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Threat of ecology aspect towards people's cocoa plantations management sustainability at Aceh Timur Regency

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Abstract. Cocoa plantations at Aceh Timur regency face many problems in its management. Currently, there is not yet existing condition data of cocoa plantations so that it becomes obstacles in management to achieve cocoa plantations sustainability. This research is aim to identify key factors of ecology aspect impact towards plantations management sustainability of people's cocoa at Aceh Timur Regency. The method used in this study is to intergrate descriptive qualitative approach, quantitaf and analysis system *Rap-kakaoatim* approach constitutes modification of *Multidimensional Scalling* (MDS). MDS utilized to assess sustainability status indexes and key factors that give lack influence of sustainability in people's cocoa plantations management. The analysis result shows that status people's cocoa plantations management is lack of sustainability by ecology dimension and institutional, from the side of economy is adequate sustainability, and with socio cultural dimension is extremely sustainable. From ecology dimension, key factor that influence people's cocoa plantations sustainability are cocoa plantations rejuvenation, shade plantations and HPT attack. Those three factors are able to give positive effect towards cocoa plantations production if its condition inclines however on the contrary it can decline cocoa plantation production if its existence decreases. To intensify sustainability indexes of ecology aspect can be carried out by insentive distribution to the farmers of cocoa and Field School Program PHT (SLPHT) for controlling HPT.

1. Introduction

Cocoa (*Theobroma cacao*, L.), Constitutes plantations eksport commodity which has high level economy value and become earnings source for a part of community and foreign exchange producer to the nation so that it has important role for national economy matters. Cocoa wide areas in Indonesia in the year 2012 had achieved 1.774.463 ha, by production 740.513 ton and average plants productivity 850 kg/ha/year so that emplace Indonesia at the third position as world cocoa producer subsequent to Pantai Gading and Ghana. Then, in 2013 Indonesian cocoa production undergo degression became 720.862 ton produced by cocoa plantation areas far-reaching 1.740.612 ha in average plants productivity 0,82 ton/ha/year [1].

Cocoa plants become pedestal of farmer's household in Aceh Province, cause the nature of plants agronomy specifically bear fruit all of the year and cocoa denotes global trade commodity. Cocoa denotes one of plantations commodity that has a very significant role for economic matters, especially as field work provider, earnings source and foreign exchange production. Cocoa constitutes superior sector plantations that are found at Pidie Regency, Bireun, North Aceh, West Aceh and East Aceh [2].

The contribution of plantations sub-sector in Aceh Province, during period 2010-2015 towards national economic more and more increase and hope it can strengthen plantations establishment completely. Special commodity of rubber trees, oil palm, coffee, cocoa, nutmeg, pepper, patchouli, cloves and cane become mainstay of plants plantations because of community zest in developing

those communities tend incline, sub-sector contribution in plantations mainstay commodity undergo enhancement and economically its cost favorable the farmers compared to another commodity. From the 21th plantations commodity that flourish in Aceh Province there are 5 (five) main developed commodities namely; rubber tress, oil palm, coffee, cocoa, and coconut [3].

Cocoa plantations broad in Aceh Province at the year 2013 reached 102.034 ha with production in the amount of 34.795 ha. East Aceh Regency possesses cocoa plantations number two the widest in Aceh Province after South East Regency that own broad 19.994 ha. The wide of cocoa plantations in East Aceh Regency at the year 2013 reach 12.484 ha by the production in a mount of 6.684 ton/year. In views of productivities, East Aceh Regency possess the lowest cocoa productivities compared to regency and the other city in Aceh Province, in the amount of 0,19 ton/ha/year. This number is still too tiny if it is compared to average productivities of cocoa plantations in Indonesia. Commonly, on the average cocoa productivities in Indonesia in the amount of 0,9 ton/ha/year. This number is still away under the expected potential average, which is in the amount of 2 ton/ha/year. The low productivities of cocoa plantations at East Aceh Regency influenced by utilization the poor planting substance, cultivation technology is less optimal, age of plants which has not been productive and height of pest attack [4].

