Chapter 10
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Scientific Investigation for Determining the Sustainability Index of Tobacco Planted in Various Types of Land Typology in Pamekasan, Madura

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ABSTRACT

Economic importance of tobacco plantation has long been undeniable for East Java. In this province, especially in Madura, Pamekasan constitutes one of the greatest tobacco producers, cultivated in many types of farm typology such as *sawah*, *tegal* and *gunung*. This current study aimed at investigating sustainability index of tobacco planted in various land typologies in Pamekasan. Data were collected using in-depth interview and focus group discussion. The study was conducted in Pamekasan, Madura, between April 2016 and March 2016. Data obtained were evaluated using Rap-Tobacco (derived from Rap-Fish) commonly known as Multi-Dimensional Scaling (MDS), covering ecological, social economy, institutional and policy and technological aspects. The results demonstrated that the highest sustainability index was observed at technological dimension, reaching up to 66.99 (*sawah*), 55.97 (*tegal*) and 58.13 (*gunung*). Although tobacco farming was sustainable in terms of technological dimension, more advanced technological supports might help it to reach a meaningful improvement, such as the use of information system for generating accurate climate data, as well as production and better distribution of proper tobacco seeds. Statistically, stress value was found <0.25%, while R^2 value ranged from 92% to 94%. In short, we could conclude that the present model successfully fitted the testing data and could satisfactorily calculate sustainability index.

Keywords: Tobacco; land typology; sustainability index; multi-dimensional scaling.

1. INTRODUCTION

Although tobacco leaf cultivation is relatively small agricultural subsector in Indonesia by economic size, it has attracted consideration related to the reform of the Indonesian tobacco excise tax system. Significant increases in tobacco taxes are highly effective in tobacco control strategy and lead to significant improvements in public health [1]. Economically, this subsector contributed to approximately 0.30% of the agricultural sector and 0.03% of gross domestic bruto as reported by Indonesian Ministry of Agriculture [2].

East Java has been well known capable of providing great contribution to tobacco industry in national scale, accounting for about 56.8% of total production in Indonesia [3]. Madura, an Island in East Java near Surabaya, is capable of producing and developing tobacco plants, as represented by farm land for the plant reaching up to 59,968 ha, existing in Sampang, Pamekasan, and Sumenep [4]. Among these areas, Pamekasan ranked at first, having tobacco farm area of 27,000 ha [5].

Data released by Central Bureau of Statistics (known as BPS-Statistics Indonesia) showed that there is a decline in tobacco farm area in Pamekasan and its productivity [5]. However, the reduction did not cause the increasing price of tobacco. In last years, tobacco farmers in Pamekasan suffered from low price of tobacco due to price fluctuation, while the price was often below Break Event Point (BEP),

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which is economically unfeasible. Although the price uncertainty has continuously occurred, most farmers in Pamekasan are still planting tobacco. Tobacco is regarded as the more suitable commodity compared to other commodities such as paddy rice and secondary crops locally named as *palawija* [6].

To date, farmers sell their tobacco entirely, but tobacco business has been undeniably hindered by several constraints, both technical and non-technical factors. In terms of technical-related problems, the major constraint comes from low quality of tobacco, which is commonly unsuitable to criteria and demand [7]. Based on aforementioned elaboration, this attracted authors to investigate index and status of sustainability for tobacco farm in Pamekasan.

2. METHODOLOGY

2.1 Determination of Attributes and Score for Sustainability Index

Study on sustainability index of tobacco farmed in various farm typologies in Pamekasan was performed to assess the sustainability of tobacco production. Farm typology was grouped into three types: *Sawah, tegal* and *gunung*. Data were analyzed using ordination method of *Rap-Tobacco* (modified from *Rap-Fish*) commonly named as Multi Dimensional Scaling (MDS). Rapfish is a new multidisciplinary rapid appraisal technique for evaluating the comparative sustainability of fisheries [8].

