Adaptive Agroforestry Model To Improve Livelihood And To Support The Management Of Minraleng Watershed In Maros Regency

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Abstract Many watershed area in Indonesia and South Sulawesi experience erosion, flood and landslide in rainy season and in dry season experience drought, like in Minraleng Watershed. This condition have impacted to food insecurity of the community that reside in watershed area. This study aim to formulate adaptive agroforestry model to increase farmer livelihood in supporting watershed management. Population study i.e. all of the farmer household in Minraleng Hulu Watershed. Study sampling was done by purposive sampling in 4 sampling village (Limampoccoe, Cenrana Baru, Timpuseng and Batu Putih). Data collection was done by in-depth interview and observation. Data was analyzed by qualitative descriptive and spatial analysis. Result of the study indicated that combination pattern of landscape agroforestry model need to be developed in dry land and the big property land in Cenrana Baru, Limampoccoe and Batu Putih. That agroforestry model known by Taungya by developing adaptive plant to drought and give livelihood diversification and adaptive to the short rainy season, secure from pest i.e. swine, monkey, and cow. In Timpuseng village, agroforestry pattern need to be was permanent intensive agroforestry which is known by Talun where farmer need to develop three to fourth strata of plant to resolve limited land by planting gamal tress and candlenut in the top of the strata, while planting coffee and pepper in second strata, and chili and elephant grass in third strata. Intensive permanent agroforestry with low labour input to resolve limited farmer labour which dominant in rice field.

1. Introduction
One of the strategies to cope with the impact of climate change, is how to develop adaptive agroforestry model, that has the role in increasing farmer income [1] to prevent or diminish flood, and to control soil erosion, [2] agroforestry as one form of land cover that have resemblance with forest that have potency to arrange water system especially water debit in catchment area, [3] and increasing livelihood diversification [4].

Land acreage in Minraleng Hulu Catchment area, that is 56.623 ha, where 18.446 hain critical land. Based on the interpretation of satellite imagery with scale 1:250.000 in 2002, while based on imagery interpretation in 2018, dominated by dryland agriculture with 18.046 ha and bushed with 14.543 ha. One of the problem in Minraleng Hulu Catchmentarea was land cover with various land use pattern...
that has not good impact to flood in the rainy season and drought in the dry season in downstream villages around Tempe Lake, so agriculture in downstream have experience drainage water shortage. Another problem that is the increasing acreage of critical land, as an impact from land governance that’s not clear, so that the community didn’t have clear right and obligation for using the land and moral obligation to take care the sustainability of land productivity, by intensification and diversification of farm business.

This study aims to research adaptive agroforestry development toward climate change associated with the government program to decrease carbon emission rate. By knowing community purpose in developing agroforestry in their land property and community attitude, knowledge to agroforestry role in increasing livelihood and quality improvement of Minraleng Hulu Catchment Area and the downstream area can be one program in the area action plan to disaster mitigation and climate change adaptation.

2. Material and Method

2.1. Study Design and Study Target Group
This study uses Minraleng Hulu Watershed as a unit analysis. Village determining was done by purposive which administratively located in the area of Minraleng Hulu Watershed, with criteria (a) have experience of disaster of climate change in the field of agriculture, animal husbandry, plantation and forestry, (b) was the village which has land cover and land use was natural forest, dry land agriculture mixed with bush, dryland agriculture (non irrigated agriculture, garden, moor), and or rice field. A sample of study location was chosen by purposive sampling, and in each sample, village was chosen 20 respondents also with purposive sampling, so the total respondents are 80 respondents. Data collection was done by observations, in depth interview, and triangulations of respondents in 4 villages.

| Objective       | Variable          | Data Observed                          | Data collection                     | Analysis       |
|-----------------|-------------------|----------------------------------------|-------------------------------------|----------------|
| Livelihood asset| Physical capital  | Slope                                  | Interview and observation           | Spatial and descriptive |
|                 |                   | Means and infrastructure               |                                     |                 |
|                 |                   | Technology and tools                   |                                     |                 |
|                 |                   | Accessibility                           |                                     |                 |
| Natural capital | Water Source      | Climate                                |                                     |                 |
|                 |                   | Soil type                              |                                     |                 |
|                 |                   | Land cover                             |                                     |                 |
|                 |                   | Environment service                    |                                     |                 |
| Human Capital   | Education         | Skill                                  | In-depth interview                  | Descriptive    |
|                 |                   | Experience                             |                                     |                 |
|                 |                   | Innovation/motivation                  |                                     |                 |
|                 |                   | Physical ability                       |                                     |                 |
| Social Capital  | Organization/ social norm of land swap |                                     |                                     |                 |
|                 |                   | Social networking                      |                                     |                 |
|                 |                   | Local wisdom                           |                                     |                 |
| Financial capital | Income           | Saving/investment                      |                                     |                 |
Debt/Credit

