The Sustainable of Environmental Carrying Capacity To Support on Food Security (Nagari Sulit Air, X Koto Diatas District, Solok, West Sumatra)

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Abstract. The existing problems such as the poverty and malnutrition showed that food security management in Nagari Sulit Air is not sustainable yet. The research objective is to analyze the food security status of households farmers and the carrying capacity of ecological environment related to food availability. The research design used to the quantitative approached with the survey method. The result shows that nutritional status of family heads are derived thin category 19.15%, 69.15% normal, and 11.70% fat. The children with ideal weight are 37.78% and 62.22% is not ideal. The behavior resilience of households with a determinant of income (Y), farmer (X_1), livestock (X_2), wages (X_3), consumption (X_4), and capital (X_5) based on the analysis of multiple regeresi model is Y = 7.868E-5 + 0.283 X_1 + X_2 0.367 + 0.417 X_3 - X_4 0.557 – 0.28 X5. The availability of water in 2013-2025 predicted is 68.119.599,7 m^3/year, while the demand of water in 2013 is 12.7072 million m^3/year and in 2025 is 16.172.267 m^3/year. The availability of land is 44.995,59 ha, the demand of land is 2.266,2 ha. The poverty and malnutrition become problems because of the other things such as the lack of education, health facilities, and inadequate infrastructure.
Keywords: Carrying capacity, sustainable agriculture, food security

1. Introduction

1.1 Background

The District of X Koto Diatas has various ecosystems and biological resources. The topography of area are dry land, bumpy and hilly with slopes > 40%. The altitude of region is 654-753 meters above sea level and just below it lays Lake Singkarak (1,129,29 Ha). According to the observation, the development of agriculture with single crop and intensive using chemical fertilizers and pesticides. The topography of region is also highly vulnerable that caused landslide and erosion.

The land slide and erosion have caused negative impact to the environment include water run off that carries silt deposit, potency of pesticide residue, and chemical fertilizer that flowing it in Lake Singkarak. This condition is potential to pollute water,which can lead to reduce the agricultural fertility and the siltation of lake. As a result, agricultural production and the catch of bili fish (local species), which is a potential for local fishermen, will be reduced. Material loss due to landslide disaster in Kecamatan X Koto Diatas is Rp 390.000.000/year [1].

The others impact of disaster and landslide are cause of poverty and malnutrition in Nagari Sulit Air. The Nagari Potential Statistics Report [2] states that the level of poverty in Solok District is also

increasing. The number of malnourished patients is 5 Nagari, the families that receive Askeskin amounted to 1.486, and 388 families have poor explanation cards. The level of poverty in Solok Regency [3] from 2009 to 2010 increased from 40.81 (thousand people) to 41.0 (thousand inhabitants). Determination of poverty prevalence level is using the indicator of poverty line. In 2009 Solok district poverty line was Rp 233,097/capita and then increased to Rp 262,010/capita. It was further reported that the number of poor families that were helped to alleviate school fees and medical expenses amounted to 48,229.

This fact shows that income and food sourced from natural capital have not been able to improve the welfare of local farmers. This condition indicates that the management of environmental capacity are not yet optimal and not sustainable, thus threatening the food security of farm households. Food self-sufficiency strategy based on the food availability paradigm proved unable to guarantee food access for all families or individuals that core of food security. Referring to the facts and conditions above, the solution of it make effort to implement the sustainable food security management based on the environmental of carrying capacity.

The management of food security based on the carrying capacity requires on comprehensive and integrate approached. This definition also includes as a system concept, including the parts that make up it and it is relationship. In addition [4] argued the management of natural capital can be sustainable if it will pay attention to the carrying capacity of land that is appropriate to commodities cultivated so that the land is not degraded.

1.2 Research Objectives

The main objective of study is to design a model of sustainability food security management based on environmental capacity in order to create a self-contained Nagari of food. While the specific objectives of research are; a) analysing the household food security status of farmers b) analysing the determinant factors of household resilience of farmers and c) to analyse the environmental of carrying capacity.