Table 1. Attributes and score for sustainability index based on ecological aspects

No.	Dimension and attributes	Status	
		Good	Bad
(1)	(2)	(3)	(4)
1.	Area of dry land, which is based on percentage of rain-dependent areas (*luas lahan kering*)	3	0
2.	Elevation of tobacco farm, expressed as above mean sea level (*ketinggian lahan tanam*)	3	0
3.	Potential tobacco farm expansion (*potensi lahan untuk perluasan lahan tembakau*)	3	0
4.	Tobacco farm land extension (*penambahan luas lahan*)	3	0
5.	Land conversion of tobacco farm land (*konversi untuk lahan tembakau*)	0	3
6.	Use of pesticide (dose per ha tobacco farm land) (*penggunaan pupuk/pestisida*)	0	3
7.	Use of organic matters derived from agricultural waste for fertilization (*penggunaan bahan organik - BO*)	3	0
8.	Tobacco productivity (kg/ha) (*produktivitas tembakau*)	3	0
9.	Land conversion, from tobacco to another crop use (*konversi lahan tembakau untuk tanaman lain*)	0	3
10.	Harvesting failure due to climate/weather disturbance (*gagal panen akibat cuaca*)	0	3
11.	Tobacco quality (*mutu tembakau*)	3	0

Index assessment was performed according to Rap-Tobacco modified from Rap-Fish, through ordering objects based on a measured order using Multi-Dimensional Scaling (MDS). MDS is a multivariate statistic tool able to determine position of an object over other objects considering their degree of similarity [9]. This method is also popular as ordination in reduced space. Ordination refers to object plotting along lines established according to ordered relationship or in a graphical system consisting of two or more lines [10]. Using ordinating concept, dispersion of multi dimension can be projected in a simpler area. Ordinating approach also allows researchers to obtain more quantitative information and projecting value. MDS is also a statistic tool capable of transforming multidimension into a simple dimension [11].

In Rap-Fish approach, the more appropriate model was indicated by lower stress value (S<0.25), with a greater R^2 value (at maximum of 1.0). Scale for system sustainability index ranged 0 – 100%, in which index of >50% is attributed to "sustainable", while index of <50% refers to "not sustainable" [12].

In this experiment, assessment of tobacco sustainability was based on 4 main dimensions covering ecology (11 attributes), social-economy (14 attributes), institution (9 attributes) and technology (10 attributes). All these attributes were specifically presented in Tables 1-4.

Table 2. Attribute and score for sustainability index based on social-economy aspects

No	**Dimension and attributes**	**Status**	
		Good	**Bad**
(1)	**(2)**	**(3)**	**(4)**
1.	Fluctuation and stability of the price (*fluktuasi harga*)	3	0
2.	Contribution to Regional Original Revenue (PAD) (*kontribusi pada PAD*)	3	0
3.	Contribution to farmer's economy (*kontribusi pada pendapatan petani*)	3	0
4.	Sufficiency in tobacco production for market demand (*lkecukupan produksi*)	3	0
5.	Benefit distribution (*distribusi pemerataan hasil*)	3	0
6.	Labor cost (*biaya tenaga kerja*)	3	0
7.	Farmer's income source excluding tobacco, i.e. from other crops/commodities (*pendapatan usaha tani selain tembakau*)	3	0
8.	Tobacco selling price (based on BEP) (*harga jual tembakau terhadap BEP*)	3	0
9.	Annual cost for production inputs (*saprodi*) (*harga saprodi dari tahun ke tahun*)	3	0
10.	Availability of *saprodi* (effectivity to farmers) (*tingkat ketepatan ketersediaan saprodi*)	3	0
11.	Product market, which is based on marketing area (*luas jangkau pemasaran tembakau*)	3	0
12.	Farmer's bargaining to costumers (*posisi tawar petani*)	3	0
13.	Own financial support (*ketersediaan modal oleh petani sendiri*)	3	0
14.	Dependence on subsidy (*ketergantungan pada subsidi*)	3	0

2.2 Analysis Steps

Ordination analysis by Rap-Tobacco was performed through several steps: 1) determination of attributes involved in sustainable tobacco production; 2) scoring of attributes based on criteria; 3) ordinating analysis to determine ordination of stress value; 4) establishment of index and status for sustainability of tobacco in general and specific perspective in each dimension, 5) leverage analysis for determining the most sensitive attributes; 6) Monte Carlo analysis for estimating the uncertainty. Scoring in these attributes represented their sustainability, indicating degree of goodness and badness.

