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Transfer of Smart Agriculture Technology from MARDI to Young Agropreneurs in Malaysia: The Case of High- Value Vegetable Production by AgroCube

Rozhan Abu Dardak, Muhd Akhtar Mohamad Tahir, Khairul Anuar Shafie and Rasmuna Mazwan Muhamad
Malaysian Agricultural Research and Development Institute (MARDI)
Persiaran MARDI-UPM, 43400 SERDANG, Selangor, Malaysia.
Corresponding e-mail: rozhanabudardak@gmail.com

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ABSTRACT

Technology transfer from a government research institution to small and medium enterprises (SMEs) is crucial to ensure the products of research and development (R&D) will gain market acceptance. Technology is useless until it benefits the community in general. However, technology transfer is the most challenging and critical process. Thus, technology developed by government research institutions must be transferred for the benefit of the community in general and in specific, the entrepreneur. This paper shares the experience of MARDI, one of the largest government research institutions in Malaysia, in transferring smart agriculture technology to young entrepreneurs. Smart agriculture refers to the application of ICT technology in producing agricultural products. MARDI developed a small-scale or container-type plant factory called AgroCube to grow high-value vegetables. MARDI transferred the smart agriculture technology through formal training (theoretical and practical) conducted at the MARDI Training Center. More than 500 young agropreneurs participated in the training, and they received a direct knowledge transfer from the researchers. After completing the training, the young agropreneurs can venture into high-value vegetables for the premium market in Malaysia. However, the challenges faced by the young entrepreneurs are related to getting financial assistance and marketing the produce. This financial issue was resolved by introducing soft loans by the Agrobank, and the marketing issue was guided by the Federal Agriculture Marketing Authority (FAMA).

Keywords: Technology transfer, smart agriculture technology, agropreneur, entrepreneurship

INTRODUCTION

The world population will continue to grow and is expected to reach eight billion people in 2025 and nine billion people by 2050. As a result, the world faces threefold challenges of meeting higher demand for food, sustaining a friendly and safe environment, and ensuring that the poor people are no longer hungry (Von Braun, 2007). The consequent challenge correlated with the higher demand for food is the greater competition for water, land, and labor. Thus, the agriculture sector requires new approaches in food production and distribution. According to the Food and Agriculture Organization (FAO) in 2009, the contribution of the future production of food will be 10% by the expansion of land, 20% by the intensification of agriculture production, and 70% by the application of new technology and the formulation of government policies on food production.

Currently, technology has been recognized as the pillar of the agriculture sector. It improves productivity and efficiencies, enhances the quality of life of the people, becomes the enabler of economic development, and reduces regional economic disparity. Technology enables more food production from the same land area, can increase yields with the same amount of resources, and improves the quality of the food produced. For example, the Malaysian Government aspires to transform the agriculture sector to be modern, dynamic and progressive by focusing on smart agriculture.

Generally, the government established research institutions to conduct and promote research and development (R&D) in specific areas, such as biotechnology, horticultural crops, industrial crops, livestock, and smart agriculture. Every year these institutions receive funds and research grants from the government, International Institutions, and private firms to conduct research and develop and generate new technologies that can increase the productivity and efficiency of agricultural commodities and related products. These new technologies are transferred and utilized by societies and entrepreneurs.

Technology transfer is a complex, dynamic and complicated process. It involves the technology generator and the different knowledge, skills, and motives of the recipients. In the past, the assumption was that technology transfer is an automatic process after it is developed. Technology transfer involves the recipient firms or the small and medium enterprises (SMEs). Even if the technology is successfully developed, the technology transfer process will depend on the acceptance by the entrepreneur, who looks at the new technology as a new business opportunity.

Technology transfer is an essential aspect of R&D in government research institutions. Nevertheless, the process of technology transfer is the most challenging and critical in the development and diffusion of new technology (Bozeman, 2000). The ability of the research officer or technology generator in the government research institution to win over the recipient (SME) is critical and one of the factors that could lead to the success of technology transfer. On the other hand, the ability of the entrepreneur to recognize the business opportunity for the newly developed technology is another factor that could complement the process.

