Possible Socio-Economic Impacts of Biotechnology in Indonesia

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ABSTRACT

There are scanty studies specifically focused on the impact of biotechnology in general, let alone the impact of biotechnology in developing countries. This is apparently due to the complexity of such an impact study which is highly determined by the dependence of a country's economy on the product concerned, its technological potential to respond to changes in the world market, and the dominant farming systems in which the crop is grown. Most of the available publication on the impacts of biotechnologies are dealing with the *possible* impacts on developing countries, which might be positive, negative, or both. Inspite of limited information about the *actual* socio-economic impacts of biotechnology in developing countries, the trend for development in developed and advanced developing countries, particularly in Asia and ASEAN countries, seem to be encouraging. This is shown by the high priority given to biotechnology in their national development programs. In many cases the different possible impacts of biotechnology on developing countries in general and on ASEAN countries in particular, are also applicable to Indonesia, especially in areas where (traditional) biotechnologies have been practiced for a long time as well as in new endeavours involving extensive and intensive utilization of the rich Indonesian biological resources. Some salient examples are presented. Obviously, more focused studies are needed at national level in order to distinguish the actual impact of biotechnologies from that of other technologies applied in the same sector, e.g. agriculture, health, animal husbandry, industry, the environment, bioremediation, biodiversity, and to establish which techniques are the most appropriate and whether they may be used in other similar locations.

Key words: Socio-economic, impacts, biotechnology.

ABSTRAK

Studi khusus mengenai dampak bioteknologi tidaklah banyak, apalagi yang khusus berkaitan dengan negara-negara sedang berkembang. Kemungkinan hal ini disebabkan oleh kompleksnya studi semacam itu yang sangat dipengaruhi oleh ketergantungan ekonomi sesuatu negara terhadap produk bioteknologi bersangkutan, potensi teknis negara bersangkutan bereaksi terhadap perubahan pasar global, dan sistem pertanian utama yang menghasilkan produk bioteknologi tersebut. Kebanyakan informasi yang tersedia adalah mengenai *kemungkinan* dampak bioteknologi terhadap negara sedang berkembang yang dapat bersifat positif, negatif, atau kedua-duanya. Meskipun informasi tentang dampak sosio-ekonomi bioteknologi yang *sebenarnya* di negara-negara sedang berkembang sangat terbatas, namun kecenderungan perkembangan yang ada di negara-negara maju dan negara-negara berkembang yang maju, khususnya di Asia dan ASEAN, cukup menggembirakan. Hal ini terlihat pada pemberian prioritas tinggi pada bioteknologi dalam program-program pembangunan mereka. Berbagai *kemungkinan* dampak bioteknologi terhadap negara-negara sedang berkembang pada umumnya dan

terhadap negara-negara ASEAN pada khususnya, dalam banyak hal, juga berlaku bagi Indonesia. Hal ini khususnya berlaku di bidang-bidang di mana bioteknologi (tradisional) telah lama dimanfaatkan, dan juga pada upaya-upaya baru yang melibatkan secara luas dan intensif pemanfaatan sumber daya hayati Indonesia yang kaya. Beberapa contoh yang relevan dikemukakan. Jelas bahwa diperlukan lebih banyak studi terarah pada tingkat nasional untuk dapat membedakan dampak *sebenarnya* bioteknologi dari teknologi lain yang digunakan dalam bidang yang sama, misalnya bidang pertanian, kesehatan, peternakan, industri, lingkungan, bioremediasi, keanekaragaman hayati, serta untuk menentukan teknik mana yang paling cocok dan apakah teknik tersebut dapat digunakan di tempat lain yang mempunyai kondisi sama.

Kata kunci: Sosio-ekonomi, dampak, bioteknologi.

INTRODUCTION

Biotechnologies offer a wide range of tools, with various levels of technical sophistication, economic investment and efforts. Hence, the possibility of choosing the appropriate techniques, with a view to achieving the most positive impacts. However, biotechnologies are neither a panacea, nor a substitute, to coventional and effective techniques such as those of crop breeding, animal breeding, or traditional vaccine production. To be effective biotechnologies need to be supported by research and extension.

In contrast to industrialized countries, most developing countries have very little, if any, modern industrial biotechnology. Programs in biotechnology deal mainly with traditional and with intermediate biotechnology. Nevertheless, there appears to be a positive trend in biotechnology development and in its impact.