2. Materials and methods

2.1 Research design

The research designs are quantitative and qualitative approached. The collected qualitative data will be quantified before analysed. The method used to survey method. Table 1 presented the research method.

Table 1. Research method.

Objective	Type of Data	Analyze Method
To analyze the status of household food security of farmers	Farm households consumption	Ratio between the weight of household consumption value of farmers and the number of energy sufficiency.
To analyze the determinants of household food security factors	• Commodity Demand • Price • Farmers' income • Availability of food • Food distribution	The multiple linear of regression model
To analyze the ecological of carrying capacity • Land availability • Land demand • Water availability • Water demand	The potential of productive area is equivalent to rice. The necessities of living and other needs are equalized to rice and converted it into land demand and water requirements. Water availability is calculated using a more detailed water balance method.	The mathematical analyze Calculating based on regulation of Environmental Departement.

3. Results

3.1 Status of farmer's domestic resilience

The farmers on their activities act as managers. They should have managerial skills on the decision to make a process particularly on managing resources as input to obtain optimal results. The resource includes the information of farmers' relationship to their environment. The role can be realized if farming activities, farmers do not only play on a limited factor of production but farmers are involved and positioned as a farming asset. Farmers and their family members are human resources that need to be considered for quality to obtain the optimal productivity of farming. The quality of human resources in the farm household can be seen from the level education achieved by the head of family and also their wives as presented in table 2.

Table 2. The education level of head family and wives

Education	Head of Family %	Wives
Elementary school	37.23	54.26
Junior high school	19.15	14.90
Senior high school	38.30	24.47
Scholar	5.32	6.37
Total	100	100

On table 2 can be pointed out that opportunities to increase the formal education are limited. Most of education level of family head and their wives is elementary school with relatively big proportion amounted 37,23% and 54,25% respectively. Household resilience is defined as everyone at all times has physical and economic accessibility to receive adequate food needed in order to alive productively and healthy. The definition indicates that household food security has three components: availability, accessibility, and food utility. The household of food security is a composite variable. The measure used to assess the food security of farmers through the process and output indicators. The process indicators are describing by the food availability and accessibility while the output indicator is food utility. Table 3 shows the performance of farm households according to various food resilience variables based on components of availability, accessibility, and food utility.

The farm land is an initial capital on production so that the managing land becomes very important. 41% of peasant that have area of arable land 52.2% less than 0.5 ha in category smallholders. The remaining 47.8% are small farmers. According to BPS [1], smallholder farmers are the land users who control the land ≥ 0.5 ha. 21.8% of these smallholders controlled land ≥ 1ha.

Land owned by most farmers (58.7%) is self-owned while the rest is rented land. The pattern of land tenure illustrates that farmers have limited land. Limited land area is exacerbated by the fragmentation so that the land is controlled in the form of plots and scattered. Related education level, formal and non-formal education is one of the socialization media about an innovation. In addition through the formal institution, the socialization process also occurs through non-formal institutions especially the community and internal institutions (family). This socialization process ultimately forms the farmer's experience of farming.

Most of farmers (94.74%) never attended non-formal education in training and comparative studies. In addition, 36% and 26.59% experience levels are in the medium and low category. As many as 37.23% of farmers have experience in high category cultivation. The experience has not been optimal in implementing land, water and biodiversity conservation principles to improve crop yields. Water source is a major obstacle in the cultivation of food crops especially rice paddy.

Dominant farmers do cultivation during the rainy season, so that within a year of rice harvest obtained 1-2 times. Based on the research in the field it can be seen that 68.5% of farmers use rain

water, 26.1% irrigation water, 4.35% water ground, and only 1.04% using water pump technology. This condition indirectly affects agricultural productivity related to food access. The productivity of food crops that is usually cultivated is relatively low at 60,4%, is 9.57% and 29,79% high.