Table 3. Attributes and score for sustainability index based on institutional and policy aspect

No.	Dimension and attributes	Status	
		Good	Bad
(1)	(2)	(3)	(4)
1.	Government's policy on tobacco trade (*Aktifitas dan kinerja pemerintah dalam kebijakan pertembakauan*)	3	0
2.	Performance of cooperation (KUD) (*Aktifitas dan kinerja kelembagaan KUD*)	3	0
3.	Availability of institution/business agent/service facilitating inputs and outputs (*Aksebilitas dan ketersediaan pelayanan saprodi*)	3	0
4.	Contribution of extension activities to farmers (*Aktifitas dan kinerja kelembagaan penyuluhan pertanian*)	3	0
5.	Financial supports by small finance bodies (bank/credit) (*Aktifitas dan kinerja kelembagaan perkreditan*)	3	0
6.	Technological service related to tobacco farm *(Aktifitas dan kinerja lembaga layanan teknologi)*	3	0
7.	Performance of marketing service by institution *(Aktifitas dan kinerja layanan pemasaran)*	3	0
8.	Performance of non-governmental organization for supporting governmental service agents *(Aktifitas dan kinerja kelembagaan swadaya masyarakat)*	3	0
9.	Performance of partnership institution on linking farmers to investors *(Aktifitas dan kinerja kelembagaan kemitraan)*	3	0

Table 4. Attributes and score for sustainability index based on technological aspect

No.	Dimension and attributes	Status	
		Good	Bad
(1)	(2)	(3)	(4)
1.	Land and water management *(pengelolaan lahan dan air)*	3	0
2.	Seeding technology *(pengadaan bibit)*	3	0
3.	The use of recommended tobacco seed, *Prancak* (95, N1, and N2) *(penggunaan bibit anjuran)*	3	0
4.	Fertilizing management based on recommendation from extension agents *(penggunaan pupuk dan pestisida)*	3	0
5.	Plant disease management *(pengendalian OPT)*	3	0
6.	Harvesting time, based on optimum plant maturity depending on farm land *(panen optimum)*	3	0
7.	The use of agriculture machinery *(penggunaan alsintani)*	3	0
8.	Appropriateness on post-harvest handling *(pengolahan tembakau)*	3	0
9.	Harvesting management, top pruning technique and gradual harvesting *(pemanenan dan pemangkasan)*	3	0
10	Climate information system *(sistem informasi iklim)*	3	0

3. RESULTS AND DISCUSSION

3.1 Ecological Dimension

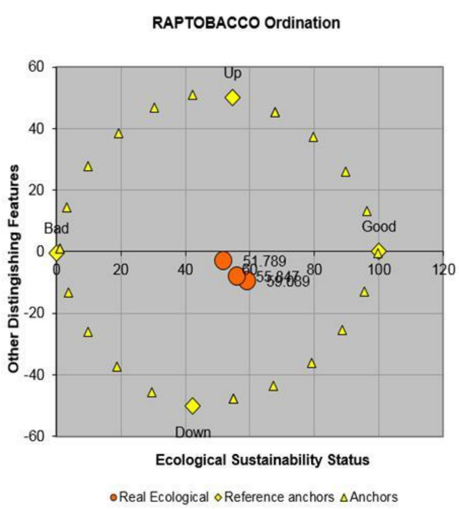
Sustainability index of tobacco planted in *sawah*, *tegal*, and *gunung* was depicted in Fig. 1. The results suggested that tobacco farming in these farm typologies was considered "sustainable", i.e.

59.089, 55.847 and 51.789, respectively. This is due to appropriateness of farming land in Madura (specifically in Pamekasan) for tobacco plantation, with rainfall average of 108 mm per year [5]. In general, local farmers in Madura are rich in local knowledge for dealing with technical barriers of tobacco farming. With a stress value of 0.1550852, the resulting model was at fair level; while R^2 value reached 94.66% (Table 5) indicating that the model appropriately fitted the data.

As exhibited in Fig. 1, the sensitive attribute was listed as follows: 1) use of organic matter; 2) use of agricultural machinery; 3) land extension. Intervention on these attributes could more significantly alter sustainability index in terms of ecological aspect. The utilization of organic matter was regarded as sensitive since organic materials derived from agricultural waste (particularly tobacco stems) were not further used for farming; but they were removed or used for traditional wood burning stove. Furthermore, agricultural machinery was also sensitive since it is not used properly by farmers as suggested by extension agents or government. This may be linked to the limitation on its availability and distribution. Next, land extension is also sensitive attribute since, at a higher selling price, farmers massively extend their tobacco farm lands for further planting session at absence of well-planned strategy.

