

## Research Article

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## Policy Analysis of Sustainable Genetically Engineered Plants (GEPs) Management Using Decision Making Method in Indonesia

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GMO Biosafety Research, 2015, Vol.6, No.1 doi: 10.5376/gmo.2015.06.0001

Received: 17 Oct., 2014

Accepted: 30 Dec., 2014

Published: 17 Feb., 2015

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Preferred citation for this article:

Deswina et al., 2015, Policy Analysis of Sustainable Genetically Engineered Plants (GEPs) Management Using Decision Making Method in Indonesia, GMO Biosafety Research, Vol.6, No.1 1-9 (doi: [10.5376/gmo.2015.06.0001](https://doi.org/10.5376/gmo.2015.06.0001))

**Abstract** Technology of genetic engineered is an alternative way to improve both the quality and the quantity of agricultural crops. Genetically Engineered Plants (GEPs) as the product of modern technology requires an excellent management strategies especially for the biosafety of the products before being released to commercialized to the public. This study aims determine the policy priorities in making the right decisions in order to GEPs management could be more effective and sustainable while reducing the side effects of this technology to the environment and human health. System analysis approach to take decisions using the Analytical Hierarchy Process (AHP) and Interpretative Structural Modeling (ISM). The outputs of possible policy making based on expert justifications were divided into four (4) levels, i.e.: Focus, Factor, Criteria and Alternative way 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 of GEPs. The gene flow of GEPs to non GEPs was 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. GEPs 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) was 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 Modeling) quadrant matrix, alternative elements are scattered into three quadrants; dependence, linkage and independent.

**Keywords** Genetically Engineered Products (GEPs); Biosafety; Environmental safety; AHP; ISM

### Introduction

The agricultural sector in Indonesia is an important in 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% (Mitchell et al. 2007). However this sector 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 (Shah et al. 2011). Temperature factor is one that provides a real impact on agricultural production, which is predicted

in the last 21st century there will be a decline in world rice production by 41% (Ceccarelli et al. 2010).

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 (Manshardt 2004). 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 has 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 (Josine et al. 2011).

### Biosafety regulations on Genetically engineered products

Genetic engineering technology has been developed in Indonesia since the 1990s and as a result of modern 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 GEPs Biosafety and Presidential Regulation (PR) No. 39 of 2010 about Commission of Biosafety of GEPs, which provide recommendations to the ministries and involved agencies related in the prerelease of GEPs. Both of these regulations confirm the status of GEPs 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.

Before the setting of GR No. 21 of 2005, 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 cotton was stopped planting because of some problems that occur due to unprepared conditions of government and communities for GEPs application. Then, in 2011, Food Safety Certificate was issued from some GEPs 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.or.id](http://www.indonesiabch.or.id)) .

The time line of the enactment of laws and regulations related to the usage of GEPs regulations in Indonesia from 1992 to 2012 (Figure 1) has produced some other regulations and laws that should be able to be implemented for GEPs management in Indonesia. But due to some technical and bureaucracy constraints of the government, the implementations of GEPs 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.

It can be noted that the legal instrument set for the implementation of the GEPs management in Indonesia has been complete, because it has been included on foods (Law (UU) No. 7/1996; Government Regulation (GR) No. 69/1999 about Labeling of GEPs food; Government Regulation No 28 / 2004 about Quality, Nutrition of Food), Plant cultivation (Law No. 12/1992; Decision Letter No 4 1999 Minister about