Low productivities of cocoa in Indonesia are generally caused by several factors. Those factors such as; pest effect and plants disease, lack of superior seed utilization which is recommended, poor garden maintenance activity, age of old plants (not productive) and fertilization that is not in accordance with recommendation. The availability of those factors indicate that unefficient exsistency of input production utilization used by cocoa farmers. This condition at last will impact income and welfare of cocoa farmers in Indonesia [5].

All this time cocoa plantations cultivation at East Aceh Regency generally carries out heteroculturally or hybrid garden. Plantations of cocoa cultivation for the most part people's plantation which is undertaken by local farmers in tiny scale and its management still traditionally. If the management does not change therefore it will threaten sustainability of people's cocoa plantations at East Aceh regency. As for the purpose of this research are to determine management sustainability status of people's cocoa plantations and to know ecology factors which threaten the sustainability of people's cocoa plantations at East Aceh Regency.

2. Materials and methods

2.1. Place and time of research

This research takes place at East Aceh Regency as one of the central of cocoa production Aceh Province. This study conducted during 6 months (initiated from April to October 2019).

2.2. Kind and source of data

Kind of data which is utilized consists of primery data and secondary data. Primery data obtained through survey method by deeply interviewing teqnique with guide of question list in the questioner. Modifier determination or attribute that give effect at every dimension in management system of people's cocoa plantations based on assestment from the selected expert/stakeholder by experience qualification, reputation, position, occupation, and credible appropriate with field of studied [6].

Secondary data obtained from the documents published by Agriculture Departement and Plantations of Aceh Province; and agency/related department at East Aceh Regency.

2.3. Analysis method

Sustainability status assessment of people's cocoa plantations management at East Aceh regency is implemented by using *Multi Dimensional Scalling* (MDS) tecnique. The tool utilized is *Rap-Kakaoatim* technique as modified approach from RAPFISH (*Rapid Apraisal for Fisheries*) program which is applied to evaluate sustainability status of catch fisheries. This method developed by Fisheries Center, University of British Columbia, Canada [7]. *Multi Dimensional Scalling* constitutes

statistic analysis technique that attempt to carry out multidimension transformation becomes simpler dimension [8].

Rap-Kakaoatim modification applied to dimentions and attributes in analysis appropriate with the research purpose. *MDS* utilized to assess sustainability status indexes and identify the most sensitive attributes from respective sustainability dimension (ecology, economy, social cultural and institutional) and identify attributes or the most sensitive factors from dimension aspect that give lack impact of sustainability in people's cocoa plantations management.

The analysis of people's cocoa plantations management at East Aceh Regency performed in several phases:

- 1) Determine the dimension which is going to be analyzed
- 2) Determine the attributes from every dimension
- 3) Score distribution on every attributes base on ordinal scale [9]. Expert assessment used for *scientific judgement* within appraises the attributes from each dimension.

Determine of sustainable indexes value and sustainable status base on the score estimation result every dimension. Sustainable Indexs category divided to four catagories, like displayed on table 1.

Table 1. Category sustainability status of people's cocoa plantations management at East Aceh Regency based on analysis indexs value of *Rap-Kakaoatim* [10].

Indexs Value (%)	Catagories
0,00 - 25,00	Bad (not sustainable)
25,01 – 50,00	Minus (less sustainable)
50,01 – 75,00	Enough (sufficient sustainable)
75,00 – 100,00	Good (sustainable)

4. Value Visualization of sustainable indexs every dimension in the form of *kite diagram*. This diagram displays sustainable indexs value every analyzed dimension.
- 5) Sensitivity Analysis to determine attributes or sensitive changer factors that give contribution or *leverage factor* towards sustainable of cocoa plantation management at East Aceh Regency. The influence of each attribute can be seen in changes "*root mean square*" (RMS) [8]. The larger RMS value the more sensitive of those attribute and contribute to impact sustainability performance of cocoa plantations management. RMS pattern as follows :

$$RMS = \sqrt{\frac{\sum_{i=1}^n \{Vf(i,1) - Vf(.1)\}^2}{n}} \quad (1)$$

where:

$Vf(i,1)$: MDS ouput value (after *rotation* and *flipping*)

$Vf(.1)$: MDS output median at *column-1*.

