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

Deswina P1, Syarief R2, Rachman LM3 and Herman M4

1Bogor Agricultural University, Baranang Siang Campus, Research Center for Biotechnology, LIPI, Indonesia
2Faculty of Agricultural Technology, IPB, Indonesia
3Agricultural Biotechnology and Genetic Resource Research and Development, Agricultural Ministry, Indonesia

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 justifications 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...
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.
Every country has its specific rules and procedures, so that in the Protocol states that each country 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 that 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 hierarchically, 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 research to the result doing from basic research to the result of GMO (0.420).

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.
GMO crop and non-GMO crop can naturally occur through pollen distance, a high sexually compatibility, especially within wild relatives the fulfillment of certain conditions such as equality types, planting the balance of the ecosystem. On the field, the gene flow between eigen values 0.278. The emergence of experts concerns of the possibility expert justification are maintained by element within happening the[10]. If there is an imbalance in any of those factors may lead us to the economic benefits and finally the public welfare is not achieved transfer will lead us to failure in technological aspects, thus reducing resources capability. The late in genetic engineering technology that should pay attention to the main three main factors as pillars; aspects (factors) are related to the principle of sustainable development 0.232 for technological aspects, 0.258 for economic aspects, 0.278 for social aspects and eigen (Figure 5). The judgment result to environmental aspects with that influence the GMO management, seem to have an almost equal study. Based on the experts judgment, hierarchy at the factor level 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 0.278. 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...
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 I3, 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 these 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 variation linkage in doing assessment of biological safety (A5) have a big 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 different procedures and circumstance based on the country need and condition.

| No | Policies alternative                                                                 | Contribution value of aspects                                                        |
|----|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| 1  | Revision of Environment Safety guidelines (0.085)                                      | Environment 0.084  Economic 0.086  Social 0.082  Technology 0.089                        |
| 2  | Making the guidelines of feed safety (0.071)                                          | Environment 0.073  Economic 0.068  Social 0.072  Technology 0.071                        |
| 3  | Making rules of experiments and developments (0.104)                                  | Environment 0.101  Economic 0.106  Social 0.104  Technology 0.106                        |
| 4  | Improving the human resource capability to test its biological safety (0.096)        | Environment 0.093  Economic 0.100  Social 0.100  Technology 0.090                        |
| 5  | Improving the TTKH capability on risk management (0.162)                              | Environment 0.153  Economic 0.163  Social 0.167  Technology 0.164                        |
| 6  | Developing the research facilities (0.069)                                            | Environment 0.079  Economic 0.066  Social 0.067  Technology 0.063                        |
| 7  | Financing consistency (0.077)                                                         | Environment 0.082  Economic 0.081  Social 0.072  Technology 0.070                        |
| 8  | Study economic-social for the sustainable GMO (0.028)                                 | Environment 0.028  Economic 0.029  Social 0.028  Technology 0.028                        |
| 9  | GMO socializing to the communities (0.031)                                            | Environment 0.028  Economic 0.030  Social 0.033  Technology 0.033                        |
| 10 | Scientific Education and Information (0.056)                                         | Environment 0.058  Economic 0.052  Social 0.056  Technology 0.056                        |
| 11 | Study of Biological Safety program in PT (0.034)                                      | Environment 0.035  Economic 0.035  Social 0.032  Technology 0.032                        |
| 12 | Law enforcement of rules and laws (0.187)                                             | Environment 0.178  Economic 0.191  Social 0.185  Technology 0.198                        |

Table 1: Contributions of alternative elements on environment, economic, social and technology aspect within implying the strategy of GMO management.
Figure 9: Matrix of driver power-dependence on the required alternative in the use of alternative sustainable GMO in Indonesia.

References

1. Mitchell B, Setliawan B, Rahmi DH (2007) Resource and Environmental Management. GadjahMada University Press. IKAPI. Yogyakarta.
2. Shah F, Huang J, Cui K, Nie L, Shah T, et al. (2011) Impact of high-temperature stress on rice plant and its traits related to tolerance. J Agric Sci 10: 1-12.
3. Ceccarelli S, Grando S, Maatougui M, Michael M, Slash M, et al. (2010) Plant breeding and climate changes. J Agric Sci 148: 627-637.
4. Manshardt R (2004) Crop improvement by conventional breeding or genetic engineering: How different are they? Biotechnology 5: 1-3.
5. Josine TL, Ji J, Wang G, Guan CF (2011) Advances in genetic engineering for plants abiotic stress control. African Journal of Biotechnology 10: 5402-5413.
6. Herman M (2008) Tanaman produk rekayasa genetik dan kebijakan pengembangannya. Vol 1. Teknologi kayasagenetik dan status of research in Indonesia. Center for Development Penelitian dan Bioteknologi dan Agricultural Genetic Resources. Agency for Agricultural Development Penelitian and. Department of Agriculture.
7. Saaty RW, Saaty TL (2003) Decision Making in Complex Environments: The Analytical Hierarchy Process (AHP) for Decision Making and The Analytical Network Process (ANP) for Decision Making with Dependence and Feedback. Creative Decisions Foundation.
8. Saxena JJP, Sushil, Vrat P (1992) Hierarchy and Classification of program plan elements using interpretive structural modelling. System Practice V: 651-670.
9. Erjatno (1998) System knowledge; Improving the Quality and Effectiveness of Management. Bogor: IPB Press.
10. Cogoy M, Steininger KW (2007) The economics of global environmental change. International cooperation for sustainability. Edward Elgar Pub. Limited. USA.
11. Rissler J, Mellon M (1996) The ecological risks of engineered crops. Massachusetts Institute of Technology, USA.
12. James C (2012) Global Review of commercialized biotech/GM crops: 2012. ISAAA Brief No 43 ISAAA, Ithaca, New York, USA.
13. Brookes G, Barfoot P (2003) GM Crops: Global socio-economic and environmental impact 1996-2009. P.G Economics Ltd. Dorchester, UK.
14. Sharma KK, Sharma HC, Seetharama N, Ortiz R (2002) Development and Deployment of transgenic plants: biosafety considerations. In vitro Cell Dev Biol Plant 38: 106-115.
15. Qaim M (2009) The economics of genetically modified crops. The annual review of resource economics 1: 685-693.
16. Buchori D, Adiwibowo S, Santosa DA, Kartodiharjo H, Triwidodo H (2005) Public participation and development of biotechnology policy in Indonesia: Challenges, obstacles, and opportunities. Department of Plant Protection. Faculty of Agriculture. Bogor Agricultural University. Indonesia.

Submit your next manuscript and get advantages of OMICS Group submissions

Unique features:
- User friendly/feasible website-translation of your paper to 50 world’s leading languages
- Audio Version of published paper
- Digital articles to share and explore

Special features:
- 250 Open Access Journals
- 21 days rapid review process
- Quality and quick editorial, review and publication processing
- Indexing at PubMed (partial), Scopus, EBSCO, Index Copernicus and Google Scholar etc
- Sharing Options Social Networking Enabled
- Authors, Reviewers and Editors rewarded with online Scientific Credits
- Better discount for your subsequent articles

Submit your manuscript at: http://www.omicsonline.org/submission