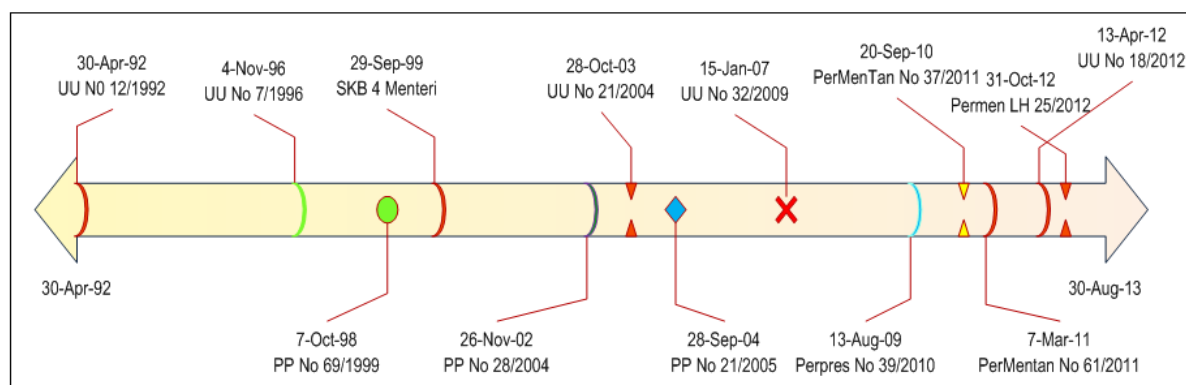


Figure 1 The time line of regulations regarding to biosafety

biosafety and food safety of GEPs; Agriculture Ministry Regulation No 37/2011 Benefit of plant genetic resources; Agriculture Ministry Regulation 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 GEPs; Presidential Regulation No 39/2010 GE Institution) (Figure 2).

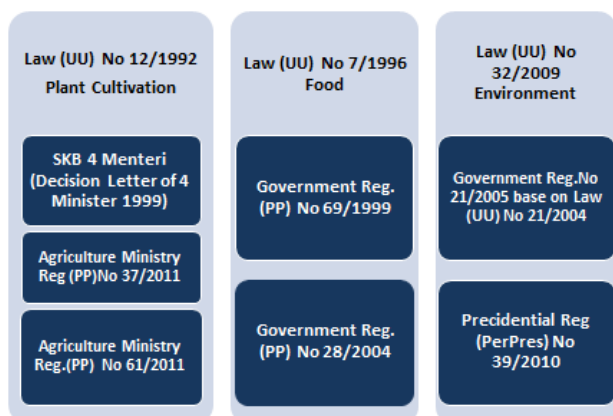


Figure 2 Hierarchy regulation of regarding policy on biosafety of GEPs

### Policy analysis of Biosafety Management

Related for filing, the GEPs 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. The agencies in charge of issuing the permission of GEPs distribution in Indonesia can be seen in Figure 3.

In accordance with the requirements for the release of each GEPs with biosafety certificates, are required some special mechanisms different to other conventional products (Herman 2008). Based on that case, Indonesia government also made efforts to promote awareness to achieve synchronization and interoperability between the information system of related stakeholders involved in biosafety informational

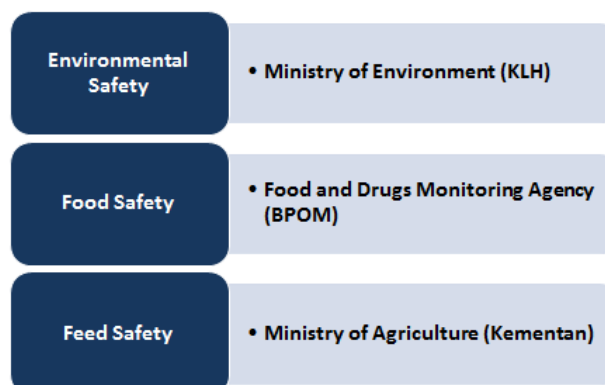


Figure 3 Authorized Agencies in issuing the permission of GEPs distribution

activities, and also 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 them. 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 attention, as well as legal sanctions for the ones who violate these rules.

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 in Indonesia. Review of the policy analysis of sustainable management of GEP was done in order to yield a recommendation to the government in managing the continuous utilization of GEPs 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 GEPs management case in Indonesia, we can add technology factor, in hopes that Indonesia can master the developing technology of GEPs and also for biosafety assessment.

### Research Methods

#### a. 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 hierarchy, both structurally and functionally (Marimin 2005). The AHP method used was developed by Saaty & Saaty (2003). This research involved five experts from various institutions associated with GEPs 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 & Saaty. (2003). Next, the processing of the data to determine the priority element in the decision-making of sustainable GEPs management policy will use the Software *Expert Choice 2000*.

Hierarchy GEPs 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 GEP management today in Indonesia. The hierarchy arrangements are:

- First Level: the focus of sustainable GEP management policy
- Second Level: the factors that play a role in influencing GEP management that consist of environmental, economic, social and technological factors
- 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 GEP 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, GEP safety for human health and the commercialized of GEP Labeling. Last, technological factors consist of human resources capability criteria in doing biological safety testing and human resource capability in doing basic research until GEP obtaining.

