecosystem conditions in the upper stream of the jeneberang watershed

Land cover change

The results of the geospatial analysis of land cover in the period of reference in this study (2000 and 2018) show that there were changes in land cover in the research area, as shown in Figure 1.

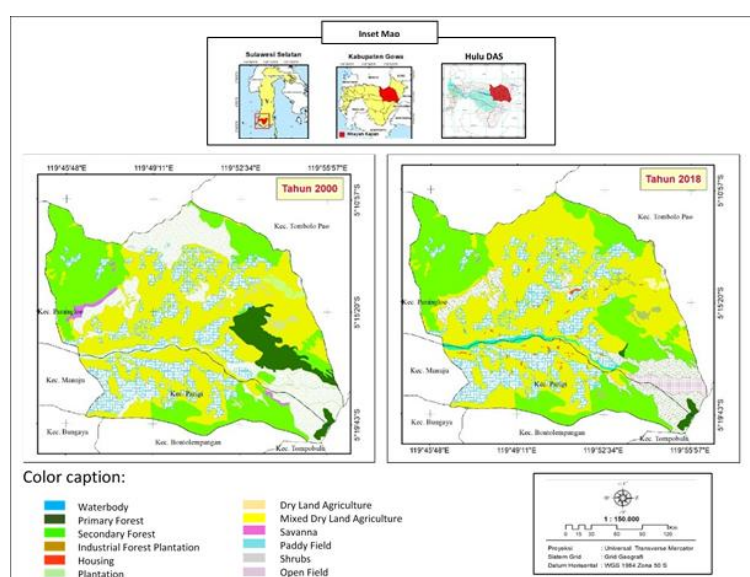


Figure 1. Map of land cover change of research area in 2000 and 2018

Based on [Figure 1](#), it appears that the land cover which was dark green in 2000 (representing primary forest land cover) in 2018 was mostly changed to light green (representing secondary forest land cover). Likewise, shrubs land cover (which is white) in 2000, mostly changed to mixed dryland agricultural land cover (which is yellow) in 2018.

This is further clarified by [Table 1](#) indicating that the secondary forest land cover is getting wider, whereas the primary forest land cover is decreasing. Likewise, it appears that the mixed dryland agricultural land cover is expanding, changing the shrub land cover and savanna land cover.

Table 1. Land cover of research area in 2000 and 2018 (ha)

No.	Land cover of research area	Year 2000 (ha)	Year 2018 (ha)
1	Waterbody	288.26	289.40
2	Primary forest	1,411.83	150.38
3	Secondary forest	5,549.19	6,559.23
4	Industrial Forest Plantation	203.51	200.67
5	Housing	2.47	95.65
6	Plantation	173.92	0.00
7	Dry land agriculture	0.00	113.56
8	Mixed dry land agriculture	9,236.89	11,114.81
9	Savanna	182.92	5.01
10	Paddy Field	4,110.47	4,213.63
11	Shrubs	4,462.09	2,374.90
12	Open Field	0.00	504.32
Grand Total (ha)		25,621.56	25,621.56

The reduced area of primary forest is replaced by an increase in the area of secondary forest. This is influenced by the increasing area of plantation crops planted by the community in agroforestry. The community in the research location planted plantation crops in agroforestry between forest plants, which caused a change in land cover from primary forest to secondary forest land cover.

The development of crop production and the area of agricultural production

Community enthusiasm for plantation crops is shown in [Figure 2](#) and [Figure 3](#), which show the production and area of plantation crops in the upstream Jeneberang watershed.

Based on [Figure 2](#), it appears that there has been an increase in yields from plantation crops in the upstream Jeneberang watershed from 2007 to 2018. The plantation crops that gave the largest yields and experienced an increase in production during that period were Arabica coffee plants, followed by cocoa plants.

The development of plantation crop production in the upstream Jeneberang watershed is inseparable from the development of the plantation area. [Figure 3](#) indicates that there was an increase in the area of several plantation crops during the period from 2007 to 2018. The plantation crops with the largest increase in the area of planting are the areas of Arabica coffee, cocoa, cloves, and pepper.

