Technology's Perspective on Maize-Based Agribusiness in Indonesia

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ABSTRACT. Considering the technological availabilities, economical feasibilities, agricultural development priorities to achieve the national food security status and options for second generation biofuel using non-food crops it should be better off to focus maize-based agribusiness in Indonesia for food and animal feed only, at present. This business should cover upstream to downstream subsystems of agribusiness. Other fundamental principles that should also be implemented are maximizing the application of technologies to minimize wastes and to diversify products. R&D activities should always be parts of the business in order to stay competitive and innovative. At the time when the required technologies for manufacturing high value molecules from maize have been acquired, then it is the time to move on to the next stage of a more sophisticated maize-based agribusiness.

Introduction

Prospect for maize-based agribusiness in Indonesia is bright, considering that up to the present, Indonesia is importing significant amount of this multiple usage commodity to satisfy its domestic demand. In 2011, Indonesia spent more than USD 1 billion for importing maize, both for food industries and for animal feed, but not for biofuel. Since Indonesia has been a net petroleum importer, it is probable that maize also be used for production of bioethanol in the future, although cassava might be economically more feasible for bioethanol production in the tropics. Nevertheless, three possible usages of maize as food crop, animal feed, and raw material for biofuel are major advantages for selecting this crop (Figure 1).

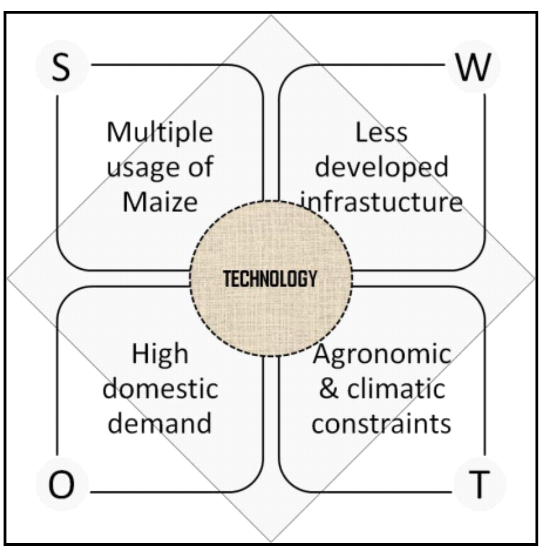

Figure 1. A simplified SWOT for maize-based agribusiness.

Main physical limitation in developing agricultural activities in Indonesia is limited infrastructure network, especially land transportation. The possibly high transportation cost for the bulky commodity produce could be overcome by including on-site processing industry, hence only high-value, small-volume processed products will be transported out of the site. In this scenario, technology will play its role.

Future maize-based agribusiness should not be designed to transport maize ears out of the field, except for sweet corn for fresh market, or export maize grains, but be better off doing upstream and downstream activities on-site and transporting out only value added products such as corn flake, corn syrup, poultry feed, bioethanol, and even pharmaceutical proteins.

As of any other agricultural activities, on-farm maize-based agribusiness will also face serious agronomic and climatic challenges, now and even more in the future. Land and water availabilities will become less and less. Portions of agricultural lands are continuously converted for other purposes and some are degraded due to chemical contamination or serious mismanagement, as also happens to water. Climate changes become harder to predict and frequency of crop damages due to extreme climates increases (Figure 2). The technology has to catch up with these challenges.

It is estimated that there are about 100.7 million hectares of lands suitable for agriculture in Indonesia. Of which, about 64.4 million hectares (64%) has been cultivated and 36.3 million hectares (36%) are available for further agriculture development. Most of the available lands are located in Papua, Kalimantan, and Sumatera islands. However, most of them can be considered as sub-optimal lands, required specific technologies in managing them for productive agriculture.

Technology is Required at All Agribusiness Subsystems

Kim *et al.* (2010) remained us that without technology innovations that bring new product development and the subsequent creation of new demand, the economic growth of the agricultural society reaches its limit. I should add, however, that the products and demands are at all agribusiness subsystems (Figure 3).

The technologies required or contribute to maize-based agribusiness may stretch all the way from technologies associated with development of high yielding varieties or hybrids with specific desired characteristics developed by conventional breeding or biotechnological procedures; designing agricultural machineries for cultivating to harvesting maize; grading and packaging; food processing; animal feed production; bioethanol production, as well as promotion and marketing.

Maize-based agribusiness can go a long way forward, from a conventional on-farm business to highly sophisticated synthesized high value added molecules factories, and from a traditional family business to highly innovative and competitive business. Roles of the technology and skilled human resources increases at high-end of this business progressive chain (Figure 4).