One of the challenges in transferring technology is the ability of the researcher to share their knowledge with the recipients. The technology generator must be willing to share all technical knowledge. At the same time, the technology recipient must uplift their expertise by attending formal training. The sharing of knowledge through formal training will speed up the process of technology transfer.

This paper highlights the transfer process of smart agriculture technology from the Malaysian Agricultural Research and Development Institute (MARDI) to young entrepreneurs in Malaysia, the issues and challenges in transferring the technology, and the way forward. It discusses the issues faced by the agriculture sector in Malaysia, especially on the production of vegetables for local consumption. The paper also discusses the government strategy in transforming the vegetable industry by focusing on smart agriculture. Specifically, this paper shares the Malaysian experience in producing high-value vegetables by using the small-scale plant factory operated by smart agriculture.

TRANSFORMATION OF AGRICULTURE SECTOR

Agriculture is an important sector in Malaysia. This sector contributed more than RM101.50 (US$24.88) billion, or equivalent to 7.1% of the Malaysian Gross Domestic Products (GDP) in 2019. Although the total production of this sector has increased significantly every year, the contribution to the GDP has reduced. For example, the agriculture sector's contribution has decreased from 10.1% in 2015 to 7.3% in 2017 and 7.1% in 2019.

The agriculture sector in Malaysia faces significant challenges and issues that need special attention from the government. The population growth will boost the demand for food. Malaysia needs to double its food production in 2050 compared to the 2017 agricultural output. However, the land area for food production is decreasing every year. The competition to use the land with other lucrative industries such as housing and manufacturing industries will disfavor the agriculture sector. Furthermore, the increase in urbanization will lead to the reduction of arable land for food production.

At the same time, the extreme climate has changed agricultural activities in Malaysia. Climate change has altered the environment and shifted the production and harvesting seasons. More drought and floods have reduced the yields and affected the quality of the products. Water resources are highly stressed, scarce, and affect agricultural activities. Farmlands are becoming increasingly unsuitable for food production. As a result, farmlands become highly degraded and are left abandoned. A report by the Department of Agriculture shows that 119,273 hectares of agricultural land were left idle in 2018 (DOA, 2020). These issues have reduced the production of agricultural products in Malaysia. Malaysia currently produces 65-70% of its rice, 70-75% of fruits, 45-50% of vegetables, and 20-25% of its beef and mutton requirements. Among the notable agricultural challenges in Malaysia are:

1. Crop yields are dependent on unpredictable weather conditions. For example, climate change has shifted the fruiting seasons and affected the production of agricultural produce.
2. Natural calamities such as floods and prolonged droughts have led to harvest loss, adversely affecting the agricultural infrastructure.

3. Majority of farmers are now aged around 60 years old. They are less educated and refuse to adopt new technologies. At the same time, young people do not want to take over the family farm holding because they want to find better opportunities in other sectors.

All the issues need imperative technology-driven solutions. The adoption and adaptation of technology solutions driven by the information and communications technology (ICT) including Internet of Things (IoT), Data-driven, GPS, cloud computing, robotics, automation, and in-field drones are crucial. Technology solutions will increase productivity, yields, and profitability, eliminate or minimize risks, and avoid under utilization of resources. Farmers need technology-driven solutions for maximum productivity and quality. For instance, IoT sensors and drones will record environmental conditions on the farm; the data will forecast the weather. Artificial intelligence tools will help farmers make decisions more efficient and cost-effective. Furthermore, this sector will reduce the dependence on labor.

The government of Malaysia has decided to transform the agriculture sector from a traditional approach to a modern, dynamic and systematic methodology by using technology and innovation. Malaysia is ready to push innovation and agricultural technology development to help this sector transform and grow. The government started to invest time and resources into smart farming. The government invites private sectors to invest in smart farming and produce high-quality and premium price agricultural produce for local and export markets.

At the same time, the modernization of the agriculture sector must be supported by green technology. The application of technology will help the government identify the demand side by the consumers and the supply side of agricultural products. Applying innovation and technology, such as sensors, devices, machines, and information technologies, will make agribusiness more profitable. Technologies will encourage more entrepreneurs to participate and invest in agricultural activities.