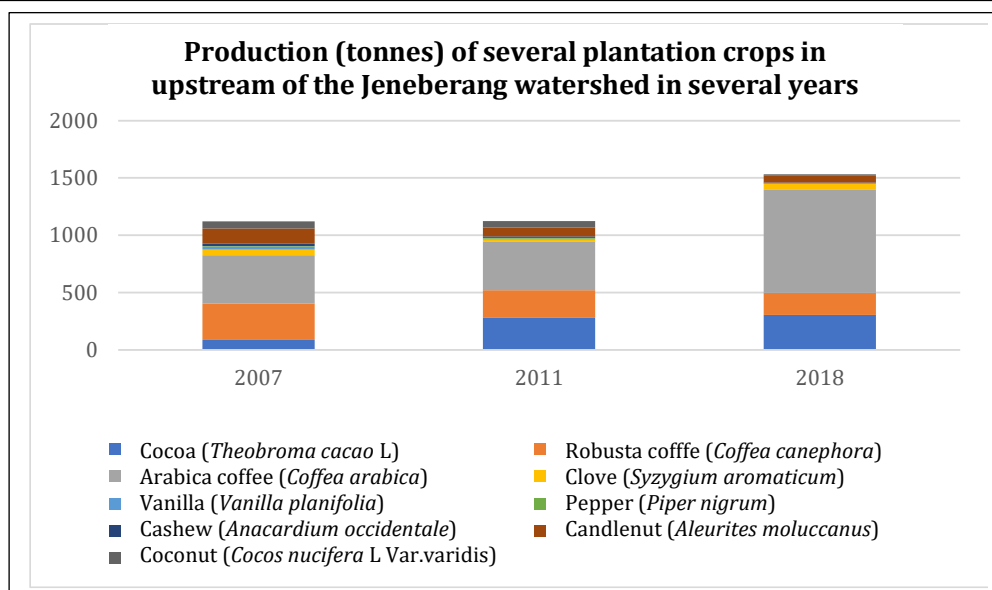


Figure 2. Production of several plantation crops in research area (Tinggimoncong District and Parigi District)

Source: Badan Pusat Statistik Kabupaten Gowa (2008, 2012, 2019)

The increase in planted area appears to be in line with the price of plantation crops. Based on Figure 4 that shows the price development of several plantation crops, it appears that during the period from 2007 to 2011 there was an increase in prices for several plantation crops. The highest increase in the price of plantation

crops was for the price of pepper, followed by cloves and Arabica coffee. Thus, there is a relationship between the price of plantation crops and the growing area of plantation crops that have high prices. The high price of crop yields makes people interested in increasing crop yields by expanding the plant area.

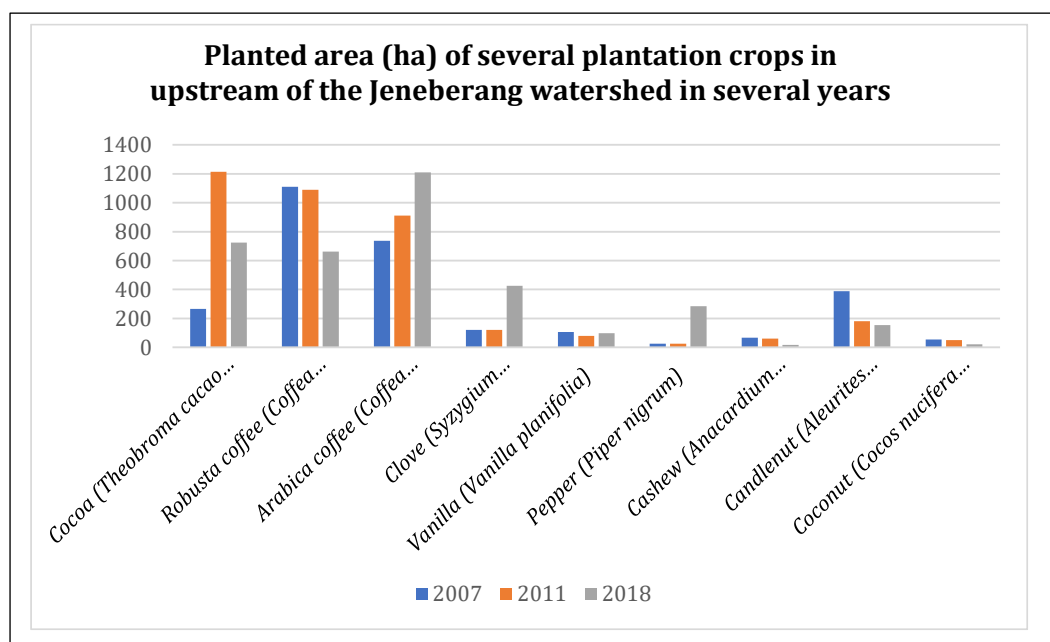


Figure 3. Development of Plantation Crop Area in research area (Tinggimoncong District and Parigi District)

Source: Badan Pusat Statistik Kabupaten Gowa (2008, 2012, 2019)