Table 3. The distribution of farmers by various variables on food security components

No.	Food Security Components	Category	Distribution (%)
1.	Type of work	1. Farmers	15,2
		2. Peasant	41,3
		3. Farmer owners	31,5
		4. Farmer owners, and non farmers	12
2.	Area of arable land	1. < 0,5 ha	52,2
		2. 0,51-0,99 ha	26
		3. > 1 ha	21,8
3.	Agricultural water source	1. Irigation	26,1
		2. Rain	68,5
		3. Water ground	4,35
		4. Water pump	1,09
4.	Non-formal education	1. Low	94,74
		2. Hight	4,26
5.	Experience of farming	1. Low	36,17
		2. Medium	26,59
		3. Hight	37,23
6.	Farm productivity	1. Low	60,64
		2. Medium	9,57
		3. Hight	29,79
7.	Nutritional status of the head of the family	1. Skiny	19,15
		2. Normal	69,15
		3. Fat	11,7
8.	Child nutrition status (> 12 years)	1. Ideal weight	37,78
		2. No Ideal weight	62,22

Food access is measured from sources and per capita income per month describing the ability of individuals to consume for both food and non-food items. The level of productivity will ultimately affect the use of food by farm households. The food utilization component will be seen from the healthy status of family members, especially the head of household (family) and children (<12years), which describes the nutritional status both in food consumption. In addition, the nutritional status of head family is reflected by the Body Mass Index (IMT).

The nutritional status of head family is a reflection of body's stature measured by the indicator ratio between weight and height. The ratio is good enough used to describe a person's physical ability. The physical capability of the household head is a measure impact of household food security conditions. The nutritional status of head family indicates the amount of energy reserves stored in the body. IMT will increase if a person has surplus energy, otherwise that will get lower if he has deficit energy.

The result shows about 19.5% of household head have IMT <18,5 (skinny) is classified as chronic energy deficiency. In this condition a person has low energy savings and weight is also low so that the person never grows normal. In addition there are 11.7% of household heads classified as more nutrient (fat) with a maximum value of IMT 27.2.

The value of IMT illustrates that the household head has the risk of a degenerative disease. Thus there are 38.9% of household heads whose nutritional status is not yet in accordance with nutritional norms. While 69,5% have IMT (18,5-25,0) with normal category. The value of IMT ≥18.5 is considered to have sufficient energy reserve so it is considered normal and there is an energy balance. Food accessibility is also evident from the nutritional status of children. Nutritional status will be reflected in the ratio of weight and age (BB/BU). The BB/BU index represents the current nutritional

status. Weight is a measure of body mass (muscle, fat). The body mass is very sensitive to sudden changes in conditions such as disease, decreased amount of food consumed or decreased appetite.

The research shows about 62.22% of children in the category of low nutrition and only 37.78% are classified as normal. Thus more children have macro nutritional problems that are less protein energy. This lack of protein energy is synonymous with less energy because no matter how high the quantity or quality of protein intake from food consumption, everything will be used by the body to shortage energy. Malnutrition disrupts growth, lowers body resistance, and decreases brain development potential and intelligence. In addition it causes 50% of deaths.

3.2. Determinant factors of food security

The results of statistical analysis with multiple linear regression analysis related to household resilience behavior with determinant factors of income (Y), farm yield (X_1), livestock (X_2), non farm and labor wage (X_3), consumption (X_4), and farming capital (X_5) with regression model as follows:

$$Y = 7.868E\text{-}5 + 0.283\ X1 + 0.367\ X2 + 0.417\ X3 - 0.557\ X4 - 0.28\ X5$$

The result shows that household resilience of productivity is significantly affected by farmers, livestock, and income from wages as labourers, consumption, and farming capital with R2 0.90. The value of R2 shows the coefficient of determination so that 90% of the household resilience condition of its productivity can be explained by the five variables. Meanwhile, ten percentages is explained by other causes that are not included in the model such as policy in agriculture, food, and nutritional knowledge.

Reviewed based on the value of beta (standard regression coefficient) household productivity is largely increased from the contribution of non-farm income and wages of farm labourers; followed by income from livestock, crop production. Conversely, productivity is reduced for consumption both food and non-food, then capital expended from farming. The largest consumption expenditure is the monthly cost of school children including transportation and pocket money. Furthermore, the annual costs of books, uniforms, and school fees. The cost of farming spent on saprotan such as seed, urea fertilizer, KCl, NPK, liquid fertilizer, and pesticide. Most of farmers use to chemical fertilizers and pesticide intensively so that decrease the soil fertility and the production of crops too.

