Planning the upstream agricultural landscape of the Jeneberang watershed using the bioregion approach

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Abstract. This study aimed to plan the agricultural landscapes in the upstream area of the Jeneberang watershed using a bioregion approach. This research was conducted in the upstream area of the Jeneberang watershed precisely in the Pattapang Village, Tinggimoncong District, Gowa Regency, South Sulawesi from May to July 2017. The research was conducted using a field survey method and literature study, which included five stages, namely the preparation, inventory, analysis, synthesis and planning stages. The criteria for the classification of the bioregions were prepared based on the characterization of the biophysical and socio-cultural aspects of the Pattapang community based on the inventory, analysis and synthesis of the data obtained. At the planning stage, the conceptualization for landscape conservation is carried out, then the development of planning concepts and the end result is a sustainable agricultural landscape plan that can still meet economic needs. Based on the results of the bioregion analysis, the study area is included in the bioregion units of the Jeneberang watershed, namely the Jeneberang watershed upstream area, consisting of 70 sub-watershed units divided into 121 landscape units based on three biophysical characters (sub-watersheds, soil types and slopes) and 156 units a place based on the socio-cultural intrinsic value of land cover. The landscape plan for sustainable agriculture consists of 61.7 ha of residential space, agricultural area (35.4 ha of rice fields, 384.3 ha of monoculture fields and 780.94 ha of polyculture fields) and forests (89.6 ha of protected forests and 520.2 ha of production forest).

1. Introduction
Changes in land use in Indonesia are known to have occurred a lot. Forms of land use that cause changes in land use include illegal logging, shifting cultivation, conversion of natural forests to other land uses, construction of housing and industry in water catchment areas. In addition, land uses that do not apply the principle of soil and water conservation also determine the form of the land uses [1,2]. The biggest changes occurred in forest areas that are generally converted into plantation crops such as oil palm, rubber, or other commodities. Changes in land use also occur on agricultural land which can produce a disaster[3]. The intensive exploitation of land resources has led to the forms of land uses in a watershed area often carried out without paying attention to the negative impacts.

The Jeneberang upstream catchment area is part of the Jeneberang watershed which includes priority of soil conservation handling according to a joint decree of the Minister of Home Affairs, Ministry of Forestry, and Minister of Public Works No. 19 of 1984, No. 059 / Kpts-II / 1985 and No.
124 / Kpts / 1984 which in its management needs special attention. The Jeneberang is a water catchment area for the multipurpose Bili-Bili Dam, which was built to meet the interests of drinking water supply for the residents of Makassar City, Sungguminasa and its surroundings, irrigation of rice fields in the downstream area of ± 30,000 ha, power plants and recreation facilities [4].

In a study conducted by Nuraeni, et al. [5] it was found that the condition of the land in the Jeneberang watershed had been damaged due to land conversion from the forest area to an agricultural cultivation area. Furthermore, it is suggested that the agricultural system carried out by farmers in the Pattapang subdistrict does not apply conservation techniques for land with a slope of over 30%, so that it adds to the potential for land damage. Principally, efforts to apply the principles of conservation of land resources in the plant cultivation systems depend on the perceptions and participation of farmers as a decisive actor in the management of their farming businesses. In view of this, a pattern and system of natural resource management based on sustainability is very urgent to be implemented where one of them is through a bioregion and/or ecosystem approach. Management of the area and natural resources using the bioregion approach provides benefits both in terms of ecological, economic and social. This is due to a link between the biological components as well as the ecosystem and humans which is an absolute requirement needed to ensure the sustainability of the natural processes that occur in the region, wherein this approach the region is seen as a unified as a whole [6].

The concept of natural resource management through a bioregion approach does not differ much from ecosystem-based management. Ecosystem-based management as the integration of ecological, economic and social principles in the management of biological and physical systems in a way to protect, preserve and maintain ecological sustainability, natural diversity and productivity of a landscape [7]. Meanwhile, management with a bioregion approach is carried out in a unified landscape that is bounded by ecological boundaries and is site-specific in nature, where the sustainability and preservation of ecosystem functions including ecological, economic and social functions is a major concern [8]. Bioregion combines terrestrial, coastal and marine ecosystems, including small island ecosystems, with their communities and culture in a spatial context. The limits of bioregion planning are determined by environmental characteristics, and more specifically, ecological parameters. The ecological parameters include types of vegetation, catchment areas and climate factors, biodiversity and others [8].