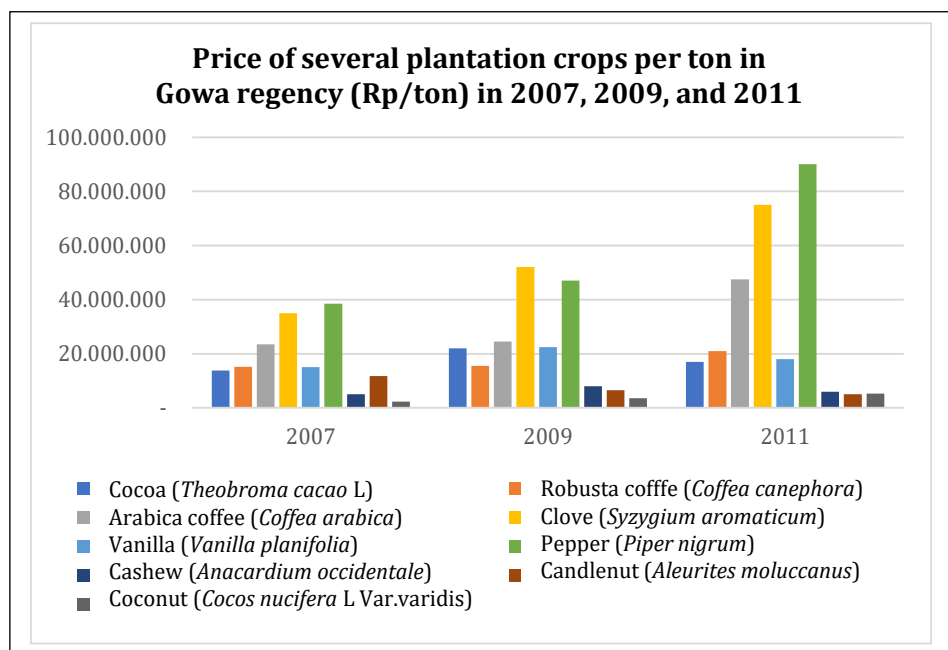


Figure 4. Prices of product for several plantation crops in Gowa Regency
Source: Badan Pusat Statistik Kabupaten Gowa (2008, 2010, 2012)

Figure 5 shows the area of rice fields that did not change from 2007 to 2018. However, there was slight increase in harvested area which resulted in a slight increase in production too.

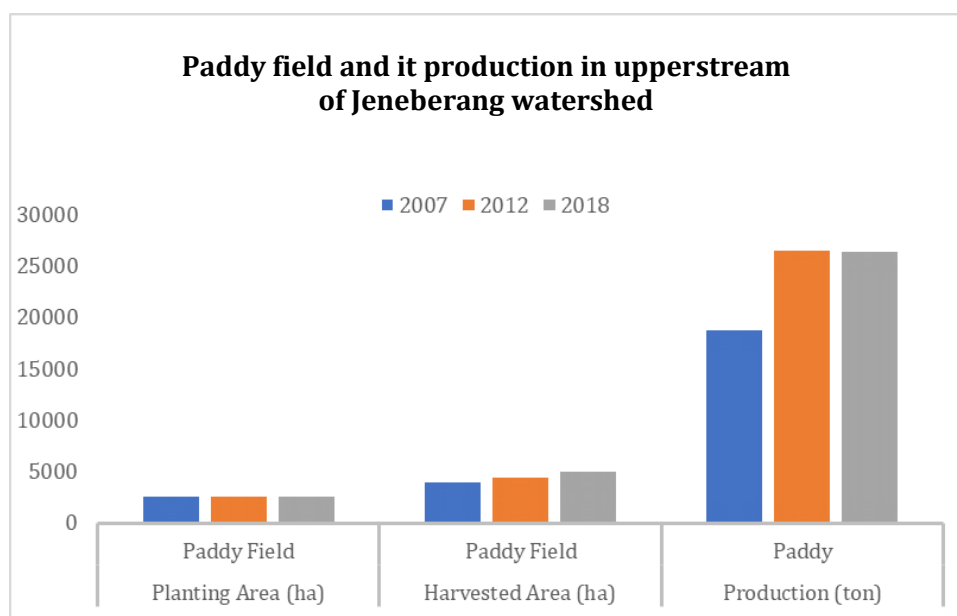


Figure 5. Area of paddy fields, harvested area and rice production in research area (Tinggimoncong District and Parigi District)
Source: Badan Pusat Statistik Kabupaten Gowa (2008, 2013, 2019)

Rice is a food plant that has the largest harvest area and provides the highest production yield in the upstream Jeneberang Watershed

compared to other food crops recorded in this study as can be seen on Figure 6.