The major constraints foreseen on the development and application of biotechnology in developing countries are as follows: (1) the lack of free flow of scientific information among scientists and from laboratories in developed countries to developing countries on account of the proprietary nature of the information, (2) the possibilities that the multinational corporations will develop technologies that will not be appropriate for developing countries, (3) the lack of scientists and trained personnel in these countries to build research institutions where appropriate technologies can be developed, and (4) the shortage of the skills required by labour and management to employ many biotechnologies (Hueth *et al.*, 1992).

There are scanty studies specifically focused on the impact of biotechnology in general, let alone the impact of biotechnology in developing countries. This is apparently due to the complexity of such an impact study which is highly determined by the dependence of a country's economy on the product concerned, its technological potential to respond to changes in the world market, and the dominant farming systems in which the crop is grown (Lee and Tank, 1989; Sasson, 1991; Commandeur, 1995a).

Most of the available publication on the impacts of biotechnologies are dealing with the *possible* impacts on developing countries, which might be positive, negative, or both. Some of these impacts include: (a) the improvement of crop productivity and overall food production through the direct use of plant biotechnologies, as a complement to conventional breeding techniques, (b) the improvement of nutrition quality, through improvement in the quality of agricultural and agroindustrial products, and the up-grading of food processing, (c) better integration of food production with bioenergy production and consumption at household and village levels; (d) the increase and improvement of livestock production and the health of domestic animals, (e) more accurate diagnosis and prevention of diseases, and on the improvement of public health, (f) the trade patterns between developing countries and industrialized countries especially in agricultural commodities and agroindustrial products, (g) the commercialization of new bioindustrial products that tend to replace foodstuffs and various biochemicals produced by the developing countries, thus depriving the latter of an important source of income (displacement effects), (g) income and employment, (h) the possible extension of cash crops at the expense of food crops, (i) the strengthening of the large agricultural estates, resulting in the displacement of small holders and landless farmers, (j) the possible decrease of genetic diversity as a consequence of the widespread distribution of new cultivars, (k) the increased privatization of research results in plant biotechnologies (OECD, 1989; Persley, 1990; Sasson and Costarini, 1991; UNCTAD, 1991).

Inspite of limited information about the *actual* socio-economic impacts of biotechnology in developing countries, the trend for development in developed and advanced developing countries, particularly in Asia and ASEAN countries, seem to be encouraging. This is shown by the high priority given to biotechnology in their national development programs (ASEAN, 1992; Sasson, 1993; Schmid *et al.*, 1995; Yuthavong and Gibbons, 1994.).

In many cases the different possible impacts of biotechnology previously mentioned are also applicable to Indonesia, especially in areas where (traditional) biotechnologies have been practiced for a long time as well as in new endeavours involving extensive and intensive utilization of the rich Indonesian biological resources. Some salient examples are presented.

POLICY ON BIOTECHNOLOGY

In Indonesia biotechnology has received a high priority in the national S and T development program. To that end, a National Committee on the Development of Biotechnology (NCDB) was established by the State Ministry for Research and Technology (SMRT) with the following functions: (a) to prepare and formulate a national policy and development program on biotechnology, (b) to provide guidance and encouragement in the development of bioindustry and its supporting R&D and

human resources, (c) to give direction for the establishment of national, regional, as well as international network for cooperation in biotechnology, and (d) to monitor the implementation of the national policy. To implement this national policy, a national program was drawn up which includes: (1) production of fine chemicals and pharmaceuticals such as antibiotics, amino acids, vitamins, (2) mass production through micropropagation of industrial, horticultural, and forestry plant species, (3) improvement of food crops quality, in particular rice and soybean, (4) improvement of beef and dairy cattle quality through embryo transfer, and (5) production of various diagnostics and vaccines for human and animal diseases (Saono, 1995).

It was also decided that the national program be implemented by the so called "Centers of Excellence", i.e. Center of Excellence on Agricultural Biotechnology I and II, coordinated by the Central Research Institute for Food Crops (CRIFC) and Research and Development Center for Biotechnology (LIPI), respectively, both in Bogor; Center of Excellence on Health Biotechnology, coordinated by the Medical Faculty of the University of Indonesia in Jakarta; Center of Excellence on Industrial Biotechnology, coordinated by the Agency for Technology Assessment and Application (BPPT) in Jakarta. Each of these centers has the task to set up a network of institutions active in its particular field (Saono, 1995; Saono *et al.*, 1995).