Bioregion is a spatial planning unit in natural resource management that is not determined by political and administrative boundaries, but is limited by the geographical, human community and ecological systems, within a range of bioregions, ecologically. The difference between classes is that there are intrinsic values that make the area unique or unique [9]. The bioregion classification characterizes the biophysical and socio-cultural aspects of society and its environment. The following bioregion classification in Table 1.

**Table 1. Classification of bioregion [9].**

| Class           | Description                                                                 |
|-----------------|-----------------------------------------------------------------------------|
| Bioregion       | Represents areas in the top hierarchy that are defined based on the homogeneity characteristics of the climate, elevation, distribution of vegetation, and boundaries of major watersheds, topography, and geology. |
| Sub Region      | Represents a bioregion subdivision that composites encompass homogeneous regions in terms of hydrological class, elevation, landform, vegetation, and soil. |
| Landscape Unit  | Representation of subdivision of the sub-regions which includes homogeneous regions characterized by slopes, land use, and socio-cultural attributes of community communities such as lifestyle and ethnicity. |
| Place Unit      | The lowest hierarchy in this subdivision is characterized by several components including land use, socio-cultural attributes of the |
Management of the area and natural resources using the bioregion approach provides benefits both in terms of ecological, economic and social. This is because in the utilization there is a link between biological components and ecosystems and humans which is an absolute requirement needed to ensure the sustainability of natural processes that occur in the region, wherein this approach the region is seen as a unified whole [10].

Based on the description above, a study was conducted to develop a sustainable agricultural landscape planning in the upstream area of the Jeneberang watershed through the bioregion approach. Through the planning for a bioregion-based agricultural landscape, it is expected to be able to conserve agricultural land use in the region.

2. Methodology
This research was conducted in the upstream area of the Jeneberang watershed precisely in the Pattapang Village, Tinggimoncong District, Gowa Regency, South Sulawesi. The study was carried out from May to July 2017. The method and stages of this research were carried out by the field survey method and literature study, which included five stages, namely the preparation, inventory, analysis, synthesis, and planning stages. Data and information collection was conducted by exploration techniques or direct roaming and observation methods, and interviews. Spatial data, including biophysical data, were collected from various sources, while data related to social aspects including spatial patterns were obtained from interviews.

Data were processed using Geographic Information System (GIS) software (ArcGIS 10.3, original "Unhas License"), hardware (computer). Bioregional analysis was carried out based on biophysical and socio-cultural characteristics, the bioregion classification of the study area is divided into 3 (three) classes, namely the bioregion unit, landscape unit, and place unit.

3. Results and discussion

3.1. Bioregional analysis
Based on biophysical and socio-cultural characteristics, the bioregion classification of the study area is divided into 3 (three) classes, namely:

3.1.1. Bioregional unit. The bioregion unit is a representative region in the top hierarchy that is defined based on the homogeneity characteristics of the climate area, elevation, vegetation distribution, boundaries of major watersheds, topography, and geology [9]. Bioregion classification is done by determining hierarchical bioregion units that are initiated based on watershed and sub-watershed boundaries. The bioregion unit and landscape unit were formed based on the division of watersheds and sub-watersheds in the Pattapang Village. Whereas the Pattapang Village Bioregion Unit Classification was initiated by looking at the topographic characteristics. Based on the topographic characteristics, it can be known that the catchment area, in each watershed has the same natural characteristics, but differ from one watershed to another watershed. Therefore, the division of space for bioregion units on the site is based on the main river basin, the Jeneberang watershed.

3.1.2. Landscape unit. The landscape unit was built by three biophysical characters (sub-watershed, soil type, and land slope). These three characters are the difference between one landscape unit and another landscape unit. The Jeneberang Watershed Bioregion Unit is arranged based on landscape units that have unique characteristics that can be distinguished based on the subwatershed boundaries, soil types, and slopes. The landscape unit in a bioregion is a representation of the characteristics of a sub-watershed that includes a homogeneous region and is characterized through slopes, land use, and socio-cultural attributes of the community, such as lifestyle and ethnicity [9,11]. The landscape unit is
determined by identifying the sub-watershed of the Jeneberang watershed bioregion unit. The landscape unit in this study can be identified by carrying out the sub-watershed classification found in the Pattapang Village. It can be seen in Figure 1, the sub-watershed units formed are as many as 70 sub-watersheds that have the same characteristics in each sub-watershed unit, but have unique characteristics that differ between their sub-watersheds.

The characteristics of 70 sub-watersheds are located in one soil type, Andosol. Furthermore, the characteristics of the 70 polygons can be distinguished based on the slope of the land. Based on the slope characteristics of the land, through overlaying seventy polygons can be divided into 121 polygons. The one hundred and twenty-one (121) polygons are landscape units that have homogeneous characteristics in each unit but differ from one landscape unit to another landscape unit.

