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Agroforestry management systems through landscape-life scape integration: A case study in Gowa, Indonesia

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Abstract. *Hasannudin DAL, Nurrochmat DR, Ekayani M. 2022. Agroforestry management systems through landscape-life scape integration: A case study in Gowa, Indonesia. Biodiversitas 23: 1864-1874.* Agroforestry has a potentially important role in increasing farmers' income and sustainable landscape management. The need to increase income from a community with limited land area, resulting in indiscriminate deforestation and shifting cultivation, has accelerated soil erosion. This study addresses the problem by evaluating land use and land cover change structure and prediction, providing plant types' preferences for agroforestry systems based on social, business feasibility, and ecological suitability. This study was conducted in Bontolerung Village, part of the KPH Jeneberang 1's working area, Tinggimoncong Sub-district, Gowa District, South Sulawesi Province, Indonesia. The data was collected from January to March 2021 using a snowball-purposive sampling method. The analysis data used land use and land cover change, land management patterns, cost and revenue, household expenditure and income, financial feasibility -Net present value (NPV), Benefit-cost ratio (BCR), and Internal rate of return (IRR), and ecological suitability (invasive series). The study finds that forest cover losses are 17% from 2010-2020 and converted into agricultural land. The agroforestry patterns of coffee, coffee-cloves, and coffee-cloves-*iles-iles* are feasible to cultivate following the NPV, BCR, and IRR criteria. Agroforestry systems contributed 26% to farmer household income. The value shows a low percentage compared to the non-agroforestry income (74%). The coffee-cloves agroforests show the highest gains with an average annual income of IDR 43,017,192 (US$ 3,024.9). This study promotes using agroforestry to reforest the existing degraded lands. Agroforestry systems offer great potential for environmental conservation and contribution to human well-being.

Keywords: Agroforestry pattern, business feasibility, Gowa District, landscape, life scape

INTRODUCTION

Appropriate forests planning is necessary to realize sustainable forest management (Yovi and Nurrochmat 2018; Santoso et al. 2019). The community-based forestry land is managed by applying non-timber forest products and an agroforestry system. Agroforestry is a land-use management system that manages main crops with combination plants and/or animal production (Purwoko et al. 2019). Agroforestry in this study included mixed dry agriculture. The agroforestry system is expected to restore forest function (Sobola et al. 2015; Harbi et al. 2018; Phondani et al. 2020; Rahmani et al. 2021). Agroforestry application relies heavily on knowledge of farmer production, farmer interaction with the landscape, and socio-economic aspects (Hughes et al. 2020; Phondani et al. 2020, Astuti et al. 2020; Rossita et al. 2021). Furthermore, non-timber forest products and agroforestry practices can significantly improve community welfare (Mbow et al. 2014; Adalina et al. 2014; Rahmani et al. 2021).

Life scape is defined as human activities, including cultural, social, and economic, that affect the biophysical conditions of environmental ecosystems (Veisi et al. 2012; Tajuddin et al. 2019). Life scape dynamics can affect the forest landscape in an increasingly better direction. It involves restoring a healthy ecosystem, protecting water sources, mitigating and adapting to climate change, conserving biodiversity, and enhancing human well-being in deforested or degraded areas through appropriate forestry policies (Sahide et al. 2015; Gibbes et al. 2017; Tajuddin et al. 2019; Nurrochmat et al. 2020), governance systems (Erbaugh and Nurrochmat, 2019; Nurrochmat et al. 2021) and collaboration between multi-stakeholders (Hasannuddin et al. 2019; Nurrochmat et al. 2017). On the other hand, intensive human activity can cause changes in structure (Tscharntke et al. 2012) and overall ecosystem function (Alvarado et al. 2018; Tan Jianbo et al. 2019). This activity led to the change from forest areas to non-forest areas (Fearnside 2018; Birkhofer et al. 2018; Sousa et al. 2019), which can trigger environmental disturbances (Dayamba et al. 2016; Haregeweyn et al. 2017; Ebabu et al. 2019; Kidane et al. 2019; Rafaai et al. 2020).

The intensification of agroforestry management has great potential for land degradation. One of the causes is the pressure of increasing population density (Mutoko et al. 2014). This pressure limits the amount of land available to the community in the forest's vicinity. Land use and land cover (LULC) is not just about the structure of geography, also about the socio-economic and institutionally organized. (Naikoo et al. 2020). So that LULC will experience changes as the population increases (Haregeweyn et al. 2017; Naikoo et al. 2020). Analysis of land cover and landscape patterns is considered effective in identifying the causative factors of changes in the forest landscape (Avanzini et al. 2016) through creating a spatial-temporal model (Beiroz et al. 2018; Harris et al. 2019; Nurrochmat et al. 2020). Appropriate landscape planning and good forest governance are needed to sustain agroforests (Erbaugh et al. 2016). Landscape management has an impact not only on the livelihood of the community around the forest but also on ecological sustainability (Jansson and Lindgren 2012). The sustainable forest management principle must be socially, economically, and ecologically sustainable (Sukwika et al. 2016; Yovi and Nurrochmat 2018).

