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AGRICULTURAL ENGINEERING RESEARCH AND DEVELOPMENT IN MALAYSIA.

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INTRODUCTION

The agricultural sector in Malaysia is involved in the production, processing and waste management of crops, livestock and fishery. It has contributed significantly to the Malaysian economy. For the first 30 years after independence, the agricultural sector was the main contributor to the national economy. In 1980 it contributed USD $ 2.9 billion or 23% of the GDP, dropping to 20% in 1989, to 13.6% in 1995 and to 8.2% in 2003. The agricultural sector attained an average growth rate of 3.2 per cent per annum for the 1985-1995 periods, with the growth rate dropping from 5% in 1985 to only 2% in 1995. In absolute terms, the total value-added of the agricultural sector increased from RM 3.3 billion in 1985 to USD $ 4.4 billion in 1995 and to USD $ 5.1 billion in 2000 (at 1987 prices).

Changes in the lifestyle of the people, as a result of urbanization and the higher level of income they received, have resulted in changes in eating habits, food purchasing and consumption patterns. And with the Malaysian population growing at 2.5% per annum, the increased demand for food has led to the increase in food imports. Total food imports increased from USD $ 0.98 billion in 1985 to USD $ 2.14 billion in 1995 and to USD $3.62 billion in 2003. With food export worth USD $ 2.23 billion, our net food import was USD $ 1.39 billion in 2003.

Over the years, agriculture has been used to finance the development of the country as well as to finance the transformation of the economy towards industrialization. During the last 10-15 years, the rapid industrialization in the country has led to a decline in the agricultural sector's relative contribution to national income; export earnings, employment and investments. Industrialization in the country and the rural-urban migration of the youths has created a serious shortage of agricultural workers in the country. The agricultural labor force in 1980 was 1,911,000 or about 39.7% of the national labor force and it dropped to 1,400,000 or about 18% the national labor force in 1995. However, most of the growers and managers in the agriculture and agro-based industry prefer to solve their labor problem by employing cheap imported foreign workers and relying on traditional manual methods of agricultural production and processing instead of adopting the more modern and efficient agricultural engineering technologies.

For Malaysian agriculture to compete effectively in the global environment, it has to change from the current traditional method of farming and cottage type agro-industry to modern commercial farms and factories. In line with this, the Third National Agricultural Policy (NAP3) has emphasized on the modernization and commercialization of the agricultural sector to lower production cost and to increase labor and land productivity.

The applications of agricultural engineering technologies constitute the major aspects of this agriculture modernization.

Agriculture engineering is needed to serve as catalysts or pacesetters to stimulate the growth in our agriculture, food and agro-based industry. At the same time, the industry must change in order to be able to make full use of agricultural engineering to respond to the changing demands of agriculture and society.

AGRICULTURAL ENGINEERING IN MALAYSIA

The level of input of engineering technologies into agriculture (comprising the production, processing and waste management of crops, livestock and fishery) is generally still low. Only land preparation is fully mechanized in both the plantations and the smallholdings. Significant progress has been achieved in the mechanization of field maintenance and crop maintenance operations in the plantations. Harvesting in the plantation is still essentially manual. Post-harvest handling and packing house operations of fruits, vegetables and other crops are also manual. In the smallholding sector, rice has achieved a fairly high level of mechanization in most operations.

Presently most of the agricultural machinery used in the country is imported and it amounts to about USD $ 70-USD $ 84 millions annually. The machines are imported either as semi knock down (SKD) or complete built up units (CBU) and either new or used (to be reconditioned locally).

The range of machinery that is locally manufactured or fabricated are broad but the volume of each type is not high. The manufacture of these machines is dependent on imported materials and components. A few of the locally manufactured machinery such as sprayers, tillers and rubber processing machines are being exported.

The locally manufactured agricultural machines include the rotary tiller, rotary slasher, rotary oil palm front mulcher, maize seeder, rice stubble slasher, fertilizer spreader, agricultural trailer tanker, oil palm fruit bunch loader, oil palm fruit bunch trailer, oil palm fruit bunch infield transporter, oil palm fruit bunch collector, manual knapsack sprayers, agricultural hand tools, and oil palm and rubber processing machines.

Most of the agro-based and food processing industry consists mostly of small sized firms. These small firms, which are mostly family concerns, are run in the traditional manner, often manual in operation and with little attention to hygiene or quality control. Their sources of funds are usually severely limited. Typical examples of the small operations are manufacturing of coffee, spices, noodle, biscuit, bakeries and fish based food.

