# Incorporating Biotechnology for Sustainable Farming: Case Study on Developing and Developed Country (Indonesia-Australia)

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**Abstract:** Biotechnology within the agricultural sector, primarily refers to genetic modification technology. Nowadays, breakthroughs in genetic modification (GM) crops have expanded regarding fulfilling the food, fuel, and fiber consumption. More food needed for human rapid population growth. Moreover, the quality of food-related to nutrition content also needs to be developed. This study aims to investigate the status of biotechnology in Indonesia compared to Australia by collecting the published article from the academic portals. It was found that the global status of the biotech crop was varied in several countries. Australia was at great in the area coverage of the biotech crop, with cotton and canola as the biotech crop is grown in Australia. Several GMO plants have received food, feed, and environmental safety certificates from the government of Indonesia, such as corn tolerant insect, sugarcane tolerance in drought, improve soybean and nutrition. However, due to incomplete biosafety assessments, there are no imported or locally developed GMO plants that have yet been commercialized. Sustainability in agriculture relates to the development of agriculture. It means that economic, social, and environment cannot be distinguished apart. Besides an economic impact due to obtaining the great yield, biotechnology can play a role in protecting the natural resources by applying to the infertile land, minimize the nitrogen usage; then, biotechnology contributes to reducing pesticide usage and increasing the human health by preventing malnutrition. The challenges to developing biotechnology come from the consumer's perspective on the side effect of the biotech product, lack of government regulation, high cost to produce the biotechnology product. Then, increasing the knowledge of the society of the biotechnology product and increasing the research and development on clean biotechnology is necessary to overcome the negative concern of biotechnology.

**Keywords:** agriculture; biotechnology; sustainable

## 1 Introduction

The rapid growth of the human population needs more food (Figure 1). Not only related to the food quantity but the food quality as well. Thus, food quality related to nutrition content also needs to be developed (Tester & Langridge, 2010). The paradigm on the developing country is to achieve agriculture productivity than sustainability, management of environmental quality, and natural resources. While sustainability and productivity should not be contrary. The productivity of agriculture is important to be increased to provide food regarding fulfilling the human consumption needs. However, the sustainability of agriculture should be maintained that lead to help the natural resources then contributes to increasing productivity (Saber, 2001).

In order to accelerate productivity and maintain sustainability, there are some challenging issue on agriculture: (1) doublings food productivity in 2050 than today's (Bruinsma, 2002); (2) reducing the negative impact on the environment due to accelerating agriculture productivity (Raven, 2008); (3) climate change adaptation practices; and (4) develop the advance technology that contributes to promoting benefit for a large and small farmer (Martino-Catt & Sachs, 2008).

Nowadays, the developing of genetic modification (GM) crops were approaches to fulfill food, fuel, and fiber consumption. Moreover, the development of GM crops has a co-benefit regarding human adaptation facing the issue of climate change like pest resistance and reducing land capability. The GM crops contribute to promoting crop productivity because it hitches the increasing of pest resistance, disease, and weed also hitch the increasing of plant stress due to lack capability of biotic source (Martino-Catt & Sachs, 2008). However, the status of biotechnology was varied in developing and developed country. Indonesia as a developing country was one of the

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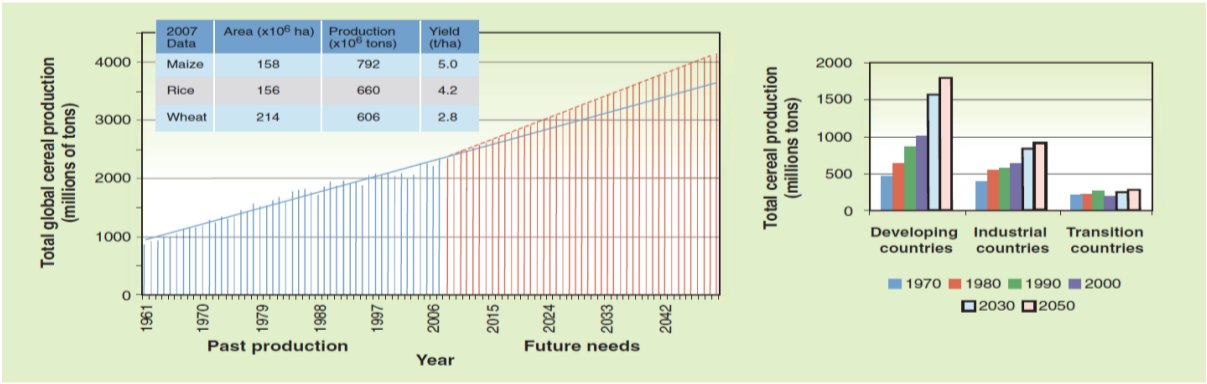
targeted markets on GM products. The United States exported GM products including herbicide-tolerant soybean and meal, Bt cotton, Bt corn, and the derived food product from GM crops to Indonesia with total value was over $1.5 billion (R. T, 2015). Australia, as one of the developed countries that a close geographic area to Indonesia, also obtains a benefit from GM crops such as cotton and canola. Australia exported their cotton to Japan without any GM standard and label (Fitt, 2003). Then, Indonesian experience on GM crops was still lack due to the regulation and negative paradigm of biotechnology (Meyer, 2004). The aim of this review was, therefore, to investigate the status of biotechnology in Indonesia represent developing countries and Australia as an Indonesian neighbor represent developed countries.




