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Model of sustainable development of smallholders in Riau Province

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ABSTRACT

Natural rubber has countless significant roles in human life. Rubber plants have the ability to maintain natural functions (they serve as carbon producers, conservationists of land and water, and habitats for wildlife) and they also produce many added values in terms of social and economy for rubber farmers or smallholders as well as become sources of their living and income. The price of natural rubber in the international market has significantly dropped in the last one decade; leaving many rubber farmers or smallholders to live in poverty. Many programs to elevate the prosperity of rubber farmers or smallholders have been created and applied by the government of Indonesia but none of the programs has been deemed successful according to the analysis results of Multi-Dimensional Scaling (MDS), the sustainable ecological index (52.95%), technological sustainability (62.35%), economical sustainability (60.18%), social sustainability (53.62%), and institutional sustainability (20.73%). The institutional management of rubber farmers is highly expected to increase the development of rubber farmers so that each and every one of them may have high competitiveness which in turn will sustainably improve their prosperity in the future.

Key words *: Sustainable development, Rubber, Farmers.*

Introduction

Many programs with various strategies and schemes aimed to improve the quality of life and prosperity of rubber farmers have been applied, and one widely known scheme is the core estate and smallholder (Perkebunan Inti Rakyat or PIR), which has been in effect since 1977. This scheme in its development has been applied in the transmigration areas known as Trans Core Estate and Smallholders (Indonesian: PIR Tran), and solely related to new land clearings, meanwhile another scheme or strategy known as the available plantation land rejuvenation is known as PPKR (Indonesian: Peremajaan Kebun Karet Rakyat) or rubber plantation revitalization. The Plantation Revitalization Program is the Indonesian government's effort to accelerate the development of smallholders' rubber plantations through expansion, rejuvenation, and rehabilitation of plantation plants supported by banking credit investment and interest subsidy given by the government by involving corporations in plantation business sector as partners in the plantation development, processing, and marketing (Damanik, 2012). Additionally, a new scheme called UPPB or Lump Processing and Marketing Unit was devel-

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oped to create a number of good smallholders and increase the number of qualified smallholders and rubber quality. This scheme is a business entity or a business unit formed by two or more groups of smallholders as the training venue of farming, processing, and temporary storing techniques, and smallholder's lump marketing. Despite all these efforts, the prosperity of the rubber farmers has not significantly improved (Liu *et al*., 2006; Husinsyah, 2006; Goswami and Challa, 2007; Septianita, 2009). A concrete solution to improve the smallholders' prosperity must be found to create rubber business sustainability.

Based on the problem background stated above, an integrative and collaborative approach of ecological, technological, economic, social and institutional factor must be created toward plantation ecosystem of smallholders' plantation in Riau Province. The problems that have to be solved through this research are as follows: a) What are the ecological, technological, economic, social and institutional characteristics of smallholders' rubber plantation sustainability in Riau Province?, b) What are significant attributes of the ecological, technological, economic, social and institutional dimension that become the factors of sustainable development arousal of smallholders in Riau Province?.

The results of this research are hoped to bring about a model and strategy for empowering smallholders in order to accelerate the sustainable economic development of in villages in Riau.The research findings are going to be beneficial to all agricultural entrepreneurs as well as the government as decision makers in regards to the business of plantation development. It is highly expected that there is progress and improvement which increase the smallholders' income to improve their prosperity.

Materials and Methods

Research location

This research was conducted in Riau Province by taking several districts as the location of the study sample. Considerations used in determine the district as the research sample is the area of rubber plantations, the amount rubber farmer households and the level of productivity of rubber plantations as well as existing rubber farmers group. Based on these considerations, three are determined districts namely; Kuantan Singingi, Kampar and Pelalawan.

Research design

This research uses a combination of quantitative and qualitative research which is done by utilizing the survey method with questionnaire instrument and structured interview guidelines. The research location is purposively determined based on the total sizes of the plantation areas and number of smallholder households. With that in mind, three districts (Kuantan Singingi, Kampar, and Pelalawan Districts) are set up as the locations for this research. Data required is primary and secondary data. The secondary data is collected from related institutions as well as private parties and rubber associations. Meanwhile the primary data is obtained by conducting interviews with the experts and distributing questionnaires to the rubber farmer households. To ascertain the sustainability level of smallholder plantations, an analysis of Multi-Dimensional Scaling (MDS) was done with the help of Rapfish software, Pitcher (1999); Liling *et al*. (2016) and Tesfamichael and Pitcher (2006).