- 6) Monte Carlo analysis to take into account uncertainty dimension and evaluate error effect by assessing ordination. The mistakes is able to be raised by the error in score manufacture because of imperfect comprehension from attribute or field condition of score variation consequence of different opinion or researcher assessment, analysis process of repeated MDS, error in data entry or there disappear data, iteration stability, and the height of stress value (stress value can be accepted if its value < 25%) [8]. *Goodness of fit* at MDS reflected from amount of S-stres value which calculated based on S and R^2 value. The lower stress value indicates conformity condition and the high S value indicate conversely matter. Through *Rap-Kakaoatim* approach, a good model can be showed from smaller stress value or less than 0,25 or $S < 0,25$ and total value of Good R^2 approaches 1,0 [10].

For supporting related information of attribute which become changes lever factor of people's cocoa plantations management, carried out through descriptive analysis from every intended factor based on available secondary data.

3. Result and discussion

3.1. Sustainability status of people's cocoa plantations management

The result of indexes *Rap-kakaoatim* analysis indicate based on every dimension that sustainability indexes value of people's cocoa plantations management at East Aceh Regency looked from ecology dimension aspect (31,52%) and institutional dimension aspect (44,89%), its sustainability indexes value is less sustainable. As for from economy dimension aspect (69,74%) and from social cultural aspect (75,46%), its sustainability indexes value is is adequate and extremely sustainable. Kites diagram of sustainable indexes of people's cocoa plantations management at East Aceh regency displayed on figure 1.

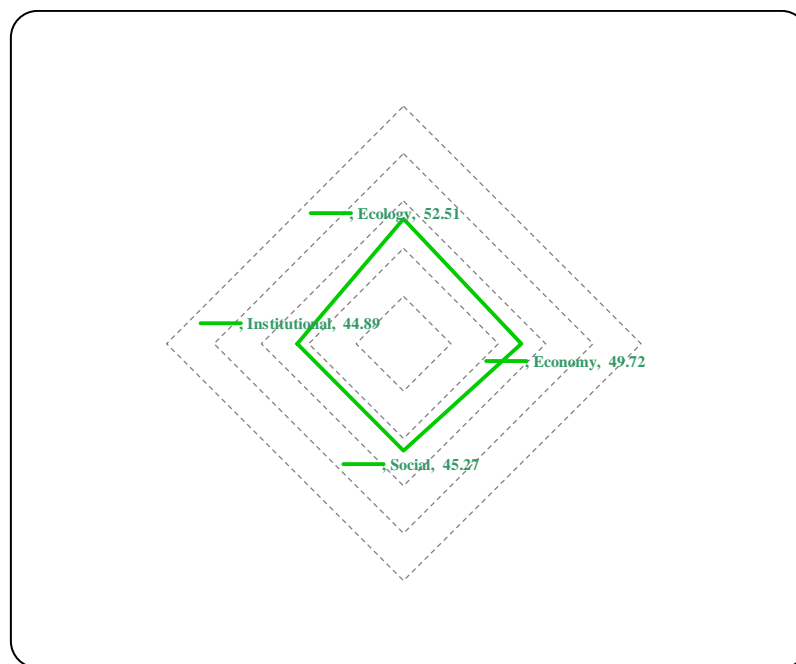


Figure 1. Kites diagram of sustainable indexes of people's cocoa plantations management at East Aceh regency.

Sustainability status of people's cocoa plantations with multidimensional manner carried out by combining appraisal towards all existence attribute from the entire dimension. This appraisal intended to view the effect of the whole attributes and factors which give sensitive influence towards people's cocoa management.

The result of sustainability indexes calibration of people's cocoa plantations management in multidimension is 46.75%. The value indicates that people's cocoa plantations management at East Aceh Regency in multidimension is in less sustainable status. This condition describes admonition towards the situation of people's cocoa plantation management at East Aceh Regency. If there is no effort to manage the key factors which influence condition changes of people's cocoa plantations management as effort to increase its sustainability status, alarmed in the future time condition of people's cocoa plantations will decrease and it can reflex towards lack of cocoa production in Aceh Province.

