

SUSTAINABLE AGRICULTURAL PLANNING IN ORDER TO SUPPORT FOOD SECURITY (FOOD ESTATE) IN THE TIMANG GAJAH SUB-WATERSHED, BENER MERIAH REGENCY

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Abstract

Good watershed management is the rational use of natural resources in the watershed to obtain maximum production in unlimited time, minimize the danger of damage (land degradation), and obtain an even water yield throughout the year. Timang Gajah sub-watershed with an area of 35,859.26 ha is one of the sub-watersheds of the Krueng Peusangan watershed. According to the results of research by Akbar et al. (2020), the Timang Gajah sub-watershed is included in the sub-watershed that needs to be restored. Judging from the critical land area, the Timang Gajah sub-watershed consists of very critical 2,398.47 ha, critical 23,989.87 ha, moderately critical 6,402.59 ha, potentially critical 3,063.97 ha and not essential 4.36 ha (BPDASHL, 2020). This shows that the Timang Gajah sub-watershed needs serious handling in its management. The purpose of this study is to develop a plan for sustainable use of agricultural land in the Timang Gajah sub-watershed that can reduce the rate of erosion ($erosion < ETol$) a decent income for each farmer ($income > KHL$). The cropping pattern planned in this study is a cropping pattern that supports food security (Food Estate). The research method that will be used in this research is a survey method which consists: 1) the preparation stage, 2) the preliminary survey stage, 3) the main survey stage and 4) the data analysis stage and the presentation of the results. The results showed that the predictive value of erosion obtained on mixed garden land use (SPL 2, 5, 12, 13 and 18) ranged from 18.70 - 103.81 tons/ha/year, while the ETol value ranged from 14.97 - 33.27 tons/ha/year. The predictive value of erosion on plantation land use (SPL 15) is 56.36 tons/ha/year, and the ETol value is 28.42 tons/ha/year. Meanwhile, the predicted erosion value for scrubland use (SPL 8, 9, 10, 11, 16 and 17) ranged from 23.81 - 73.67 tons/ha/year and ETol values 14.01 - 27.72 tons/year. Ha/year. The recommended intercropping pattern at the research location, especially in mixed garden land use, is potato and corn (A1) plus other businesses (livestock), potato and soybean (A2) intercropping, potato and peanut intercropping. Green (A3), intercropping of potato with chilli (A4) and monoculture potato plus other livestock business (A5) generate net income above decent living income for local farmers (Rp 66.400.000 / household/year).

Keywords: Planning, food security, watershed management

1. PRELIMINARY

1.1 Background

Land use in a watershed generally does not pay attention to the interrelationships of the elements that make up the watershed system, even though the condition of the environmental carrying capacity of a watershed is determined by many factors that have complex relationships and relationships and this is one of the causes of watershed damage in Indonesia. (Kartodihardjo et al. (2004). Good watershed management is the rational use of natural resources in the watershed to obtain maximum production in an unlimited time and minimize the danger of damage (land degradation), and obtain an even water yield throughout the year. Land management without

considering the ability and carrying capacity of the land will also cause damage to a watershed so that soil erosion, river sedimentation, river discharge fluctuations (floods in the rainy season and drought in the dry season) will decrease, and will reduce the productivity of a land.

Timang Gajah sub-watershed with an area of 35,859.26 ha is one of the sub-watersheds of the Krueng Peusangan watershed. According to the results of research by Akbar et al., (2020), the Timang Gajah sub-watershed is included in the sub-watershed that needs to be restored. Judging from the area of critical land, the Timang Gajah sub-watershed consists of very critical 2,398.47 ha, critical 23,989.87 ha, moderately critical 6,402.59 ha, potentially critical 3,063.97 ha and not critical 4.36 ha (BPDASHL, 2020) . This shows that the Timang Gajah sub-watershed needs serious handling in its management. Efforts that need to be made in the Timang Gajah sub-watershed are planning for sustainable agricultural farming. The sustainable indicators used in this study are reducing the rate of erosion (erosion < ETol), decent income for each farmer (income > KHL), the applied agrotechnology does not cause damage to land resources (erosion), and is acceptable and developed (replicable) by farmers with local knowledge and resources owned by farmers. The cropping pattern planned in this study is a cropping pattern that supports food security (Food Estate), this is in accordance with the national program that aims to improve the welfare of farmers and the community, especially in the Timang Gajah sub-watershed.