Linier agroindustry metamorphosis model shown in Figure 4 is a simplified version of a reality, neglecting many possible variants of external factors that may alter the transformation process at any stage. In most cases, at early stage, management improvement of agribusiness could increase efficiency in managing resources and increase productivity. After better standard practices had been established, needs for research and development (R&D) to increase efficiency and/or productivity emerge. Two options may be available, namely (1): increasing in-house R&D capacity or increasing technology adoption capacity, and (2)r initially strengthening technology adoption
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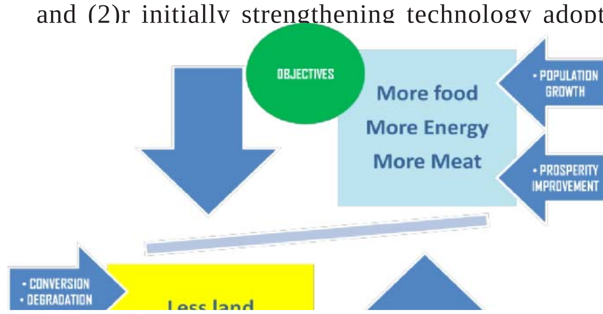

Figure 2. Challenges in on-farm maize-based agro industries.

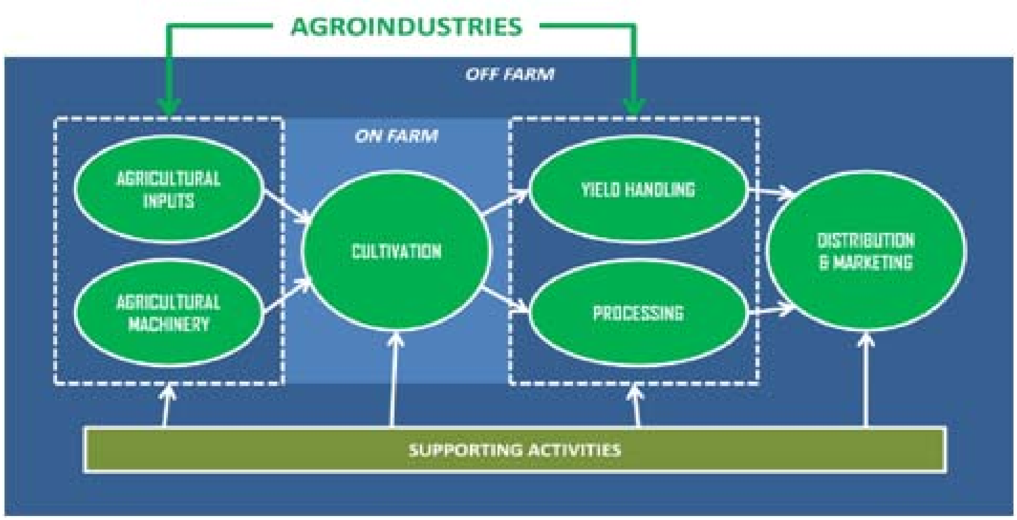

Figure 3. Agroindustry and other agribusiness subsystems (Lakitan 2011).

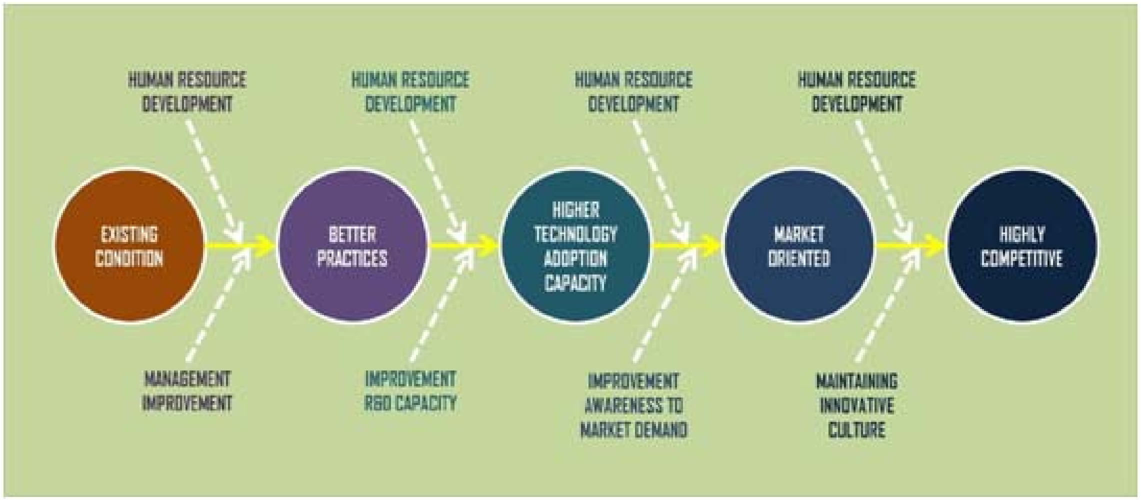

Figure 4. Linier agroindustry metamorphosis.