Under the National Agriculture Policy 2.0 (2021-2030), the government has set a new direction for the development of the agriculture sector. One of the strategies is to focus on producing agricultural produce through smart agriculture. The IoT-based smart agriculture in Malaysia aims to improve the agriculture sector and improve poverty in the country overall. The implementation of smart agriculture through IoT also aims to achieve an economy of scale and generate higher income for farmers.

For Malaysia to revitalize its agricultural sector, a comprehensive overhaul is required, and adopting smart farming or precision agriculture is the way to move forward. Smart farming, also known as the Third Green Revolution, refers to applying information and communications technology (ICT) in agriculture. Smart farming practices include drones to carry out crop spraying, soil and field analysis, planting, and crop monitoring.

The Malaysian government needs to address some challenges if it plans to adopt better farming practices, especially the farming community's mentality. The first step is to raise awareness among farmers of the benefits of new farming technology. This issue is particularly challenging because the average Malaysian farmer is 60 years old. On the other hand, many rural youths have relocated to urban centers because they are attracted by the promise of employment and a modern lifestyle. Given this demographic makeup, transferring new farming technology becomes a lengthy and complicated process.

It is pertinent to attract and retain youths within the farming industry, particularly technology-savvy ones, by providing suitable employment opportunities. For example, the modern high-tech farm creates many job opportunities, establishing permanent food parks, building learning institutions for modern farming, and forming an agriculture outsourcing service (AOS). It would be easier to incorporate new farming technology and change farming culture with youth involvement. At the same time, favorable financial schemes have to be expanded to enable farmers to upgrade and modernize their farms. The government has to encourage the establishment of AOS to help farmers put smart farming into practice.

MANAGEMENT OF TECHNOLOGY AT MARDI

Overview of MARDI

The Malaysian Agricultural Research and Development Institute (MARDI) was established in 1969. MARDI has been mandated to conduct scientific, technical, economic, and sociological research to produce, utilize, and process all crops, except three agriculture commodities (rubber, oil palm, and cocoa) and livestock. MARDI is a statutory body under the Ministry of Agriculture and Food Industries (MAFI). MARDI is the largest government research institution in terms of R&D and operational budgets and the number of researchers in Malaysia. Currently, MARDI employs more than 500 researchers and more than 2,500 support staff. Its main objectives are to develop, generate, and promote indigenous science and technologies and advance Malaysia's food, agriculture, and agro-based industries. At the same time, MARDI serves as a center for collecting and disseminating knowledge and information in this sector.

MARDI's core function is to conduct R&D for the development of the Malaysian agriculture sector. The Federal Government primarily allocates MARDI's R&D expenditures. At the same time, MARDI receives R&D grants from International Institutions, and Internal sources called the MARDI Reserve fund. MARDI research officers also received research grants from Research Grant Management at the Ministry of Science and Innovation. Research officers carry out all R&D projects at MARDI Headquarters and 28 research stations throughout Malaysia. During the 11th Malaysian Development Plan (2016-2020), MARDI received RM208.57 (US$49.67) million for its R&D and operational expenditures. However, in the 12th Malaysian Development Plan (2021-2025), the allocation was reduced to RM153.80 (US$36.61) million because the Government emphasized fighting the COVID-19 pandemic. The Government provides less funding to other sectors during this period, including the agriculture sector. MARDI uses its Reserve Fund as an instrument to address the insufficiency of the fund for operational expenditure. The implementation of research projects is monitored stringently following the standard of procedure (SOP) under the MS ISO9001-2015 quality management system.

The development of smart agriculture technology

During the 11th Malaysian Development Plan, MARDI carried out more than 100 research projects, and out of these, five projects were related to the development of smart agriculture technology, including:

1. Development of an urban agricultural system for sustainable urban community;
2. Up-scaling of precision agricultural technology in the rice granary area for productivity improvement;
3. Development of modern agricultural production systems: smart and precision agriculture, which is integrated with industrial technology 4.0 and biotechnology;
4. Development of high-impact and cost-effective integrated agricultural engineering packages for the production, post-harvest handling, and processing of selected agricultural products (rice, fruits, and vegetables); and
5. Development of innovative crop production systems for food security, sustainability, and community well-being

Smart agriculture is a new concept that refers to the use of ICTs in producing agricultural produce. The application of technologies such as communication systems, location systems, software, and sensors aims to increase the productivity and quality of crops with minimum use of labor. The application of smart agriculture is in line with the effort to address the challenges faced by the agriculture sector.