1.2 Research purposes

This study aims to develop a sustainable agricultural land use plan in the Timang Gajah sub-watershed that can reduce the rate of erosion (erosion < ETol), a decent income for each farmer (income > KHL). The cropping pattern planned in this study is a cropping pattern that supports food security (Food Estate).

2. RESEARCH METHODOLOGY

a. Place and time

This research was conducted in the Timang Gajah sub-watershed located in Bener Meriah district. The research location is 100 km from the city of Lhokseumawe (Figure 1). Research time in the field estimated to last for two months, followed by research in the laboratory.

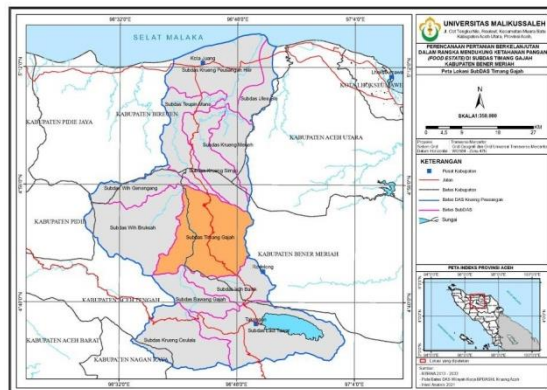


Image 1. Research Location (Timang Gajah sub-watershed)

b. Tools and materials

The tools used in this study consisted of a sample ring, Abney level, GPS (Global Positioning System), compass, ground drill, hoe, machete, shovel, writing instrument, map, a set of computers and ArcGIS 9.3 software. The materials needed in this research are chemicals used for soil analysis in the laboratory. Research methods The research method that will be used in this study is a survey method consisting of: 1) the preparation stage, 2) the preliminary survey stage, 3) the main survey stage and 4) the data analysis and presentation stage.

2.1 Data collection technique

Erosion Prediction. Erosion measurements were carried out on each land unit and type of farming using the Universal Soil Loss Equation (USLE) equation (Wischmeier and Smith 1978), namely $A = R K L S C P$.

This data is used to plan the type of sustainable farming and appropriate agrotechnology for each land unit in the Timang Gajah sub-watershed. Soil data were obtained from soil observations in the field and soil analysis in the laboratory representing each land unit. Soil samples taken consisted of intact soil samples for analysis of soil physical properties and incomplete soil samples for analysis of chemical properties (C-organic, pH, CEC and KB) and soil texture.

2.2 Data analysis

Data analysis includes analysis of biophysical data (physical and chemical properties of soil, land characteristics and climate). This data is for land evaluation analysis. While the analysis of decent living income, income and feasibility of each type of farming is used for socio-economic data analysis.

- **Analysis of Land Characteristics** .Land characteristics were analyzed descriptively including biophysical data and continued with an assessment of the land capability class. Land suitability class assessment is carried out on the basis of the classification framework issued by the USDA (1976), namely by assessing or comparing land quality in each land map unit with land capability criteria.
- **Agrotechnology analysis (soil conservation measures).**PeThe choice of agrotechnology is preceded by an inventory of existing agrotechnology in the Timang Gajah sub-watershed, then an agrotechnology analysis is carried out for each type of farming based on the predictive value of erosion. The selected agrotechnology was evaluated based on the comparison of erosion resulting from the application of several types of farming with ETol values. The selection of agrotechnology was based on simulation using the USLE model (Weischmeier and Smith 1978).