Data analysis

Data analysis method is a technique or method of processing data into information that can provide result for problems being studied. Data analysis is a method or way to process a data into information so that the characteristic of the data easily understand and also useful for finding solution, which are mainly problem concerning a study. Furthermore it is stated that the purpose of data analysis is to describe a data so that it can be understood, and also to draw conclusion or draw conclusion about the characteristics of the population based on data obtained from the sample, which is usually made on the estimation basis and hypotheses testing. The data analysis method developed in this study is a quantitative analysis approach with data analysis techniques including; MDS (Multidimensional Scaling) analysis with Rapfish (modification) software helps. Furthermore, the analytical method used is called Rap-Rubber (Rapid Appraisal for Rubber).

Rap-Rubber is a modification of MDS-Rapfish. MDS-Rapfish developed by Pitcher (1999). This approach is based on the Multi Criteria Analysis (MCA) principle by relying on an algorithm called MDS algorithm. Multidimensional Scaling (MDS) is a statistical analysis technique that carries out multidimensional transformation. Modifications made

in Rap-Rubber include; management dimensions studied, attributes of each dimension and assessment or scoring given to attribute. This method is chosen considering that it can provide more stable results.

In The MDS method, there are two points or the same object mapped in a point adjacent to each other. Conversely, objects or points that are not the same are depicted with far apart points. The coordinator of distance determination technique in MDS is based on Euclidian Distance in dimensionless space. The closeness between object is obtained by the Euclid distance formula (Euclidean Distance).

$$d_{ij} = \sqrt{\sum_{k=1}^{p} \left(x_{ik} - x_{jk}\right)^2}$$

Explanation:

dij = Euclidean Distance or distance between object I to j

p = number of dimensions

xik = the value from the i row and the k column

xjk = the value from the j row and the k column

The technique used in regressing the equation above is ASCAL Algorithm (Alder *et al.* 2000; Fauzi & Anna 2005). The ALSCAL method optimized the square distance (square distance=dijk) against square data (origin=Oijk), on the three dimension (i, j, k) written in a formula called S-Stress as follows:

$$s = \sqrt{\frac{1}{m} \sum_{k-1}^{m} \frac{\sum_i \sum_j (d^2ijk - O^2ijk)\text{^}2}{\sum_i \sum_j O^4\, ijk}}$$

The square distance is the Euclidian distance weighted, or written follow;

$$d^2ijk = \sum_{a-1}^{r} w_{ka}\left(X_{ia} - X_{ja}\right)\text{^}2$$

Goodness of fit in MDS is reflected in the magnitude of the S-Stress value which is calculated based on the above S value and RSquare (Malhotra, 2006). Low stress values indicate good fit, while high S values indicate otherwise. In the RAPFISH approach, a good models is indicated by a stress value smaller than 0,25 or S < 0.25 (Fauzi and Anna 2005). A good RSquare close to 1.

Through MDS, the sustainability point position can be visualized in two dimensions, namely the horizontal axis and the vertical axis, the horizontal axis shows the difference in the system studied in the "bad" (0%) to "good" (100%) ordinance for each dimension analysed. Whereas the vertical axis shows the difference of the attribute mix score between the system studied. The result of the analysis showed a value which is the sustainability index value of the reviewed system. This ordination analysis also can be done to analyse how far the sustainability status for each dimension is. An overview of the sustainability analysis between dimensions can be visualized in an kite diagram.

The sustainability scale of the system studied has an interval of 0-100%. If the index value is more than 50%, then the system studied can be categorized as sustainable and if the index is less than 50%, then the system under study can be categorized as sustainable and if the index is less than 50%, then the system studied is categorized as not/not yet sustainable. In this sustainability study the sustainability criteria are based on Pitcher (1999), as follows;

Table 1. Categories of sustainability index

Value Index	Category
0 – 25	Bad; not continuous
26 – 50	Less; less sustainable
51 – 75	Enough; quite sustainable
76 – 100	Good; very sustainable

Sensitivity analysis (leverage) in this study was conducted to see which attributes were very dominant or sensitive affecting sustainability compared to other attributes. To evaluate the impact of random errors on all dimension in the ordinance value estimation process Monte Carlo analysis is used with the method of "scatter plot" (Kavanagh, 2001; Fauzi and Anna, 2005). This analysis is a simulation method that can see aspects of uncertainty that can be caused, among others; 1) the impact of scoring errors due to lack of information, 2) the impact of diversity in scoring due to differences in assessment, 3) errors in data entry and 4). High stress value obtained from ALSCAL algorithm.