(a) (b)

*Figure 1. The cereal production in Past and Future.* ***(a)*** *Global cereal productivity development from 877 million metric tons to 2351 million metric tons in 1961 to 2007 (blue). Then, the prediction of food demand in 2050, increasing cereal production to over 4000 million metric tons in 2050 is needed (red);* ***(b)*** *The developing countries demand on cereals is greater*
(Source: Tester & Langridge, 2010).

## 2 Methods

This study was a desk-based review of a published policy document, reports, and scientific articles related to biotechnology crops in Indonesia and Australia from academic portals. Then, some success story of biotechnology crops to develop economically and inhibit hunger from a developed country not only from Australia was examined to capture the status of advance biotechnology. Afterward, the obstacles to promote biotechnology and its negative impact were lined.

## 3 Result and Discussion

### *3.1 Global, National and Farm Level Implications*

The status of GM crops was varied globally. The total area cover of GM crops was 180 million hectares by 2015. The larger biotech area was in the United States of America, with around 71 million hectares in 2015. 40% of worldwide biotech was grown in the US with commodities such as soybean, corn, canola, potato, and cotton (Table 1) (Clive, 2009).

Table 1: Global Area of Biotech Crops in 2015 by Country (Million Hectares)**

| Rank | Country | Area (million hectares) | Biotech Crops |
|---|---|---|---|
| 1 | USA* | 70,9 | maize, soybean, cotton, canola, sugar beet, alfalfa, papaya, squash, potato |
| 2 | Brazil* | 44,2 | soybean, maize, cotton |
| 3 | Argentina* | 24,5 | soybean, maize, cotton |
| 4 | India* | 11,6 | cotton |
| 5 | Canada* | 11,0 | canola, maize, soybean, sugar beet |
| 6 | China* | 3,7 | cotton, papaya, poplar |
| 7 | Paraguay* | 3,6 | Soybean, maize, cotton |
| 8 | Pakistan* | 2,9 | Cotton |
| 9 | South Africa* | 2,3 | Maize, soybean, cotton |
| 10 | Uruguay* | 1,4 | Soybean, maize |
| 11 | Bolivia* | 1,1 | Soybean |
| 12 | Philippines* | 0,7 | Maize |
| 13 | Australia* | 0,7 | Cotton, canola |
| 14 | Burkina Faso* | 0,4 | Cotton |
| 15 | Myanmar* | 0,3 | Cotton |
| 16 | Mexico* | 0,1 | Cotton, soybean |
| 17 | Spain* | 0,1 | Maize |
| 18 | Colombia* | 0,1 | Cotton, maize |

| Rank | Country | Area (million hectares) | Biotech Crops |
|---|---|---|---|
| 19 | Sudan* | 0,1 | cotton |
| 20 | Honduras | <0,1 | Maize |
| 21 | Chile | <0,1 | Maize, soybean, canola |
| 22 | Portugal | <0,1 | Maize |
| 23 | Vietnam | <0,1 | Maize |
| 24 | Czech Republic | <0,1 | Maize |
| 25 | Slovakia | <0,1 | Maize |
| 26 | Costa Rica | <0,1 | Cotton, soybean |
| 27 | Bangladesh | <0,1 | Brinjal/eggplant |
| 28 | Romania | <0,1 | maize |
| | Total | 179,7 | |

* 19 biotech mega-countries growing 50,000 hectares, or more, of biotech crops
** Rounded off to the nearest hundred thousand
Source: Clive (2009)

Australia, with total area cover at 0.7 million hectares of GM, was at rank 13 with the main biotech crop was canola and cotton (Table 1). The Australian GM cotton was related to herbicide-tolerant and insect resistance cotton. With Liberty Link® and Roundup Ready FLEX® cotton cultivars that tolerance on herbicide, while, the *Bacillus thuringensis* (Bt) or *Ingard*®, *Wide Strike TM and Bollgard II*® cotton cultivars for insect resistance cotton. The main issue on the Australia farming system was pest control, with a cost of 35 to 40% of the total cost production (Fitt, 2003). The Bt cotton contributes a great impact on pest control at the farm level. Cotton in Australia produces more than 3 million bales annually, with 90% of products are exported (Fitt, 2003) with no GM label requirement. Japan accepts Australian transgenic cotton due to provides a good production practice (Chang & Nguyen, 2002).