The criteria used to determine the maximum CP value that is used as an alternative to agrotechnology is the CP value that results in erosion that is less than or equal to tolerable erosion (ETol), namely:

A Etolor RKLSCP Etol

- **Analysis of Farming Type Characteristics.**Analysis of the characteristics of the type of farming includes the characteristics of farmers, the area of land cultivated, soil and water conservation techniques, the inputs used and the resulting production.
- **Farming Income Analysis.**PeFarming income is obtained by analyzing farming by using inputs in the form of: 1) farm income, 2) farming costs and 3) farm income.

Farming analysis using these three variables is known as cash flow analysis (Soekartaw, 2002).

3. RESULTS AND DISCUSSION

3.1 Land Map Unit

Land map unit (SPL) is a map obtained from the results of overlaying soil type maps, slope maps and land use maps. This land map unit map will make it easier to observe in the field, especially in the Timang Gajah sub-watershed. The map overlay results obtained 19 land map units (Table 1). Furthermore, the intensive observations in this study were on land map units 2, 5, 8, 9, 10, 11, 12, 13, 15, 16, 17 and 18.

Table 2 Land Map Units in Timang Gajah Sub-watershed, Bener Meriah Regency

SPL	Slope (%)	Type of soil	Land Cover	Area (ha)
1	16 – 25	Andisol	Protected forest	3.224
2	16 - 25	Andisol	Mixed garden	199

3	26 - 40	Andisol	Protected forest	1.149
4	> 40	Andisol	Protected forest	1,461
5	16 - 25	Inceptisol	Mixed garden	355
6	8 - 15	Inceptisol	Settlement	267
7	8 - 15	Andosol	Settlement	546
8	8 - 15	Ultisol	Shrubs	509
9	8 - 15	Inceptisol	Shrubs	1.425
10	8 - 15	Andisol	Shrubs	4.339
11	8 - 15	Entisol	Shrubs	1,246
12	8 - 15	Entisol	Mixed garden	868
13	8 - 15	Andisol	Mixed garden	1,849
14	< 8	Inceptisol	Ricefield	552
15	< 8	Inceptisol	Plantation	279
16	< 8	Inceptisol	Shrubs	2,355
17	< 8	Andisol	Shrubs	2.375
18	< 8	Inceptisol	Mixed garden	4.644
19	8 - 15	Ultisol	Water Body	163
Total				27.706

Source: Overlay Results and Field Observations, 2021

3.2 Land Use

The results of field observations and analysis of land use maps, land use in the Timang Gajah sub-watershed consists of rice fields, plantations, water bodies, settlements, protected forests, shrubs and mixed gardens of the seven land uses in the research location, only three land uses only intensive observations were carried out, namely the use of mixed garden land, plantations and shrubs, and of the three land uses the dominant land use in the research location was shrub.

3.3 Evaluation of Land Capability and Land Use

The land capability classification system used in this study is a classification system issued by the USDA, where the determination of land class is based on the assessment of the worst land class and the heaviest obstacle (Arsyad, 2010).

The results of the evaluation of land use at the research site (use of mixed gardens, shrubs and plantations) obtained land capability classes of class II, III, and IV with limiting factors in the form of slope (l), erosion sensitivity (KE) and erosion hazard level (e) .

Land capability class for mixed garden land use is found in class IV, land capability class for plantation land use is found in class IV and land capability class for shrub land use is found in class II, III and IV. For land that is included in class II (SPL 16), which is suitable for limited to intensive agricultural arable land. The inhibiting factor in this class is erosion, so the effort that needs to be done on class II land is to carry out a terraced farming system, especially in hilly areas. The contour farming system (Figure 2) is very appropriate to be applied to class II land, because contour farming is a planting system based on the contour lines of a soil so that the plant root system will be more solid and able to hold the soil when heavy rains occur.

