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Policy Analysis of Sustainable GMO Management Using Decision Making Method in Indonesia

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Abstract

Technology of genetic modifying is an alternative way to improve both the quality and the quantity of agricultural products. Genetically Modified Organism (GMO) as the product of new technology requires an excellent management strategies especially for the biosafety of the products before being released and commercialized. This study aims to determine the policy priorities in making the right decisions in order to manage a sustainable GMO while reducing the side effects of this technology to the environment and human health. The outputs of policy making based on experts justification are divided into four (4) levels, they are: Focus, Factor, Criteria and Alternative ways level. The synthesized of experts justifications on environmental, economic, social and technological factors, give a nearly equal *eigen* values to the previous four levels, so they are concluded in having the same priority in managing GMO. The gene flow of GMO crop to non GMO crop is the most important element to be considered with the *eigen* values 0.278. The increase of farmer's income with *eigen* values 0.358 is considered as the most important criteria of economic factor. GMO safety to human health (0.464) is the preferred social elements. Last but not least, the human resource capability in doing biosafety test (0.580) is the most important criteria for the technology factor. Based on the alternatives compiled by the experts, law enforcement elements of the rules must be done by 0.187 *eigen* values-compared with other alternatives. Also based on ISM (Interpretative Structural Modelling) quadrant matrix, alternative elements are scattered into three quadrants; dependence, linkage and independent.

Keywords: Genetically Modified Organisms (GMOs); Biosafety; Environmental safety; Analytical hierarchy process; Interpretative structural modelling

Introduction

The agricultural sector is an important sector in Indonesia developing strategy, because it is able to provide a big amount of job occasions and become the main source of income in rural areas. Besides, it is also being the source supply for national food security. This sector also gives contributions to the national economy gains with approximation score 20% [1]. The agricultural sector in Indonesia is very vulnerable to the climate change and its variability. Global warming and extreme climate change have affected the quality and quantity of agricultural production. Global climate change is believed to be one of the factors that cause the decreasing of agricultural products [2]. Temperature factor is one that provides a real impact on agricultural production, which is predicted in the last 21th century there will be a decline in world rice production by 41% [3].

Although the conventionally improving of agricultural quality can raise the quality and quantity of Indonesia agricultural products, but this system is no longer tenable because the limited sources of genes needed by plants to overdue the environmental stresses, become more complex [4]. Like the resistance to pests and diseases, they are one trait that is not found in every plant, so it requires a technological breakthrough that can use of the gen sources of other individual both same and different type of itself. One of technique used is the genetic modifying technology that can move some certain properties from an individual to another, even though if the individual is a different specification. This technology has been utilized for the fixing of the nature of plants, including their resistance to biotic and abiotic stress, their tolerance to certain conditions such as drought, salinity, herbicides, aluminum or iron [5].

Biosafety Regulations on Genetically Modified Organism

Genetic modifying technology has been developed in Indonesia since the 1990s and as a result of new technology, it is necessary to manage the product settings to prevent some causes like bad influences on human, animal and the environment, especially biodiversity. The regulatory and management of Indonesia biological safety have been established by Governmental Regulation (GR) No. 21 of 2005 about GMO Biosafety and Presidential Regulation (PR) No. 39 of 2010 about Commission of Biosafety of GMO, which provide recommendations to the ministries and involved agencies related in the prerelease of GMO. Both of these regulations confirm the status of GMO that will be commercialized in Indonesia have to pass the biosafety assessment in accordance with the precautionary principle on Cartagena Protocol. The uniqueness of biosafety assessment in Indonesia is that there are some additional considerations like; religion or belief values, ethics values and esthetics values, which are included in the terms of doing risk assessment. Besides, the main goal of this protocol is to ensure the adequate protection level on transferring, handling and using safe delivery or cross-border transfer of GMO.