3.3. The Environmental of Carrying Capacity

3.3.1. Analysis of Water Availability. The carrying capacity of water in Nagari Sulit Air calculates based on Government Regulation of State Minister of Environment Number 17 Year 2009 [5] regarding Guidance to Determine Environmental Capacity Support in Spatial Planning. To calculate the weighted coefficient of run off land include agricultural and non-agricultural presented in table 4.

Table 4. Calculation of runoff coefficient

Land use	Coefficient of runoff (Ci)	Area of land (ha) (Ai)	(Ci x Ai)
Primary forest	0.01	1075	10.75
Secondary forest	0.05	316	15.8
Pond	0.2	25	5
Settlement	0.9	3175	2857.5
Irrigated rice field	0.2	677	135.4
Open ground temporary	0.95	10.35	9.8325
		5278.35	3034.283
C = ZCi X Ai / ZAi			0.574854

Based on Table 7 the coefficient value for Nagari Sulit Air is 0.575. Calculation of Average Rainfall Analysis Water availability is done by taking into account the availability of water. The equation for the calculation of water availability as follows:

SA = 10 x C x R x A
C = Σ (Ci x Ai)/Σ Ai
R = Σ Ri/m

The mean annual algebraic rainfall is obtained based on annual rainfall ratio against the number of rainfall observation stations, as calculated based on the above equation, the result is:

R = 2245/1 = 2245 mm /year

Then obtained the value of water availability in Nagari Sulit Air with the equation:

SA = 10 * 0.574854 * 2245 * 5278.35 = 68.119.599.71 m^3/year

The calculation of population projection in Nagari Sulit Air per year with Least Square method is presented in table 5 as follows:

Table 5. Calculation of population projection

Tahun	X	Y	XY	X2
2013	1	7942	7942	1
2014	2	7554	15108	4
2015	3	7537	22611	9
	6	23033	45661	14

A = (23.033x14)-(6x45661)/(3x14)-(6)2 = 8082.67
B = (3 x 45661) - (6 x 23033)/(3 x 14)-(6)2 = 202.5

Thus, using the least square equation can be calculated projected population of Nagari Sulit Air in 2025, the equation is as follows:

Y = a + Bx
Y = 8082.67 + 202.5 (x)
= 8082.67 + 202.5 (2025-2015)
= 10107.67

Thus, by using the Least square method of population growth Nagari Sulit Air in 2025 is a number of 10107.67 people. The water requirement for proper life is obtained from the needs of water for domestic purposes and water needs is 1,600 m^3air/capita/year. So the water requirement in Nagari Sulit Air is based on the equation: DA = N x KHLA m^3/year = 7.942 x 1.600 = 12.707.200 m^3/year. So, the water requirement in 2015 is 12,707,200 m^3/year and the prediction of 2025 water requirement is 16,172,272 m^3/year. The food commodity water requirement can also be known by the equation, which refers to the virtual water requirement as presented in table 6.

Based on the calculation of the water demand for food commodities is 16,553,662 m^3/year and the projection for the next 10 years (2015-2025) is known to increase water demand. If the estimated availability of water is fixed and not increased by 68.119.599.71 m^3/year due to land use for the coming year (2015-2025) is unknown, so water availability in 2015 used to a reference work to predict in 2015-2025. If water availability is assumed to be fixed and does not increase then it can be seen the surplus water carrying capacity status (sufficient water demand) both in terms of domestic needs, food and other needs.

To ensure the availability of water in Nagari Sulit Air is sufficient for people, the local community must maintain the land function according to the conservation aspects and preventability of

degradation. Maintaining the conservation area as a natural reservoir to keep water demand, the environmental functions associated with the water system should be conserved due to considerate environmental sustainability. Availability of potential water resources should be good for planned utilization and conservation [6].