| Adaptive agroforestry model drought withstand | Increasing livelihood | Plant species | Plant pattern | Plant species shifting | Infrastructure using | Using of quality seeds which drought withstand | Technology of harvest | Rain forecasting and plant time |
|---------------------------------------------|----------------------|---------------|---------------|-----------------------|----------------------|-----------------------------------------------|----------------------|------------------------------|
| Interview, observation and triangulate       | Descriptive          |               |               |                       |                      |                                               |                      |                              |

Watershed quality improvement

- Soil and water conservation
- Local wisdom knowledge

Data analyze done by qualitative descriptive to describe (a) land cover and land use, the potency of livelihood asset, potency of support and obstacle of adaptive agroforestry development which held in Minraleng Hulu watershed. Based on various potency we can describe adaptive agroforestry model that can be adopted to increase community livelihood in the area of Minraleng watershed and to support watershed quality improvement.

3. Results and discussion

3.1. Land cover

The Based on spatial imagery analyses in 2018, indicated that land cover in the upstream of Minraleng Hulu Watershed dominated by dryland agriculture with acreage 18.046 ha and low-density forest with acreage 10.302 ha (Table 2). Dominations of bushes and dryland agriculture (63.5%), needs more handling to improve the land cover for improving the quality of Minraleng Watershed all at once improving livelihood of landowner through agroforestry model development.

| Table 2. Land Cover and Land Use in Minraleng Watershed Areal |
|-------------------------------------------------------------|
| No | Land Cover Type               | Acreage (ha) | %   |
|----|------------------------------|--------------|-----|
| 1  | Low density dryland forest   | 10,302,37    | 20  |
| 2  | High density dryland forest  | 239,54       | 0,5 |
| 3  | Plantation forest            | 1,105,68     | 2,2 |
| 4  | Grassland                    | 112,9        | 0,2 |
| 5  | Settlement                   | 715,46       | 1,4 |
| 6  | Dryland agriculture          | 18,046,54    | 35  |
| 7  | Rice field                   | 5,464,00     | 11  |
| 8  | Bushes                       | 14,543,29    | 28,5|
| 9  | Open land                    | 3,92         | 0,01|
| 10 | Water Body                   | 407,92       | 0,8 |
|    | Total                        | 50,941,84    | 100 |

3.2. The Retarder and Supporting Agroforestry Development

Based on survey and interview with farmer respondent, it can be acquired the description of a factor of availability of water source (water spring, river and irrigation infrastructure) very support agroforestry development by a community of landowner in Minraleng Watershed (Table 3).
Table 3. Supporting Factor of Agroforestry Development di Minraleng Hulu Watershed

| No | Village         | Natural resources | Physical resources | Social resources | Human resources | Financial resources | Developed Agroforestry         |
|----|----------------|-------------------|--------------------|------------------|-----------------|---------------------|-------------------------------|
| 1  | Cenrana Baru   | Big land          | Concrete road      | Farm road        | Traditional agriculture skill | Financial access to middleman and wood trader inter regency | Mix stand dominant with teak and candlenut |
| 2  | Limampoccoe    |                   |                    | Land swap        | Intensive agriculture skill   |                     | Mix stand dominant with teak and candlenut |
| 3  | Batu Putih     |                   |                    |                  | Intensive agriculture skill   |                     | Mix stand dominant with teak and candlenut |
| 4  | Timpuseng      | River and water   | The pipeline, check dams, irrigation, and road | Intensive agriculture skill |                   |                     | Agri-silviculture |

The potency of large dryland ownership and limited paddy field, require the farmer to develop Taungya agroforestry pattern [5], and after annual plant can’t do it again, and the establish dominantly teak and candlenut. Annual plant agriculture like corn, papaya and chili were done in rainy season to overcome the limited water because there was no water spring, river and water construction (irrigation, check dams, and pipeline). Teak and candlenut stand as main plant were developed because these species resistant to drought (Table 4). Annual plant (corn, papaya and chili) were developed dominant to semi commercial in fulfillment of subsistence, whereas log is cutting while regeneration were done to make orientation semi commercial to fulfill family education and health need.