Before the setting of GR No. 21 of 2005 set, the government uses The Decree of Four Joint Minister which was signed in 1999. Under this decree, Bt cotton eventually obtain the permission from the Minister of Agriculture to be released in a limited field (South Sulawesi) in 2001, in succession until 2003, even though after that planting of Bt

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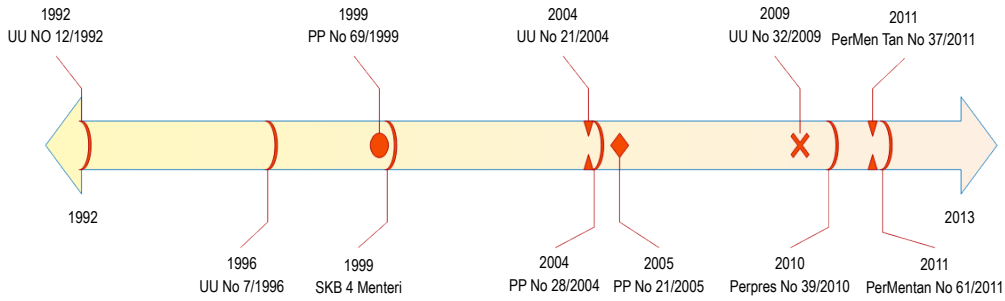

Figure 1: The time line of regulations regarding to biosafety.

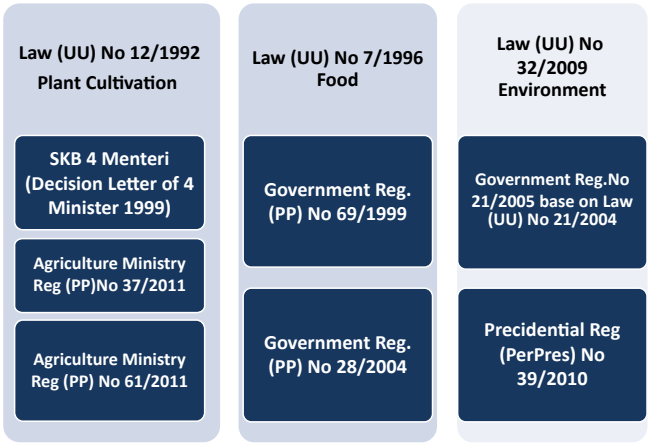

Figure 2: Hierarchy regulation of regarding policy on biosafety of GMOs.

cotton was stopped planting because of some problems that occur due to unprepared conditions of government and communities for GMO application. Then, in 2011, Food Safety Certificate was issued from some GMO crops like corn and soybean-with some properties from different events. In the same year, permission of feed product distribution (Ronozyme AX (CT)) and permission of the releasing the sugarcane in order to tolerant the drought, as the result, of the development of the national private companies are also issued by the relevant institution (www.indonesiabch.org).

The time line of the enactment of laws and regulations related to the usage of GMO regulations in Indonesia from 1992 to 2011 (Figure 1) has produced some other regulations and laws that should be able to be implemented for GMO management in Indonesia. But due to some technical and bureaucracy constraints of the government, the implementations of GMO management become not optimal as can be seen on so many aspects defined in the regulations but have not been able to be implemented yet.

Noted that the legal instrument set for the implementation of the GMO management in Indonesia has been complete, because it has been included on foods (Law (UU) No. 7/1996; GovReg (GR) No. 69/1999 about Labeling of GMO food; GovReg No 28/2004 about Quality, Nutrition of Food), Plant cultivation (Law No. 12/1992; Decision Lett. 41999 Minister about biosafety and food safety of GMOs; Agriculture Ministry Reg No 37/2011 Benefit of plant genetic resources; Agriculture Ministry Reg No 61/2011 Assessment and release of plant variety) and Protect and Manage of Environment (Law No. 32/2009; Gov. Reg No 21/2005 about the Biosafety of GMOs; PrecidentialReg No 39/2010 GMO Institution) (Figure 2).