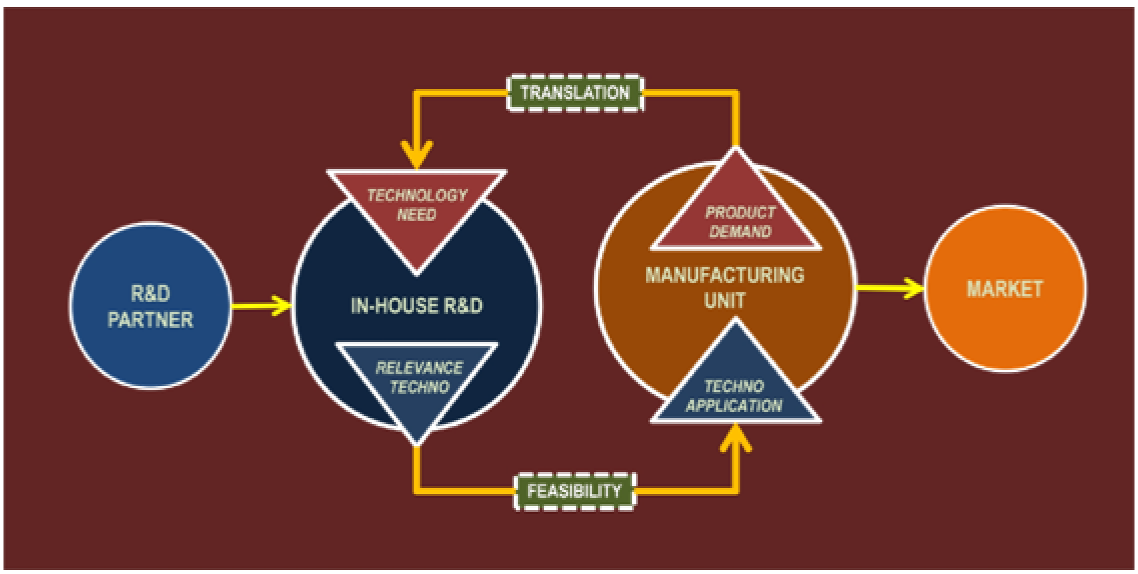

Figure 5. An example of a maize-based agribusiness innovation system.

competitive products as demanded by the markets. Maize-based agribusiness should establish its own innovation system (Figure 5). Signal of market demands on specific products received by the marketing unit is transferred to the manufacturing unit, which then by the R&D unit is translated into technological needs. In-house R&D unit collaborates with or without its external partners develop relevant technologies for manufacturing the requested products. Economic feasibility of the technology may be further evaluated and its efficiency may be further improved as requested by the manufacturing unit to keep business more competitive.

Existing position of Indonesian maize-based agribusiness at present perhaps could be considered as at its early stage with some progress into primary processing in food and animal feed industries. There is still huge opportunities at on-farm businesses. Technologies are still needed to increase the maize productivity from current (2011) national average of 4.56 ton/hectare (less than half compared to that of USA at 9.4 ton/hectare), especially technologies for developing adaptive varieties and best cultural practices for sub-optimal lands. However, to increase competitiveness of this agribusiness, the on-farm activities needs to be coupled with processing industries to produced more valuable products, be it food, feed, or fuel products, depending on the market demand.

Food, Feed, Fuel, or Others

In general, composition of maize grain based on its wet weight (16% water) consists of 61% starch, 19.2% protein and fiber, and 3.8% oil. This composition makes it favorable for maize to become a multi-usage crop. In many countries, maize is a main staple food. In other countries, it main usage is as animal feed or become a major source of biofuel. Now, it is also considered as raw material for manufacturing high value molecules. And technology makes the differences!

For instance, in USA (2009) maize was used for feed and residuals (42.5%), bioethanol (32.1%), High Fructose Maize Syrup (3.5%), other usages (6.2%), and the rest was exported (15.7%). Almost all (97%) of the bioethanol used as biofuel in USA was produced from maize (Ajanovic, 2011). In Indonesia (2011), it is estimated about 47% of maize was used for animal feed, 53% for food, and none was commercially used for production of biofuel.

Interestingly, how a country predominantly use maize seems to be associated with its technology advancement, since maize can be directly consumed as food or used as animal feed, required a relatively more advance technology for processing it into biofuel, and sophisticated technology for production of high value pharmaceutical or industrial molecules. Besides, from maize grain as major source, bioethanol can also be produced from maize biomass that contains lignocelluloses (Hoekman, 2009), although it needs a higher cost with a lower recovery rate (Figure 6). Furthermore, lignocellulosic waste can be used for production of single cell proteins for animal feed supplement (Mathews *et al*., 2011).