![Figure 1. Landscape unit map of Pattapang Village, Tinggimoncong District, Gowa Regency](image)

3.1.3. Place unit. The place unit in bioregion is the lowest hierarchy in the bioregion subdivision which is characterized by several components, namely land use, socio-cultural attributes in the community which includes ethnicity, community aspirations, the sense of place, the meaning of place and various forms of local values[12]. This explains that the place unit is the smallest unit that makes up the bioregion unit. In this study, place units are classified based on land cover in landscape units.

This land cover characteristic contains an intrinsic value which can be interpreted as a form of activity (culture) in the Pattapang Village area. In Figure 2, based on these characteristics, the landscape unit in the Pattapang Village is divided into 156 place units. Land cover at the place unit was obtained from the results of the interpretation of the image carried out previously, namely the settlement space, rice fields, fields, and shrubs. Intrinsic value contained in this place unit is an expression of physical elements (sub-watershed, soil, and slopes). Land cover is used as a basis in
determining the place unit because the land cover can describe an activity (culture) in Pattapang Village.

![Place unit map of Pattapang Village, Tinggi Moncong District, Gowa Regency](image)

**Figure 2.** Place unit map of Pattapang Village, Tinggi Moncong District, Gowa Regency

### 3.2. Bioregion planning

**3.2.1. Basic concepts.** The basic concept of agricultural landscape planning in the Upstream Jeneberang watershed precisely in the Pattapang Village which is a horticultural crop production centre, especially in the South Sulawesi region, is to become an agricultural area that applies the basic principles of sustainable agriculture namely economic, ecological, technological and social as well as institutions that support each other. Through the application of landscape science, modeling was carried out for sustainable agricultural areas on the basis of land use conservation both biophysically and culturally.

**3.2.2. Development of the concepts.** Based on the basic concept, the concept of agricultural area is developed to be used as a direction for land use while still taking into account the principle of sustainable agriculture. This development concept is described in the spatial concept, the concept of circulation and the concept of green or vegetation.

**3.2.3. Spatial concepts.** The spatial concept developed based on bioregional analysis, namely land use based on the slope of the land and soil type while taking into account the economic and ecological
value obtained by the community. The spatial concept in the area was divided according to the function and spatial allocation needed. The division of space in the area included horticultural farming areas of vegetable species, horticultural agriculture of fruit types (agroforestry), settlements, rice fields and protected forests or conservation forests. The division of space based on pre-existing space, which is then divided into several sub-spaces that are adjusted to the slope of each region to determine the type of commodity to be planted in the area.

3.2.4. Concept of circulation. Circulation is important for connecting one space to another. The concept of circulation developed in the Pattapang Village was based on inter-space connectivity. Primary road or main lane in the form of access links between villages to villages. Secondary road or connecting lane is access liaison between settlements, access liaison fields and settlements. In addition, there is an access link between the settlement and the rice fields to the fields. The concept of circulation was still based on the conditions that already exist in the Village Pattapang.

3.2.5. Concept of vegetation. Based on the evaluation results, there are three forms of land that are important for conservation. Because each form of land has different vegetation criteria. Development of vegetation concepts for each landform, namely:

3.2.5.1. Settlement. The term settlement in the concept of vegetation is a yard in the form of land that is a home garden. In this concept, the yard of each settlement contains ornamental plants, spices producing plants, fruit plants and medicinal plants which are cultivated just to meet household needs. This area is a pre-existing area, which is located along the circulation path, especially on the main route.

3.2.5.2. Farm/agricultural areas. The field is the largest area in the planning area considering that Pattapang Village is a horticultural plant centre. In this area, where horticulture commodities are planted with vegetables, conservation methods will be applied both vegetative and mechanical methods. Conservation methods that can be applied include planting cover crops, strip stripping, utilizing crop residues, contouring tillage, contouring, making terraces, making terraces, planting grass on the terrace, repairing drainage, and making check dams or reservoir. Vegetation cultivated on this land were previous superior commodities such as potatoes, carrots, cabbage, leeks, mustard greens and tomatoes. Through the preparation of cropping patterns that are overlapping cropping patterns. Preparation of crop patterns, especially vegetable horticulture was largely determined by the spread of rainfall each year. In addition to horticultural farming areas, there are also rice fields. The rice fields in the Pattapang Village are on a gentle slope to a rather steep slope and are far from settlements. In rice fields there are plants that grow naturally, namely coconut and banana which are scattered randomly. The existence of rice fields on a rather steep slope, requires the application of terracing systems in rice fields.