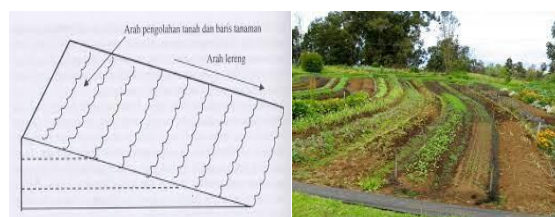


Figure 2. Cultivation of the Contour Farming

System Another effort that needs to be done in class II is to plant cover crops with the aim that soil particles in the area remain in place. The types of plants that are good for use as ground cover are easy to propagate, have a root system that does not cause heavy competition for staple crops, and have good soil binding properties (Hardjowigeno, 2010).

The selection of ground cover plants in addition to meeting the requirements, should also consider the economic benefits of plants. It is hoped that, apart from being useful in preserving the environment, local residents can also earn additional income from these plants. One example of a plant that meets these criteria is bamboo. Bamboo has a strong fibrous root structure that is able to withstand the rate of erosion. The growth of bamboo clumps is also very fast and environmental tolerance is very high, and has the ability to improve effective water catchment sources so it is very suitable for reforestation in open or deforested forests due to logging (illegal logging). Bamboo plants are also very good for use as protective plants on river cliffs or ravines (Figure 3)



Figure 3. Three types of bamboo are often used as ground cover plants. From left to right: Gigantochloa apus, Dendrocalamus asper, and Bambusa bambos

Land that is classified as class III (SPL 10) is suitable for limited to moderate agricultural arable land with slope and erosion limiting factors. Land use in class III can still be maintained for moderate agriculture. Conservation actions that need to be taken are by making terraces, planting in strips and alternating plants with cover crops so that later they can maintain the sustainability of land use to support the future life and welfare of farmers and their families.

Planting in strips (strip cropping) is a method of farming with one or several plants, where each type of plant is planted in alternating strips, on a plot of land and arranged according to contour lines or cutting the direction of the slope. Planting in strips has the aim of slowing the runoff rate, protecting the plant rows from the effects of runoff (Figure 4).



Figure 4. Planting Strip Cropping System

Plants that are generally used are food crops or annual crops interspersed with denser plant strips in the form of cover crops or green manure. In this system all tillage and planting work is carried out across the slope. For better results, it is recommended that this system be combined with crop rotation and the use of mulch.

Land that is classified as class IV (SPL 2, 5, 8, 9, 11, 12, 13, 17 and 18) has a limiting factor of hilly slopes (13), heavy erosion (e3) and very high soil sensitivity (KE₆). This class of land according to the criteria of land capability is more suitable for limited agricultural arable land, this is due to the high limiting factor.

In tropical countries such as Indonesia, the strength of raindrops and the ability of runoff to erode the soil surface are the main destroyers of soil aggregates. According to Hudson (1976), in

addition to soil properties, soil management/treatment factors also greatly affect the level of soil erodibility. Furthermore, Hardjowigeno (2010) also added that soil with a high dust content is the soil that is most easily eroded. For this reason, soil conservation measures that need to be carried out on the limiting factor of soil erodibility is the application of organic matter with the aim of maintaining the stability of soil aggregates. Soil erodibility will decrease linearly with the increase or addition of organic matter in the soil (Asdak, 2010).

3.4 Evaluation of Cropping Patterns and Agroecotechnology

The results of the field analysis of the application of cropping patterns in mixed gardens in the research location are generally irregular, where the planting of side plants is inserted between the main plants with irregular spacing. The actual cropping pattern for mixed gardens and plantations applied in the Timang Gajah sub-watershed can be seen in Table 2. This cropping pattern is a cropping pattern applied directly in the field by local farmers, this cropping pattern (mixed garden) can change by looking at market conditions and farmers' needs.