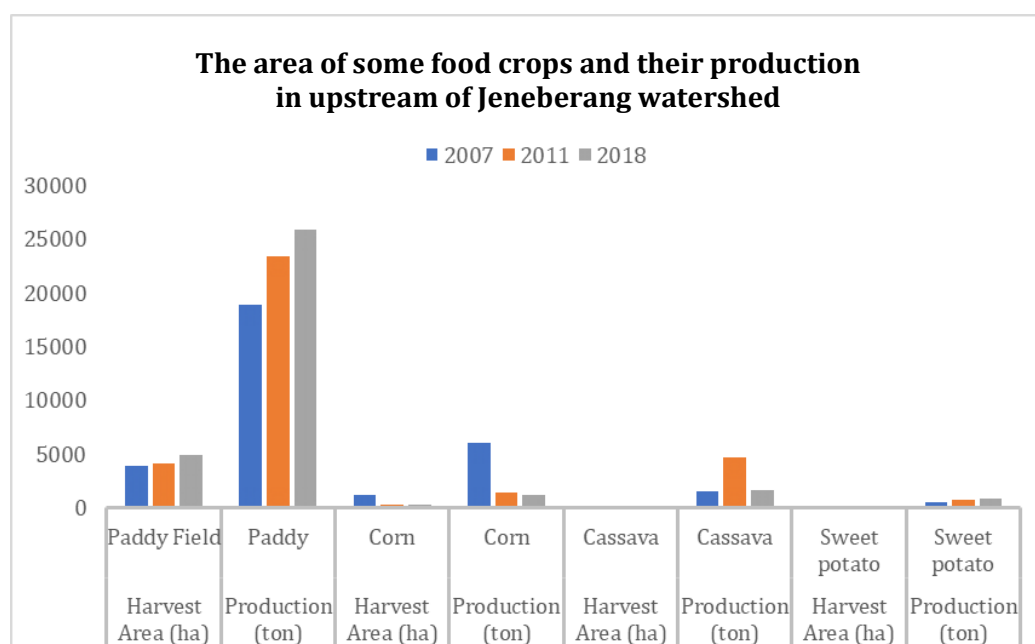


Figure 6. Harvested area and production of several food crops in research area (Tinggimoncong District and Parigi District)

Source: Badan Pusat Statistik Kabupaten Gowa (2008, 2012, 2019)

Community Preferences in Conducting Agroecosystems

There are various farming activities in the upstream area of the Jeneberang watershed. There is horticulture farming, rice field farming, crop plantations, agroforestry, agrotourism. When deciding on a farming activity,

farmers have several considerations. In Table 2, it can be seen the priority order of farmers' considerations in choosing their farming activities. This can be seen from the percentage of respondents who choose a consideration in determining their farming activities.

Table 2. Farmers' considerations in choosing their farming activities

No.	Criteria to be considered in choosing farming activities	Respondent Percentage (%)
1.	Profit that can be obtained from farming activities	25.71
2.	Capital needed to develop farming activities	22.86
3.	Manpower available to develop farming activities	17.14
4.	The farming activity is a hereditary activity	15.71
5.	Physical resources that support this farming activity	8.57
6.	Land suitability with farming activities	5.71
7.	The contribution of this farming activity to environmental sustainability	2.86
8.	The success of other farmers in carrying out farming activities	1.43
		100.00

Meanwhile, farmers have several considerations in choosing the types of plants to be planted on their land. As shown on Table 3, price is the first priority considered by

farmers, followed by market demand, and crops that have been commonly grown for generations on the land.

Table 3. Farmers' considerations in choosing plant types to be planted on their land

No.	Criteria to be considered by farmers in choosing types of plants to be planted on their land	Respondent Percentage (%)
1.	High price in the market	30.00
2.	Market demand	25.71
3.	Plants that have been planted for generations	20.00
4.	Land suitability	15.71
5.	Rainfall	5.71
6.	Agro-tourism opportunities	2.86
		100.00

Types of farming activities which are prioritized by the respondents can be seen on Table 4. Rice farming is the first alternative farming activity chosen by most of farmers, followed by planting plantation crops in the form of agroforestry and implementing vegetable farming.

Table 4. Farming activities prioritized by the respondents

No.	Farming activities	Respondent Percentage (%)
1.	Paddy fields	28.57
2.	Plantation in the form of agroforestry	27.14
3.	Horticultural (vegetable) farming	24.29
4.	Horticulture (fruit) farming	5.71
5.	Horticulture (flower) farming	2.86
6.	Organic farming	7.14
7.	Agrotourism	4.29
		100.00

Types of sub system that are mostly done by the respondent of farmers in the upstream of Jeneberang watershed can be seen on Table 5. Based on the percentage on Table 5, it can be seen that rice field sub system is the most sub system done by the respondent, followed by plantation sub system in the form of agroforestry, then vegetable garden sub system.

Table 5. Farming sub system done by farmers

No.	Types of sub system	Respondent Percentage (%)
1.	Paddy field sub system	61.99
2.	Plantation sub-system in the form of agroforestry	26.61
3.	Vegetable garden sub system	11.40
		100.00

SWOT Analysis for developing agricultural landscape management strategies for upstream Jeneberang watershed

Based on internal and external factors that exist in the upstream Jeneberang watershed,

using the SWOT matrix several alternative strategies are made to manage the agricultural landscape in accordance with the objectives. More details on the SWOT matrix can be seen in Table 6.