Table 6. The virtual of water requirement

Commodity	Virtual water requirement (m^3/ton)	Production (ton)		Water requirement m^3/year
Paddy	2150	2031		4366650
Corn	1285	5		6425
Coconut	2071	125		258875
coffee	17665	2.5		44162.5
Nut	2030	3		6090
Livestock		Quantity	Weight (kg)	
Cattle	14818	1958	400	11605458
Goat	4543	950	40	172634
Chicken	5549	8413	2	93367.47
Total needs of water				16.553.662

3.3.2. Analysis of Land Availability. The data required in the calculation of availability of land is the actual production of commodity (Pi) and the price of rice at the producer level, unit price of commodity at producer level (Hi), and rice productivity in Nagari Sulit Air (Pt). Total production value of commodity in Nagari Sulit Air is presented in table 7.

3.3.3. Analysis of Land Requirements. Land requirement is minimum requirement of life. Population pressure on land carrying capacity can be determined based on the comparative value of population and percentage of farmers with minimum land area for proper life [7]. To determine the adequacy of land supply can be done by comparing the amount of available land with the land needs. The: DL = N x KHL

The amount of land needed for proper life needs per population is a viable living requirement (KHLL) per population divided by the productivity of local rice. The need for proper life per population is assumed to be 1 ton equivalent of rice/capita/year. The local rice productivity of Nagari Sulit Air is an average of 3 tons/ha. From the calculation results can be seen the carrying capacity of Nagari land are:

KHLL = Proper life needs per resident/Productivity of local rice
= 1 ton of rice/capita/year/3000 kg/ha/year
= 0.33 ha/person

Then the value of bearing capacity (DL) of land is: DL = 7554 x 1/3 = 2,266.2 ha Land carrying capacity is obtained from comparison between land availability (SL) and land requirement (DL) (LH Regulation No. 17 Year 2009, [9]):

When SL> DL, the carrying capacity of the land is declared surplus.
When SL <DL, the carrying capacity of the land is declared deficit or exceeded.

Based on the results can be concluded the value of availability and demand of land as follows: The availability of land (SL) is 44995.59 ha. The land demand (DL) is 2,266.2 ha. Thus, the value of SL> DL and the carrying capacity of land is declared surplus or sufficient.

Table 7. Total production value of commodity in Nagari Sulit Air

Commodity	Area of harvest (ha) Pi	Price Hi
Paddy	677	58333330
Peanuts	3	140000000
Corn	2	43750000
Cloves	15	300000000
Coconut	25	3000000
Chili	3	150000000
Tomato	0.25	26900000
Cucumber	0.25	6024000
Vegetables	0.75	10050000
Coffee	5	4000000
Rambutan	20	22040000
Durian	8	16150000
Petai	7	98000000
Jengkol	2	27900000
Chocolate	20	34500000
Beans	0.25	4260000
Total (Pi x Hi) =		944.907.330

Land availability calculation (SL) based on the equation as follows:
SL = 944.907.330/7000*(1/3) = 44995.59 ha so, the availability of land (SA) in Nagari Sulit Air is 44995.59 ha.

4. Discussion

Gapoktan Jonjang Seribu Nagari Sulit Air [8] is an active farmers group and officially registered at the Agricultural Department of Solok Regency. Gapoktan has 201 members from 13 Jorong (village). Activity undertaken by Gapoktan is a regular meeting held every month. Dynamics in the group have not given the optimal effect to improve household food security status. Household food security status has not reached the optimum point because the productivity of households (farmers and non-farmers) is still low (0.64%).

The low productivity of households is not expected to be optimal in the transformation of knowledge and skills as well as assistance to implementation of sustainable farming. This is due to the minimum number of agricultural counseling, just 2 (two) people for each district, so that they are not yet adequate to service. Low household productivity will be affect on food availability in terms of both quantity and quality. The low productivity will be affect to income received. Based on the analysis, the average income of households is Rp 258,953 per capita per month. The income received by this household is still below the poverty line. The consequence will be decreasing the purchasing power of households, so that can be affect to household food security.