The aims of this study were to assess the land use and land cover change and prediction, analyze the preferences of species that will be, and have been, developed, calculate the business feasibility of the cultivated types of plants, and analyze the ecological feasibility of plant species (invasive series). This study also provides recommendations on plant types cultivated by the community based on social and economic aspects. The combination of landscape and life scape analysis is expected to be one of the best approaches in decision-making on land management. Thus, it will increase integrity between landscape and life scape and improve the community's welfare in a better direction.

MATERIALS AND METHODS

Study area

This research was conducted in Bontolerung Village (5°17'17,60" S; 119°53'55,95" E), Tinggimoncong Sub-district, Gowa District, South Sulawesi Province, Indonesia (Figure 1). The village consists of four environments, i.e.: Topidi, Panaikang, Biroro, and Bontote'ne. These four environments have different heights ranging from 700 to 1200 m above sea level. The Bontolerung Village is part of the Jeneberang-1 Forest Management Unit *(KPH Jeneberang-1*), available for various types of land use, agroforestry patterns, agroforestry income, and commodities. According to the long-term forest management plant of KPHP unit XIV-I (RPHJP KPHP 2019), the number of deforestation reported increased rapidly by 68% of the total KPHP area in 2019.

Data collections

The data was collected from January to March 2021 using a snowball-purposive sampling method. According to Nurrochmat et al. (2016), the snowball approach is frequently used in policy research to determine respondents in deliberate sampling. The researcher will interview key informants who prior key informants recommended. The selected respondents are the farmers practicing the agroforestry system. Respondents chosen in this study amounted to 40 farmers (representing farmer group's members) with the criteria of having land that implemented agroforestry systems. The tools used are GPS, recorder, ArcGIS, QGIS Microsoft Office Excel, semi-structured interviews, and open questionnaires. Data collection methods are field observation, semi-structured interviews, and open questionnaires.

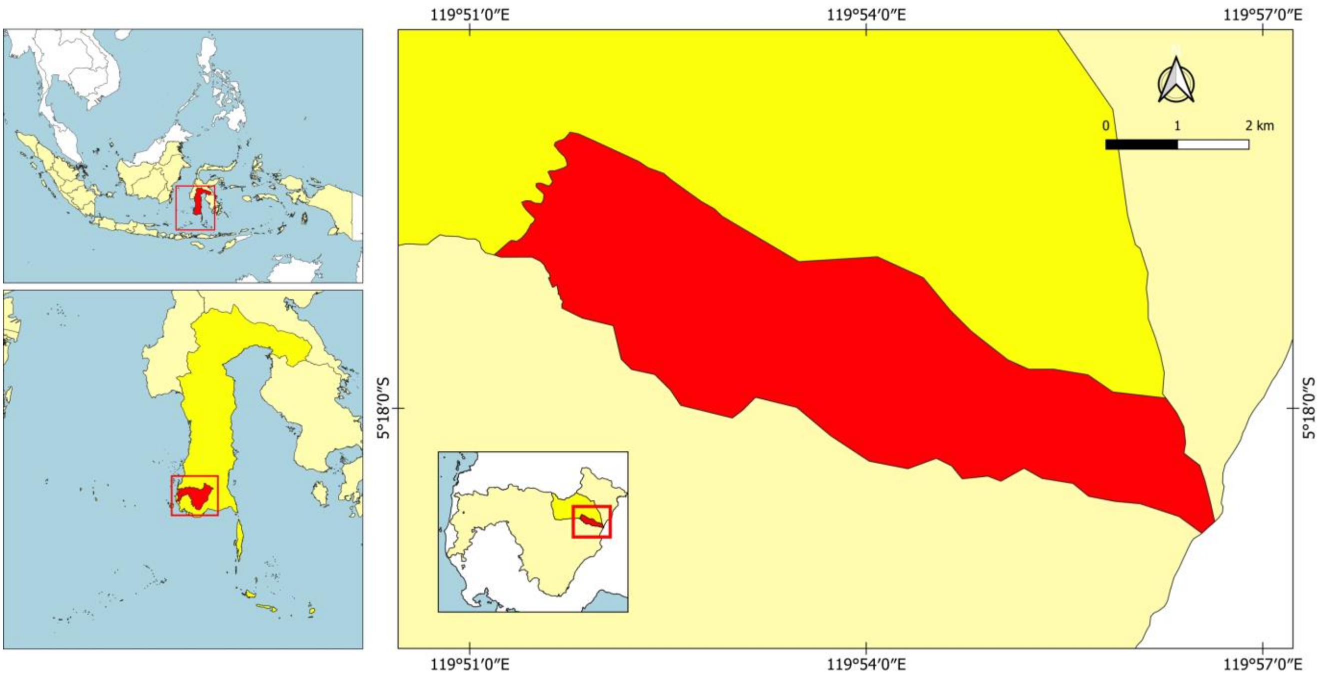

Figure 1. Map of research site in Bontolerung Village, Tinggimoncong Sub-district, Gowa District, South Sulawesi Province, Indonesia

This research employs two types of data, i.e., primary and secondary data. Primary data is gathered to obtain: (i) the identity of respondents; (ii) the types of species that have been developed, and the preferences of the types of species to be developed; (iii) land management patterns; (iv) cost and revenue from agroforestry system. Secondary data is land use and land cover in 2010, 2015, and 2020 using Landsat image 7 ETM+ and 8 TIRS; road network map; river network map; map of definitive administrative boundaries of *Kementerian Dalam Negeri Republik Indonesia (Permendagri*); invasive series; and village monograph.