Table 6. SWOT Matrix of agricultural landscape management strategies towards a resilient agroecosystem in the upstream Jeneberang watershed

IFAS	Strengths	Weaknesses
EFAS	1) Has a variety of plantation plant products with high selling prices	1) The community is active in agricultural activities, it causes changes in natural land cover to agricultural land cover, which accelerates the rate of erosion and soil surface erosion.
	2) Paddy field cover has been fairly stable in 20 years	2) The community's concern for the suitability of planting with their land is still defeated by the desire of the community to increase greater production
	3) Has the potential for natural tourism and agrotourism	3) Not all farmers own their own land. There are still farmers who rent land from other farmers.
	4) Has many agricultural activities, such as horticultural farming activities, plantation crop farming activities, food crop / rice field farming activities, agrotourism, agroforestry	4) To increase agricultural production, farmers are only interested in using inorganic fertilizers, very few farmers are willing to use organic fertilizers.
Opportunities	S - O Strategy	W - O Strategy
1) Has a cool climate	1) Increase profits from agricultural products through modification of agricultural activities with tourism activities	1) Encourage people to be creative in creating ideas that can take advantage of their agricultural activities so that they can still benefit from agricultural activities without the need to expand agricultural land or exploit existing agricultural land too much.
2) The community have a very good will to be more successful and have a better life	2) Create ecotourism and agrotourism programs for tourists, by involving the community, thus environmental awareness increases and community income increases	2) Developing better cooperation among farming communities in the form of farmer groups based on their farming activities

... continued Table 6.

Threats	S - T Strategy	W - T Strategy
1) Agricultural activities have penetrated into conservation and protected forest areas 2) Higher prices for plantation crops can attract people to expand the planted area for plantation crops towards the forest	1) Planting forestry crops in areas that require tree planting to reduce the danger of landslides 2) Conducting an agroforestry system when it is going to plant plantation crops in a conservation forest area by following the planting rules of the relevant agency	1) Providing information to the community on how to plant plantation crops in an agroforestry manner 2) Providing counseling to farming communities to care for the environment

Discussion

Potential opportunities and challenges of agroecosystem resilience in agricultural landscapes in the upstream Jeneberang watershed

A resilient agroecosystem can be realized, according to (Marten, 1988) if it meets the criteria, namely: the productivity of the plants in the agroecosystem is high, sustainable, the production is stable, and the results obtained cause an even distribution of conditions in the community, and the agroecosystem should be independent, does not depend on outsiders, so it should have a high diversity.

The agricultural landscape in the upstream Jeneberang watershed has several factors that can be opportunities as well as challenges to make the agroecosystem in the area more resilient, which are:

1. The productivity of the managed landscape;
 - a. High productivity of plantation crops in the upstream area of the Jeneberang watershed. As also reported by (Anwar, 2018), that in the upstream Jeneberang watershed some of the plantation crops are included in the leading commodities that can supply to other areas so that they are profitable.
 - b. In addition to high productivity, the price of plantation crops has also increased as can be seen on Figure 4.
 - c. Another productivity potential that can be developed in the upstream landscape of the Jeneberang watershed is tourism activities (Atrianingsi et al., 2019). Agrotourism activities can be an

alternative activity that has the potential to be developed by farmers to provide additional income besides farming.

2. Sustainability of the managed landscape;
 - a. The land cover in the upstream Jeneberang watershed has changed from primary forest land cover to secondary forest land cover by carrying out agroforestry activities by farmers, and changing scrub land cover to mixed dry land agricultural land cover. In order for land cover changes to remain in line with the spatial plan that has been set by the government, it is necessary to determine the direction of land use (Arsyad et al., 2017).
 - b. Agricultural activities are very intensive. Intensive agriculture causes soil fertility to decrease due to erosion, runoff and leaching in upstream area. Thus, it is necessary to implement a conservation farming system.
 - c. Intensive agriculture requires a high input of fertilizer. Therefore, it is necessary to have alternative fertilizers that are more environmentally friendly. The community needs to be motivated and directed to use organic fertilizers.
 - d. Some agricultural activities in the horticultural area do not follow the planting requirements as they should. Planting is carried out in areas with a fairly high slope, without using terracing (Purwanti, 2007). This can put the sustainability of the land at risk.