The few large food-processing plants are equipped with modern machinery and utilize up-to-date processing technology and they keep abreast with the latest innovation in the industry. They include the canning, sugar refineries, beverage and instant noodle industries.

Agricultural engineering plays an increasingly pivotal role in supporting the continued growth of the agriculture and agro-based industry under the current full-employment situation where labor is scarce and costly. The national policy to reduce dependence on unskilled foreign labor is encouraging the agriculture and agro-based industry sector to consider adopting capital-intensive and management-intensive agricultural engineering or mechanization technologies.

CONSTRAINTS AND CHALLAENGES IN AGRICULTURAL ENGINEERING

Some of the major constraints and challenges affecting the generation and adoption of agricultural engineering technologies in Malaysia are as follows:

High and increasing cost of production

Malaysian agriculture is operating under competitive global environment and is losing grounds due to increasing costs of production especially that of labor, machinery use and water control. They are related to the high costs of imported technology of agricultural machinery and irrigation equipments. Apart from that there is a serious shortage of agricultural workers due to competition from other sectors of the economy especially the manufacturing and the construction sector. This problem is expected to worsen in the near future and will be particularly acute in the rice, oil palm, rubber and cocoa plantations as well as in the rice and fruit producing areas.

Intensification of production per unit area

Resources especially land and water are and will be the limiting factor in agricultural production. Therefore there is a need to optimize the use of land resource such as by intensifying the production capacity per unit area and to reduce the risk factor of water in crop production so as to stabilize yield and quality. This calls for a change in the approach towards a better planned and more systematic system which incorporates higher level of agricultural engineering inputs.

Competition from other sector

The input and utilization of agricultural engineering technologies is highly capital intensive investment, requiring long term commitment in the terms of resources such as finance and full management support. In such a situation, the agricultural sector has to compete for the resources with other sectors of economy. Finance and credit facilities are also not easily and readily available. Small farm entrepreneurs are reluctant to invest in machinery preferring instead to rely on contract hiring services and other short term options that are available.

Limiting water resources

The total fresh water withdrawal is expected to increase from the present 11.6 billion cubic meters to 15.2 billion cubic meters by year 2010 with the substantial increases expected from higher priority domestic and industrial consumers while agriculture's consumption is projected to drop from 75 to 68 %. Irrigated agriculture must therefore

improve on the efficiency of water use. Rainfall harvesting is still effective with only 2.1 % of total rain water actually harvested. Suitable on-farm water resources must be developed.

Limiting land resources.

With the rapid pace of industrialization and high population growth in the country, more and more agricultural lands that are close to the urban centers are being converted into industrial lands and residential lands. Agriculture has to expand into the problem lands that have inherent constraints to the application of agricultural engineering technologies. Each has its own specific problems that are related to machine access and water control. Peat has high water table, wood obstruction and low bearing capacity problems; steepland has erosion, machine access and manoeuvrability problems while wet clay soils are difficult to drain and have very poor machine trafficability performance.

Uneconomic farm size

Within the smallholding sector, the farming plots, particularly those which are used for food crop production, are smaller than their respective minimum economic farm sizes to be able to enjoy economy of scale of production with respect to the use of farm machinery and other engineering technologies. Past experience in land consolidation has indicated that significant improvement in machinery usage and water control which resulted in a more efficient production capability being achieved.

Concept of agricultural modernization

Agricultural modernization is synonymous with the application of engineering technologies in agriculture. The concept of mechanized farming is not fully understood and practiced in the agricultural sector in this country. Mechanization has always played the supporting role in agricultural development. In years to come, due to labor and cost constraints, only those crops that can be highly and effectively mechanized will be able to service and sustain in the highly competitive local and global environments. Water control and management has never been institutionalized as a factor of production, side from paddy, and to a certain extent tobacco, floriculture and vegetable.

Research and development contribution

Agricultural engineering technologies in general are still lacking. The development of sufficient research facilities and training of more skilled personnel including exposure to the latest technologies that are available overseas are urgently needed to accelerate research and development efforts in the generation of innovation technologies to solve the immediate problems besetting the agriculture sector.

Import duty on machinery and equipment

Machinery parts and components that can be used for both agricultural and non-agricultural purposes tend to be categorized under non-agricultural purposes. Hence tax exemption is denied and this makes their use in agriculture costly and non-viable. An agricultural soft soil transporter, for example is classified under the same category as

construction machinery due to its possible use in the construction industry. It is slapped a hefty 35 % import duty and in addition is subjected to 10 % sales tax.