The average food and non-food consumption expenditure per month exceeds the income received per capita household per month (Rp 809,666 versus Rp 258,953). This condition can be affect to household food security because the food consumed not optimal for nutritional status of the

household. This is characterized by low household consumption of calories (<2000 cal per capita per month) when compared with normal caloric consumption according to the nutritional adequacy rate of 2100 cal per capita per month. In addition, household food consumption still below recommended nutritional status is also influenced by wife education. Most of the level of education of the wife is elementary level, so it can affect the presentation (both the quantity of food and the quality of food consumed).

Based on Global Nutrition Report Independent report, the nutritional condition of children is 17.8% under five is considered out of the way to reach the target of World Health Assembly 2025. The indication is the prevalence of 14% of cases of wasting in under-five children in Indonesia is the largest in ASEAN region. Furthermore, in the case of stunting, Indonesia is only better than Laos and Timor Leste. Prevelens Indonesia recorded 36%, while Laos 44%. The Minister of Health explained there are multifactor affect to malnutrition problem in Indonesia, including are economic and knowledge issues [9].

Household food security is related to the carrying capacity of the production aspect. According to the analysis results, the carrying capacities of land and water have not been exceeded but the access has not been adequate. Ecological constraints of land topography are generally hills and water sources are located lower than farmers' land, so it takes a lot of energy to reach it. The results of interviews from the Public Works Department related to water distribution facilities and infrastructure Nagari Sulit Air not optimal because the high cost of infrastructure drains (± 3 billion).

There is an obstruction in funding to develop agricultural infrastructure. In addition, the extent of critical land and degraded forest cause a decrease in water catchment potential. The calculation of environmental carrying capacity, Nagari Sulit Air has carrying capacity of land status that sufficient to fulfil the biological production for people who live in Nagari. The availability of land in Nagari Sulit Air is greater than the land demand. In order to the land carrying capacity remaining state of surplus, the community have to reforests on deforested soil.

The carrying capacity of land is stated as surplus for biological product according to As-syakur [10] influenced by several factors such as: (a) the level of diversity commodities in large agricultural sector, (b) most of the people work in agriculture, (C) agriculture is a sector with comparative and competitive advantages; (d) conversion of agricultural land to non-agricultural land is relatively small; (e) the area has fertility soils and the climate is suitable for agriculture.

The policy of protection agricultural productivity is directed to suppress the land conversion by applying incentive and disincentive policies, licensing mechanisms, and its extension. The low standard of living of the villagers is not related to the carrying capacity of the water and the carrying capacity of the land, since based on the calculation of water availability and water demand and the availability of land and land demand shows that the environmental of carrying capacity is sufficient for both domestic and domestic human needed. Low living standards can be caused by other things such as inadequate infrastructure (roads, healthy facilities and educational facilities), incomes still relatively low, inadequate housing, and less employment opportunities [11].

5. Conclusion

Status of farm household resilience can be seen from the nutritional status of head family with the skinny category 19.15%, normal 69.15%, and fat category 11.70% while the nutrition of children under five is illustrated from ideal weight 37.78% and not ideal 62,22%. The behavior of household resilience with determinants of income (Y), farm yield (X_1), livestock (X_2), labor wage (X_3), consumption (X_4), and capital (X_5) based on the results of multiple regression analysis can be modeled $Y = 7.868E\text{-}5 + 0.283\ X_1 + 0.367\ X_2 + 0.417\ X_3 - 0.557\ X_4 - 0.28\ X_5$. Referring to Environmental Regulation number 17 in 2009, for the availability of water in Nagari Sulit Air Sub-district in 2015-2025 for 68.119.599,71 m^3/ year while for water demand in 2015 was 12,707,200 m^3/year and In 2025 has increased to 16.172.267 m^3/year. This surplus water carrying capacity indicates the current availability of water and predicted for the next 10 years to meet water demand in terms of both domestic and food needs and others. Preferably the current condition is maintained in accordance with

the function of the land. Land availability is 44,995,59 ha, while the land requirement is 2,266,2 ha. The poverty and malnutrition are not related to environmental carrying capacity. Possible causes by other things such as: lack of education, healthy facilities, and inadequate infrastructure.

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