3.2 Social Economical Dimension

The results indicated that sustainability index of tobacco planted in *sawah, tegal* and *gunung,* reached up to 48.47, 49.55 and 47.02, respectively, suggesting that tobacco farming was less sustainable in terms of social economical dimension. Currently, tobacco have received a myriad of social-economic pressures, including tobacco recognized as addictive materials, no smoking campaign and FAO recommendation according to Frame Work Convention on Tobacco Control—FCTC, resulting in a declined demand of tobacco. Among these attributes, three attributes predominantly affecting social economical dimension were identified, including 1) labor cost, benefit distribution and 3) selling price (Fig. 2, Table 6).



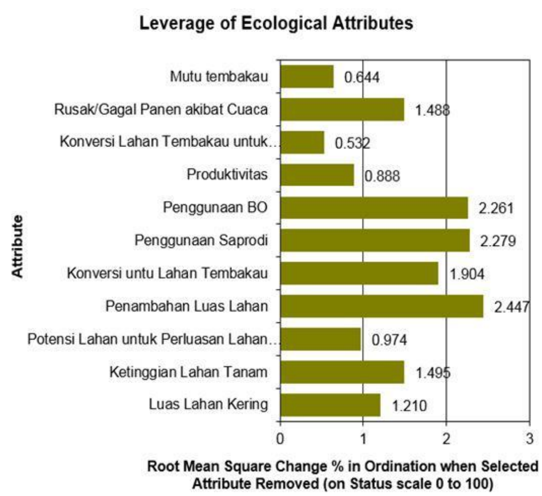


Fig. 1. Sustainability index and sensitive attributes for tobacco planted in *sawah*, *tegal*, and *gunung* based on ecological dimension

Table 5. Stress value for ecological dimension

Stress =	0.1550852	Iteration	Stress	Delta
Squared Correlation (RSQ) =	0.9465894	1	0.226478	9E+20
Number of iterations =	2	2	0.22615	0.000328
Memory needed (words) =	6782			
Return value (error if > 0)	0			
Rotation angle (degrees) =	184.88043			

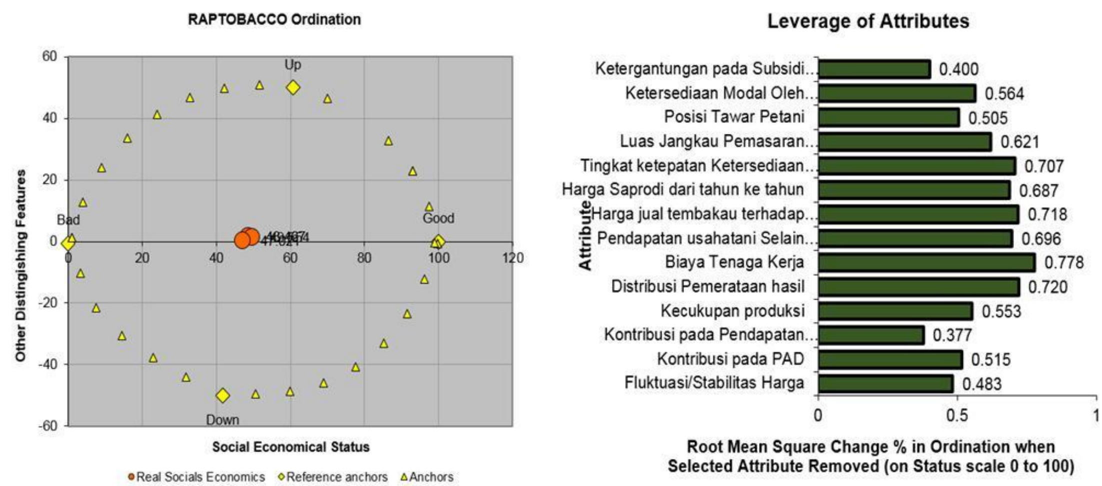


Fig. 2. Sustainability index and sensitive attributes for tobacco planted in *sawah*, *tegal*, and *gunung* based on social economical dimension

Sensitivity of labor cost resulted from high cost of employment. For fresh tobacco (*tembakau basahan*), irrigation accounted for 20.55% of total cost, while it contributed to 24.22% of total cost for dried tobacco (*tembakau rajangan*), as reported by a previous work [13]. Income distribution was considerable as a sensitive attribute since main source of income for most tobacco farmers in Madura was from tobacco cultivation, reaching up to 60 – 80% of total income [14]. This condition is supported by the selling price of tobacco. Based on AMTI [15], tobacco was recorded to have the highest benefit (Rp. 20.6 million / Ha), being much higher than rice (Rp. 8.2 million /Ha), chili (Rp. 4.1 million / Ha), maize (Rp. 3.1 million / Ha), and onion (Rp. 2.3 million / Ha).