Table 2. Actual Cropping Patterns in Mixed Gardens and Plantations in Timang Gajah Sub-watershed

SPL	Cropping Pattern	KPT
Mixed Garden		
2, 5, 12, 13, 18	Annual crops and food crops	A
Plantation		
15	Annual plant	B
Shrubs		
8, 9, 10, 11, 16, 17	Saplings and tree stands	C

Note : KPT = Cropping Pattern Code; SPL = Land Map Unit

The selection of agrotechnology for each land map unit was obtained through simulation using the USLE model (Wischmeier and Smith 1978). The predictive value of erosion (A) is obtained from the values of the R, K, L and S factors measured in the field on each land map unit, while agrotechnology can be determined by simulating the value of the C factor (plant management) and the P factor value (conservation measures).

For the selection of agrotechnology, it must be preceded by an inventory of existing agrotechnology and other appropriate agrotechnology and can be applied by the community in the Timang Gajah sub-watershed location. The criteria used to determine the maximum CP value that will be used as an alternative to agrotechnology at the research location is the CP value that can suppress the erosion rate (A) or equal to the tolerable erosion value (ETol).

3.5 Erosion Evaluation and Erosion Tolerance

The erosion value in each land map unit (SPL) was analyzed using the USLE equation. The results of the analysis and field observations show that the parameter values in each land map unit indicate that the erosion value varies greatly. In order for production to be maintained and sustainable, the erosion value obtained in each land map unit must be less than the tolerable erosion value (ETol). On the other hand, if the erosion value obtained is greater than the ETol value, then land productivity will immediately decrease, so that high production cannot be maintained anymore. This later in addition to reducing land productivity will also have an impact on critical land (degraded land).

The results of the calculation of several parameters in calculating erosion for each research location (mixed gardens, shrubs and plantations) then obtained the erosion value in each land map unit (Table 3).

Table 3. Comparison of Predicted Results of Erosion and ETol on Various Land Uses and Actual Cropping Patterns in the Timang Gajah sub-watershed

SPL	Type Plant	KPT	A (ton/ha/thn)	ETol (ton/ha/thn)
Mixed Garden				
2, 5, 12, 13, 18	Annual crops and food crops	A	18,7 - 103,81	14,97 - 33,27
Shrubs				
8, 9, 10, 11, 16, 17	Saplings and tree stands	B	23,81 - 73,67	14,01 - 27,72
Plantation				
15	Annual plant	C	56,36	28,42

Table 3 shows that the calculated erosion prediction value (A) in the field is greater than the tolerable erosion value (ETol). For mixed garden land use (SPL 2, 5, 12, 13 and 18) the erosion values ranged from 18.70 to 103.81 tons/ha/year while the ETol values ranged from 14.97 to 33.27 tons/ha/year. Land use for plantations (SPL 15) obtained an erosion value of 56.36 tons/ha/year and an ETol value of 28.42 tons/ha/year. Meanwhile, for the use of scrub land (SPL 8, 9, 10, 11, 16 and 17) the erosion values ranged from 23.81 - 73.67 tons/ha/year and ETol values 14.01 - 27.72 tons/ha/year.

The predicted erosion value obtained is greater than the ETol value due to hilly and steep slopes. Steeper slopes can increase the velocity of runoff, so that with a strong velocity, the soil particles will be stronger. Another factor that results in the high predictive value of erosion is land use that is not accompanied by vegetative soil conservation techniques, such as crop rotation, use of cover crops, minimum tillage, use of mulch or a combination of these conservation techniques. For this reason, it is necessary to change cropping patterns and apply alternative agrotechnology to reduce the predictive value of erosion.

3.6 Analysis of Farming Costs and Income

The cost and income analysis of farming carried out in the Timang Gajah sub-watershed is a mixed garden cropping pattern. This analysis includes components of labor wages, procurement of seeds/seeds, equipment rental, procurement of fertilizers and pesticides. Meanwhile, the income component includes production, total revenue and income. This analysis aims to determine the results obtained from farming patterns and agrotechnology applied to farming in order to improve the standard of living of farmers in the Timang Gajah sub-watershed and be sustainable (sustainable).