Unavailability of suitable technology locally

Dealers in agricultural and food machinery, for example, are reluctant to supply specialized machinery that are not commonly and widely used in this country due to the uncertainties involved and the high cost of stocking spare parts. Under such situation, it would be impossible to obtain and utilize the most economically optimum agricultural engineering technology packages.

Farm setup not designed for use of agricultural engineering technologies

Most of the present farm layout and infrastructural facilities are generally not designed for efficient use of agricultural engineering technologies. Mechanization and irrigation are usually not taken into account in the initial planning stage. When the need for the technologies is realized at a larger stage, the optimum design will have to be compared within the existing layout and situation. The physical nature of the farm itself such as soft soil, water-logged, and steep terrain often makes it not conducive for mechanization and this has resulted in low mechanization efficiency. The application of the wrong mechanization package can lead to negative long term effects such as the soil erosion and loss in productivity in steep terrain and the destruction of the hardpan of the paddy fields.

Formal industry linkages

Current efforts towards establishment of formal linkages between the agricultural engineering research and development centers with the machinery manufactures, dealers and the extension agencies should be intensified up for better and more efficient flow of information, technology and feedback to and from farmers. Similar linkages with international research and development centers to increase the flow and exchange of the latest information on technological developments should be developed.

Certification of agricultural machinery and irrigation components.

There is no mandatory certification of agricultural machinery before they are allowed to be used in this country. The effect of this is that inappropriate machinery that are of flow quality and detrimental to the environment, soil structure and operators safety are being marketed in the country freely. The same applies to irrigation equipments and components (such as emitters and filters) which have never really been tested to verify the manufactures' claims.

Funding and skill technical workers

The lack of industrial extension, and difficult access to fund for pilot production and commercialization of research and development results are the factors that contribute to the slow and difficult. Process of technology transfer from local R&D centers to the industry. Technical manpower relevant to the agriculture machinery industry comprising of technicians, mechanics, and machine operators are seriously lacking in the country. A programme is required to increase the supply of these workers.

High capital investment
Mechanized agricultural and food production requires higher capital investment than the traditional manual method. But agricultural enterprises involve higher risks compared to other economic activities and they yield relatively lower returns. Strategies that ensure cost effectiveness and viability of mechanized technologies should be put in place.

DEMAND OF ADVANCEMENT IN AGRICULTURAL ENGINEERING

Agricultural engineering is the application of a variety of engineering disciplines in agriculture to produce agricultural products and to manufacture agro-based products. It is dedicated to the application of engineering principles for the advancement of food production, fiber production, and other biological needs.

Field operations such as irrigation, drainage, soil conservation and environment conservation are important in successful farming and they make use of knowledge in agricultural engineering that are integrated with knowledge in biological other sciences. As an example, knowledge in agricultural chemistry are useful in dealing with vital farm problems such as uses of fertilizer, insecticide, and fungicide, soil makeup, analysis of agricultural products, and nutritional needs of farm animals. Meanwhile, agricultural engineering provides the machinery and equipment to apply the fertilizer, insecticide and fungicide efficiently.

Scientific methods are applied to pest control, limiting the widespread use of insecticides and fungicides and applying more varied and targeted techniques. New understanding of significant biological control measures and the emphasis on integrated pest management have made possible more effective control of certain kinds of insects. Meanwhile agricultural engineering provides the chemical application equipments and the strategies to use them safely.

Plant breeding and genetics contribute immeasurably to farm productivity. Genetics has also placed livestock breeding on a scientific basis. Meanwhile, agricultural engineering provides the machinery for mechanization to reduce the drudgery of farm work and to cope with the increased farm productivity. More significantly, mechanization has enormously increased farm efficiency and productivity.

Agricultural engineering covers environmental systems, food production, biological resources or ecological systems, and power and machinery systems. Basically, agricultural engineers are equipped with knowledge and capability in writing, social sciences, and economics, along with mathematics (calculus and statistics), chemistry, physics, and biology. Agricultural engineers are provided with fundamental knowledge of the life sciences and how biological systems interact with their environment. In addition, they are equipped with expertise in thermodynamics, mechanics, instrumentation and controls, electronics and electrical circuits, and engineering design.

Agricultural Engineering has advanced to the stage where it may now be sub-divided into the following specialized categories:

Biological (Agricultural) Engineering
One of the most rapidly growing sub-disciplines of agricultural engineering is biological engineering that applies engineering practice to problems and opportunities presented by living things and the natural environment. This category of agricultural engineers is involved in a variety of exciting interests that continue to emerge as our understanding of science and nature grows. Areas of interest range from environmental protection and remediation, to food and feed production, to medicine and plant-based pharmaceuticals and packaging materials. Biological agricultural engineers may also design medical implants and devices, instrumentation and imaging products while others may develop techniques and strategies for natural pest control and treatment of hazardous wastes, for composting, and for enzyme processing of biomass, food, feed, and wastes.