One of the sub-projects under smart agriculture technology is the development of a plant factory. The plant factory is an indoor farming facility that enables the production of high-quality vegetables to be carried out continuously all year round by using an artificial controlling cultivation environment such as lights, temperature, humidity, carbon dioxide, and culture solution.

Technology transfer

The concept of technology transfer is not new but has been in existence for a long time. It refers to applying technology by new users, a process by which the technology is developed either in a different application or by a new user. The transfer is done systematically and in a planned manner. Technology transfer involves two parties, and it is a planned action and is carried out on purpose.

The technology transfer process will occur more efficiently if the technology generator is willing to share the technological knowledge fully and the technology recipient is ready to adopt it completely. One of the critical issues in managing the technology transfer process is involving a technology generator in all activities, from the beginning of the transfer until the product technology reaches the marketplace. The technology generator is the leading actor in technology transfer, and his involvement and commitment are prerequisites for a smooth transfer process. A lack of involvement by technology generators in technology transfer seems to contribute to a failure.

The process of technology transfer, from a reverse perspective, is determined by the entrepreneur's absorptive capacity and adoption of technology. It is on the part of a firm to recognize the value of the new technology and apply it on a commercial basis. Prior knowledge such as human resources, financial management, and technological expertise will determine the ability of an entrepreneur to commercialize a technology.

Technology transfer is MARDI's second core function. MARDI will transfer its technologies to benefit farmers and society in the country. The technology transfer system in MARDI has evolved from simple dissemination of technology through technical papers presented at seminars and conferences to technical training and finally to a complete technology transfer system package. In the early years of its establishment, MARDI transfers its technologies to extension agencies such as the Department of Agriculture (DOA), Farmers' Organization Authority (FOA), Department of Veterinary Services (DVS), and the Malaysian Pineapple Industry Board (MPIB). Thus, technology is transferred through agencies or intermediaries before it finally reaches the farmers or stakeholders.

MARDI created a technology transfer approach that adopted the marketing concept in 2002. MARDI understood market needs and wants and began to transfer its technology by means and forms needed and required by the customers and users. Thus, the new approach is to share the technology directly with customers and users, mainly entrepreneurs. The process flow of technology transfer carried out by MARDI is illustrated in Figure 1.