Policy Analysis of Biosafety Management

Related for filing the GMO biosafety requires a complex mechanism because it involves several government agencies, before finally being decided by the competent ministries or agencies. In Indonesia, the decision for biosafety case will be issued by the Ministry of Environment, food safety by the National Management Agency of Drug and Food, feed safety by the Ministry of Agriculture. The filing for the environmental safety for agricultural products by the proponents are addressed to the Ministry of Agriculture and notified the Minister of the Environment, while for forest products should be addressed to the Minister of Forestry to be notified by the Minister of the Environment. And the agencies in charge of issuing the permission of GMO distribution in Indonesia can be seen in Figure 3.

In accordance with the requirements for the release of each GMO with biosafety certificates, are required some special different mechanisms differ to other conventional products [6]. Based on that case, there are the needs to do the socialization for related stakeholders and the strong implementation from the government as policy makers. Because the application process involves more than one institution, it needs a clear coordination and cooperation between those institutions. Submission process for biosafety is related to the prevailing bureaucratic system in Indonesia so that the monitoring procedures and clarification intense between the applicants and the examiners are available. Besides, the compliance to the established regulations and laws need to gain attentions, as well as legal sanctions for the ones who violate these rules.

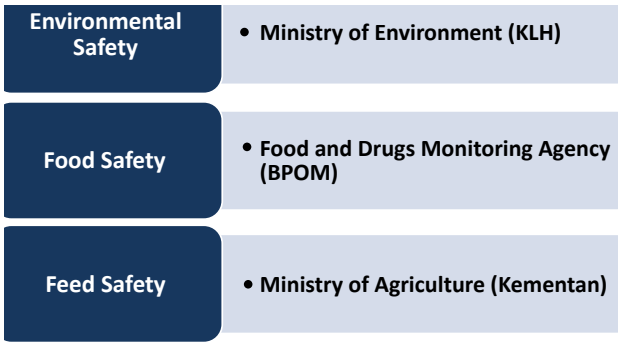

Figure 3: Authorized Agencies in issuing the permission of GMO distribution.

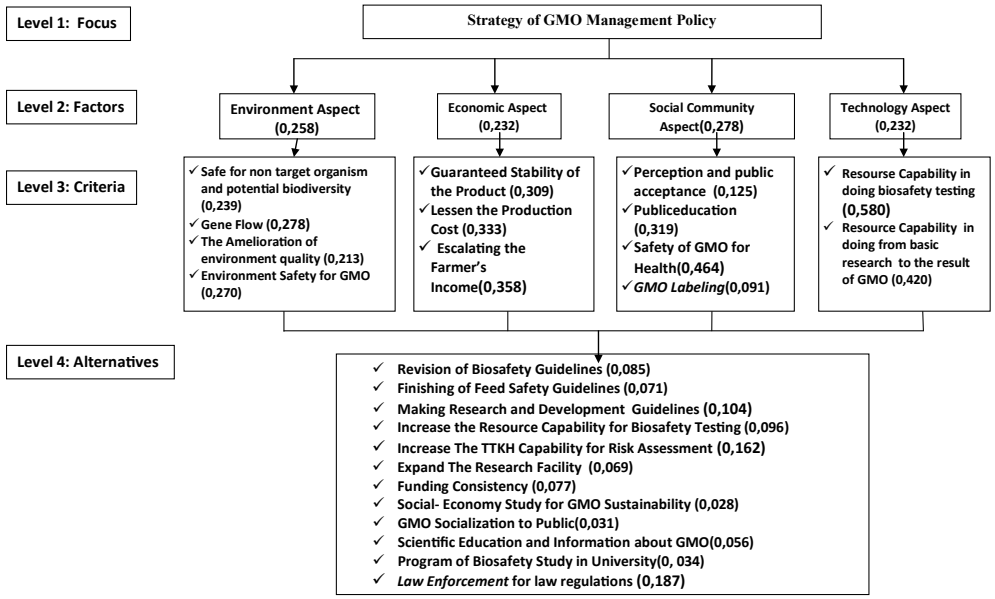

Figure 4: Hierarchy structure by AHP for strategy of management policy analysis.