The analysis of decent living for farmers in the Timang Gajah sub-watershed location is carried out for each family consisting of 5 people (father, mother and 3 children) can be fulfilled if they have a net income equivalent to Rp. 66.400.000 / household / year (320 kg). /person/year x 2.5 (multiplier index value) x 5 people x Rp 16,600 (current price of rice in the research location). housing, education, health, social activities and savings.

According to Sajogyo (1990), one of the indicators to assess the level of land productivity and the level of welfare for farmers in an area is based on farmers' income, where the higher the income for the farmer, the more prosperous the farmer's life will be. For this reason, cropping patterns that can increase farmers' income in the Timang Gajah sub-watershed will later be recommended as a sustainable cropping pattern.

The financial analysis carried out in the Timang Gajah sub-watershed is on the use of mixed garden land, namely for one year for each cropping pattern carried out by local farmers. The income obtained from the results of farming is gross income minus production costs (including wages for labor in the family), while gross income is all income from sales obtained from all sources in farming.

Based on the actual cropping pattern applied by local farmers, it is necessary to conduct a financial analysis to determine the income earned by farmers in one year. The results of the analysis of farmers' costs and income for cropping patterns on mixed garden land use can be seen in Table 4.

Table 4. Results of Cost and Income Analysis for Cropping Patterns on Mixed Garden Land Use in Timang Gajah Sub-watershed

SPL	KKL	KPT	Gross income (Rp/KK/Tahun)			Total expenses incurred (Rp/kk/ha/year)	Net Expense (Rp/kk/ha/year)
			Farming	livestock business	Other Business		
2	IV	A1	81.000.000	2.458.000	1.850.000	18.747.000	66.561.000
5	IV	A2	85.800.000	1.137.000	1.150.000	18.707.000	69.380.000
12	IV	A3	90.600.000	-	-	18.712.000	71.888.000
13	IV	A4	88.800.000	-	1.450.000	18.882.000	69.918.000
18	IV	A5	78.000.000	6.337.000	2.450.000	18.432.000	68.355.000

Information : SPL : Land Map Unit ; MPA: Land Capability Class; KPT : Cropping Pattern Code ; A1 : Potato + Corn ; A2: Potato + kc.soybean; A3 : Potato + kc.green A4 : Potato + chili ; A5 : Potato monoculture

Based on the results of the analysis of costs and income for various alternative cropping patterns in mixed gardens (Table 4), it can be seen that farmers' incomes increase when carried out by the application of several cropping patterns such as intercropping, intercropping or tupang insertion accompanied by the application of agro technology, namely the application of soil conservation techniques such as making mound terraces, planting according to contours and providing mulch. Meanwhile, additional efforts that need to be made to increase income are through livestock business (chicken and goat) and processing of agricultural products such as making banana chips, fried peanuts, fried bananas which later this additional business can support the success of the farming.

Table 4 also shows that from the intercropping pattern of potato and corn (A1) coupled with other businesses (livestock business) it generates a net income of Rp. net income of IDR 69,380,000 /ha/year, intercropping of potato with green bean (A3) resulted in net income of IDR 71,888,000/ha/year, intercropping of potato and chili (A4) resulted in net income of Rp 69,918,000/ha/yr and monoculture potato plants plus other livestock businesses (A5) generate a net income of Rp 68,355,000/ha/yr. Here it can be seen that the five recommended cropping patterns on mixed garden land use generate income above a decent living income for local farmers (Rp 66.400.000 / household / year).