Data analysis

Land use and land cover change (LULC) and the prediction

The analysis of LULC aims to understand the landscape structure based on trends in land cover change due to community life scape interventions (Müller 2016; Gibbes et al. 2017). Data patterns from Landsat 7 ETM+ and 8 TIRS photos for the last ten years were separated into three (three) periods, namely 2010, 2015, and 2020. The data were analyzed with ArcGIS 10.4.1 software. In 2010, 2015, and 2020, picture segmentation and manual imagery were used to create a closed map of image interpretation findings.

Furthermore, the image interpretation results are used for LULC in the next ten years (2030), including driving elements such as the road network, river network, and Permendagri's definite administrative border map. Then, using an Artificial Neural Network (ANN) system with Multi-layer Perceptron (MLP) and Cellular Automata (CA) approaches, a projected study of land cover changes was performed. Artificial Neural Network (ANN), sometimes known as ANN, is an empirical modeling method capable of calculating, forecasting, and implementing data recognition and classification. It is more flexible than regression models (Ali et al. 2016; Yang et al. 2018). ANN is also widely used in remote sensing classification studies, including land-use change, geological mapping, and forest fire categorization (Chasia et al. 2017).

Establishing ground checkpoint locations. A field check, also known as a ground check, is a stage in which the outcomes of picture interpretation are tested. The ground check location locations are determined by identifying points on the land cover map. The Slovin formula was used to calculate the number of samples (Mauliana et al. 2021):

$$n = \frac{N}{1 + Ne^2}$$

Where:
n : The number of samples
N : The number of polygons per class
e : Error tolerance

A total of 35 sample sites were taken. Purposive sampling is a method of determining location selection that considers the accessibility of each location.

Accuracy test of land usage and land cover. The results of picture interpretation in 2020 were compared to the actual land cover in 2020 using a confusion matrix. The data from the confusion matrix table is then double-checked for accuracy using the overall and kappa accuracy calculations (Jaya, 2015):

Overall accuracy

$$OA = \frac{\sum_{i=1}^{r} X_{ii}}{N}$$

Kappa accuracy

$$K = \frac{N \sum_{i=1}^{r} X_{ii} \quad \sum_{i=1}^{r} X_{i+} X_{+i}}{N^2 \sum X_{i+} X_{+i}}$$

Where:
X_{ii} : The diagonal value of contingency matrix from the row-i and the column-i
X+i : The number of pixels in column-i
Xi+ : The number of pixels in row-i
N : The number of pixels in sampling

Analysis of determination of land management patterns

The aim of defining land management patterns is to analyze the species that have developed and become accepted (socially acceptable) by the community's culture. The following analysis is required based on the explanation: (i) The socio-economic conditions of respondents work in land management in the research area. The characteristics of the respondents were the factors studied. (ii) The types of species have been developed, and the species' preferences to be set. (iii) Then, confirm the acceptance of these species based on the socio-culture of the local community.

Business feasibility analysis

Business feasibility analysis aims to evaluate the costs and income of agroforestry commodities. The financial feasibility analysis included cost analysis, revenue analysis, farmer household expenditure analysis, and income analysis (Sundari MT 2011; Suriadi et al. 2015). The formula used is as follows:

Cost analysis

$$TC = FC + VC$$

Where:
TC : Total cost (IDR/year)
FC : Total fixed cost (IDR/year)
VC : Total variable cost (IDR/year)

Revenue analysis

$$TR = Q \times P$$

Where:
TR : Total revenue (IDR/year)
Q : Total production (kg/year)
P : Selling prices (IDR)

Farmer household expenditure analysis

$$Tp = Pp + Pn$$

Where:
Tp : Total farmer household expenditure (IDR/month)
Pp : Total food (IDR/month)
Pn : Total non-food (IDR/month)

Income analysis

$$\pi = TR - TC$$

Where:
π : Income (IDR/year)
TR : Total revenue (IDR/year)
TC : Total cost (IDR/year)

Furthermore, confirming the type of plants based on financial analysis. The financial analysis parameters consist of Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR) (Wijaya et al. 2015; You et al. 2016; Zhan et al. 2019). The formula used is as follows:

Net Present Value (NPV)

$$NPV = \sum_{t=0}^{n} \frac{Bt - Ct}{(1+i)^t}$$

Where:
BT : benefit at time t
Ct : cost in year t
n : length of agroforestry in years
r : discount rate

Benefit Cost Ratio (BCR)

$$BCR = \frac{\sum_{t=0}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=0}^{n} \frac{Ct}{(1+i)^t}}$$

Internal Rate of Return (IRR)

$$IRR = i_1 + \left(\frac{NPV_1}{NPV_1 + NPV_2}\right)(i_2 - i_1)$$

Where:
i_1 : discount rate resulted from NPV positive
i_2 : discount rate resulted from NPV negative
NPV_1 : NPV in interest level i_1
NPV_2 : NPV in interest level i_2

Ecological suitability

The types of species that have been studied are based on social and economic factors. After identifying plant kinds that are effective in terms of ecology, suggestions are made for plant types acceptable for use in the region based on social, economic, and ecological factors. Then ecological factors are considered by identifying plant species that threaten the environment (invasive series). Invasive plant species can endanger native plant species and harm ecosystems (Sutomo 2018; Ramadhan et al. 2020).