As a consequence of this policy, there has been a significant increase of budget allocation to the relevant organisations as well as through the so called the Integrated Superior Research (RUT) scheme to support research and development activities in biotechnology (Brotonegoro *et al.*, 1992; Saono, 1995; Darussamin *et al.*, 1996).

With a very few exceptions, most of the activities in biotechnology are still in the research and development stage. As it would take time to translate the results of research and development activities into commercialization, it is hard to give a conclusive assessment on the socio-economic impacts of biotechnology in various fields of endeavours. The most that could be done is to asses the possible impacts of biotechnology application in a number of fields in the foreseeable future in Indonesia.

FOOD CROPS

Specific constraints for sustainable agriculture production of important food crops that may be alleviated by the use of biotechnology are as follows: (1) lack of rice cultivars resistant to stem-borer and viral diseases and lack of soybean cultivars resistant to pod-borer and environment stresses; (2) inadequate supply of good seeds and planting materials for horticultural crops because most of them are introduced temperate/subtropical species; (3) many of the introduced horticultural species lack of resistance against numerous local pests and diseases.

Through the application of biotechnology it is expected that in the near future new varieties of rice, corn, and soybean resistant to their common pests and diseases,

as well as hybrid rice, will be created. Likewise, new horticultural crop cultivars resistant to prevalent local pests and diseases will be developed (Saono, 1996a,1996b).

On the other side, biotechnology will allow also the development of plant varieties resistant to increased use of chemical inputs (fertilizers and pesticides) and could provide a means for corporations to tie the purchase of seeds to use of these chemicals (Dembo *et al.*, 1987).

While hybrid seeds could boost production, they could have an adverse impact in terms of loss of biodiversity and loss of ability of seed saving, which forces farmers to buy new seed every year. More and more aspects of farming, from seed supply to the processing and marketing of the harvest, are controlled by companies in the agribusiness. This dependency might have adverse effects, given the fact that the private sector is largely controlled by the narrow profit motives. Another potential consequence of the private sectors control over the seed production is that food production will be replaced by production for luxurious consumer markets and for export (Pandey, 1994).

CASH CROPS

Biotechnology increasingly offers opportunities for product and yield improvement of major Indonesian cash crops such as coffee, cocoa, tea, oil palm. Most of the research are in progress, results may only be available in the near or distant future. Examples of commodities which may be effected by development achieved in developed countries include:

Coffee

Although genetic engineering of coffee is still in the early stages, some researchers are concerned about the social and economic impacts on small farmers and rural communities in developing world. With the exception of Brazil, Colombia, Kenya and Indonesia, coffee is not generally a plantation crop but grown by small farmers on diversified land holdings. As research concentrates on *C. Arabica*, coffee production, and in the future also coffee exports, increasingly will be dominated by few successful arabica varieties.

The potential negative consequences include: (a) genetic uniformity, (b) overproduction and lower prices. It is usually the largest coffee producers who can afford to adopt new coffee varieties, and they will be the most likely to survive a restructuring in the coffee economy, and (c) transfer of production from poor to more advanced developing countries.

Overall, the application of new biotechnologies to coffee could facilitate a fundamental shift to large-scale coffee growing plantations in the developing world (Anonymous, 1990, 1995).

Vegetable Oil

Since 1966 Eoropean Union (EU) policy support vegetable oil production with the objective to increase self-sufficiency of oil meals, for animal meal in particular. Imports of oil seeds and oil meals were not restricted, in contrast to the import levies for vegetable oils, ranging from 4% for unrefined palm oil to 15% for refined oils. Countries (such as Indonesia) have a relative advantage over those producing saturated coconut oil. To a certain degree such an advantage is the fruit of application of biotechnology in oil palm production. If the policy is liberalized or changed to one favouring environmentally-friendly production techniques, greater benefits will be gained by these countries (Commandeur, 1995b).

A negative impact for palm oil exporting countries may come from attempts by a number of developed countries to produce a rapeseed variety that makes oil containing lauric acid, low erusic acid, and low glucosinolate. Such variety produces nutritionally-oils for human consumption and to develop meal suitable for animal feed. This is certainly a threat to the traditional lauric acid-containing oils from coconut and palm kernel (Bijman, 1994).