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

1. The results of the calculation of erosion predictions obtained on mixed garden land use (SPL 2, 5, 12, 13 and 18) ranged from 18.70 - 103.81 tons/ha/year, while the ETol value ranged from 14.97 - 33.27 tons/ha/year. The predictive value of erosion on plantation land use (SPL 15) is 56.36 tons/ha/year and the ETol value is 28.42 tons/ha/year. Meanwhile, the predicted erosion value for scrub land use (SPL 8, 9, 10, 11, 16 and 17) ranged from 23.81 - 73.67 tons/ha/year and ETol values 14.01 - 27.72 tons/year. ha/year.
2. A decent living income (KHL) in the research location is Rp. 66.400.000/person/year (320 kg/person/year x 2.5 (multiplier index value) x 5 people x Rp. 16,600 (rice price).
3. Recommended intercropping patterns at the research location, especially in mixed garden land use: potato plants with corn (A1) plus other businesses (livestock business), potato crop intercropping with soybean plants (A2), potato crop intercropping with mung bean crop (A3), potato intercropping with chili (A4) and monoculture potato crop coupled with other

livestock business (A5) generate net income above decent living income for local farmers (Rp 66.400.000 / household / year) .

BIBLIOGRAPHY

- Akbar, H, Murti Laksono K, Sinukaban N, Arsyad S. 2015. Optimization of Cocoa-Based Farming Land for Sustainable Agricultural Development in the Krueng Seulimum Watershed, Aceh Province. *Journal of Humans and the Environment*, Vol 22 No 3: 357-364.
- Arsyad, S. 2010. *Soil and Water Conservation*. Bogor : IPB Press Library Series.
- Asdak, C. 2010. *Hydrology and Watershed Management*. Yogyakarta. Gadjah Mada University Press.
- [BPDASHL] Krueng Aceh Watershed Management Center and Protected Forest. 2020. Database and information. Aceh Province.
- Hudson, WW. 1976. *Soil Conservation*. BT. Batsford Limited. London
- Hardjowigeno, S. 2010. *Soil Science*. Jakarta : Academic Pressindo.
- Kartodihardjo H, Murti Laksono K and Sudadi U. 2004. *Watershed management institutions (concepts and introduction to policy analysis)*. Bogor : Faculty of Forestry IPB.
- Reijntjes C, Haverkort B and Water-Bayer A. 1999. *Agriculture of the Future. Introduction to Sustainable Agriculture With Low External Inputs*. Jakarta: Kanisius.
- Roose, J. 1986. Runoff and Erosion Before and After Clearing Depending on the Type of Crop in Western Africa. p. 317-330. In R. Lai, PA Sanchez, RW Cummings, JR (Ed.) *Land Clearing and Development in The Tropics*. AA, Balkema Rotterdam/Boston.
- Sajogyo and Sajogyo P. 1990. *Rural Sociology*. Volume 2. Yogyakarta : Gadjah Mada University Press.
- Sinukaban N, Pasaribu H, and Siagian O. 2001. Management of Lake Toba: opportunities and threats in soil and water conservation policies in supporting the implementation of regional autonomy. Inside: Proceedings of the IV Congress and the MKTI national seminar. Medan, 25 – 27 May 2000.
- Sinukaban N. 2007. Building Agriculture into a sustainable industry with conservation agriculture. In: *Soil and Water Conservation the key to sustainable development*. 1st Ed. Jakarta : Director General of RLPS Ministry of Forestry. Pages: 226 – 241.
- Sinukaban, N. 2004. *Watershed management*. Watershed Management Lecture Material. IPB Bogor.
- Soekartawi. 2002. *Farming Analysis*. University of Indonesia Press. Jakarta.
- Wischmeier WH and Smith. DD. 1978. Predicting Rainfall Erosion Losses. Guide to conservation planning. USDA. *agric. Eng* 29 : 458 – 462.
- Wood SR and Dent FJ 1983. A land evaluation computer system methodology. AGOF/INS/78/006. Manual 5 Version 1. Ministry of Agriculture Govern of Indonesia in corporation with UNDP and FAO