RESULTS AND DISCUSSION

Structure of land use and land cover change (LULC)

The image interpretation and digitization results show that eight classes of LULC have changed the form of addition and reduction of the area from 2010 to 2020. These classes had increased and decreased area size changes, including primary dryland forest, secondary dryland forest, settlement areas, mixed dry agriculture, paddy field, shrub, bare ground, and water bodies (Table 1). The agroforestry is included in mixed dry agriculture. The total area of Bontolerung Village is 2053 ha.

Table 1 presents that the settlement class experienced the most remarkable growth in area addition, with a percentage of 23 %, increasing by 6.48 ha in 2020. The same changes were seen in Gowa District, according to Djamaluddin et al. (2019). The primary dryland forest class, on the other hand, saw the greatest drop in the area between 2010 and 2020, with a reduction of 17 %, followed by secondary dryland forest with a loss of 16 % from the beginning area in 2010. According to Heidarlou et al. (2019), forest cover also shows a decrease in size. Bruggeman et al. (2016) stated that forest cover decreases by 14.4 km^2/y. Surprisingly, the settlement areas had the least land utilization, but it shows the highest increase, by 19%, during the same period. The chart of land use and land cover changes in 2020, 2015, and 2020 can be seen in Figure 2.

The result depicted that the shrub occupied most of the region in 2010, 2015, and 2020. Similar results were found by Fagerholm et al. (2016) and Ngaji et al. (2021), followed by mixed dry agriculture, paddy field, secondary dryland forest, primary dryland forest, water bodies, bare ground, and settlements. As detailed in Figure 2, the shrub area comprised 565.54 ha in the initial period and showed another significant growth until the end of the period, reaching 624.5 ha. Shrubs can change into other classes depending on their intended use, for example, cultivated plants and settlement areas. According to Asra et al. (2020), the community uses shrubs as agricultural land. On the contrary, this study indicates a sharp drop in forest cover over ten years (17%). Land use and land cover class conversion from 2010 to 2020 can be seen in Table 2.

The LULC also converted functions into other classes (Table 2). The land classes that experience the most land conversion are paddy fields, shrub, and mixed dryland agriculture. The most extensive land conversion is secondary dryland forest into shrubs of 41.55 ha from 2010 to 2020. These changes can occur due to natural factors, farmers' needs (Yonaba et al. 2021), forest encroachment, and logging (Syam et al. 2012). The conversion from forest to Settlement area of 0.12 ha at the end of a given period. Wang et al. (2021) also found that intense conversion from forest to built-up occurred in Babesa and Serbithang areas. Most of the northern areas' bare ground was converted to the built-up area. Bare grounds were previously agricultural land. The study also found 5.11 ha of mixed dry agriculture were converted into settlement areas in Bontolerung Village. Wang et al. (2021) stated that rapid urban expansion would lead to considerable decreases in forest and farmland and an increase in urban population.

The data interpretation results showed that the eight classes of LULC were following the conditions in the field. Based on the results of matrix confusion, field checking points are known to have 35 sample points (N). The number of proven correct issues in the field is 31 points (X). The accuracy of acceptable image interpretation is greater than 85% (Arsa et al. 2020). The study had an overall classification accuracy of 88.57% and a Kappa coefficient of 86.18%. The percentage indicates that the interpretation of Landsat imagery results is acceptable.

Table 1. Composite table of area statistics (ha) of Bontolerung Village, Gowa, Indonesia from 2010 to 2020

LULC types	**Area (ha)**			**Overall change 2010-2020**	
	2010	**2015**	**2020**	**Area (ha)**	**Area (%)**
Primary dryland forest	216,36	205,72	178,67	-37,69	-17%
Secondary dryland forest	247,88	229,1	207,84	-40,04	-16%
Settlement areas	28,10	30,71	34,58	6,48	23%
Mixed dry agriculture	365,36	380,91	358,76	-6,60	-2%
Paddy field	284,05	277,85	310,2	26,15	9%
Shrub	565,54	583,01	624,5	58,96	10%
Bare ground	162,77	162,77	161,84	-0,93	-1%
Water bodies	183,31	183,31	176,98	-6,33	-3%
Total	2053	2053	2053	-0.01	0.03