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

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. (1992). 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 (Eriyatno 1998). 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

### a. Hierarchy GEP Management Policy using AHP

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

The interest rates based on the role of each level are analyzed to the implementation of GEP management policy bases the continuous study. Based on the experts judgment, hierarchy at the factor level that influence the GEP 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 (Cunningham & Saigo 2001).

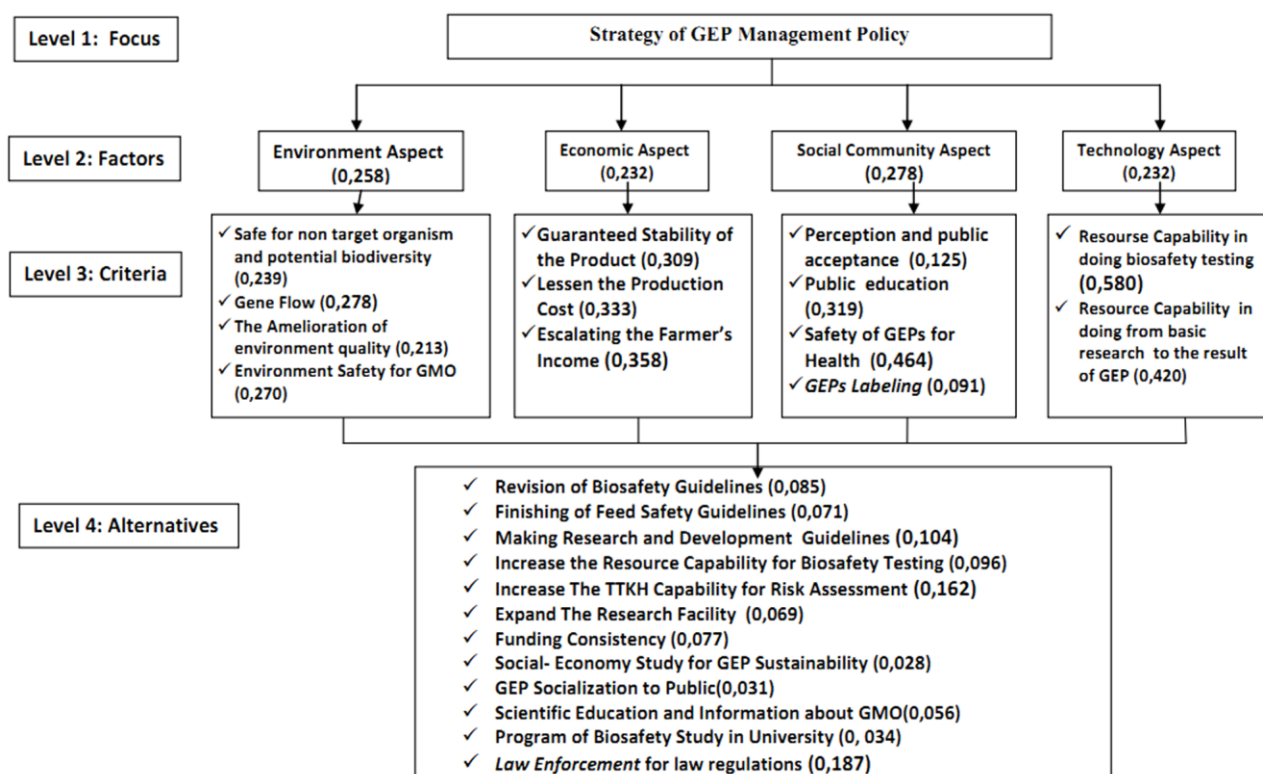


Figure 4 Hierarchy structure by AHP for strategy of management policy analysis

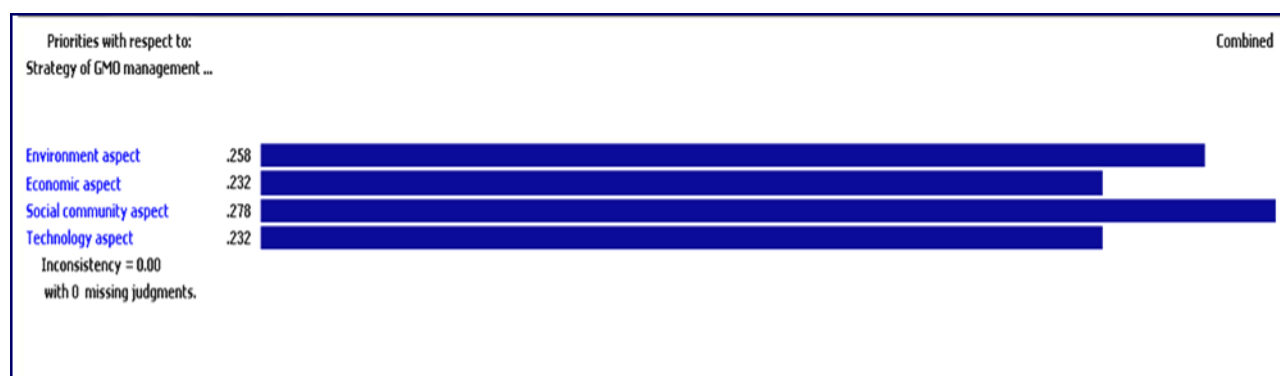


Figure 5 The eigen value to the level of aspects that affect the GEP management

As a modern technology product, the success of the GEPs 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 (Cogoy and Steininger 2007). If there is an imbalance in any of those factors may lead us to unsustainable usage of GEPs.

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 GEPs to non-GEPs, is the main criteria that is expected can influence environment with eigen values 0.278. The emergence of experts concerns of the possibility of gene flow in GEPs is reasonable enough because it will affect the balance of the ecosystem. On the field, the gene flow between GEP crops with similar crops yet non GEP crops can be happened with the fulfillment of certain conditions such as equality types, planting distance, a high sexually compatibility, especially within wild relatives (Rissler & Mellon 1996). If all requirements are met, then the crossing must happen so fertile offspring can be produced. Concerning the rice case, the gene flow