The result of the determination of the sustainability from each dimension is then converted to a kite diagram to see the sustainability trade-off from the management of the rubber plantations. The index value of the sustainability in each

dimension is depicted in Figure 1.

To learn which attribute is the most crucial in each dimension a prospective analysis is done. This prospective analysis aims to determine the rankings of inquisitive attributes so that key attributes or *driving variables* in the management of rubber plantations are achieved in the research locations. The prospective of the outputanalysis comes up with four quadrants which are the ranks of the inquisitive attributes as seen in Figure 2, Hardjomidjojo (2002); Wibowo (2010); Yusuf *et al.* (2016).

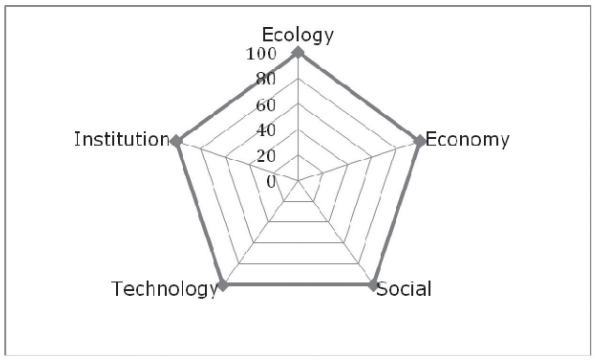

Fig. 1. Illustration of sustainability index kite diagram

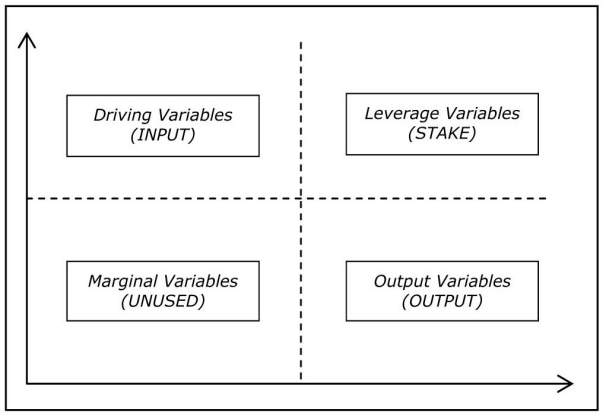

Fig. 2. Graph of variable influence and dependency

Results and Discussion

Ecological Dimension

The result of the ecological parameter measurement on the smalholders' plantations shows that there are seven attributes which predictably affect the sustainability of the ecological dimension, and those attributes are: (1) rubber seed type; (2) number of rubber tapping days/rubber tapping frequency; (3) rainfalls; (4) land administrative status; (5) land size; (6) land fertility; (7) land type. The value of the sustainability index and the leverage attributes of the ecological dimension are as follows:

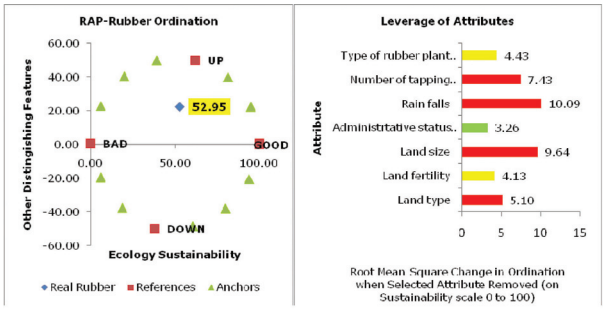

Fig. 3. Sustainability index and leverage attributes of the ecology dimension

The MDS analysis of the ecology dimension shows an index score of 52.95% or is categorized as quite sustainable. Role of each attribute in the ecology dimension is then analyzed with the leverage analysis which is aimed to look for an attribute which is sensitive in contributing to the sustainability of the ecology dimension. The result of the leverage analysis is gained from the Root Mean Square (RMS) value of each attribute. The determination of the sensitive attributes which influence the sustainability of the ecology dimension uses a combination of leverage analysis and Pareto analysis (Kusbimanto, 2013). The Pareto analysis was conducted by arranging the RMS values of the highest to the lowest value and then weighting them in percentage and then accumulating the till the maximum cumulative value limit of 75%. The results are obtained four sensitive attributes in the ecology dimension which affect the sustainability of the smallholders' plantations. The total cumulative percentage of the RMS which is 72.80%. Those sensitive attributes are (1) rainfalls; (2) land size; (3) tapping frequency, and (4) land type. These four attributes of ecological dimensions are considered to be the next step towards developing the sustainable development model for rubber farmers in Riau Province.