Validity calibration by comparing the result of Monte Carlo analysis and MDS analysis of credibility degree 95% indicate there is deviation between both of those analyses (table 2). Different deviation of four dimensions is about less than 1%. This condition indicates that MDS analysis which is produced adequate to guess the sustainability indexes value of people's cocoa plantations management at East Aceh regency. This value difference indicates that error in analysis process can

be minimized or avoided. The error that caused score giving on each attributes, variation in score giving which is have the quality of multidimension because difference opinion relatively small, repeated process in data analysis relatively stable, and mistake in doing data input and the missing data can be avoided. Difference value of sustainable indexes between MDS result and Monte Carlo presented on table 2.

Table 2. Indexs value difference of people's cocoa plantations management sustainability at East Aceh Regency in *Rap-kakaoatim* analysis and Monte Carlo analysis.

Sustainable Dimension	Sustainable Indexs Value (%)		
	MDS	Monte Carlo	Difference
Ecology	31,52	32,61	-0,09
Economy	69,74	69,77	-0,03
Social Cultural	75,46	75,98	-0,52
Institutional	44,89	45,08	-0,19
Dimension Combination	46,75	47,09	-0,34

From *Rap-kakaoatim* analysis result obtained coefficient determination (R^2) at about 0,94-0,95 larger than 0,80 or near 1.00. This case signifies of good and suffice sustainable indexes estimation model [6]. Stress value in *Rap-kakaoatim* analysis at about 0,13-0,14 or smaller than 0,25 so that MDS analysis model which is obtained has a high level accuracy to appraise sustainability indexes of people's cocoa plantations management at East Aceh Regency. Stress value and coefficient determination of hasil analisis *Rap-kakaoatim* analysis result can be seen on table 3.

Table 3. Stress value and coefficient determination of *Rap-kakaoatim* analysis result.

Parameter	Sustainable Dimension			
	Ecology	Economy	Social	Institutional
Stress	0,13	0,13	0,13	0,14
R^2	0,93	0,94	0,95	0,94
Iteration	3,00	3,00	3,00	3,00

3.2. Ecology factors which threat people's cocoa plantations sustainability

The sustainability of ecology dimension constitutes depiction sustainable level of people's cocoa plantations management related to ecology aspect. Sustainable analysis indexes towards ecology dimension in the amount of 31.52% on scale 0-100% explain that based on sustainability critarian, this indexes is there at category of less sustainable. This case shows that the existence ecology attributes in ecology dimension lack of support to maintain the sustainability of people's cocoa plantations management at East Aceh Regency. Ordination graph of ecology dimension sustainability is presented at figure 2.

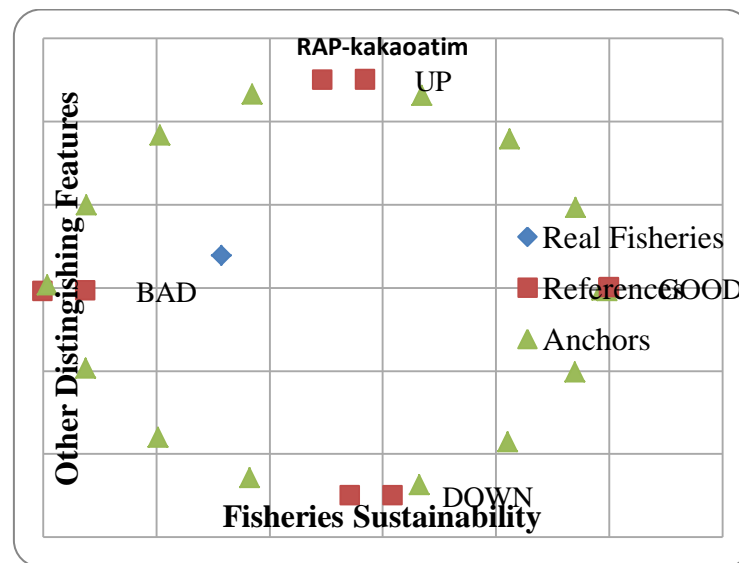


Figure 2. Ordination graph of ecology dimension sustainability.