between GEP crops and non GEP crops can naturally occur through pollen carried by the wind, even the possibility is so tiny, because rice is the

self-pollination plant. According to experts, the most important element that has to be noticed from gene flow parameter, is the environmental aspect (Figure 6).

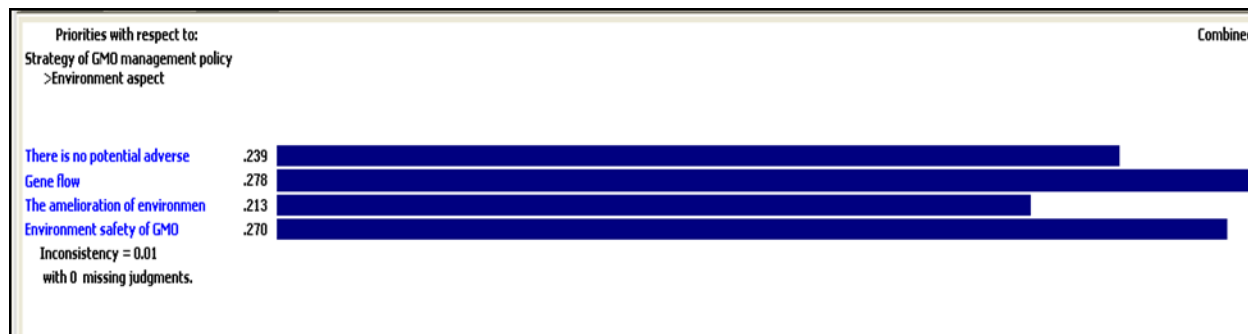


Figure 6 The eigen value of the priority criteria of environmental aspect in GEPs management

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 farmers' income (0.358). Then, the elements of cost reductions of crop (0.333) as well as the stability of GEPs (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 (2012) the usages of GEPs in some developing countries have increased the income and welfare of the farmers. Especially for plants that have enhanced resistance to pests, it can reduce the farmers costs of using insecticides. The biggest benefit to the environment like planting Bt cotton is reduced insecticide using up to 39%, which provides benefits to the increasing production by 31% (Brookes & Barfoot 2003). This figure proves

that the benefit of GEPs especially for the economic increasing can give the communities hope for the government to use GEPs as an alternative to improve crop production and economic industry. The consideration of economic factor is important before utilizing GEPs, because these calculations are required in conducting long-term benefits in achieving national food safety. According to Sharma et al. (2002), 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 (Qaim 2009).