Technology Dimension

The result of the technology parameter measurement mentions that there are 14 attributes that are forecast to be influential on the sustainability of the technology dimension, and those attributes are: (1) fertilization frequency of productive plantations; (2) care frequency of productive plantations; (3)

pestiside frequency/pest control frequency of productive plantations; (4) behaviour of farmers regarding clean lump; (5) knowledge of clean lump; (6) knowledge of coagulant; (7) knowledge of tapping technique; (8) knowledge of care/maintenance technique of productive plantations; (9) spacing/planting time of productive plantations; (10) knowledge of spacing/planting time; (11) seed source; (12) knowledge of quality seeds; (13) terrace making, and (14) knowledge of farming. The value of the sustainability index and the leverage attributes of the technology dimension are as follows:

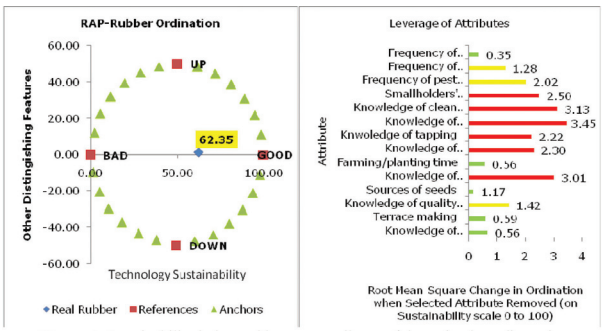

Fig. 4. Sustainability index and leverage attributes of the technology dimension

The MDS analysis of the technology dimension attributes shows an index value of 62.35% or is categorized as quite sustainable. The role of each attribute was then analyzed with the leverage analysis which was done to find any sensitive attributes contributing to the sustainability of the dimension. The result of the leverage analysis is gained from the Root Mean Square (RMS) value of each attribute. The results of the Pareto analysis show that 6 leveraging attributes are the sustainability of the technology dimension. The six attributes affect the sustainability of rubber farmers. Those attributes were retrieved from the total percentage of the RMS cumulative which is 70.20%. The six sensitive attributes are (1) knowledge of coagulant; (2) knowledge of clean lump; (3) knowledge of planting time; (4) behavior of farmers regarding clean lump; (5) knowledge of productive plantation care, and (6) knowledge of tapping technique. These six attributes were the consideration for the next step in creating the model.

Economy Dimension

The result of the calculation of the economy parameters shows that there are 12 attributes that are assumed to be able to influence the sustainability of the economy dimension, and they are: (1) perception of rubber price; (2) perception of nine basic needs adequacy; (3) access to rubber price information; (4) access to capital; (5) access to transportation; (6) access to clean water; (7) obstacles in selling agricultural products; (8) access to market; (9) marketable right; (10) debt; (11) saving, and (12) household income. The value of the sustainability index and the leverage attributes of the economy dimension are as follows:

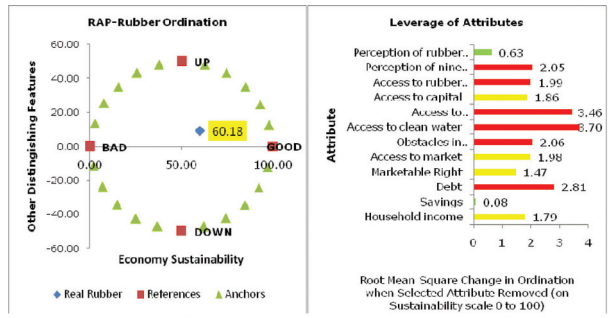

Fig. 5. Sustainability index and leverage attributes of the economy dimension

The results of the MDS analysis of the economic dimension show that the sustainability index is 60.08% or categorized as quite sustainable (>50%). While the results of the leverage attribute analysis found that there were 6 attributes that became a lever for the sustainability of the management of the economy dimensions of rubber farmers in Riau province. The six attributes are; a) access to clean water, b) access to transportation, c) debt, d) obstacles in selling agricultural products, e) perception of rubber price and f) access to rubber price information. The total cumulative percentage of RMS with the Pareto analysis approach is 67.29%.