3. Stability of the production;
 - a. The production of plantation crops shows an increasing trend, but this has led to changes in land cover from primary forest land cover to secondary forest land cover. Implementing agroforestry system is an alternative to planting the plantation crops in the forest. This method is expected to reduce erosion that can occur when compared to the monoculture method. In addition, in this way, it is hoped that the function of forest land can still be maintained.
 - b. The beauty of upstream Jeneberang Watershed landscape and its natural environment can be categorized as the product of the area. Thus, the landscapes and its natural beauty are things that need to be preserved. To maintain its existence, it can be done by conducting environmental care education and knowledge of environmentally friendly agriculture to tourist through ecotourism and agrotourism activities. Through this activity, it could make tourists and villagers/regional residents to be more aware of the surrounding environment, and farmers and surrounding communities will still get additional income without changing land cover (Palit et al., 2017).
 - c. The stability of land cover can be an indicator of farming activities that provide a sense of comfort for the local community. Human pressure is one of the factors that influence land cover change (Geldmann et al., 2014; Guerra et al., 2019). Thus, when communities feel that a land cover can help meet their basic needs, they will defend the land. Based on this research as can be seen on Table 1 and Figure 5, it is known that the stable land cover is paddy field cover.
 - d. Another thing that can also affect the stability of land cover is the existence of binding regulations from the government regarding land use. This is prioritized for land that is critical and less suitable to be converted into agricultural land.
 - e. The air temperature in the upstream area of the Jeneberang watershed is quite cool, but not as cold as it was 30 years ago. It was stated by the respondent farmers in the area. Temperature change could be affected by the land cover change. As stated by (Tanika et al., 2013) that changes in land cover will eventually have an effect on climate change. For this reason, environmental sustainability in this area needs to be maintained by the community and local government by controlling the land cover change.
4. Equity; In the upper Jeneberang watershed, the main activity is farming. But not all people who carry out farming activities own their own land. On the other hand, there are also farmers who own land but do not have the power to cultivate the entire land. If this is the case, the land can be leased by landless farmers with a profit-sharing system. This has been done by most of the landowners and tenants in the upstream Jeneberang watershed. Thus, good communication between communities can provide benefits for the local community. In addition, other activities of the upstream community of the Jeneberang watershed are trading as well as conducting business in tourism activities.
5. The diversity of plants and the diversity of farming activities creates opportunities for an area for autonomy; being able to complete the needs of their own region without being dependent on other regions is a criterion for being resilient.
 - a. The types of plants and farming activities in the upstream area of the Jeneberang watershed are quite diverse. There are types of food crops, horticulture, and plantations. Thus, there are also food crop farming activities, plantation crop farming activities, and horticultural crop farming activities. There are also livestock

activities, nature tourism activities and agro-tourism

- b. When viewed from the dependence of farmers on fertilizer needs, autonomy has not yet occurred in the upstream Jeneberang watershed. The dependence of farmers on fertilizers is quite large. Thus, the solutions are the farmers produce their own fertilizer, improve cropping patterns, and implementing conservation farming system. All of these activities would be able to maintain productivity as well as to support agro-tourism.

Agricultural landscape management strategies to implement resilient agroecosystems in the upstream watershed

Based on the SWOT matrix shown in Table 6, several strategies have been formed based on the strengths, weaknesses, opportunities and threats that exist in the upstream Jeneberang watershed.

To be able to move towards a resilient agroecosystem, environmental management can be done by balancing production with environmental conservation, as stated by (Fischer et al., 2006) that integration of production and ecosystem conservation in agriculture is a key in the context of sustainable development, from both an ecological and long-term economic perspective. Therefore, the main strategies for managing the agricultural landscape in the upstream of the Jeneberang watershed towards a resilient agroecosystem are:

1. Keep diversity: convince the community to continue to manage various types of crops according to the capabilities of their respective agricultural lands. Thus, it could create some variety of farming activities. Agricultural systems with high diversity are more resilient (Ge et al., 2016).
2. Technology and land capacity: motivating people to use technology that is suitable for their land capacity, technology that can protect their environment for being better, not only to get higher production. Selection of the right technology needs to be done so that there is no degradation of

natural resources and the environment (Charnsungnern & Tantanasarit, 2017)

3. Good communication among the community: encourage the community to reactivate farmer groups based on their farming activities. Then direct each farmer group to link up with other farmer groups that have different farming activities, so they can exchange information and needs. In the agroecosystem, humans play a key-stone role by influencing their environment. The role could be benefit if that influencing role is enacted by a well-informed, well-connected, and well-supported populace (Cabel & Oelofse, 2012).
4. The community, supported by the local government, develops agrotourism or eco-tourism activities, so that farming communities can manage their agricultural land to get profit not only from their agricultural products, but also from tourism activities on their agricultural land. Carrying out tourism activities in agricultural areas is one way to educate people to love and respect the environment, even to protect the environment itself (Hunter, 1997)

Conclusion

To develop an agricultural landscape management strategy in the upstream Jeneberang watershed towards a more resilient agroecosystem, there are several things that need to be done:

1. Maintain diverse agricultural activities, such as horticulture farming, food crop farming, and plantation crop farming on the right land with appropriate technology.
2. Reduce the dependence on agricultural inputs from outside by using right technology that is suitable with land capability, combine with local knowledge.
3. Revive farmer groups based on their farming activities that can help the community to cooperate and communicate with each other.
4. Develop a conservation-based agricultural system by improving cropping patterns and also develop some agricultural activities that can support agrotourism

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Author's declaration and contribution

The authors reported there is no potential conflicts of interest. TD, KM and MSS initiated study conception and design. TD and HI collected data. TD, KM, MSS analysed data and interpreted result. TD, HI, FU prepared draft manuscript. All authors read and approved the final version of the manuscript.