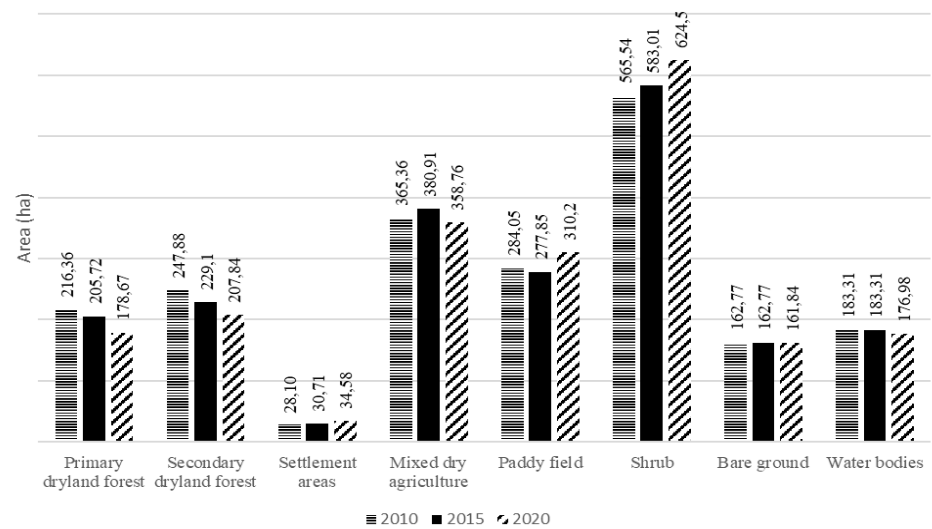

Figure 2. The chart of land use and land cover changes in Bontolerung Village, Gowa, Indonesia from 2020, 2015, and 2020

Table 2. Land use and land cover class conversion in Bontolerung Village, Gowa, Indonesia from 2010 to 2020

Land use land cover in 2010	**Land use land cover in 2020**								**Total area in 2010 (ha)**
	Primary dryland forest	**Secondary dryland forest**	**Settlement areas**	**Mixed dry agriculture**	**Paddy field**	**Shrub**	**Bare ground**	**Water bodies**	
Primary dryland forest	178.66	7.65	0.12	9.71	0.07	20.16	-	-	216.36
Secondary dryland forest	0.02	200.10	-	4.39	1.83	41.55	-	-	247.87
Settlement areas	-	-	28.02	0.08	-	-	-	-	28.10
Mixed dry agriculture	-	-	5.11	324.07	34.66	1.53	-	-	365.36
Paddy field	-	-	1.33	17.39	265.33	-	-	-	284.05
Shrub	-	0.00	-	3.13	6.75	555.67	-	-	565.54
Bare ground	-	-	-	-	-	-	159.28	3.48	162.77
Water bodies	-	0.09	-	-	1.56	5.61	2.56	173.49	183.31
Total area in 2020 (ha)	178.67	207.84	34.58	358.76	310.20	624.50	161.84	176.98	2053

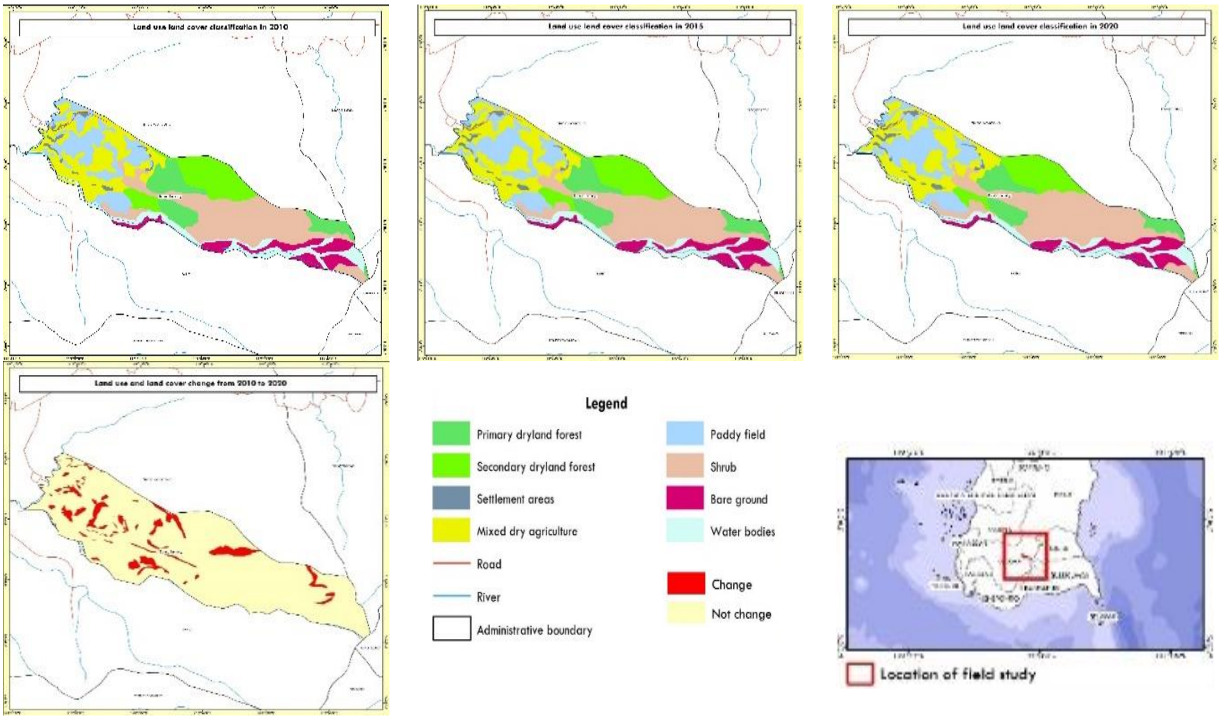

Figure 3. Land use and land cover transition map in 2010, 2015, 2020 in Bontolerung Village, Gowa, Indonesia