Every country has its specific rules and procedures, so that in the Protocol states that each county gets allowance to make its own rules adapted to the conditions of each country, including the consideration of its environment, economic and social communities. Review of the policy analysis of sustainable management of GMO was done in order to yield a recommendation to the government in managing the continuous utilization of GMO that will not be detrimental to the environment and human health. The factors that have roles in the sustainability of a business or activity are influenced by three main pillars; environmental, economic and social. On GMO management case in Indonesia, we can add technology factor, in hopes that Indonesia can master the developing technology of GMO and also for bio safety assessment.

Research Methods

Analytical hierarchy process (AHP) and interpretative structural modeling (ISM) analysis

AHP is used to determine the key elements to be addressed and expected to be able to solve the complex issues so the decision issues making can be simplified and expedited. AHP is considered from the experts' judgment to capture variety of information from multiple influential elements on the completion of the case. This method uses knowledge as an analysis tool and then processes them into the components arranged hierarchily, both structurally and functionally. The AHP method used was developed by Saaty and Saaty [7]. This research involved five experts from various institutions associated with GMO management policy in Indonesia. Final data used was the geometric average of the aggregate opinion of those experts. The judgment of each level was obtained from completed filled questionnaires of some experts from different backgrounds of scientific fields that may represent their own institutions. First level called 'focus to only one element' is the target to be achieved on the research. The next level, each of them is composed of several elements corresponding to the input from the experts. By using AHP analysis, the order of priority of each element is expressed in numerical values or percentage. Then, every element at each level is weighted by the experts using the *eigen* as defined by Saaty and Saaty [7]. Next, the processing of the data to determine the priority element in the decision-making of sustainable GMO management policy will use the Software *Expert Choice 2000*.

Hierarchy description by using AHP method is based on the achievement of objectives, the affected factors, the determining of criteria and the determining of alternatives policy. The numerical values that must be exist on each problem variable will assist the decision makers to maintain a cohesive patterns of mind and to reach a conclusion.

After having gained the *eigen* for each level with AHP processing, specifically at the alternative level followed will be continued by analyzing of sub element on the complex system based on the experts opinion, with ISM. The method of ISM decision making was developed by Saxena et al. [8]. Fundamental principles of ISM are the identification of structures in a system that gives a very clear description of the elements system and its flowing relations in order to obtain a better decision [9]. Classification of sub-elements in a single element is based on the refined of Reachability Matrix (RM) by knowing *Driver-Power Dependence* value. The classifications of sub-elements is classified into four sectors; Autonomous (Sector I), Dependent (Sector II); Linkage (Sector III) and Independent (Sector IV)-while the data processing using *Excel 2007* program.

Result and Discussion

Hierarchy GMO management policy using AHP

Hierarchy GMO management policy are arranged according to the experts justification that consist of four levels; objectives (purposes), factors, criteria and alternatives, which can describe the condition of GMO management today in Indonesia. The hierarchy arrangements are:

- First Level: the focus of Sustainable GMO management policy
- Second Level: the factors that play a role in influencing GMO management that consist of environmental, economic, social and technological factors

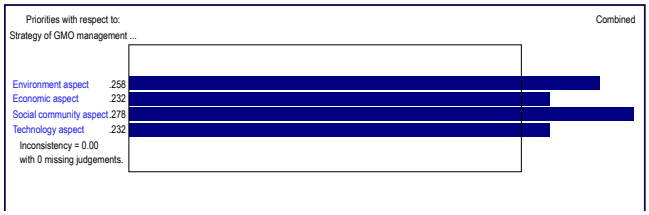

Figure 5: The eigen value to the level of aspects that affect the GMO management.