References

- Anwar, A. (2018). Penggunaan lahan pertanian berdasarkan komoditas unggulan di Kabupaten Gowa. *AGROTEK: Jurnal Ilmiah Ilmu Pertanian*, 2(1), 69–81. [CrossRef](#)
- Arsyad, U., & Sainuddin. (2007). Kebiasaan masyarakat Dusun Bawakaraeng dalam pengamanan hutan di Sub DAS Lengkesse Das Jeneberang Hulu. *Journal of Community Forestry Service*, 1(1), 46–57.
- Arsyad, U., Soma, A. S., Wahyuni, W., & Arief, T. R. (2017). Kesesuaian dan arahan penggunaan lahan berdasarkan rencana pola ruang wilayah di Hulu Daerah Aliran Sungai Kelara. *Jurnal Hutan Dan Masyarakat*, 9(2), 75. [CrossRef](#)
- Atrianingsi, A., Lahi, B., & Mirsa, S. (2019). Peran pemerintah dalam mengembangkan wisata Malino sebagai "Beautiful Malino" di Kabupaten Gowa. *Jurnal Ilmiah Pranata Edu*, 1(1), 57–68. [CrossRef](#)
- Bachrein, S. (2006). Penelitian sistem usaha pertanian di Indonesia. *Analisis Kebijakan Pertanian*, 4(2), 109–130. [CrossRef](#)
- Badan Pusat Statistik Kabupaten Gowa. (2008). *Gowa dalam angka 2008*. BPS Kabupaten Gowa.
- Badan Pusat Statistik Kabupaten Gowa. (2010). *Gowa dalam angka 2010*. BPS Kabupaten Gowa.
- Badan Pusat Statistik Kabupaten Gowa. (2012). *Gowa dalam angka 2012*. BPS Kabupaten Gowa.
- Badan Pusat Statistik Kabupaten Gowa. (2013). *Gowa dalam angka 2013*. BPS Kabupaten Gowa.
- Badan Pusat Statistik Kabupaten Gowa. (2019). *Gowa dalam angka 2019*. BPS Kabupaten Gowa.
- Bennet, E., Carpenter, S. R., Gordon, L. J., Ramankutty, N., Balvanera, P., Campbell, B., Cramer, W., Foley, J., Folke, C., Karlberg, L., Liu, J., Lotze-Campen, H., Mueller, N. D., Peterson, G. D., Polasky, S., Rockström, J., Scholes, R. J., & Spierenburg, M. (2014). Toward a more resilient agriculture. *The Solutions Journal*, 5(5), 65–75. [Direct Link](#)
- Cabel, J. F., & Oelofse, M. (2012). An indicator framework for assessing agroecosystem resilience. *Ecology and Society*, 17(1). [CrossRef](#)
- Charnsungnern, M., & Tantanararit, S. (2017). Environmental sustainability of highland agricultural land use patterns for Mae Raem and Mae Sa watersheds, Chiang Mai province. *Kasetsart Journal of Social Sciences*, 38(2), 169–174. [CrossRef](#)
- Danial, M., Arsyad, U., & Demmallino, E. B. (2020). Strategi pengelolaan hulu Daerah Aliran Sungai Jeneberang Provinsi Sulawesi Selatan. 9, 11–31. [CrossRef](#)
- Fischer, J., Lindenmayer, D. B., & Manning, A. D. (2006). Biodiversity, ecosystem function, and resilience: Ten guiding principles for commodity production landscapes. *Frontiers in Ecology and the Environment*, 4(2), 80–86. [CrossRef](#)
- Ge, L., Anten, N. P., van Dixhoorn, I. DE, Feindt, P. H., Kramer, K., Leemans, R., Meuwissen, M. P., Spoolder, H., & Sukkel, W. (2016). Why we need resilience thinking to meet societal challenges in bio-based production systems. *Current Opinion in Environmental Sustainability*, 23(November), 17–27. [CrossRef](#)
- Geldmann, J., Joppa, L. N., & Burgess, N. D. (2014). Mapping change in human pressure globally on land and within protected areas. *Conservation Biology*, 28(6), 1604–1616. [CrossRef](#)
- Gibbs, H. K., Ruesch, A. S., Achard, F., Clayton, M. K., Holmgren, P., Ramankutty, N., & Foley, J. A. (2010). Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proceedings of the National Academy of Sciences of the United States of America*, 107(38), 16732–16737. [CrossRef](#)
- Guerra, C. A., Rosa, I. M. D., & Pereira, H. M. (2019). Change versus stability: Are protected areas particularly pressured by global land cover change? *Landscape Ecology*, 34(12), 2779–2790. [CrossRef](#)
- Hunter, C. (1997). Sustainable tourism as an adaptive paradigm. *Annals of Tourism Research*, 24(4), 850–867. [CrossRef](#)
- Knickel, K., Redman, M., Darnhofer, I., Ashkenazy, A., Calvão Chebach, T., Šūmane, S., Tisenkopfs, T., Zemeckis, R., Atkociuniene, V., Rivera, M., Strauss,