BIOFERTILIZERS AND BIOPESTICIDES

The likely impact of biofertilizers and biopesticides application are positive in terms of increased productivity of tropical crops, opening up of new opportunities for the use of marginal lands and reduction of the use of pesticides for the succeeding crops. Even now there are already two of Rhizobium inoculant producers in operation, respectively the Faculty of Agriculture - Gadjah Mada University at Yogyakarta producing "Legin", and a private company at Bogor producing "Rhizogin" (Saono, 1992). Other biofertilizers, such as phosphorous solubilizer and mycorrhiza inoculant are in the pipeline and most probably will be produced by one of the state plantations.

Most of the works on biopesticides are still at the research stage and will take some time before commercialization. The majority of the products presently available in the market are imported. As the majority of these biopesticides were developed for crops and pests of importance for home country, the direct significance of these products for developing countries is not very large. To benefit from such product developing countries have to invest in the adaptation of the imported product.

Widespread dependence on limited protection of biopesticides, such as Bt, may also lead to an increase in the genetic vulnerability of crops to pests and diseases. On the other hand, widespread use of transgenic herbicide-tolerant genotypes may lead to environmental pollution and negative impacts on sustainable agriculture due to more widespread and increased use of herbicides (Woodend, 1994).

LIVESTOCK

The application of biotechnology to animal husbandry does not lead necessarily to an increase in animal protein availability to developing country populations especially the poor. In the worst case, the possibilities for increase in animal consumption by the rich as well as in production for export, could divert crops from food sources for the poor (Dembo *et al.*, 1987).

One of the well documented issues on the impact of biotechnology is the application of bovine somatotropin (BST). Although at present the debate is taking place in the developed countries, as soon as it is settled, it might be relevant to Indonesia. BST is the only biotechnical development that has been subject to intensive evaluation thus far. It is likely that BST will accelerate, but not dramatically, dairy production. The farms most likely to profit from rBST are the modern, moderate sized dairy farms, which operate like dairy farms in industrialized countries. In general, effectiveness may be determined by the usually poorer economic and technical context. It is very likely that adoption will not only be determined by technological factors or farm economics: cultural, political and national economic factors will have significant influence as well (Hueth *et al.*, 1992; Bijman, 1996).

BIOINDUSTRIAL PRODUCTS

Biotechnology provides a means by which chemicals formerly produced by plants in developing countries and sold at high prices in developed countries, can be produced in laboratories anywhere, thereby displacing important sources of income to farmers and peasants as well as export revenues in these countries. The technology also leads to the displacement of export crops as the end products from these crops (e.g., drugs based on medicinal plants) can be made through biotechnological methods thereby avoiding and undermining controls by developing countries.

Applications such as the production of fuel alcohol, substitute products of vanilla, some medicinal plants, pyrethrum, some oilseed crops, and cocoa butter will affect the current use and production of crops. Thus, the use of sugar cane for fuel alcohol, for example, would result in lessened availability of sugar cane for other purposes. In addition, expanding land use for alcohol production, would lead to the possibility of the removal of lands for food and animal food production (Dembo *et al.*, 1987; Woodend, 1994).

There are economic potentials making research in biotechnological production of cocoa butter and pyrethrin feasible. The annual world market for the natural pyrethrum insecticide has been estimated to be as high as US$ 400 million (1992), while the conventional production of natural pyrethrins is still below global market demand. If bio-pyrethrin and cocoa butter substitute would cost less than the natural products and capture a substantial share of the market, this could prove to be economically very damaging to a very large number of small scale pyrethrum farmers in East Africa and small holders' cacao plantations in Indonesia (Jovetic, 1994; Saono, 1996b).

Another well-known example of the negative impact of the substitution of traditional commodities as a result of the application of biotechnology is the introduction of High Fructose Corn Syrup (HFCS), the product of an enzymatic transformation of corn starch. It is the most important sugar substitute in the USA. In the past 2 decades, HFCS share in the total US domestic sweetener consumption has gradually increased: between 1975 and 1985 this share grew from 5 to 34%. In 1984, Coca Cola and Pepsi Cola decided to stop the use of refined sugar and to utilize HFCS as a substitute sweetener in the USA. After 1984 the US sugar quotas for the Philippines were sharply reduced (Pistorius, 1994).