Furthermore, stress value of the model was 0.1634116, categorized as fair level, while the R^2 value reached 94.26% (almost 1.0), indicating that the model could properly fit the data.

3.3 Institutional and Policy Dimension

The results showed that sustainability index of tobacco planted in *sawah, tegal* and *gunung* was 45.09, 46.29 and 47.66, respectively, which suggested that tobacco farming in terms of institutional and policy dimension was less sustainable. The factor mainly responsible for the unsustainability is associated with the failure of relevant institution (in this case *KUD*) to facilitate farmers. Afterwards, the top three sensitive attributes included: (1) performance of credit institution, (2) technological service, and (3) accessibility and availability of agricultural machinery (Fig. 3, Table 7). Financial support seemed to be very sensitive due to absence of governmental policy on offering affordable credit scheme to farmers through either state or private institutions. Technological service was also recorded as sensitive attribute, mainly for institutional performance on feeding farmers with various technologies for better tobacco farming activities. Subsequently, accessibility of agricultural machinery was also not proportionally distributed and even inaccessible for some farmers living far from city.

Table 6. Stress value for social economical dimension

Stress =	0.1634116	Iteration	Stress	Delta
Squared Correlation (RSQ) =	0.9425861	1	0.227909	9E+20
Number of iterations =	3	2	0.226239	0.00167
Memory needed (words) =	8438	3	0.226272	-3.3E-05
Return value (error if > 0)	0			
Rotation angle (degrees) =	0.2348149			

Statistically, the model demonstrated adequate stress value, i.e. 0.1696784, which makes it at fair level. Similarly, the R^2 value was 94.00%, which means that the model of the testing data is satisfactory.

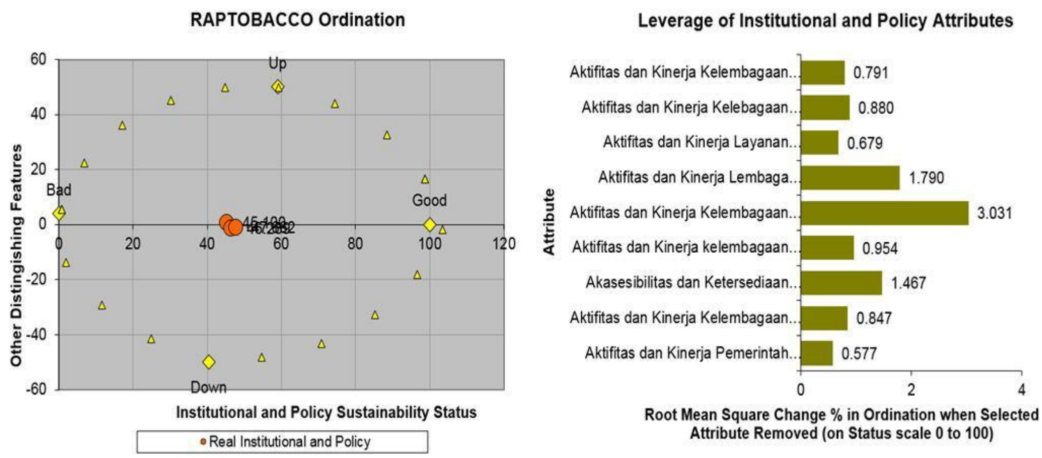


Fig. 3. Sustainability index and sensitive attributes for tobacco planted in *sawah*, *tegal*, and *gunung* based on institutional and policy dimension

3.4 Technological Dimension

The technological dimension in this experiment was classified as sustainable since the index reached 66.99, 55.97 and 58.13 for each farm typology, respectively. Based on sensitivity assessment, climate information system is recorded at first rank, followed by the use of recommended seed, and provision of seed [16,17]. Information system for climate prediction is essential considering that tobacco is highly susceptible to rainfall, requiring an accurate prediction of climate. To date, technology in the climate prediction is rarely used by farmers; but they have mostly depended on traditional method for climate estimation [18]. The use and provision of recommended tobacco seed is sensitive attribute since most farmers tended to use unstandardized seeds that are produced by themselves with conventional method. Furthermore, statistical assessment on the model showed that the stress value was 0.1648743, with a fair level. Meanwhile, with R^2 of 92.48%, the testing data could be well fitted by model.