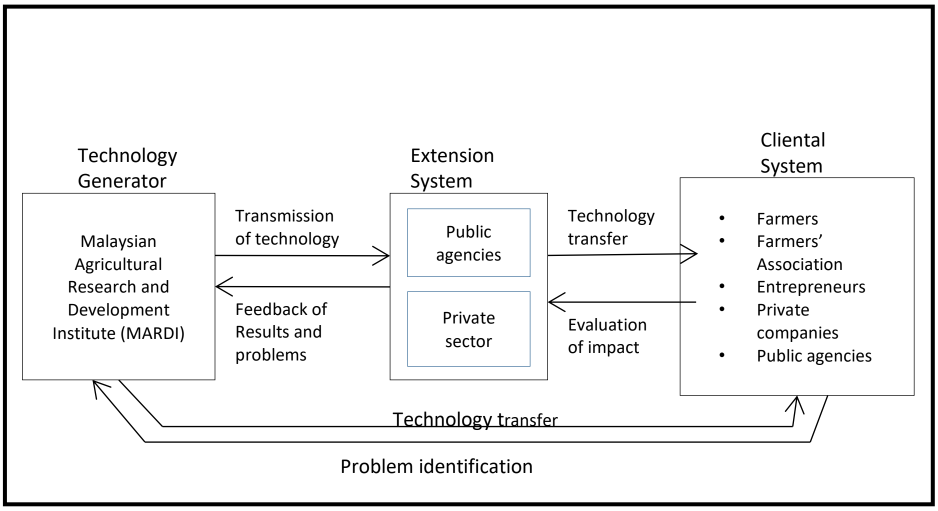

Fig. 1: Process flow of technology transfer at MARDI

According to Figure 1, R&D outcomes are not directly transferred from MARDI to its stakeholders. In the first stage, MARDI transfers its technology to extension agencies such as the DOA, FAO, and private firms. After this stage, the technology is transferred to stakeholders or users such as farmers, farmers' associations, entrepreneurs, and public agencies. In other words, technology is transferred from MARDI to the extension system before it finally reaches the cliental system or technology users. However, starting from 2002, the technology is transmitted directly to the entrepreneur. MARDI implements different approaches for different technology transfers. For example, the consultancy services or training approach aims to transfer public domain technology, while licensing the intellectual property (IP) approach is used for transferring new technology to the established SMEs. Public domain technology refers to technology that can be transferred to farmers freely (the recipient does not need to pay royalties) while licensing the IP of technology requires the recipient to pay the licensing fee plus the royalty to MARDI.

CASE STUDY: THE TRANSFER OF AGROCUBE TECHNOLOGY TO YOUNG ENTREPRENEUR

One of the reasons for the development of smart agriculture technology in Malaysia is to address the performance of the vegetable industry in Malaysia. The vegetable is one of the essential industries in Malaysia. This industry provides source of vitamins, offers job opportunities, and generates income for farmers. However, the production of vegetables is low and unable to meet the demand of local consumers. In 2020 Malaysia produced 1.030 million MT of vegetables, which decreased by around 3.7% compared to 2019. As a result, the self-sufficiency level (SSL) for vegetables decreased to 45.00% in 2020, from 46.64% in 2017. Malaysia imported more than 1.383 million MT of vegetables in 2020 (Table 1).

Table 1. The production, import and SSL of vegetables in Malaysia

	ITEM	2017	2018	2019	2020
1.	Production (MT)	1,003,536	996,745	1,069,891	1,030,064
2.	Import (MT)	1,859,000	1,887,000	1,949,000	1,383,793
3.	Self-Sufficient Level (%)	46.64	44.56	45.03	45.00

Source: Department of Agriculture, Malaysia

Malaysia needs to increase the production of vegetables for local consumption, and the production of vegetables by plant factories is one of the options. The production of vegetables in plant factories is critical, especially for high-value vegetables that require special treatments and controlling artificial environments.

The development of AgroCube technology

Malaysia is looking forward to expanding the application of plant factories to produce high-value vegetables, and the research on this matter has been carried out extensively. One of the action plans taken by MARDI as a research institute is to develop an economic scale plant factory that is suitable for young agropreneurs. A plant factory is a closed growing system that enables the production of vegetables all year around. Among the benefits of a plant factory package are high-quality products, increased product weight per unit of at least 33-75%, and a reduction in fertilization cost (Santiteerakul et al., 2020).

There are two types of plant factories developed and currently operating at MARDI: the building type (large scale) and the container type (small scale). MARDI built a building type or a large-scale plant factory for big-scale investment. The total floor area of the building is around 4,200 square feet, and the height is about 30 feet. The large-scale plant factory can easily grow more than 100,000 salad crops in one cycle. On the other hand, MARDI also built a container-type plant factory and was branded as AgroCube. The size of the AgroCube is ten feet wide, 40 feet long, and ten feet high. The main feature of these closed systems is creating an indoor microclimate that allows the cultivation of a variety of plants, regardless of soil conditions and other climatic factors. In these plant factories, high-value vegetables are grown with the help of a customized light-emitting diode (LED) lighting system that replaces sunlight and a precise supply of carbon dioxide (CO_2). The ambient temperature and humidity are also controlled accordingly using air-conditioning systems. The vegetables were grown in a hydroponic system where the supply of water and fertilizers was automated. The production of vegetables in a closed system will produce high-quality vegetables with higher yields without being affected by outdoor conditions.