Natural Resource (Agricultural) Engineering
Our environment is fragile. Events like the El Nino phenomenon remind us that our soil and water are vulnerable to degradation by both natural and man-made forces. These agricultural engineers are equipped with expertise in environmental work to better understand the complex mechanics of these resources, so that they can be used efficiently and without degradation. These engineers determine crop water requirements and design irrigation systems. They are experts in agricultural hydrology principles, such as controlling drainage, and they implement ways to control soil erosion and study the environmental effects of sediment on stream quality. Natural resources engineers design, build, operate and maintain water control structures for reservoirs, floodways and channels. They also work on water treatment systems, wetlands protection, and other water issues.

Power Systems and Machinery Design (Agricultural) Engineering
These agricultural engineers focus on designing advanced equipment, making it more efficient and less demanding of our natural resources. They develop equipment for food processing, highly precise crop spraying, agricultural commodity and waste transport, and turf and landscape maintenance. This is in addition to the tractors, tillage equipment, irrigation equipment, and harvest equipment that have done so much to reduce the drudgery of farming. Their work remains challenging as technology advances, production practices change and equipment manufacturers expand globally.

Structures and Building Environment (Agricultural) Engineering
These agricultural engineers understand the importance of creating and maintaining a healthy environment for growing agricultural commodities and for the laborers who produce them. They also understand that our natural resources must not be diminished, in quality or availability, by agricultural operations. Toward these ends, these agricultural engineers are equipped with expertise in structures and building environment to design animal housing, storage structures, and greenhouses, with ventilation systems, temperature and humidity controls, and structural strength appropriate for their climate and purpose. They also devise better practices and systems for storing, recovering, reusing, and transporting waste products.

Food and Bioprocess (Agricultural) Engineering
Food, fiber, and timber are only the beginning of a long list of products that benefit from efficient use of our natural resources. The list includes biomass fuels, biodegradable packaging materials, and nutraceuticals, pharmaceutical and other products. These engineers understand microbiological processes and use this expertise to develop useful products, to treat municipal, industrial and agricultural wastes, and to improve food safety. They are experts in pasteurization, sterilization, and irradiation, and in the packaging, transportation and storage of perishable products. Food and processing agricultural engineers combine design expertise with manufacturing methods to develop economical and responsible processing solutions for the industry as well as look for ways to reduce waste by devising alternatives for treatment, disposal and utilization.

Information and Electrical Technologies (Agricultural) Engineering
The application of information and electrical technologies in agriculture is very versatile. It is applied to virtually all the other sub-disciplines of agricultural engineering, from machinery design to soil testing to food quality and safety control. Geographic information systems, global positioning systems, machine instrumentation and controls, electro-magnetic, bio-informatics, bio-robotics, machine vision, sensors, spectroscopy are some of the exciting information and electrical technologies being developed and used today in agriculture and agro-based industry.

Forest (Agricultural) Engineering
Agricultural engineers apply engineering principles to solve natural resource and environment problems in forest production systems and related manufacturing industries. Engineering skills and expertise are needed to address problems related to equipment design and manufacturing, forest access systems design and construction; machine-soil interaction and erosion control; forest operations analysis and improvement; decision modeling; and wood product design and manufacturing. Forest engineers are involved in a full range of activities in natural resource management and forest production systems.

Energy (Agricultural) Engineering
Energy is needed to power the machines, devices, and systems in our homes and workplaces. But many of the energy sources are nonrenewable and create undesirable byproducts. Agricultural engineers are at the forefront of the effort to identify and develop viable energy sources such as biomass, methane, and vegetable oil and to make these and other systems cleaner and more efficient. These engineers also develop energy conservation strategies to reduce costs and protect the environment, and they design traditional and alternative energy systems to meet the needs of agricultural operations.

Aquacultural (Agricultural) Engineering
As natural fish supplies are threatened, agricultural engineers are needed to help design farm systems for raising fish and shellfish, as well as ornamental and bait fish. They specialize in water quality, biotechnology, machinery, natural resources, feeding and ventilation systems, and sanitation. They seek ways to reduce pollution from aquacultural discharges, to reduce excess water use, and to improve farm systems. They also work with aquatic animal harvesting, sorting, and processing.