THE HEALTH SECTOR

Although there is still an urgent need for new vaccines, drugs and other pharmaceutical products, it is quite unlikely that the developing countries will be in position to compete with the industrial countries in the development and production of these pharmaceutical products. This is due to the high cost of biotechnology research as well as the instransparency of the market and pricing of pharmaceutical products. What the developing countries could probably participate is in the development, and eventually also the production, of some relatively cheap diagnostics specific for tropical diseases which might not be attractive to the multinationals. As an example, a genetically engineered anti-hepatitis B vaccine costs about US$ 15 a dose while those currently used by WHO cost only a few US cents (Anonymous, 1991).

ENVIRONMENT AND BIODIVERSITY

The possible serious impact of biotechnology application to the environment and biodiversity is due to the introduction, adoption and widespread distribution of biotechnologically improved and rapidly propagated genotypes and new cultivars. The problem is compounded by the establishment of the "Timber Plantation Forests" using plantlets or seedlings derived from tissue or organ culture. Such an introduction

may create a disastrous impact on plant genetic resources if the necessary precaution is not observed because Indonesia represents one of the biodiversity centers of the world (Sasson, 1991; Sasson and Cosstarini, 1991; Woodend, 1994; Adiwibowo *et al.*, 1995; Hartiko, 1995; Kathen, 1996).

In the distant future biotechnology could eventually help to recreate lost plant and animal species. However, at present and the near future what could be expected from the application of biotechnology is for storage and maintenance of endangered species (Dembo *et al.*, 1987).

TRADE

Applications of biotechnology will first of all affect trade in agricultural products. It will make many importing countries more self-sufficient and increase trade conflicts among overproducing countries. While overall agricultural exports from developing countries will probably stagnate, biotechnology will help to substitute products from specific (more developed) countries for commodities from other (less advanced) developing countries, contributing to a stronger concentration of agricultural production for the world market on fewer developing countries known as 'Newly industrializing countries' (NICs), such as Indonesia, which has resource endowment comparative advantage thanks to the specific conditions required for growth. Given the technological capabilities, these NICs will also be able to boost their agricultural production (OECD, 1989; Junne, 1992).

EMPLOYMENT

In the distant future, new biotechnologies will develop opportunities for labour savings due to the substitution character of new innovations, especially in agriculture, and the cost reduction policies of the large industrial companies active in biotechnology. Conversely, particularly in agriculture, these labour savings might delay the diffusion of biotechnology by a few years. Otherwise, biotechnology might during this period, add to the unemployment problem. The figures could vary considerably between countries, depending upon the size of their agricultural sector. The countries least vulnerable to negative job-impacts of biotechnology are those where technical progress has already had large-scale effects and where employment in agriculture is comparatively small. In these countries, where Indonesia is one of them, the additional job-losses due to new biotechnology alone, if any, might be compensated for by new employment created by new biotechnology products and markets, or by expanding biotechnology exports (OECD, 1989).

Therefore, it is very important to identify the category of labour displaced by biotechnologies. If they displace primarily family labour, the impact on the market for

hired labour will be limited. But if biotechnology applications lead to massive displacement of hired labour, this will significantly depress the rural wage rates for the related agricultural operation (Saono, 1992).

BIOSAFETY, INTELECTUAL PROPERTY RIGHTS (IPR), AND ETHICAL ISSUES

It is true that the release of genetically engineered microorganisms or plants raises safety and ethical issues and lends itself to debate, including in Indonesia, on the effects of such a release on the environment.

While there are no specific guidelines for GMOs application, the existing regulations administered by a variety of ministries, e.g. on the safety of production and efficacy of products by the Ministry of Health; on patents by the Ministry of Justice; on quarantine by the Ministry of Agriculture; on pollution by the State Ministry for the Environment to a certain extent are still applicable.

In 1993 a guideline on Genetic Engineering Research has been released by the State Ministry on Research and Technology. Although the emphasis of the guideline is on the requirements for and control of research on genetic engineering, indirectly it provides additional protection against possible hazard of GMOs release (Saono, 1995). Meanwhile, guidelines for the importation and planned introduction of GMOs are being drafted by the Ministry of Agriculture. The planned guidelines will be applicable to all uncontained field trials preparatory to large scale and commercial introductions.

Indonesian Patent Law had been passed in 1989. Patent protection is granted for 14 years. With respect to biotechnology, however, the law is not too supportive because no patent will be granted to, among others, (1) any process for the production of foods and drinks for human and animal consumption, (2) foods and drinks for human and animal consumption, (3) new plant varieties and animals, (4) any process for the production of new plant and animal or their products (Saono, 1995).