MARDI built the AgroCube by refurbishing and modifying the used marine refrigerated container. The reason for using the refrigerated mobile container was its prefabricated insulation to reduce heat transfer from the environment into the AgroCube and the capability to move when and where needed. The AgroCube consists of two rows of trays on the left and right sides and a service area approximately two feet wide in the center. Each row consists of four levels in which trays for growing leafy crops are carefully stacked. Each tray is equipped with an individual LED lighting system, water, and fertilizers pumped into the bottom of the tray. A carbon dioxide (CO_2) gas tank provides the plants with a concentration of about 500 ppm to allow photosynthesis. The production system in the AgroCube consists of a racking, light, and watering system. The racking system for planting the crops is presented in Table 2.

Table 2. Racking system specification complete with LED

ITEM	DESCRIPTION
1. Racking frame and container material	Plastic Polymer
2. Racking system dimensions	2,200 mm x 700mm
3. Height in between layer	350 mm
4. Distance in between pot holes (center to center)	100 mm
5. Length of racking system	8,534 mm
6. LED color type	Red, Green and Blue
7. Numbers of LED per layer	28 nos.

The AgroCube is also equipped with a control and monitoring system for the control environment and micro-irrigation. The environment control system monitors the desired parameters and controls mechanisms or actuators in the AgroCube, such as air conditioning, exhaust fan, and ventilation fan. The climate control system is controlled based on the optimal conditions required for the internal environment in the AgroCube to ensure optimal growing conditions. The optimal temperature range for leafy vegetables has been set at 24-28 degrees Celsius and the relative humidity at 60-70%.

The AgroCube uses the hydroponic system. A hydroponics system is a way to grow plants using formulated, nutrient-rich water instead of soil. In hydroponics, the plant is suspended with a net pot that allows the plant to grow above the water. The plant's roots go down through the netting and into the water solution. The micro-irrigation system is equipped with an irrigation tank, a water pump, two electric injectors for hydroponic nutrition fertilizer A and B, and a control system. This specially formulated hydroponics fertilizer is tailored to grow leafy greens. This fertilizer has the ideal balance of growing nutrients needed for a healthy, vibrant leafy crop. The sensor system consists of a pH sensor, an Electrical Conductivity (E.C) sensor, and a water temperature sensor. The sensors are connected to the Supervisory Control and Data Acquisition (SCADA) system, which sets the parameters for E.C and pH and visualizes the data via the SCADA control panel. All data is synchronized with cloud storage, and the information is displayed on the dashboard to meet the optimum growth requirements of the plants accurately. The AgroCube technology developed by MARDI is as in Figure1.

Fig. 2. AgroCube at MARDI

The AgroCube produces free of herbicides and pesticides in vegetables since they are hydroponically grown. Three types of vegetables can be planted in the AgroCube, such as salad, *kailan*, or water spinach and mustard greens. In this project, the researcher planted three varieties of salads: Red Leaf lettuce, Green Leaf lettuce, and Butter lettuce. These varieties are premium vegetables that could be sold at a premium price. The price of these salads is ranged between RM16.00 (US$3.80) and RM25.00 (US$5.95) per kilogram.

The production of vegetables takes between 20 and 35 days, depending on the maturity of the vegetable. For example, the baby salad takes 20 days to harvest, while a matured salad takes 35 days. Generally, baby salad is more expensive than matured salad.

The selection of vegetables is also determined by the light used in the production system. Light is essential for photosynthesis. Photosynthesis is the process in which light energy is converted into chemical energy. In general, plants use the energy of sunlight to synthesize carbon dioxide and water. Light is absorbed by complexes made up of chlorophyll and proteins called photosystems, located in the chloroplasts. The intensity of the light will affect the growth of the crops. For example, the combination of red, blue, and green light will grow water spinach faster, while the red and blue light are used to produce green salad.

On the other hand, red, blue, and infrared light produces red salad. MARDI has generated a light technology that could shorten photosynthesis's duration. The conventional system requires around 16 hours for photosynthesis, while the lighting technology developed by MARDI requires approximately 12 hours to complete the process. This technology has reduced energy use and, consequently, reduced production costs.