Nursery and Greenhouse (Agricultural) Engineering
Nursery and greenhouse operations like large-scale production agriculture have many similar needs such as irrigation, mechanization, disease and pest control, and nutrient

application. However, other engineering needs also present themselves in nursery and greenhouse operations such as equipment for transplanting; control systems for temperature, humidity, and ventilation; and plant biology issues, such as hydroponics, tissue culture, and seedling propagation methods.

Safety and Health in Agricultural Engineering
Farming is one of the few industries in which the families work and live on the premises and are at risk for injuries, illness, and death. Agricultural engineers analyze health and injury data, the use and possible misuse of machines, and equipment in compliance with standards and regulation. They constantly look for ways in which the safety of equipment, materials and agricultural practices can be improved and for ways in which safety and health issues can be communicated to the public.

STRATEGIC AND DIRECTION OF AGRUCULTUAL ENGINEERING

In the face of labor shortage occurring in the agricultural sector, the agricultural machinery industry is a critical support industry to the sector. Befitting this role, it would be given an integrated attention in terms of direction and structural development in addition to financial incentives and other supports to ensure its accelerated growth. The dependence by the agricultural sector on unskilled foreign labor would be reduced.

Their employment would be restricted to agricultural operations that currently cannot be mechanized. Incentives would be given for agricultural producers to adopt capital intensive mechanization and automation technologies. The introduction of high technology in mechanization and automation of agricultural production would be intensified. R&D programme and technology transfer work in this area would be strengthened.

National Committee on Agricultural Mechanization and Automation will be established to provide strategic direction and coordination on all aspects of agricultural mechanization (i.e. application of agricultural engineering inputs). Its members would comprise representatives from the public and private sectors. A technical committee and a permanent secretariat would assist the committee.

The 'Malaysian Network on Agricultural Mechanization and Automation' would be established to facilitate technology awareness, information sharing, and industry feedback. This government-sponsored network or information hub (iHub) would draw its membership form the general public, government agencies, and private sectors with interest in the industry. It would set-up an Implementation Task Force, an iHub Internet Website, Mechanization Information Unit and Newsletter. It would be a programme under the National Committee on Agricultural Mechanization and Automation.

The Implementation Task Force would undertake national baseline technical, economic and socio-economic surveys. It would then undertake the identification and quantification of national mechanization priorities. Emphasis would be placed on land and crop adaptation for Mechanized production. They include the development of strategies and action plans in land consolidation, land leveling, input/output access, irrigation and

drainage, cropping layout, adaptive plant breeding, demonstration farms and commercial farming.

Strategies on accelerated transfer of global technologies would be implemented. They include the establishment of Technology Transfer Fund and the development of action plans in technology identification, acquisition, field evaluation, commercialization and extension.

Detailed action plans would be developed to strengthen and streamline research, development and commercialization on the agricultural engineering mechanization of the farm and factories (food and non-food processing). The plans would cover Priority R&D (Research and development), Vision 2020 R&D and joint venture R&D with local and international manufacturers.

Private sector involvement in agricultural engineering would be promoted by providing financial incentives, and creating favorable business environment for their participation. They include development of strategies and action plans for farm machinery contractors, farmer owner-operators of machinery, SMI (Small and Medium Scale) development, finance-credit facilities and entrepreneur development packages Strategies in Human Resource development would be comprehensive and would cover higher education, vocational training, DOA (Department of Agriculture) training, School Net adult education, Internet extension, and DOA extension.

CONCLUSION

Agricultural engineering is necessary to provide technologies for farm mechanization, irrigation, electrification, structures and food processing. It has contributed significantly to the industrialization of the Malaysian agriculture and it has brought Malaysian agriculture into the present Information Age.

The use of agricultural engineering inputs in agricultural production and agro-based processing is essential to overcome the various operational constraints such as unfavorable plant growth environment, high handling losses and inefficient work rate. High technology farming, including hybrids for rice, and other grains, better methods of soil conservation and irrigation, and the use of fertilizers has led to a significant increase in the production of food in this country, particularly rice. Malaysian agriculture should now position and prepare itself to adopt the latest contribution from agricultural engineering which include precision agriculture, animal waste management, nutrient transport and water quality, food safety, crop bio-processing and bio-sensors.

As the Malaysian population increases, more food, energy, and goods are required. Our natural resources are limited and while it is necessary to produce more with less, it is equally important that the higher productivity does not degrade our environment. In the search for new ways to use agricultural products, byproducts, and wastes, our agricultural engineers should come up with viable, environmentally sustainable solutions. Our agricultural engineers should ensure the sustainability of the necessities of life. They

include safe and plentiful food to eat, pure water to drink, clean fuel and energy sources, and a safe, healthy environment in which to live.

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