Social Dimension

The result of the social parameter calculation results in 10 attributes that are thought of being influential on the sustainability of the social dimension, and those attributes are: (1) social relationship pattern in society; (2) relationship pattern of farmers and proprietors; (3) employment rate; (4) local wisdom and knowledge; (5) population density; (6) level of natural resources conflict; (7) economical facilities/infrastructures; (8) educational facilities; (9) social facilities; (10) society participation rate. The value of the sustainability index and the leverage attributes of

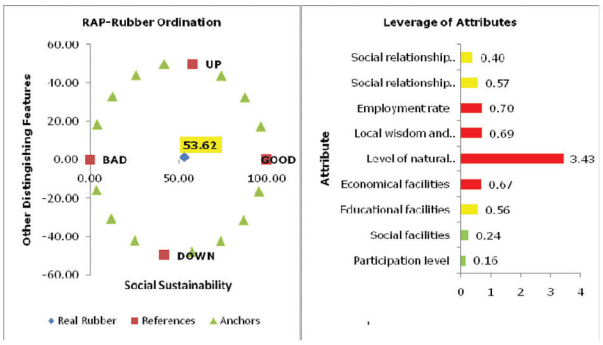

Fig. 6. Sustainability index and leverage attributes of the social dimension

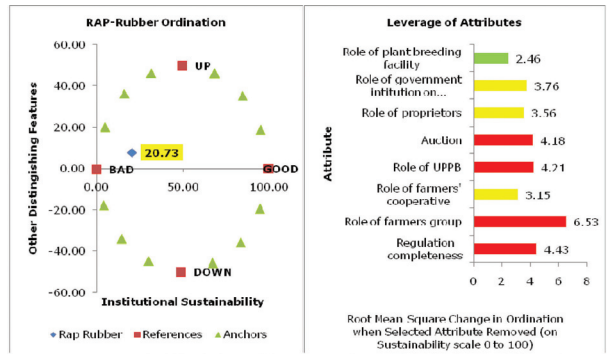

Fig. 7. Sustainability index and leverage attributes of the institutional dimension

the social dimension are as follows:

The results of the MDS analysis of the social dimension show that the sustainability index is 53.62% or categorized as quite sustainable (>50%). While the results of the leverage attribute analysis found that there were 4 attributes that became a lever for the sustainability of the management of the social dimensions of rubber farmers in Riau province. The four attributes are; a) employment rate, b) local wisdom and knowledge, c) level of natural resources conflict, and d) economical facilities. There are four sensitive attributes found in the social dimension influencing the sustainability of the smallholder plantations. These four sensitive attributes were found from the total percentage of the RMS cumulative which is 73.99%. If another attribute is added, it will be over the limit (82.67%) as the maximum cumulative value limit is 75%.

Institutional Dimension

The result of the institutional parameter calculation produced 8 attributes which are presumed to be influential on the sustainability of the institutional dimension, and those 8 attributes are: (1) role of plant breeding institution; (2) role of government institution in empowering the smallholders; (3) role of the take or proprietors; (4) role of auction market; (5) role of UPPB; (6) role of agro-cooperative; (7) role of farmers groups; and (8) regulation completeness. The value of the sustainability index and the leverage attributes of the institutional dimension are as follows:

The MDS analysis of the institutional dimension attributes shows an index value of 20.73% which is classified as bad (unsustainable). The role of each attribute in the institutional dimension was then analyzed by using the leverage analysis to find out which of the attributes are sensitive and contribute to the sustainability of the ecology dimension. The result of the leverage analysis was gained from the Root Mean Square (RMS) value in each attribute. The determination of the sensitive attributes influencing the sustainability of the institutional dimension uses a combination of the leverage analysis and the Pareto analysis. The Pareto analysis was done by sorting the RMS value of the leverage analysis result from the highest to the lowest value and then weighting was done in percentage and it was accumulated until the maximum cumulative value limit of 75%.