Besides legal aspects, introduction of biotechnological products has also to consider the existing ethical aspects subscribed by the major religions in Indonesia, i.e. Islam, Catholic, Protestant, Hindu, and Budhhism. There is a general consensus that the application of new technologies, including biotechnology, are acceptable to followers of these religions as long as these technologies do not violate the religious teachings and laws (KONPHALINDO, 1996).

CONCLUSION

More focused studies are needed at national level in order to distinguish the actual impact of biotechnologies from that of other technologies applied in the same sector, e.g. agriculture, health, animal husbandry, industry, the environment, bioremediation, biodiversity, and to establish which techniques are the most appropriate and whether they may be used in other similar locations.

REFERENCES

Adiwibowo, S., H. Triwidodo, dan D.B. Hasibuan. 1995. Bioteknologi dan dampaknya terhadap sosial, ekonomi dan etika. *Dalam* Krishnayanti, I.N. dan H. Jhamtani (*Eds.*). Bioteknologi dan Keselamatan Hayati, hal. 23-37 (Biotechnology and its impact on social, economy and ethics. *In* Krishnayanti, I.N. and H. Jhamtani (*Eds.*). Biotechnology and Biosafety, pp. 23-37). KONPHALINDO, Jakarta.

Anonymous. 1990. Coffee and biotechnology. Biotechnology and Development Monitor 4: 20-22.

Anonymous. 1991. WHO: fighting tropical diseases al low cost. Biotechnology and Development Monitor 9: 9-10.

Anonymous. 1995. Genetic engineering of coffee: biotechnology company brews genetically engineered java - gene altered java brewing. Genetic Engineering and Biotechnology Monitor 2(1): 14-15.

ASEAN Subcommittee on Biotechnology. 1992. Biotechnology in ASEAN. ASEAN-Australian Biotechnology Project. Bangkok. 33 pp.

Bijman, J. 1994. Oilseed rape. Biotechnology and Development Monitor 21: 10-11.

Bijman, J. 1996. Recombinant bovine somatotropin in Europe and the USA. Biotechnology and Development 27: 2-5.

Brotonegoro, S., J. Dharma, L. Gunarto, and M.K. Kardin (*Eds.*). 1992. Agricultural Biotechnology: Proceedings of a Workshop on Agricultural Biotechnology. Central Research Institute for Food Crops, Bogor.

Commandeur, P. 1995a. A diversified assessment. impact of biotechnology on the world trade in vegetable oils (1). Biotechnology and Development Monitor 23:4-7.

Commandeur, P. 1995b. A diversified assessment. Impact of Biotechnology on the World Trade in Vegetable oils (2). Biotechnology and Development Monitor 24: 17-20.

Darussamin, A., I.P. Kompiang, S. Moeljopawiro, I. Prasadja, and M. Herman (*Eds.*). 1996. Current Status of Agricultural Biotechnology in Indonesia. Research, Development and Priorities, vol. 1: 13-33. Agency for Agricultural Research and Development, Ministry of Agriculture, Republic of Indonesia. xix+197 pp.

Dembo, D., C. Dias, and W. Morehouse. 1987. Third world and biotechnology. Genetic Engineering and Biotechnology Monitor II: 75-78.

Hartiko, H. 1995. Aspek penerapan bioteknologi dan dampaknya terhadap lingkungan. *Dalam* Krishnayanti, I.N. dan H. Jhamtani (*Eds.*). Bioteknologi dan Keselamatan Hayati, hal. 1-21 (Aspects of Biotechnology Application and its Impacts on the Environment. *In* Krishnayanti, I.N. and H. Jhamtani (*Eds.*). Biotechnology and Biosafety, pp. 1-21). KONPHALINDO, Jakarta.

Hueth, D.L., Shain-Dow Kung, and R. Colwell. 1992. The effects of emerging biotechnologies on plant and animal agricultyre - a view point. *In* Da Silva, E.J., C. Ratledge and A. Sasson (*Eds.*), Biotechnology: economic and social aspects. Issues for developing countries, pp. 354-368. Cambridge Univ. Press.

Jovetic, S. 1994. Natural pyrethrins and biotechnological alternatives. Biotechnology and Development Monitor 21: 12-13.