Figure 7 The eigen value of the criteria of economic aspect in GEPs management

From the elements that become priority in social community 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

topublic education about GEPs (0.319), community perception and acceptance (0.125), and labeling factor of GEPs (0.091)- as the complete sequence of priorities presented in Figure 8 below.

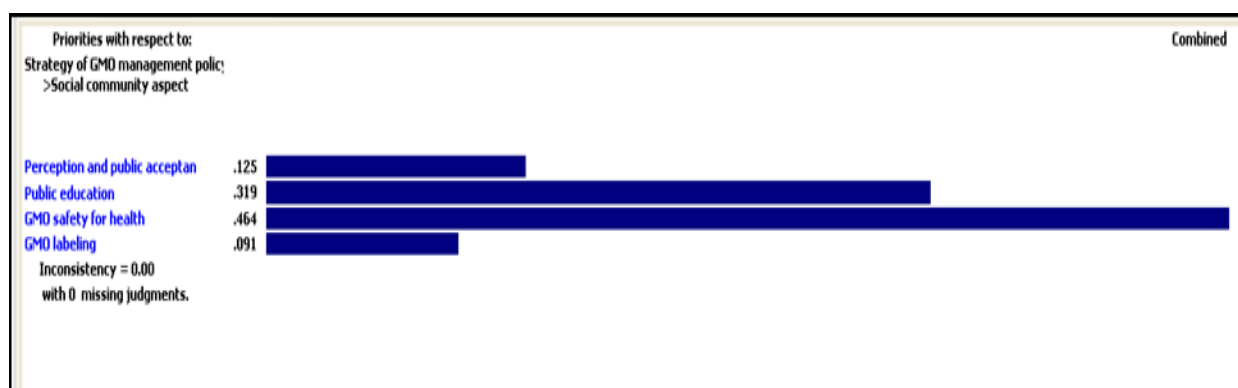


Figure 8 The eigen value of the criteria of social community aspect in GEPs management

The main priority for the GEPs 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 GEPs 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 GEP in Indonesia is still ongoing, especially between the public opinion and acceptance about GEP the risks on the environment and human health. Based on the labeling regulation established since 1996 under Law No. 69 in 1999 on the Labeling of GEP Food, there is a requirement to label any released GEP, but this rule can not be applied until now due to bureaucratic problems in government level.

Eigen values for the alternative of GEPs 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 GEPs 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 GEPs 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.

#### b. Analysis of the required alternative elements in the GEPs 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 GEPs 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 GEPs in Indonesia. Besides, the three sub- elements have a big driver power to other the sub- elements, so that the changes occurring to these three key elements can affect the other elements. Key elements which are at the IV sector need attention and serious study in their implementation.

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

No	Policies alternative	Contribution value of aspect			
		Environment	Economic	Social	Technology
1	Revision of Environment Safety guidelines (0.085)	0.084	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)	0.100	0.093	0.100	0.090
5	Improving the Technical Team of Biosafety (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 GEPs (0.028)	0.028	0.029	0.028	0.028
9	GEPs 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