The development cost of the AgroCube is RM135,000.00 (US$32,142.00), as in Table 3:

Table 3. Development cost of AgroCube

ITEMS	COST (RM/US$)
Mobile Container ((10' x 40' x 10') and seedling nursery	RM55,000.00/ US$13,095.00
Multi-storey planting system (including irrigation system and LED lighting)	RM60,000.00/US$14,285.00
Environmental control and monitoring systems	RM20,000.00/US$4,762.00
Total investment cost	**RM135,000.00/US$32,142.00**

Financial analysis

AgroCube produces consistent, high-quality vegetables with a high frequency of production. However, the AgroCube production costs are higher than those of the conventional farms due to initial investment costs, including infrastructure, maintenance, lighting devices, running costs for electric power supply (LED), and production equipment.

The researcher conducted the financial analysis to measure the project's cost, return on investment, and profit margins. The three most common approaches to measuring the profitability of AgroCube technology are Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost ratio (BCR). Financial indicators are important because it is the easiest method to prove the technology's economic viability in agricultural production (Slavickiene & Savickiene, 2004). Besides, it can guide the management of innovation projects by providing indications of their potential financial value (Žižlavský, 2014).

Net Present Value (NPV) is a vital indicator for evaluating the viability of a project that considers the value of money over time. In other words, NPV indicates the value of future returns. NPV is regarded as a superior method of evaluating the cash flows from a project because it can rank projects of different sizes over varying periods to determine the most profitable course of action. By contrast, the internal rate of return (IRR) is used to evaluate the profitability of possible investments. It refers to the rate of project return and capital cost invested in the form of a percentage. Furthermore, the benefit-cost ratio (BCR) shows the return on investment per RM1.00 (US$1.00) invested. Finally, the break-even period indicates the time taken to recover the original investment capital that has been issued by the entrepreneur (Ronald and William, 1999).

The economic analysis is presented based on the production of red and green coral lettuces in the AgroCube container, and the projection is calculated for ten years (Table 4).

Table 4. Production of red and green coral lettuces

ITEM	**Details**
AgroCube Container (10 ft x 40ft)	400 sq feet
Plant density	3,000 crops
Duration of production per season	24 days (15 seasons per year)
Average yield per crop of lettuce	0.22 Kg
Average total yield per season	326.70 Kg
Farm price	RM16.00/kg/ US$3.80/kg
Total sale per season	RM5,227.20/US$1,244.60
Net profit per year	RM22,410.70/US$5,335.90
Net profit per month	RM1,867.60/US$444.65

The average yield of the red and green coral lettuces collected from a 400 sqft2 container is 367.2 kg per season (assuming a 0.1% loss), and this yield generates the gross sale of RM5, 227.20 (US$1, 244.57) per season.

The viability of the AgroCube project is presented in Table 5.

Table 5. Economic viability of AgroCube Project

Item	Value
Net Present Value@10% for 10 years	RM87,039.90/ US$20,737.80
Internal Rate of Return (IRR)	25%
Benefit Cost Ratio	1.37
Pay-back Period	Year 4 (3 years and 6 month)

The Net Present Value (NPV) for premium lettuce production technology showed a positive value of RM 87,039.87 (US$20,723.77). The NPV, in general, indicates the cost of future returns, where the higher the value, the more viable the project. This project's Internal Rate of Return (IRR) is about 25%, higher than the 10%, considered an economical rate. The return of the investment period takes four years, while the Benefit-Cost Ratio (BCR) is RM 1.37. The analysis shows that with the RM 1.00 investment, the return will be RM 0.37.

The project was carried out for two cycles to measure the projection of profit and loss from the production and the selling of the high-value vegetables. The forecast of the profit of the project is presented in Table 6.