Water availability through river and water spring and water construction (pipeline, irrigation) is supporting the development of intensive agrisilviculture in Timpson Village. The availability of paddy field land ownership and limited dry land with support water availability, local community, have the opportunity to develop agroforestry intensive plot to combine agriculture plant, horticulture and forestry that secure from swine, monkey, and cow.

Table 4. Limiting Factor of Agroforestry Development In Minraleng Watershed

| No | Livelihood Asset | Limiting Factor                  | Cenrana Baru | Limampoccoe | Batu Putih | Timpuseng |
|----|------------------|----------------------------------|--------------|-------------|------------|-----------|
| 1  | Natural Resources| Limited waters source (water spring and river) | Limited land | Type C Climate | Swine, monkey and cow pest |
| 2  | Physical Resource| Limited water construction       |              |             |            |           |
| 3  | Human Resources  | Unskilled in combining plant species based on time and space |              |             |            |           |
Financial Resources
Limited access to bank credit
Income source seasonally

Adaptive agroforestry
Landscape agroforestry that adaptive to drought and need to develop
income weekly and seasonally

3.3. Agroforestry Model Development to Increase Livelihood and Watershed Quality.

The Combination pattern of landscape agroforestry model while [6] was agroforestry model that can be developed in dryland in Cenrana Baru, Limampoccoe and Batu Putih, where this agroforestry model adaptive to drought and to give livelihood diversification [7] by weekly, monthly and annually in Cenrana Baru Watershed, Limampoccoe, and Batu Putih that can overcame limiting factor of agroforestry development like monthly rainy season that have only five months in a year, plant often get drought in dry season because no water source, and swine pest, monkey and beef cattle and dominant of vast dry land ownership from farmer.

Agroforestry model developed by farmer was mix agroforestry candlenut and teak that classified as periodic concomitant pattern Taungya model [6], where after completing planting of annual plant like corn, peanut, and/or chili simultaneously with candlenut and teak planting with natural regeneration for three years, so it can’t give monthly income but only yearly income from candlenut while four years and at the end of rotation (minimum 15 years of age of teak and candlenut), after those plant mature as raw material of furniture industry, or teak for sawn timber, while candlenut wood formal board. Those model need to be improved by introducing plant species like coffee, and or pepper interplanting with candlenut and teak with a cover stand like Gliricidia for cattle food, and to resolve drought season where there was limited food. It also acts as fence and protector plant of coffee and pepper, and it also contributes to the diversification of weekly and monthly income [4] and using of farmer household wherein drought season they become jobless.

In Timpuseng village, with the characteristic of water source like river, water spring, check dam, irrigation and pipeline, limited land, so agroforestry pattern developed similar to the model in three villages before. To differentiate it we need to develop intensive plot agroforestry permanent pattern that we called “Talun” [5], where the farmer permanently developed about three and four strata of the plant to resolve the limited land by planting Gliricidia and candlenut in the top strata, while in the second strata they developed coffee and pepper. In the lowest strata they developed chili and or elephant grass. Those agroforestry model was more intensive than pattern recommended in Batuputih Village, Limampoccoe and Cenrana Baru Village, because the opportunity water availability with higher technology input, so the farmer can balance the activity of paddy and peanut cultivation in the rice field, while in agroforestry land they developed chili and animal feed intensively to resolve limited land of farmer own.

| No | Village     | Agroforestry model needs to be developed | Role for livelihood | Role in watershed quality |
|----|-------------|----------------------------------------|--------------------|----------------------------|
| 1  | Cenrana Baru | Landscape agroforestry combination pattern | 1. Diversification of livelihood | 1. Diversification of livelihood |
| 2  | Limampoccoe | Periodic concomitant/intermittent taungya model | 2. Worker development | 2. Worker development |
| 3  | Batu Putih  | Co-incident protective tree with coffee and |
| 4  | Timpuseng   |                                        |                    | 3. to minimize the critical and to speed up recovery |
permanen permanent combination pepper, and gliricidia and white teak under candlenut stand