• Third Level: the criteria of each factor for the environment that consists of GMO safety to non-target organisms & potential biodiversity, transfer of genetic material, improving environmental quality and the safe GMO for the environment itself. Economic factors consist of the stability of production criteria, the reducing of production costs and the increasing of farmers' income. Then, the criteria for social factors consist of the public perception and acceptance, public education, GMO safety for human health and the commercialized of GMO Labeling. Last, technological factors consist of human resources capability criteria in doing biological safety testing and human resource capability in doing basic research until GMO obtaining

• Fourth Level: the alternatives that have been restricted by experts into twelve alternatives that can be considered in the decision making of sustainable GMO management policy.

Synthesized results and the *eigen* values for each option in the structure of AHP depicted cumulatively as shown in Figure 4.

Contribution role based on level

The interest rates based on the role of each level are analyzed to the implementation of GMO management policy bases the continuous study. Based on the experts judgment, hierarchy at the factor level that influence the GMO management, seem to have an almost equal *eigen* (Figure 5). The judgment result to environmental aspects with *eigen* 0.258, 0.232 for economic aspects, 0.278 for social aspects and 0.232 for technological aspects. The almost equal values of all the aspects (factors) are related to the principle of sustainable development that should pay attention to the main three main factors as pillars; economic, environmental and social.

As a new technology product, the success of the GMO management can strengthen the technology sector, both infrastructure and human resources capability. The late in genetic engineering technology transfer will lead us to failure in technological aspects, thus reducing the economic benefits and finally the public welfare is not achieved [10]. If there is an imbalance in any of those factors may lead us to unsustainable usage of GMO.

At the next level, the criteria of each aspect, based on the results of expert justification are maintained by element within happening the migration of genetic material from GMO crops to non-GMO crops, is the main criteria that is expected can influence environment with *eigen* values 0278. The emergence of experts concerns of the possibility of gene flow in GMO crops is reasonable enough because it will affect the balance of the ecosystem. On the field, the gene flow between GMO crops with similar crops yet non GMO can be happened with the fulfillment of certain conditions such as equality types, planting distance, a high sexually compatibility, especially within wild relatives [11]. If all requirements are met, then the crossing must happen so fertile offspring can be produced. On rice case, the gene flow between GMO crop and non GMO crop can naturally occur through pollen carried by the wind, even the possibility is so tiny, because rice is self-pollination plant. According to experts, the most important element that has to be noticed from gene flow, noted, the environmental aspects (Figure 6).

AHP analysis results with each *eigen* value of the criteria that is being elements of economic aspect, provide the highest value for the increasing element of farmer's income (0.358). Then, the elements of cost reductions of crop (0.333) as well as the stability of GMO product (0.309) can be seen in Figure 7. The reduction of productivity costs and stability during the harvest will make income and the farmer welfare increase. According to James [12] the usages of GMO crops in some developing countries have increased the income and welfare of the farmers. Especially for plants that have resistance to pests, it can reduce the farmers costs of using insecticides. The biggest benefit to the environment like planting Bt cotton has reduced insecticide using up to 39%, which provides benefits to the increasing production by 31% [13]. This figure proves that the benefit of GMO especially for the economic increasing can let the communities hope for the government to use GMO as an alternative to improve crop production and economic industry. The consideration of economic factor is important before utilizing GMO plants, because these calculations are required in conducting long-term benefits in achieving national food safety. According to Sharma et al. [14], the economic benefits would be obtained if the utilization of biotechnology products is accordance with the additional nature of the plants and they are applied on a wide planting area. Moreover, economic research plays an important role in the implementation of an efficient form of regulatory mechanisms as well as the innovations are needed in enlarging technology quality of agriculture [15].

From the elements that become priority in social community

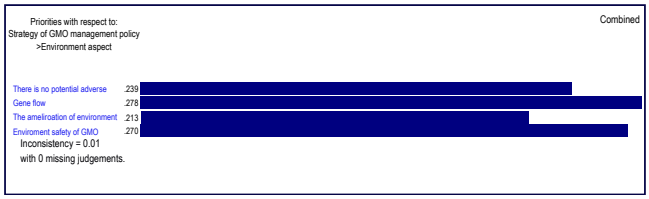

Figure 6: The eigenvalue of the priority criteria of environmental aspect in GMO management.