Another GM crop grown in Australia is canola. The triazine-tolerant (TT) for a herbicides tolerant canola was the most successful conventional breeding (Foster, 2003). In Australia there is two company that accept to produce and release GM canola, Bayer Crop Science produce In Vigor® cultivar, while Monsanto produces Roundup Ready® as two GM canola that tolerant to herbicide (Tasman, 2007). Besides herbicide tolerance, the GM canola promotes 20% higher in gross margin than non-GM canola. However, the cost for GM canola technology did not include gross margin calculation (Tasman, 2007).

Then, GM crop case in Indonesia as a developing country did not develop due to a lack of regulation. The Bt cotton already introduced in Indonesia with Monsanto as a seed supplier. However, Monsanto stops the seed supply in 2002 and closed by 2003. The Bt cotton was unsuccessful in Indonesia because of complaints on pricing and yield. Moreover, GM production also against Environmental Management Law No. 23/1997 (Meyer, 2004). Then in 2005, release Government Regulation number 21/2005 as regulation on approval of GM product regulation mentioned that Biosafety of Genetically Engineered Products requiring a "monitoring and control" system (Clive, 2009).

The Indonesian government already accept some biotech plants that received safety for food, feed, and environmental certificates such as sugarcane tolerance in drought, corn tolerant insects, and improved soybean and nutrition. However, there was no commercialized yet on GM plants and also imported plants and products due to incomplete biosafety assessments (Foster, 2003).

While the approval is still in process, Indonesia is developing biotech plant such as rice with drought, salinity tolerant; Nitrogen Use Efficiency (NUE) rice, rice with resistance to planthopper, sugarcane tolerant to drought, and another crop like cassava, papaya and tomato (Foster, 2003). Rice is the concern on Indonesian GM technology due to the rice function as a staple food for Indonesian.

### *3.2 The Triple Bottom Lines*

**1.** Economy:
- 1.1 Approximately around 18 million farmers gain benefits from biotech crops from 1996 to 2015; around 90% comes from low-income farmers (Clive, 2009).
- 1.2 Cost production to produce GM crops is high, and developing countries gain difficulties in approaching the fund and technology (Johnson, 2002).
- 1.3 Strong market (Jasper, 2016).
- 1.4 Increase yield and reduce production costs.
- 1.5 Opportunities to grow cotton in areas of high pest infestation

**2.** Social*:*
- 2.1 Biotechnology needs high skill workers (Sevier & Dahms, 2002).
- 2.2 Increasing people knowledge regarding health and environmental issues (people aware of global warming, emission, biosafety of GM, the side effect of GM, etc.) (Oladele & Akinsorotan, 2007). The European ~70% do not admit to GM food due to a negative campaign of GM food. However, around 74% of American 74% accept GM food due to low-price food (Cormick, 2002).
- 2.3 Countering malnutrition (golden rice: adding nutrition and vitamins on the rice) (Potrykus, 2012).
- 2.4 A native gene on the native crop will disappear and replace by a biotech crop.
- 2.5 Does not require 'GM' labeling for Australian cotton (Cotton Australia, 2012).

**3.** Environment*:*
- 3.1 Developing crops resistance to pest, disease, and insect contribute to reducing the pesticide usage (Phipps & Park, 2002). Then, it also contributes to reducing the farmer exposure to insecticides (Hossain et al., 2004).
- 3.2 Environmental friendly product-Nitrogen Use Efficiencey crop (Han et al., 2015).
- 3.3 Pest becomes resistant because of the evolution of the pest due to defense mechanism on the metabolic form (Kennedy, 2008).
- 3.4 Useable on marginal land— crop with tolerant in salinity and drought.
- 3.5 Biogenetic biodiversity might be lost.

### *3.3 Sustainability*

Sustainable agriculture development related to agriculture that meets the current needs without reducing the next generation's abilities to face their own (Saber, 2001). It means socio-economic and environment cannot separate apart, should be in one unity. For a socio-economic pint of view, the GM crop contributes to increasing productivity by producing food, fiber and feed to promote security. Furthermore, the GM crop reduces the cost production, pesticide usage, and labor, then gains US$116.9 billion from 1996 to 2012, globally (Clive, 2009). However, Indonesia, which has great human and natural resources, cannot afford the economic benefit of GM crops due to lack of regulation.