- A., Kristensen, L. S., Schiller, S., Koopmans, M. E., & Rogge, E. (2018). Between aspirations and reality: Making farming, food systems and rural areas more resilient, sustainable and equitable. *Journal of Rural Studies*, 59, 197–210. [CrossRef](#)
- Koohafkan, P., Altieri, M. A., & Holt Gimenez, E. (2012). Green agriculture: Foundations for biodiverse, resilient and productive agricultural systems. *International Journal of Agricultural Sustainability*, 10(1), 61–75. [CrossRef](#)
- Landis, D. A. (2017). Designing agricultural landscapes for biodiversity-based ecosystem services. *Basic and Applied Ecology*, 18, 1–12. [CrossRef](#)
- Laurance, W. F., Sayer, J., & Cassman, K. G. (2014). Agricultural expansion and its impacts on tropical nature. *Trends in Ecology and Evolution*, 29(2), 107–116. [CrossRef](#)
- Marten, G. G. (1988). Productivity, stability, sustainability, equitability and autonomy as properties for agroecosystem assessment. *Agricultural Systems*, 26(4), 291–316. [CrossRef](#)
- Nuraeni, Sugiyanto, & Zaenal. (2013). Usahatani konservasi di hulu DAS Jeneberang (Studi kasus petani sayuran di hulu DAS Jeneberang Sulawesi Selatan). *Jurnal Manusia Dan Lingkungan*, 20(2), 173–183. [CrossRef](#)
- Palit, I. G., Talumangan, C. ., & Rumagit, G. A. J. (2017). Strategi pengembangan kawasan agrowisata Rurukan. *Agri-Sosioekonomi*, 13(2A), 21. [CrossRef](#)
- Purwanti, R. (2007). Pendapatan petani dataran tinggi Sub Das Malino (studi kasus: Kelurahan Gantarang, Kabupaten Gowa). *Jurnal Penelitian Sosial Dan Ekonomi Kehutanan*, 4(3), 257–269. [CrossRef](#)
- Rangkuti, F. (2008). *Analisa SWOT Teknik Membedah kasus Bisnis*. PT Gramedia Pustaka Utama.
- Ruspindi, D., Hadi, S., & Rusdiana, O. (2013). Kajian perubahan penutupan lahan pada Das Ciliwung Hulu dengan pendekatan spasial dinamik. *Jurnal Lanskap Indonesia*, 5(2), 1–5. [CrossRef](#)
- Solle, M. S., & Ahmad, A. (2016). Landslides intensity on river morphology of Jeneberang watershed after collapse of caldera wall at Mt. Bawakaraeng. *Research Journal of Applied Sciences*, 11(9), 874–878. [CrossRef](#)
- Surni, Baja, S., & Arsyad, U. (2015). Dinamika perubahan penggunaan lahan, penutupan lahan terhadap hilangnya biodiversitas di DAS Tallo, Sulawesi Selatan. *Prosiding Seminar Nasional Masyarakat Biodiversity Indonesia*, 1, 1050–1055. [CrossRef](#)
- Suyana, J. (2008). Studi keragaan agroekosistem untuk pengembangan potensi pertanian di Kabupaten Sukaharjo Propinsi Jawa Tengah. *Sains Tanah – Jurnal Ilmiah Ilmu Tanah Dan Agroklimatologi*, 5(II). [CrossRef](#)
- Tanika, L., Pawitan, H., Noordwijk, M. Van, Thoha, M., & Zulkarnain. (2013). Dampak perubahan tutupan lahan dan iklim terhadap fungsi hidrologi Daerah Aliran Sungai Konawe Hulu. *Jurnal Sumber Daya Air*, 9(2), 155–168.
- Wilson, M. H., & Lovell, S. T. (2016). Agroforestry-The next step in sustainable and resilient agriculture. *Sustainability (Switzerland)*, 8(6), 1–15. [CrossRef](#)