3.2.5.3. Protection forest and production forest. Protection forests and production forests are areas that are used as conservation forests as well as production forests. Vegetation planted in the form of forest trees and tree species that produce high economic value fruits, such as avocados, rambutan, jackfruit and passion fruit cultivation. Among other forest trees, acacia, pine, eucalyptus, and banyan. This area is an ecological buffer zone without reducing the income of farmers.

3.3. Landscape planning
At the planning stage of sustainable agriculture, landscapes carried out by collecting the final results in the form of a landscape plan. Landscape plan drawings are made based on the concept of planning. Then each unit of the same place as settlements, fields/dryland agriculture and shrubs were arranged according to the bioregion analysis that has been done. Through the bioregion approach, landscape planning for the preservation of the area is expected to be able to improve the land use of agricultural
areas in the Pattapang Village. Thus, bioregion-based agricultural landscape planning is projected to be able to make agricultural areas in Pattapang Village, ecologically, socially, economically and culturally sustainable. The agricultural landscape plan for Pattapang Village can be seen in Figure 3.

Figure 3. Agricultural landscape plan for Pattapang Village, Tinggimoncong District, Gowa Regency

3.3.1. Spatial plan. Land cover and slope are the basis for making agricultural space plans in the Pattapang Village. There are three spaces, namely settlements, fields / agricultural areas and forests that really need to be preserved because they are related to the ecological conditions in the area. Spatial planning is based on land use as stated in the spatial concept. The space is important to be conserved because it is closely related to the sustainability of the agricultural system in the Pattapang Village. The space is then developed in several sub-spaces determined based on the type of commodity to be developed in the area.

3.3.1.1. Settlement. In Pattapang Village there are no rules governing the form of buildings or community houses. The community builds houses based on their individual needs. Residential areas will be developed the concept of yard farming to create community independence in meeting their own household needs. For this reason, the selected types of plants are herbs, medicinal plants and ornamental plants. Landscape planning results obtained a total area of settlements that is 61.7 ha. This residential area is a pre-existing area, which is then directed to make each community’s yard more organized.

3.3.1.2. Farm / agricultural area. This land is on a flat, gentle slope, rather steep, steep and very steep, so the fields are then divided into several areas. To restore soil fertility when opening fields and
planning, there needs to be a fallow stage, where land must be filled with trees to overcome natural disasters. Highly intensive agricultural activities provide opportunities for ecological impacts that affect the ecosystem. The absence of the application of ecological principles in agricultural business carried out further increases the chances of ecological impacts, for example erosion to landslides, reduced levels of soil fertility, reduced biodiversity, to health impacts that will result from the continued use of chemicals on the results-agricultural product.

At present, most of the land that should be a conservation forest area has been cultivated by the community and used as a horticultural crop production land. The planting technique that was carried out did not pay attention to the rules of land conservation. Society is mostly oriented towards meeting the needs of the economy, i.e. to get as many results as possible. The land that is cultivated by the community is the status of use rights, which are hereditary. In the dry season some land will be left neglected and not cultivated, especially land far from water sources.

The government is having difficulty enforcing the prevailing regulations regarding land clearing permits or land processing permits. So what can be applied is to replace a number of commodities grown on land that has a rather steep and steep slope with tree crops that remain of high economic value, for example fruit species such as avocados and are projected to increase the diversity of trees that have a sale value and combined with trees from forest that are still cultivated to maintain the ecosystem in the form of productive natural forests.

The development of farmland is oriented as a buffer zone so that exploitation of conservation forests can be minimized. In addition, land ownership must be under government supervision so that there is no abandoned land which triggers problems in the form of disasters or land conflicts. Saida [13] argued that sustainable farming systems will only be realized if land is used for the right farming system with appropriate management methods. If land is not used properly, productivity will quickly decline and ecosystems will be threatened with damage. Appropriate land use in addition to ensuring that land and nature provide benefits to users today, also ensures that these natural resources are useful for future generations, taking into account the agroecological conditions, land use in the form of production systems and the right plant choices can determined.