Ecology dimension factor that consist of shade plants, natural enemy, exploration of biological agency, *hara* status, clone of plants disease pest (HPT) resistant, vegetative substance, rejuvenation of cocoa plants and HPT attack all of them less supporting towards the sustainability of people's cocoa plantations management at East Aceh regency. This case has a negative value which can cause the changes of ecology attributes to the degradation direction such as *hara* status and HPT attack necessary to be avoided and prevented so that the sustainability of people's cocoa plantations management from ecology dimension can be guarded. While shade plants attribute, exploration of biological agency, clone of HPT resistance, vegetative substance and rejuvenation of cocoa plants necessary to be fixed and intensified in the case of people's cocoa plantations management sustainability at East Aceh Regency.

From the sustainability value can be elaborated that people's cocoa plantations management if it is still implemented by the pattern and the same condition as at the present, then it will experience damage and not sustainable if not performed farther intervention that disturb the ecology quality such as present condition. Therefore ecology attributes that give the negative effect towards sustainability indexes value at ecology dimension necessary managed and upgraded in order to encourage increasing indexes value of ecology dimension sustainability.

Based on *leverage* analysis which stated in the form of *root mean square* value, from the eighth attributes that appraised in this research indicated there are three attributes become lever factor caused its changes sensitive effect towards indexes value of ecology dimension sustainability. The third attributes are rejuvenation of cocoa plants, shade plants and HPT attack. This case indicates that those third attributes constitute determination factor of ecology aspect of people's cocoa plantations management to achieve sustainable plantations. The result of *leverage* analysis from ecology dimension is presented on figure 3.

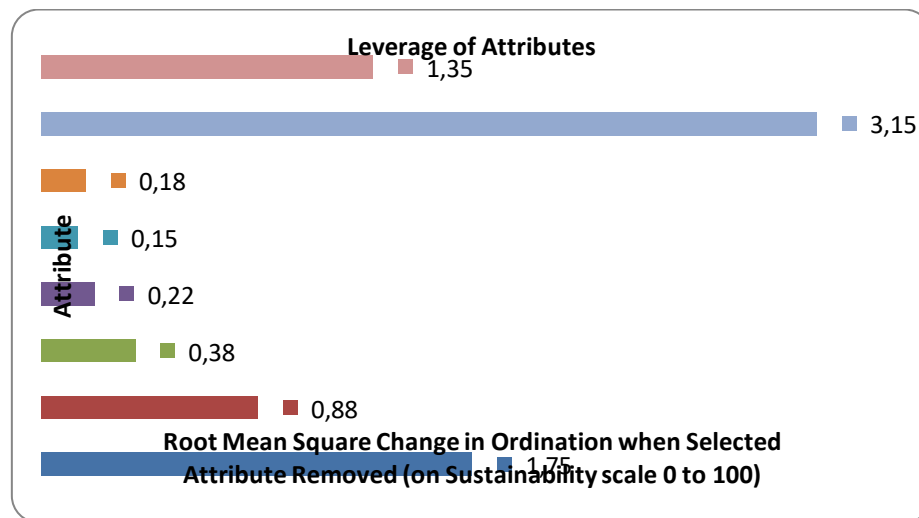


Figure 3. The result of *leverage* analysis from ecology dimension.

The changes of these third factors will easily impact escalation or reduction of sustainable indexes value in ecology dimension. Shade plantations Management encompass plantations and shade maintenance. From the result of observation in the field at the entire of people's cocoa plantations exist at East Aceh Regency largely do not perform plantations of shade plants at their garden. Even so found partly of those cocoa's garden had not been maintained anymore so that it switch over the forests. Reluctance of cocoa's garden owner to plants shade plantations because they assume that shade plantations can influence towards cocoa growth due to occurring competitions of nutrient element absorption. Besides that by the existence of shade plants will limit cocoa plantations area at their garden. Then according to the cocoa farmers without shade produce bigger cocoa at the first year to the third year enter harvest time. In the next year cocoa plantations need hara in large number and very easy attacked by Plant Pest (OPT).

The existence of shade plantations mainly at plantations which do not produce yet have the important role to create optimal micro climate needed by cocoa plantations and become living place and source of food for natural enemy. Because shade plants related to micro climate condition, existence of natural enemy, avoid nutrient washing and prevent of erosion occurring [11].