Table 3. Predicted land use and land cover in Bontolerung Village, Gowa, Indonesia from 2020 to 2030

LULC types	Area (ha)			Over all change 2020-2030	
	2010	2020	2030	Area (ha)	Area (%)
Primary dryland forest	216,36	205,72	178,67	-11,21	-6%
Secondary dryland forest	247,88	229,1	207,84	10,08	5%
Settlement areas	28,10	30,71	34,58	0,91	3%
Mixed dry agriculture	365,36	380,91	358,76	31,68	9%
Paddy field	284,05	277,85	310,2	-19,76	-6%
Shrub	565,54	583,01	624,5	-13,37	-2%
Bare ground	162,77	162,77	161,84	15,15	9%
Water bodies	183,31	183,31	176,98	-13,33	-8%
Total	2053	2053	2053	0.14	0.03

Table 2 shows LULC prediction using CA-ANN analysis in 2030. The mixed dry agriculture and bare ground are expected to grow by 9% each. On the other hand, integrated dry agriculture will have the highest rise, with 31.68 hectares. The highest percentage of expected area decline, on either hand, happens in water bodies (8%). It is followed by primary dryland forest, paddy field, and shrub. Surprisingly, the percentage of secondary dryland forest will grow by 5% or 10.08 hectares.

Analysis of determination of land management patterns

Respondent's characteristics

The most significant percentage of respondents' age is in the age range between 30-49 years and 50-69, each of which is 43% of the total respondents (40 people). Most completed elementary school (35%), and only 5% graduated with a bachelor's degree. The average percentage of the most significant number of dependents in the family is 3-4 people (50%), and the rate of the smallest number of dependents is >7 people (8%). The average land area is 0.2-2 ha. The land area boundaries use natural boundaries such as large trees, large rocks, and rivers.

Species have been cultivated, and the preferences of the species to be set

A total of 7 plants were recorded in Bontolerung Village using agroforestry systems. Arabica coffee *(Coffea arabica* L.), cloves (*Syzygium aromaticum* L.), and *iles-iles (Amorphophallus muelleri* Bl.) are cultivated high-value commodities in the village. Usually, they are grown with other shade trees to form an agroforestry system. The type of shade trees is silk tree (*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes), easter flower (*Erythrina variegata* L.), Beechwood (*Gmelina arborea* Roxb.), and redcedar (*Toona sureni* Merr.). Plant species belong to three life forms: trees, herbs, and shrubs. Figure 4 shows the percentage of plant types developed and the preferences of the types of plants to be set.

According to Jaya et al. (2018) and Firnawati et al. (2021), the local community in Gowa District has cultivated arabica coffee and cloves in managing its agricultural land. Arabica coffee (*C. arabica*) is the most dominant commodity cultivated by farmers (56%), followed by cloves (*S. aromaticum*) (39%). Meanwhile, *iles-iles* (*A. muelleri*) contributed the lowest cultivated plants (5%) in the agroforestry system. Furthermore, the easter flower (*E. variegata* L.) is the most abundant shade tree (43%), followed by silk tree (*F. moluccana*) (33%), redcedar (*T. sureni*) (14%), and beechwood (*G. arborea*) (10%).

Coffee (*C. arabica*) was the dominant (55%) type of plant. Farmers still want to increase the number of trees on their land because coffee sales provide added value and create jobs for the surrounding community (Putra et al. 2020). Surprisingly, the percentage of *iles-iles* (*A. muelleri*) represents significant growth (20%) of the types of plants to be developed. Utami (2021) argues that iles-iles (*A. muelleri*) is the type of plant least planted by farmers because it is the most sought-after crop.

These plants are cultivated using an agroforestry system: coffee, coffee-cloves, and coffee-cloves-*iles-iles*. About 50% of respondents have been involved in coffee agroforests. The others cultivated coffee-cloves agroforests (40%) and coffee-cloves-*iles-iles* agroforests (10%).

Silk tree is the most widely planted by farmers as their shade trees in coffee agroforest (42%). Interestingly, the easter flower (*E. variegata*) is the dominant plant in both coffee-cloves (43%) and coffee-cloves-*iles-iles* agroforests (100%). Evizal et al. (2012) state that easter flowers can influence coffee productivity with high yields.