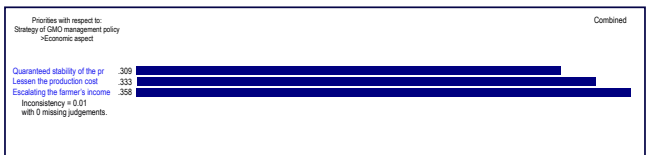

Figure 7: The eigenvalue of the criteria of economic aspect in GMO management.

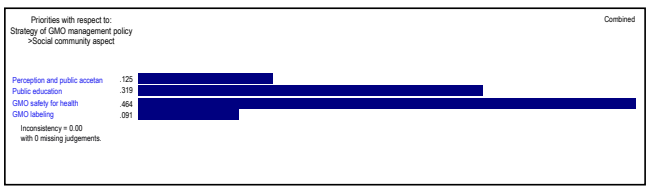

Figure 8: The eigenvalue of thecriteria of social community aspect in GMO management.

aspects, the results of AHP analysis provide a value of safety factor on human health as the most important element (0.464) when being compared to; public education about GMO (0.319), community perception and acceptance (0.125), and labeling factor of GMO (0.091)- as the complete sequence of priorities is presented in Figure 8.

The main priority for the GMO safety to human health is the same as what has been determined by law No. 7 in 1996 Article 13, paragraph 1 "that any person who produces food or uses raw materials, food additives and or other auxiliaries in the food activity or production process resulted from the modifying genetic process must be, first, checked and claimed as a safe food for human health before circulated." As a top priority of AHP analysis, food safety (it is important to note- as this is related to the sustainability of human life) in accordance with the terms of the GMO releasing have to meet the environmental safety point and safe food and/or feed safety point (PP No. 21/2005). The polarization between the pro and cons of the GMO in Indonesia is still ongoing, especially between the public opinion and acceptance about GMO the risks on the environment and human health. Based on the labeling regulation established since 1996 under Law No. 69 in1999 on the Labeling of GMO Food, there is a requirement to label any released GMO, but this rule cannot be applied until now due to bureaucratic problems in government level.

Eigen values given by the experts for some alternative level elements can be seen in Table 1. *Eigen* values for the alternative of GMO management policy are based on environmental aspects, economic aspects, social aspects and technology aspects. Based on the *eigen* values given, we gain law enforcement of regulations and laws as key element. The second highest element of *eigen* values is the upgrading capabilities of TTKH-element in assessing the biological safety. Both of these elements are the main alternative to be done in implementing the strategy of improving GMO management in Indonesia to be sustainable. Regulatory compliance as well as the ability of the government as the relevant institutions in conducting an assessment to the development of new technologies that may give negative effects on the environment and human health, should be the focus of concern for policy makers in this country, so that there will be no error in making GMO management policy. Results of the expert's assessment on the alternative elements are based on environmental, economic, social and technological aspect as shown in Table 1.

Analysis of the required alternative elements in the GMO management using interpretative structural modeling analysis (ISM)

Twelve alternative elements that have been given their *eigen* values by the experts are continued their assessment to determine the relationship pattern amongst the elements and their roles in the chosen policy using graphical applications theory or ISM method. On Figure 9, it can be seen that all the selected elements by the experts become the sustainable alternative of GMO management and they are scattered in sectors II, III and IV (none of them in sector I (Autonomous)). Sub element of law enforcement to the regulations (A12), an increase of TTKH quality in doing assessment of biological safety (A5) and human resource capacity building in doing biological safety testing (A4) are located at sector IV (independent sector) as sub- key element and as the most important alternative to be noticed that will deliver a high effects to other sub- other element in the using of sustainable GMO in Indonesia. Besides, the three sub- elements have a big driver power to other the sub-elements, so that the changes occur to these three key elements can affect other elements. Key elements which are at the IV sector need attention and serious study in their implementation.