Landscape agroforestry model development in Batu Putih, Limampocoe and Cenrana Baru Village will improve watershed quality with the change of land cover that this time dominant with bush and dryland agriculture to become agroforestry land cover that the function similar to a natural forest [2], and it hopes can improve microclimate. The development of Gliricidia intermittent with candlenut and teak simultaneously can become the role as the increasing of depth root, increasing of base flow, increasing of infiltration and percolation and decreasing of soil sediment while the increase of number and plant species that cultivated can increase soil organic matter [6] and soil nutrient [8]. The role of agroforestry developed in Timpuseng Village to quality improvement of a watershed, primarily to reduce the risk of soil landslide [9] where the village dominant of paddy field and intensively dryland agriculture.

4. Conclusion
a. Landscape agroforestry model combination pattern temporary (Taungya), was agroforestry model that need to develop in dryland, with the ownership oh farmer land in Cenrana Baru, Limampocoe and Batu Putih Village. Those agroforestry model adaptive to drought and give diversification of livelihood in weekly, monthly and yearly and undisturbed by swine, monkey, and cattle.

b. In Timpuseng village that dominantly owned by narrow land farmer, agroforestry pattern need to be developed was permanently pattern intensive agroforestry (Talun), where the farmer developed three to four strata of plantation to resolve the limited land by planting Gliricidia and candlenut in the top of the strata, while in the second strata were coffee and pepper, and the lowest strata were big chili and elephant grass. Intensive permanent agroforestry with low labor input to resolve limited farmer-labor that dominantly has activity in the rice field.

c. Agroforestry model development in Minraleng Watershed can improve quality of watershed by changing land cover dominantly shrub and dryland agriculture to become agroforestry land cover will increase microclimate. The development of Gliricidia interplanting with candlenut and teak simultaneously can play a role in increasing root depth, increasing base flow, increasing infiltration and percolation, and decreasing soil sediment. By increasing, multi strata plant species and a number of cultivation will increase soil organic matter and soil nutrient.

References
[1] Hairiah, K dan Ashari, S 2013 Pertanian Masa Depan Agroforestry, Manfaat, dan Layanan Lingkungan Pros. Seminar Nasional Agroforestry 3 7-9
[2] Junaedi E, Siaruddin M, Indrajaya E, Widyanto A. Lusiana, B; Rosbetho M.J dan Santoso, B.H. 2015 Dampak Perubahan Penggunaan Lahan Agroforestry di Hutan Rakyat Terhadap Kondisi Hidrologi DAS Balangtieng, Bulukumba Sulawesi Selatan Research Gate Paper 8 89
[3] Junaedy E. 2013 Peranan Penerapan Agroforestry Terhadap Hasil Air Daerah Aliran Sungai (DAS) Cisadane Jurnal Penelitian Agroforesti 1 41-53
[4] Tata, L.H. Mulyoutami, E Martini E 2013 Analisis Kelayakan Finansial Beberapa Pola Agroforestry Di Daerah Tapanuli Sumatera Utara Proc. Seminar nasional Agroforesti 1-5
[5] Sardjono, A.M. Djogo T. Susilo H. Arifin dan Wijayanto W. 2003 Klasifikasi dan Pola Kombinasi Komponen Agroforestry Bahan Ajaran 2 World Agroforestry Centre (ICRAF) p 99
[6] Akinbisoye, O. S., 2Oke, S. O., 1Adebola, S. I. and 1Mokwenye, A. I 2014 Influence of Taungya Agroforestry System on Diversity of Native Woody Species and Soil Physico-Chemical Properties in Nigeria. International Journal of Scientific and Research Publications 4 2250-3153
[7] Pandit, H.B., Shrestha, K.K and Bhattarai, S.S 2014 Sustainable Local Livelihood Through Enhancing Agroforestry Systems in *Nepal Journal of Forest and Livelihood* **12** 1

[8] Khususiyah N., Rakayu S dan Suyanto, S. 2013 Agroforestry Sistem Penggunaan Lahan yang Mampu Meningkatkan Pendapatan Masyarakat dan Menjaga Keberlanjutan *Pros. Seminar Nasional Agroforestry* **5** 8-10

[9] Ashari, S. dan Hairiah K. 2013. Pertanian Masa Depan Agroforestry, Manfaat dan Layanan Lingkungan. *Pros. Seminar Nasional Agroforestry* **5** 45-50