The number of coffee trees in the agroforestry system, i.e., coffee trees, coffee-cloves, coffee-cloves-*iles-iles*, was 1,516 stems, 1,112 stems, and 692 stems, respectively. The number of clove trees in coffee-cloves agroforests and coffee-cloves-*iles-iles* agroforests were 267 stems and 242 stems, respectively. Meanwhile, *iles-iles* is planted 30% of the total area of 1 ha, as many as 2,049 stems. This study indicates that farmers, who planted coffee agroforests, gained a smaller income than those who cultivated coffee-cloves agroforests.

The results of interviews and literature studies show that no types of plants are not allowed by the community to be planted due to local culture. In addition, there is no zoning of areas used as sacred places or archaeological sites in Bontolerung Village. Thus, the community can accept all types of plants being planted and farmers' preferences based on social aspects.

Feasibility analysis

*Cost, **r**evenue, and income on agroforestry management*

Farmers' production costs consist of fixed costs and variable costs. Fixed costs in this study include hoes, machetes, sickles, sprayers, crowbars, sacks, tarpaulins, and taxes. Meanwhile, variable costs include the purchase of fertilizers and labor costs for land preparation, planting holes, planting, fertilizing, and harvesting. The cost, revenue, and income of each on agroforestry management in Bontolerung Village are described in Table 4.

As discussed in Table 2, the average total income of a household in Bontolerung Village in the agroforestry system is IDR 11,366,838/year/ha (US$ 799.3). Meanwhile, the total income from non-agroforestry is IDR 32,968,804/year/ha (US$ 2,318.31). Thus, the contribution of agroforestry income to a farmer's household income was 26.08%. The value shows a low percentage compared to the contribution of non-agroforestry income to the total farmer income of 73.92%. It is due to the respondents are elderly, and it affects the physical ability and age, and the number of commodities. According to Desmiwati et al. (2021), it is caused by low human resource capacities, including knowledge in commodities production, weak motivation, low skills, less experience in cultivating various types of intercropping plants, and age affects the physical ability.

This study indicated that most respondents are elderly (50-60 years old), and 8% of them are above >70 years old and completed only an elementary school (35%). This study indicated that most respondents are elderly (50-60 years old), who completed only an elementary school (35%). On the other hand, food and non-food expenditures amounted to IDR 15,902,400/year (US$ 1,118.2). It indicates that people have savings of IDR 28,969,991/year (US$ 2,037.1) or 64.96% from their income on agroforestry and non-agroforestry, which can support their lives. Furthermore, the contribution of agroforestry business to whole food and non-food expenditure is 73.14%.

Business feasibility analysis on agroforestry management

The calculation of the financial analysis is carried out with a 25-year cycle in an agroforestry system. The financial analysis results are considered the NPV, BCR, and IRR (Table 5).

This study shows that the agroforestry systems are feasible to cultivate due to NPV>0, BCR>1, and IRR> interest rate values (8%) (Wijaya et al. 2015; You et al. 2016; Magni et al. 2020). The coffee-cloves agroforestry pattern will generate the largest average potential income at IDR 43,017,192.00/ha/year (US$ 3,024.9). Followed by coffee-cloves-*iles-iles* agroforests pattern at IDR 40,009,811/ha/year (US$ 2,813.4), and coffee agroforestry pattern stood at IDR 10,726,258.00/ha/year (US$ 754.3).

Ecological suitability

Based on previous social and economic factors, confirming plant species produced three types of primary commodities and four types of shade plants, for a total of seven types of plants. Based on the online database of invasive plants, the identification results of invasive plant species show two categories of plants included in invasive plants, as shown in Table 6.

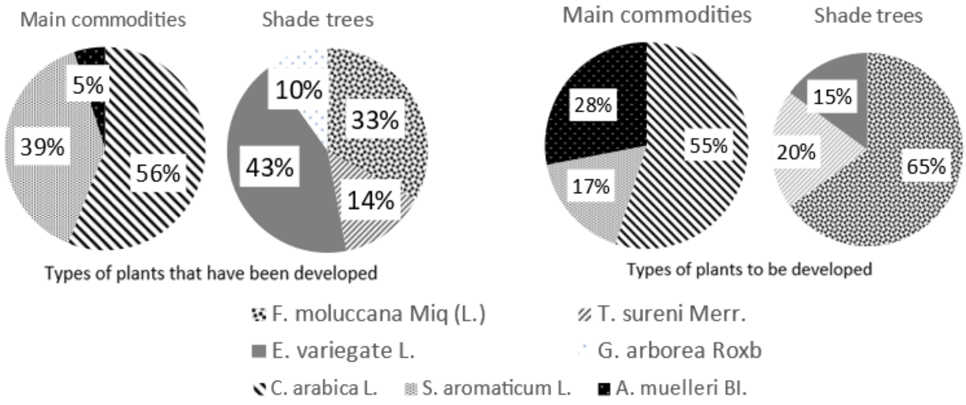

Figure 4. Percentage of types and preferences of species has been developed

Table 4. Average of cost, revenue, and income on agroforestry management in Bontolerung Village, Gowa, Indonesia (in IDR)