Junne, G. 1992. The impact of biotechnology on international commodity trade. *In* Da Silva, E.J., C. Ratledge and A. Sasson (*Eds.*), Biotechnology: economic and social aspects. Issues for developing countries, pp. 165-188. Cambridge University Press.

Kathen, A. de. 1996. The impact of transgenic crop releases on biodiversity in developing countries. Biotechnology and Development 28:10-14.

KONPHALINDO. 1996. Seminar dan diskusi sehari: Dampak Paten pada Bahan Hayati/Mahluk Hidup terhadap Kehidupan Manusia dan Etika (One-day Seminar and Discussion on the Impact of Patent of Biological Materials/Living Organisms on Human Life and Ethics). Jakarta, 4 June 1996.

Lee, H.H. and F.E. Tank. 1989. The socio-economic impact of agricultural biotechnology on less developed countries. Technology and Employment Programme. WEP 2-22/WP.199. ILO, Geneva. 41 pp.

OECD. 1989. Biotechnology. Economic and wider impacts. Paris. 112 pp.

Pandey, B. 1994. Hybrid seed controversy in India. Biotechnology and Development Monitor 19: 9-11.

Persley, G.J. 1990. Beyond Mendel's Garden. Biotechnology in the Service of World Agriculture. CAB International. xi+155 pp.

Pistorius, R. 1994. Negros revisited: The impact of sugar substitution by HFCS in perspective. Biotechnology and Development Monitor 21: 14-15.

Saono, S. 1992. Application of biological nitrogen fixation technology in Southeast Asia. *In* Advanced Technology Assessment System, Issue 9, Winter. Biotechnology and Development. Expanding the Capacity to Produce Food, pp. 204-210. United Nations, New York.

Saono, S. 1995. Biotechnology in the member states of ASEAN Indonesia. *In* Rehm, H-J. et al. (*Eds.*), Biotechnology, vol. 12: 409-415. VCH, Weinheim.

Saono, S., Wisjnuprapto, A.T. Karossi, and E. Sukara (*Eds.*): 1995. Direktori bioteknologi Indonesia (Indonesian Directory of Biotechnology). LIPI-ASEAN Subcommittee on Biotechnology. Jakarta. iii+77 pp.

Saono, S. 1996a. Peranan biotek dalam pengembangan agroindustri di Indonesia. *Dalam* Forum Komunikasi. Tanggapan Pendidikan Tinggi Dalam Bidang Agroindustri Menghadapi Era Pasar Bebas. Departemen P dan K, Direktorat Jendral Pendidikan Tinggi (The role of biotechnology on the development of agroindustry in Indonesia. *In* Communication Forum. Response of Higher Education to Agroindustry in Anticipation of the Free Market). Department of Education and Culture, Directorate General of Higher Education). Cisarua 8-11 December. 13 pp.

Saono, S. 1996b. Agricultural biotechnology and biosafety in Indonesia. Conference Highlights. Agricultural Biotechnology International Conference.. Saskatoon, Saskatchewan, Canada. pp.132-135.

Sasson, A. 1991. Conclusions. *In* Sasson, A, and V. Costarini (*Eds.*), Biotechnologies in perspective: socio-economic implications for developing countries, pp. 163-166. UNESCO.

Sasson, A. 1993. Biotechnologies in developing countries: present and future. Vol. 1: regional and national survey. UNESCO. xvii+764 pp.

Sasson, A. and V. Costarini (*Eds.*). 1991. Foreword. In: Biotechnologies in perspective : socio-economic implications for developing countries, pp. 5-7. UNESCO.

Schmid, R.D., Bong-Hyun Chung, A.J. Jones, S. Saono, J. Scriven and J.H.J. Tsai. 1995. Biotechnology in the Asian-Pacific Region. *In* Rehm, H.-J. and G. Reed (*Eds.*). Biotechnology 12: 371-432. VCH, Weinheim, New York.

UNCTAD. 1991. Trade and development aspects and implications of new emerging technologies: The case of biotechnology. Document No. TD/B/C.6/154. 31 pp.

Woodend, J.J. 1994. Biotechnology for cash crops of developing countries: opportunities, prospects and threats. Genetic Engineering and Biotechnology Monitor 1(1 & 2): 75-81.

Yuthavong, Y. and G.C. Gibbons. 1994. Biotechnology for Development. Principles and Practice Relevant to Developing Countries. ASEAN Subcommittee on Biotechnology- ASEAN Committee on Science and Technology. 186 pp.