The results of the plan divide the area of fields into three areas based on their slope, namely monoculture fields and polyculture fields or intercropping. Monoculture fields are in a flat area that is between 0-8% of 384.3 ha, while polyculture fields are in sloping areas, which is between 8-15% 543.6 ha, besides polyculture fields or intercropping fields. in a rather steep area, ie at a slope of 15-25% covering an area of 237.3 ha. Rice fields in landscape planning are rice fields that previously existed in Pattapang Village, but management of rice fields has not yet implemented a good conservation system. Considering that the paddy field is on a slope between sloping to rather steep, the application of the terracing system is very much needed. Besides terracing planting plants on the lip of the terrace is also important to do. Plants used for example lemongrass and elephant grass. Rice field area in landscape planning is 35.4 ha. Selection of plant types based on conservation functions and economic value. Lemongrass plants and elephant grass have a dense recording system, so as to withstand the rate of erosion.

3.3.1.3. Production forests and conservation forests. This area is an area that was previously a shrub and even most of the community has been processed into horticultural agriculture. Shrubs are on steep to very steep slopes, so the area is very suitable to plant tree species to protect the ecosystem in the form of productive natural forests and to preserve biodiversity in the Pattapang area. These plants aside from preserving germplasm, their main function is to maintain the balance of the ecosystem in the area. Considering that the area grew a number of rare plants and live several rare species of animals such as the Sulawesi eagle, black monkey and several species of birds. The forest area has an area of 609.8 ha.

This area serves as a protection for life support systems, preservation of plant and animal species diversity, as well as sustainable use of biological natural resources and their ecosystems, sources of various types of wood that can be utilized for building needs, as well as nature conservation areas for
the purpose of collection of natural plants and animals. or not natural, original or non-original types that are used for the purposes of research, science, education, supporting the cultivation of plants and or animals, culture, tourism and recreation.

3.3.2. Vegetation plan. The vegetation plan was developed based on an analysis of the agricultural system applied by farmers. Based on the spatial plan, five areas were formed based on the vegetation plan, including; yards, monoculture fields, polyculture fields, rice fields, conservation or production forests and protected forests. In settlements, will be the area of agricultural development in the yard. The plan to plant vegetation is centered on ornamental plants, cooking spices and medicines. While on agricultural land or fields, it becomes the center of various types of horticultural crops, which are distinguished in two regions based on the cropping patterns applied, namely monoculture fields and polyculture fields. In addition to the hot center, the agricultural area also consists of rice fields. In the shrub area will be used as a buffer zone or conservation forest, there are several types of tree plants whose fruit is of high economic value or types of trees that remain of economic value for example as building material. However, vegetation originating from protected forests will also be cultivated on farms given that protected forests are conservation spaces. There are four categories of vegetable planting patterns applied by farmers in the fields, namely intercropping cropping patterns consisting of three types (potatoes-cabbage-tomatoes, carrots-potatoes and potatoes-cabbage-potatoes) and intercropping patterns (intercropping onions with cabbage / tomatoes / mustard greens). This cropping pattern is based on water availability and analysis of market needs, so that at any time it can change. Forest area is the area with the most diverse types of vegetation, including various types of fruit plants with high economic value, such as mangoes, jackfruit, rambutan, avocado and passion fruit. Passion fruit is a plant that has been cultivated by the Tinggimoncong community since the 60s. In 1981, which was marked by the presence of PT Markisa Segar, passion fruit farming was increasingly popular [14]. The main problem that causes passion fruit farming is not developing is the selling price is too low, passion fruit prices are low because the quality of the fruit is also very low. The processing factory complained about the quality of the fruit obtained, generally below the physiological ripe level, so that the quality of the juice product produced was very low. The existence of this underage harvest is due to the practice of bonded labor which is carried out by traders to farmers, especially when pressed in economic difficulties. In addition, the utilization of fresh passion fruit company land has never been used optimally. Another thing that causes farmers to discontinue passion fruit farming is the length of payment received from collecting traders [14].

4. Conclusions

Based on the research that has been done, the following conclusions are obtained:

1) The landscape of the agricultural area in the Pattapang Village has landscape characteristics in the form of biophysics and culture that form bioregion units. Based on the analysis, the study area is included in the bioregion unit of the Jeneberang watershed, namely the Jeneberang watershed upstream which is divided into 121 landscape units based on three biophysical characters (sub-watersheds, soil types and slopes) and 156 place units based on socio-cultural intrinsic values namely land cover.

2) Based on an evaluation of the bioregion characteristics of the agricultural area in Pattapang Village, the landscape plan for the agricultural area consists of a residential area of 61.7 ha, an agricultural area (35.4 ha of rice fields, monoculture field of 384.3 ha) and polyculture fields or intercropping fields covering an area of 780.94 ha) and forest (protection forest covering 89.6 ha and production forest covering 520.2 ha).

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