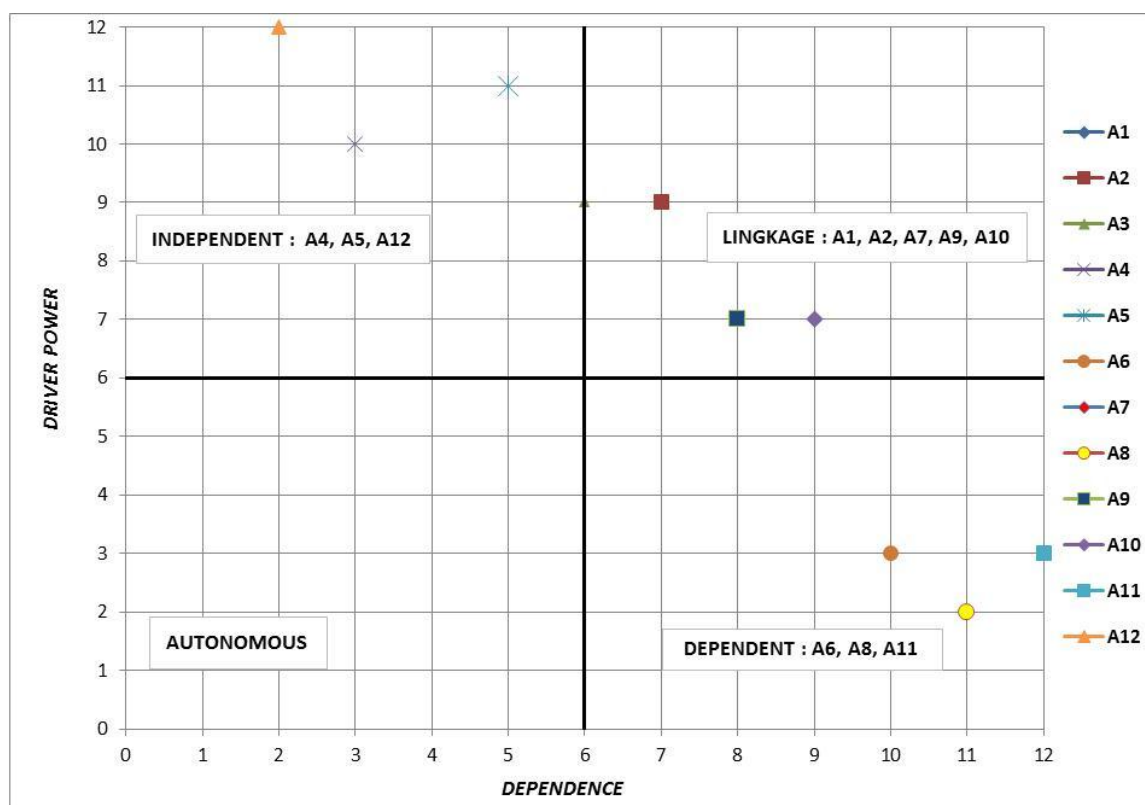


Figure 9 Matrix of driver power - dependence on the required alternative in the use of alternative sustainable GEPs in Indonesia

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 GEPs (A8) and make biological safety courses in college (A11). All of those three elements belong to the dependence sector, which means these three elements can be

selected if they are reinforced by other elements (A1,A2,A3,A4,A5,A7,A9,A10, A12) 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 GEPs (A10) including the third sector are a variable linkage. On the sector III (Linkage 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 GEPs, and in the contrary, if these elements are ignored, they will lead us to the failure in the using of GEPs in Indonesia. It had ever happened in Indonesia on the trial of Bt cotton planting in South Sulawesi, which failed because of Indonesia government did not do a whole study before this GEPs being released and used on the communities. By the existence of the assessment system before GEP using policy, it can reduce the failure as before (Buchori et al. 2005).

## Conclusions

The new technology has risks, which can be positive or 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 GEP being used. The agreement of these states is listed on the Cartagena Protocol, which was signed by Indonesian representative too. Releasing and utilization of GEPs policy in each country have each different procedures and circumstance based on the country need and condition. There are seven regulations that closed related with the biosafety in Indonesia i.e. Decision Letter of four Ministry, Governmental Regulation (GR) No. 21 of 2005 about GEP Biosafety and Presidential Regulation (PR) No. 39 of 2010 about Commission of Biosafety of GEP.

1. The regulatory and laws related with the management policy of GEPs consist of law No 12/1992 about plant genetic resources that are cover the GEPs plant, law 18/2012 about food especially GEPs food safety and law no 32/2009 about protection and management of environment that are cover the GEPs biosafety.

2. GEPs management policy analysis based on making decision method of AHP has resulted four hierarchies level; focus, factors, criteria, and alternatives. For each hierarchy have resulted the important factors in GEPs management for focus are environment, economic, social and technology. Environment factor is the gene flow from GEP crops to non-GEP crops, economic factor is escalating the farmer's income, for social factor is safety of GEPs for health, for technology factor is resource capability

in doing biosafety testing. First priority for alternative level is law enforcement to law regulatory.

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 the most important alternatives to be noticed that will deliver a high effects to other sub- other element in the using of sustainable GEP in Indonesia.

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