Naqvi *et al.* (2011) believed that maize was at the beginning of a new agricultural revolution, where maize grains were used as factories to synthesize high-value molecules. Maize is useful for pharmaceutical proteins, because they can be stored for years, even at room temperature without the recombinant protein losing activity. A mature maize seed is desiccated lacks active proteases and contains a rich mix of molecular chaperones and disulfide isomerases, helping to ensure correct protein folding, assembly, and enhanced stability.

In addition to its physiological and biochemical properties, according to Naqvi *et al.* (2011), maize may also be used as a platform for high-value products due to its: (1) GRAS (Generally Regarded as Safe) status; (2) established agricultural infrastructure; (3) well characterized genetic properties; (4) amenability to *in vitro* manipulation and gene transfer, (5) efficient biomass production, and (6) C4 photosynthetic pathway.

High value molecules that can be produced from maize grain include primary metabolites, vitamins and minerals, and recombinant proteins (Table 1).

Clearly, technology has opened many options for use of maize as food, feed, fuel, and high value molecules, mostly for health purposes. Some developed countries have this full spectrum of options are viable, but Indonesia may not be ready for taking up all the options yet. If it is not due to technological limitations, it may be due to

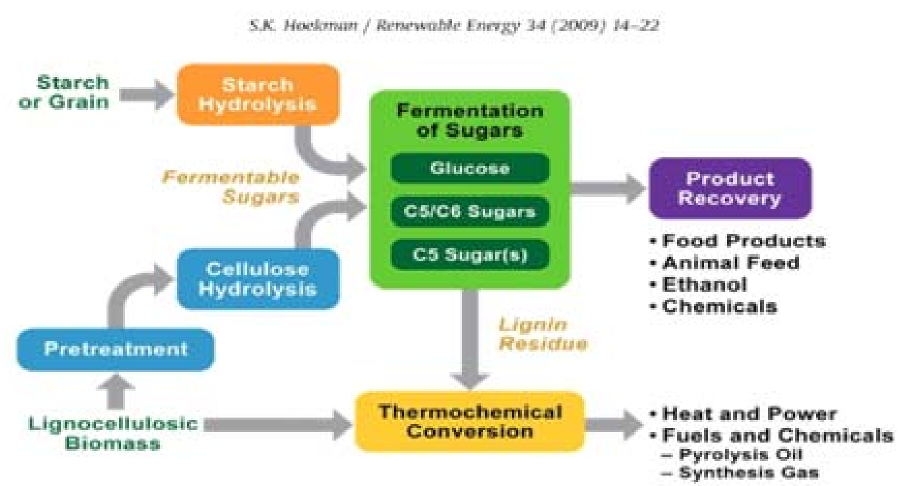

Figure 6. Bioethanol processing from maize grain and biomass (Hoekman 2009).

Table 1. High value molecules can be produced from maize.

Primary metabolism	Vitamins & minerals	Recombinant proteins
Carbohydrates Amino acids Fatty acids	Micronutrients Carotenoids Vit B9, C, E	Pharmaceutical proteins Industrial proteins

Source: Naqvi *et al.* (2011)

economical constraints, such as the case of biofuel development in Indonesia during last few years, despite the National Energy Policy that strongly encourage the increase of biofuel in the national energy mix. In contrast, there were immediate positive responses to the passage of the 2007 U.S. Energy Independence and Security Act, in the form of massive investments in the U.S. ethanol plants and dramatic increases in the maize demand (Martin, 2010). Public policy seems to work if the required technologies are available, economically affordable by government and the people, and supported by private sectors.

Open option for maize usage may also has a drawback. Competition for its use as food and for fuel has been a hot issue, as also for other food crops that has the potential to be used as feedstock for the first generation biofuel. For instance, in the US, from 2006 to 2007, maize acreage grew by 19% (70.000 km2) to almost 370.000 km2. Most of this expansion came at the cost of soybean planting, which decreased by 17% (50.000 km2) from 310.000 to 260.000 km2. This is approximately 6% of the world's area used for soybean, and resulted in prices of soybean being driven up. For this reason, other countries had increased motivation to expand soybean production, possibly by increasing deforestation. Further discussions in this issue can be read in Goldemberg and Guardabassi (2009), Hoekman (2009), Martin (2010), and Ajanovic (2011).

Closing Remarks

Considering the technological availabilities, economical feasibilities, agricultural development priorities to achieve national food security status, and options for second generation biofuel using non-food crops; it should be better off to focus maize-based agribusiness in Indonesia for food and animal feed only at present. This business should cover from upstream to downstream subsystem agribusiness. Other fundamental principles that should also be implemented are maximizing the application of technologies to minimize wastes and to diversify products.

R&D activities should always be part of the business in order to stay competitive and innovative. At time the required technologies for manufacturing high value molecules from maize has been acquired, then it is the time to move on to the next stage of a more sophisticated maize-based agribusiness.

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