Regarding on environment, biotechnology promotes conservation of biodiversity by avoiding deforestation because the biotech crop can grow in the marginal land, does not need land clearing (Engelmann, 2010). Then, this technology-related on the land saving regarding on higher productivity. Besides, biotechnology leads to reducing methane, nitrous oxide, and carbon-dioxide emissions regarding greenhouse gas mitigation action to agriculture as a source of emissions (Brookes & Barfoot, 2009). Also, biotechnology application promotes fewer pesticides and insecticides usage (Phipps & Park, 2002).

However, accelerating agriculture production through biotechnology and intensification to feed the world tends to reduce natural resources. Along with intensification, land clearing practices, pesticide usage, and fertilizer demand were increase. Then, it contributes to reducing the ability of land and natural resources to sustain productivity. Several farming systems have been established to encounter reducing sustainability in the farming system. This system approaches the clean farming concept to support sustainability. The combination of biotechnology and clean farming concept tend to promote the sustainability of the farming system.

The application of organic fertilizer, biofertilizer, biopesticides, and bioremediation of the agricultural ecosystem combine with biotechnology practices will obtain the sustainability of farming systems supporting the clean biotechnology. First, providing the nutrition for plant growth, the integral concept of clean biotechnology along with organic and biofertilizer application contribute to support the soil capacity (Saber, 2001). Moreover, organic fertilizer application is one of the carbon sequestration concepts to mitigate greenhouse gas emissions and increase soil organic carbon (Lal, 2004). Second, application of bio-pesticides by utilizing of organic material and organism that contain active biological agent as a natural mode of having been formulated widely as a biocontrol of pest in agriculture that supports clean farming (Copping & Menn, 2000), then, it contributes to reducing the exposure of consumer to the chemical/synthetic pesticides. Third, the bioremediation to agriculture ecosystem to reduce the toxic pollutant such as pesticide residue contribute to promoting sustainable farming system (Saber, 2001). Then, for safety biotechnology practices, the regulation from the government is needed to support the clean biotechnology and farming system. Furthermore, the labelling of the biotechnology and its derivatives product will secure the consumers. Thus, adopting the clean farming practices will accelerate the clean biotechnology concept to support sustainable farming.

### *3.4 Management of risk*

There is an issue related to food safety. The allergic reaction on the human body to new protein forms from the GM crops is debatable (Metcalfe et al., 1996). Then, another issue is unskilled, and low knowledge farmer on biotech crop promotes social vulnerability such as suicides issue on cotton farmers in India. The massive GM crops marketing inform that it can produce high yield promote the farmer's interest to grow GM crops. Then, the loan money. When the yield was not as high as their expectation, they depress and collapse (Gruère & Sengupta, 2011). Implementing risk management on GM crop is important to minimize the health and social issues. Then, ecological risk assessment is a must before releasing GM crops regarding minimizing the negative impact of GM crops even it takes a year to assess the environmental impact (Hilbeck et al., 2011).

Then the government plays a role in GM crop regulation. For example, in Australia GM regulation is under the National Scheme. The Gene Technology Act 2000 and The Gene Technology Regulation 2001 are creating to protect the safety and health of the people and the environment. Including in this regulation are risk identification and solving, centralized database, monitoring, power enforcement and compliance. Especially in Western Australia (WA), under Genetically Modified Crops Free Area Act 2003, WA farmers now obtain a free change to grow Gene Technology Regulator Licenced commercial GM crops cultivar (Department of Primary Industries and Regional Development, 2019). Another regulation from a developed country such as the USA is they have three departments related to GM product approval. The Food and Drug Administration (FDA), The U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) (Sheldon, 2002).

Another important thing regarding on risk management of GM product is the labelling. It is important as information for the customer/market. Then, the market can decide otherwise to accept the GM product or not. Furthermore, the GMO product with labeled provides detection and traceability (Davison, 2010), also as a part of developing knowledge of the market/consumers.

## 4. Conclusion

Biotechnology is one of the solutions to promote the sustainable farming system as far as carefully thought. Biotechnology promotes economic impact by providing a great yield. Moreover, biotechnology plays a role in natural resource protection. However, the acceptance level of biotechnology crop to the society is quite low due to the negative perspective of the biotech product, and the lack of regulation from the government contribute to slow acceptance of biotech crop. The concept of clean biotechnology and clean farming system by using organic fertilizer, bio-pesticides, bioremediation, and support from government regulation tends to succeed the incorporating biotechnology for the sustainable farming system.

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