Shade plants manure is also become source of organic nutrient for cocoa plants. To prevent erosion, generally shade plantations have a deep root so that able to protect soil from damage caused by rain water. As for base on economy side, the existence of shade plants can add farmer's extra income. Kind of shade plants can be planted at people's cocoa garden at East Aceh Regency consist of two kinds, namely temporary shade plants (banana) and permanent shade plants (areca nut and coconut).

Cocoa plants at east Aceh Regency had been initiated to be planted since the year 1991, cocoa plants central at the time was located at Idi Rayeuk Sub District, then the location of its plants spread over another sub district territorial at East Aceh Regency. Since the plants was carried out at the year 1991 until now seldom implemented rejuvenation of cocoa plants by the farmers of cocoa. Average age of cocoa's plants that lie at people's cocoa garden of East Aceh Regency is >25 years (over the top limit of production). The farmer's reason do not do rejuvenation of cocoa plants because it needs a large cost and they do not want to loose their earnings source during cocoa trees do not produce yet and have no excellent cocoa's clone.

Cocoa plants begin to produce at the age of 4 years after planting. Fruit cocoa's production at the first year tends to little and it keeps increasing concomitant with age accretion. The optimal productivity achieved at the age 8-10 years. Cocoa's plants productivity start to decrease after the age 15-20 years, where its productivity only remains half of the potential of its productivity [12]. To solve the case is needed rejuvenation of cocoa plants.

Rejuvenation of cocoa plants intends to substitute cocoa plants which have passed productive age with new high productive plants, high quality and economically much more advantages than the previous plants. Towards old cocoa plants or damage is able to be executed to replant or rehabilitation. To replant cocoa plants require the cost about 7.000.000 IDR/ha at the first year. As for if the rehabilitation carried out by side connect and insert seed to replace the inanimate plants need cost at about 9.000.000 IDR/ha [13].

The total number of cocoa plantation wide area in Aceh Province is 46.427 ha by production in the amount of 40.664 ton/year. Cocoa production in Aceh Province is in average 300-400 kg/ha. This number is too far if compared to cocoa production in Sulawesi that reaches 700 kg/ha/year [14]. One of the low productions of people's cocoa at East Aceh Regency caused by clone usage which is not superior and not resistant of HPT attack so that productivity and cocoa quality produced is less. Due to HPT attack, wide range areas 6.858,8 ha of cocoa plantations in Aceh Province undergo severely damage and as broad as 7.719,6 ha undergo slight damage [3].

Kind of main plantations disease pest which attack cocoa plants at East Aceh Regency is *Phytophthora palmivora* and *Conopomorpha cramerella*, Snellen (Lepidoptera: Gracillariidae) eminent as CPB (Cocoa Pod Borer). *Phytophthora palmivora* cause decay disease and cocoa stem cancer. At Peunaron East Aceh Regency, this disease attack cause production lost of cocoa plants at about 40-65% [14]. Based on the result of field observation, CPB pest has largely power damage at young cocoa fruit, so that reduce production and quality cocoa nut of people's plantations at East Aceh Regency.

P. palmivora constitute main species that attack the entire phase of cocoa fruit development so that cause fruit decay and withered *cherelle* [15]. The occurring of high fruit decay found at the phase of extremely tiny fruit (*cherelle*) by occurring 38,7% and tiny fruit (*cherelle wilt*) by the occurring 18,8% [16]. Fruit decay disease can cause loss of cocoa plantations production reach 90% [17].

Due to this CPB pest attack has caused the low of cocoa production and farmers' income. State that one of the low cocoa production cause in Ghana is CPB pest attack [18]. Proclaims that CPB pest can reduce cocoa production reach 80%. In Papua New Guinea, CPB is the biggest threat towards society's economy [19]. CPB cause great difficulty to the farmers whom impact towards decrease of income so that influence the low capability to fulfill educational necessity, health and defend life quality generally [20]. Due to CPB attack can reduce production up to 80% and nut damage reach 82%, so that it is afraid of the farmers and cocoa plantations entrepreneur [21].