Elements that have a fairly high level of dependency on other elements are in the II sector, they are; the development of research facilities (A6), conduct socio- economic studies before the using of GMO (A8) and make biological safety courses in college (A11). All of those three elements are the dependence sector, which means these three elements can be selected if they are reinforced by other elements as their supporters.

The availability of environmental and food safety guidelines (A1, A2), the consistency of funding (A7), public education (A9) and the right education about GMO (A10) including the third sector area variable linkage. On this sector, all of these elements have a big enough driver power, so that the success of the implementation will provide the success too in the using of GMO, and in the contrary, if these elements are ignored, they will lead us to the failure in the using of GMO in Indonesia. It had ever happened in Indonesia on the trial of BT cotton planting in South Sulawesi, which failed because it did not do a whole study before this GMO being released and used on the communities. By the existence of the assessment system before GMO using policy, it can reduce the failure as before [16].

Every new technology, of course, has risks, both positive and negative for human health and the environment. Related to those facts, some nations of the world have made an agreement to implement prudential and conduct risk assessment with raw scientific method before the GMO being used. The agreement of these states is listed on the Cartagena Protocol, which was signed by Indonesian representative too. Releasing and Utilization of GMO policy in each country have each different procedures and circumstance based on the country need and condition.

No	Policies alternative	Contribution value of aspects			
		Environment	Economic	Social	Technology
1	Revision of Environment Safety guidelines (0.085)	0084	0.086	0.082	0.089
2	Making the guidelines of feed safety (0.071)	0.073	0.068	0.072	0.071
3	Making rules of experiments and developments (0.104)	0.101	0.106	0.104	0.106
4	Improving the human resource capability to test its biological safety (0.096)	0.093	0.100	0.100	0.090
5	Improving the TTKH capability on risk management (0.162)	0.153	0.163	0.167	0.164
6	Developing the research facilities (0.069)	0.079	0.066	0.067	0.063
7	Financing consistency (0.077)	0.082	0.081	0.072	0.070
8	Study economic- social for the sustainable GMO (0.028)	0.028	0.029	0.028	0.028
9	GMO socializing to the communities (0.031)	0.028	0.030	0.033	0.033
10	Scientific Education and Information (0.056)	0.058	0.052	0.056	0.056
11	Study of Biological Safety program in PT (0.034)	0.035	0.035	0.032	0.032
12	*Law enforcement* of rules and laws (0.187)	0.178	0.191	0.185	0.198

Table 1: Contributions of alternative elements on environment, economic, social and technology aspect within implying the strategy of GMO management.

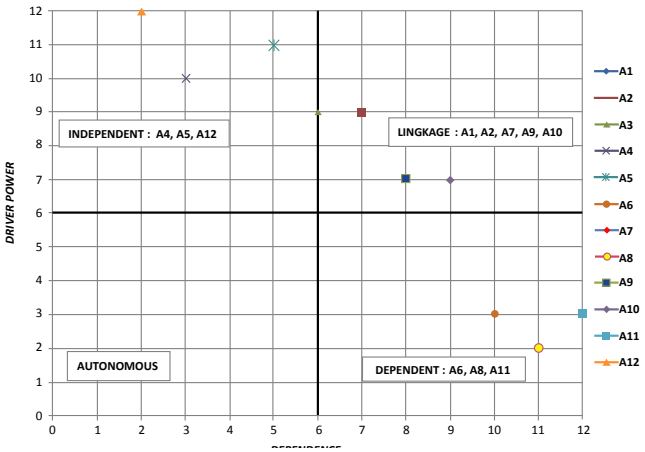

Figure 9: Matrixof driver power-dependence on the required alternative in the use of alternative sustainable GMO in Indonesia.

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