Table 7. Stress value for institutional and policy dimension

Stress =	**0.1696784**	**Iteration**	**Stress**	**Delta**
Squared Correlation (RSQ) =	0.9400167	1	0.235113	9E+20
Number of iterations =	3	2	0.233684	0.001428
Memory needed (words) =	6062	3	0.233708	-2.4E-05
Return value (error if > 0)	0			
Rotation angle (degrees) =	6.4476357			

Table 8. Stress value for technological dimension

Stress =	**0.1648743**	**Iteration**	**Stress**	**Delta**
Squared Correlation (RSQ) =	0.9248397	1	0.241661	9E+20
Number of iterations =	3	2	0.239434	0.002227
Memory needed (words) =	6062	3	0.239625	-0.00019
Return value (error if > 0)	0			
Rotation angle (degrees) =	238.13672			

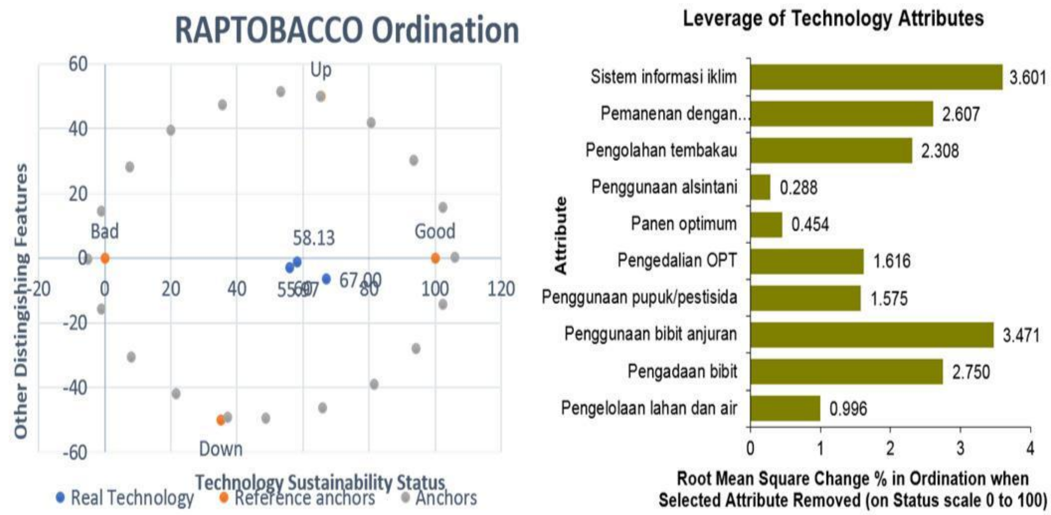


Fig. 4. Sustainability index and sensitive attributes for tobacco planted in *sawah*, *tegal*, and *gunung* based on technological dimension

4. CONCLUSIONS

Assessment of sustainability index using Rap-Tobacco based on ecological, social economy, institutional and policy, and technological aspects for tobacco planted in various types of land typology in Pamekasan demonstrated that the highest sustainability index was attributed to technological dimension, with regard to the sustainability status reaching up to 66.99 (*sawah*), 55.97 (*tegal*) and 58.13 (*gunung*). Additionally, assessment on attribute sensitivity put the climate information system in the first rank, followed by the recommended seed availability and seed distribution. Next, ecological dimension was also considered sustainable, with the sustainability status of 59.089 (*sawah*), 55.85 (*tegal*) and 51.7 (*gunung*), while the sensitive attribute on this aspect included the use of organic matter, agricultural machinery, and land extension. On the other hand, the two remaining dimensions (institutional and policy dimension; economical and social dimension) were known to be less sustainable; thus, further consideration on the key attributes within these aspects needs to be highlighted in order to achieve sustainable availability of Madura tobacco.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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