Level of Smallholders Plantations Sustainability

The partial analysis of the smallholders' plantation sustainability for each dimension where five dimensions have sustainability value in between 52.95% to 60.35% except for the institutional dimension which is only 20.73%. Meanwhile the average stress value is 15% and the determination coefficient value (R^2) can be seen in Table 6.

The results shows that the sustainability index of the smallholders' rubber plantations in multi dimensions is categorized as quite sustainable with a value of 53.73% or >50%. The pressure value on the model is just 12.90% or <20%. Meanwhile the determination coefficient value (R^2) reaches 95.77% which means that only 4.23% that cannot be explained by the model. Even though the sustainability index of the smallholders' rubber plantations is categorized as pretty sustainable, by taking the five dimensions into account, the sustainability value of the institution dimension is considered less sustainable as seen in the kite diagram in Figure 8.

Table 2. Sustainability value, pressure value, and determination coefficient value (R^2)

Dimension	Sustainability Value (%)	Pressure Value (%)	Determination Coefficient Value (R^2)
Ecology	52.95	13.73	94.60
Technology	62.35	13.10	95.47
Economy	60.18	13.64	95.30
Social	53.62	15.40	94.55
Institutional	20.73	13.75	95.25
Smallholders' rubber	53.73	12.90	95.77

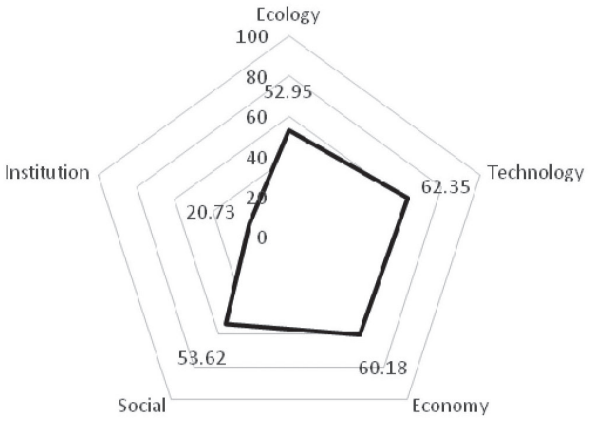

Fig. 8. Five-Dimension Analysis of Smallholders' Rubber Sustainability

Prospective Analysis

The prospective analysis was then conducted which was aimed to determine the positioning of the driving attributes so that the key attributes of the driving variables in carrying out the development of smallholders in the framework of the sustainable rubber plantation management could be found. The perspective analysis output was gained in the form of four quadrants which are the positioning of the driving attributes as seen in Figure 9.

Based on the participative prospective analysis,

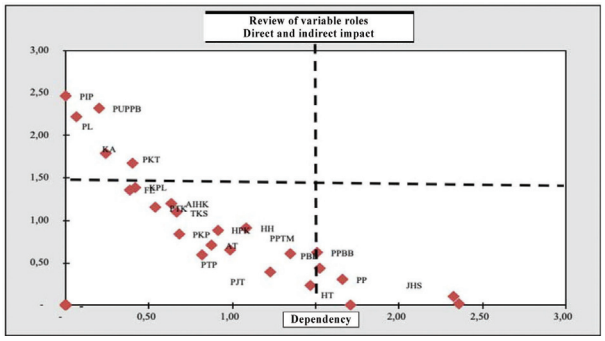

Fig. 9. Graph of variable influence and dependency

there is an indication that the five factors below determine the sustainability of the smallholder development consist of; a) improvement of the role of the government, b) improvement of the role of UPPB, c) improvement of the role of rubber auction market, d) improvement of regulation completeness and e) development of agricultural groups.

Conclusion

From the analysis result and discussion of the previous parts, it can be concluded that: 1) Based on the Multidimensional Scaling (MDS) method as a whole the smallholders' plantations are categorized as pretty sustainable with an index value of 53.73. Of the five dimensions, the institutional dimension is the only unsustainable dimension with an index value of 20.73 and the technology dimension is the most sustainable one. Therefore, to create sustainable smallholders' plantations good institutional management is a must, and 2) Based on the leverage analysis, there are twenty five driving attributes of the fifty attributes that influence the sustainability of the smallholders plantations, and based on the participative prospective analysis, of the twenty five driving attributes there are five which are categorized as driving variables, i.e. improvement of the role of the government institution, improvement of UPPB, improvement of the rubber bid/auction market, improvement of the completeness of the regulations and development of the farmer groups.

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