3.3. Effort to escalate sustainability of people's cocoa plantation from ecology aspect

The loss of result which is caused by HPT attack on people's cocoa plantation East Aceh Regency cause decrease of its production and cocoa plantation productivity. From the year 2015 to 2017, in average every year as broad as 1.290 ha of cocoa plantation experience damage at East Aceh Regency. This plantation damage impact towards lessening of cocoa plantation production. At the year 2015, with broad area plantation is 12.745 ha production of cocoa plantation as large as 6.806 ton/year. At the year 2017, with wide area plantation is 12.757 ha production reduce become in amount of 6.793 ton/year [22].

CPB pest attack is able to cause cocoa fruit production reduction to > 80% and relatively difficult to be controlled [23]. In Papua New Guinea, CPB attack cause the damage of cocoa plantation and economic reduction of cocoa farmers in the short time [20]. The failure of Papua New Guinea government in eradicating CPB since the year 2006, has caused reduction of cocoa production in a amount of 6%/year [24].

The low of PHT knowledge owned by cocoa farmer impact towards broad lessening of cocoa plantation and threat the sustainability of people's cocoa plantation at East Aceh Regency. Control OPT attack of cocoa plants is in order to not impact towards productivity decline and farmers income; there have been many offered concept [25]. One of them through sustainability plantation application intends to carry out plants protection by Integrated Pest Control (PHT) system. The advantage of PHT

system can reduce cost production in a mount of 11% from previous practice, besides that it also can escalate result significantly and more advantages than pest control practice nowadays practiced by farmers [26].

That farmers in Colombia who do not apply cocoa cultivation practice appropriately largely have the low income and basic necessity such as health, education and public service is not fulfilled. Inappropriate cocoa cultivation also cause natural degradation so that cocoa plantation which made effort by farmers lead to no continuous [27].

Insentive distribution to cocoa farmers and Field School Program of PHT (SLPHT) to control the Pest of Plants Disease (HPT) constitute correct way which can be done to increase production and productivity of cocoa plantations. Insentive distribution intends to give assistance in the form of money and goods which can be utilized by cocoa farmers to carry out HPT control at cocoa plantation that they own. The availability of this insentiveis hoped the growth of willingness from farmers to carry out management of cocoa garden which look at sustainability aspect so that production and its cocoa productivity incline and enviroentment condition is also well guarded. According to [28] the demand inclines to cocoa plantation that sustainability and certify then needed more attention availability from all of elements towards cocoa farmers. One of the attentions which can be given is by insentive distribution to farmers in effort to achieve cocoa plantation that sustainability.

Effort to control HPT attact at cocoa plantation at East Aceh Regency has been implemented Field School Program of PHT (SLPHT) in every sub district through Plantations Department of East Aceh Regency/Aceh Province and Keumang Non-Governmental Organization. This program constitutes one of application method of Intergrated Pest Control which can be selected to increase knowledge and farmers capabilities in comprehending Plant Pest (OPT) of cocoa. The purpose of this SLPHT cocoa activity is in order to SL-PHT participant and farmer's instructor can introduce PHT to broader society, so that cocoa SL-PHT which at initial only has local quality will continually develop. The activity of this cocoa SL-PHT gives opportunity to community or farmer group to develop knowledge and their expertise through training process at the ditermined place by cocoa SL-PHT participant. The participant of cocoa SL-PHT group learns to analize agroecosystem at the area and also make planning to collaborate in solving pest attact and cocoa plants desease.

4. Conclusions

The appraisal result towards sustainability analysis of four dimensions (ecology, economy, social cultural, and institutional) indicate that ecology dimension aspect and institutional constitute dimension which is less sustainable in supporting the sustainability of people's cocoa management at East Aceh Regency. There are three factors that threat sustainability of people's cocoa management at East Aceh Regency from ecology aspect, namely: rejuvenation of cocoa plants, shade plants and HPT attact. The third of those factors can give positive effect towards cocoa plantations production if its condition incline, however, on the contrary can decline production of cocoa plantation if its existence decline. To intensify sustainability indexes of ecology aspect can be done by insentive distribution to the cocoa farmers and Field School Program PHT (SLPHT) to control HPT.

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