Village	Cost		Total cost (IDR/year/ha)	Revenue (IDR/year/ha)	Income (IDR/year/ha)
	Fixed cost (IDR/year)	Variable cost (IDR/year)			
Topidi	325,167	9,533,000	9,858,167	28,345,750	18,487,583
Panaikang	507,417	4,156,500	4,663,917	13,208,100	8,544,183
Biroro	297,917	4,544,000	4,841,917	12,520,500	7,678,583
Bontote'ne	339,000	5,264,000	5,603,000	16,360,000	10,757,000
Average	367,375	5,874,375	6,241,750	17,608,588	11,366,838

Table 5. NPV, BCR, dan IRR in agroforestry systems with a 25-year in Bontolerung Village, Gowa, Indonesia

Agroforestry patterns	Financial value		
	NPV (IDR/ha)	BCR	IRR (%)
Agroforestry-based coffee	268,156,462	3.15	29.82
Agroforestry-based coffee clove	1,075,429,798	1.90	38.90
Agroforestry-based coffee clove iles-iles	1,000,245.286	1.83	44.49

Note: 1 US$= IDR 14,221

Table 6. Invasive plant species

Family	General name	Species	Type of plant
Verbenaceae	Beechwood/gmelina	*Gmelina arborea* Merr.	Tree
Fabaceae	Silk tree/sengon	*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes	Tree

Source: Invasive Species Specialist Group (ISSG (2022), Centre for Agriculture and Biosciences International (CABI) (2019)

Silk tree (*F. moluccana*), is native to Indonesia, namely Maluku, Papua, and South Sulawesi (Gunawan et al. 2019), Papua New Guinea, and the Solomon Islands (Niemiec et al. 2017). Silk tree (*F. moluccana*), is recognized for its rapid wood development (Lelana et al. 2018; Gunawan et al. 2019), with a canopy width and height of up to 10 m and 30 m, respectively, and an 80 cm trunk diameter (Hughes et al. 2012). This plant, however, was shown to be an invasive species (Niemiec et al. 2017; Nopiyanti et al. 2019). Meanwhile, Beechwood (*G. arborea*), has a natural range that stretches from South Asia to Southeast Asia, including Indonesia. Invasive plant species have a harmful influence on humans in addition to the environment, notably in the areas of human health and the economy (Sutomo 2018; Ramadhan et al. 2020). Characteristics of invasive plant species can lead to the extinction of native species. As a result, ecosystems and biodiversity may be jeopardized.

Discussion

Forest class experienced the most significant percentage decline at 19%, while settlements increased 19% in the same period (2020). However, the shrub class has the largest area in Bontolerung Village. This class of shrubs can change to other areas of use depending on their intended use. In the Bontolerung Village, the shrub changed to mixed dry agriculture and rice fields in 2010-2020. Furthermore, mixed dry agriculture and bare ground are expected to grow by 9% each. In comparison, primary dryland forest is predicted to decline by 6% in 2030.

The agroforestry system provides an appropriate concept for reforesting degraded lands using different commercial trees and crops in Gowa District. The three kinds of patterns evaluated in this study, i.e., coffee agroforest, coffee-cloves agroforest, and coffee-cloves-*iles-iles* agroforest are socially acceptable, economically feasible, and ecologically suitable. Land management with coffee agroforest can also improve ecological functions, especially soil moisture and biomass (Asfaw et al. 2021). The agroforestry scheme can increase farmers' income. According to Staton et al. (2022), agroforestry can increase cumulative gross mixed income (GMI) relative to arable systems. Compared to non-agroforestry contributions, which can reach 74%, agroforestry systems can contribute 26% to farmers' income. Land with more commodities will generate more revenue than land with fewer commodities (Wulandari et al. 2014). However, the coffee-cloves agroforests provide a high income compared to other agroforestry schemes. This condition is because of the various types of commodities and the amount in the land.

This study recommends employing an agroforestry system to reforest degraded lands (shrubs). Paul et al. (2017) stated that agroforestry had been suggested as a global solution to increase land-use efficiency while reducing farmers' environmental impacts and economic risks. Besides, according to Karmini et al. (2017), agroforestry is mostly used in degraded regions as part of a land rehabilitation program. Then, planted those lands with plants that have been selected based on social, economic, and ecological aspects. Farmers can continue cultivating crops that are allowed following local culture (socially based), as long as they do not contradict the local community's norms. The plants are then chosen based on the economic aspect, using a feasibility analysis to determine whether the farmer's type of business is feasible and whether it would benefit the farmer/not when planted. Then, confirm the plants based on the ecological aspect (invasive series) that can harm the ecosystem.

It is expected that land could turn into the forest again - not a primary forest but agroforestry. The management of the area is based on function and the scope of the site's landscape (for example, the river basin), which can refer to new criteria and indicators of sustainable forest management, according to Supratman et al. (2020). Thus, realizing appropriate and integrated forest area management between landscape and life scape and improving community welfare in a better direction is imperative. Furthermore, the methods can lead to opportunities for healthy productivity, the capabilities for optimal utilization, and the sustainability of the major farming systems. This agroforestry system could be potentially employed as a land-use conflict resolution (Nurrochmat et al. 2020). It could be promoted as an appropriate concept for reforesting degraded lands and increasing the community's income (Pokorny et al. 2021).

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