Table 6. Projection of profit and loss account (production of red salad by AgroCube)

Items	Year 1	Year 2	Year 3	Year 4	Year 5
A. INCOME					
Production of Red Salad (kg)	4,900.50	4,900.50	4,900.50	4,900.50	4,900.50
Sales of Red Salad (RM)	**78,408.00**	**78,408.00**	**78,408.00**	**78,408.00**	**78,408.00**
Variable Cost					
Seedling	720	720	720	720	720
Seedling media (Tray, floral foam, rock wool, starter plug, perlite (growing media) etc.	3,150.00	3,150.00	3,150.00	3,150.00	3,150.00
Fertilizer A&B + acid solution	2,700.00	2,700.00	2,700.00	2,700.00	2,700.00
Maintenance and treatment	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
Operation (Transportation and documentation)	600	600	600	600	600
Other inputs (packaging etc.)	4,320.00	4,320.00	4,320.00	4,320.00	4,320.00
Utility cost (Electricity)	12,000.00	12,000.00	12,000.00	12,000.00	12,000.00
Utility cost (water)	420	420	420	420	420
B. TOTAL VARIABLE COST	**26,910.00**	**26,910.00**	**26,910.00**	**26,910.00**	**26,910.00**
Gross Margin	**51,498.00**	**51,498.00**	**51,498.00**	**51,498.00**	**51,498.00**
Fix Cost		-	-	-	-
Depreciation of Mobile content and infrastructure (10 years) *10%:		-	-	-	-
- Heat -proof infrastructure, air conditioning installation, ventilation, anti-fungal paint and CO2 injector installation	5,500.00	5,500.00	5,500.00	5,500.00	5,500.00
- Elevated plant system (Rack)	6,000.00	6,000.00	6,000.00	6,000.00	6,000.00
-Environmental monitoring control system	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
General worker	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Miscellaneous cost (5%)	97.28	97.28	97.28	97.28	97.28
Total Fix Cost	**14,597.28**	**14,597.28**	**14,597.28**	**14,597.28**	**14,597.28**
Margin/Net profit/year	36,900.72	36,900.72	36,900.72	36,900.72	36,900.72
Margin/Net profit/month	3,075.06	3,075.06	3,075.06	3,075.06	3,075.06
Production cost per kilogram	5.49	5.49	5.49	5.49	5.49
Net present value (NPV) @10%	87,039.87				
Internal Rate of Return (IRR) @ 10%	25%				
Benefit Cost Ratio (BCR)	1.37				
Payback period	Year 4	3.59			

The financial analysis indicates that the AgroCube project is viable and creates a business opportunity for young agropreneur in Malaysia. The investment in the production of smart agriculture by AgroCube shows a small profit for young agropreneur. The main factor contributing to the low-profit margin is the higher initial capital for developing the AgroCube container and its infrastructure. In general, the cost of building a container plant factory at the government research institution is around 30% higher than that of the private sector. If the young agropreneur can reduce the initial cost, it will result in a higher profit margin. Thus, several strategies can be implemented, such as reducing the development and operating costs and increasing crop density and turnover.

Young agropreneur

Entrepreneurship has been recognized as one of the main drivers of economic development. It can generate income, provide employment and improve the socioeconomic of the community. However, statistics show that youth involvement in agribusiness is shallow in Malaysia. The Ministry of Agriculture and Food Industry (MAFI) report revealed that only 15% of the Malaysian youth population is involved in this sector. The MAFI addressed this issue by creating a Young Agropreneur Unit in 2013 for all Malaysian aged between 18 and 40 years old. The approach of this unit is to facilitate and encourage higher involvement of youth in Agriculture-based entrepreneurship, including all activities within the agriculture industry value chain such as crops and food processing (agro-based industry), marketing, and technical advice. During the Malaysian 11th Development Plan (MDP-11, 2016-2020), the government allocated RM100.00 (US$23.80) million to provide financial and technical assistance via a grant, financing, and technical training for the young agropreneur program.

Consequent to the initiative by the MAFI, MARDI established its Young Agropreneur Program in 2014 to plan, organize and administer activities that foster the utilization of technology and innovation among the young agropreneurs, specifically in crops and food processing (agro-based industry). The main objective of this program is to change the perception and encourage the involvement of youth in agribusiness through various structured programs such as technical training and consultation as well as financial and marketing. This program aims to develop young agropreneurs who are progressive, competitive, creative, and innovative and ultimately will generate high income from their ventures.

During the 11th Malaysian development Plan (2016-2020), MARDI registered 5,688 participants under the MARDI Young Agropreneur Program. The Young Agropreneur Program focuses on three main clusters, namely agro-based industry (IAT), crops, and livestock. Participants were given access to entrepreneurship training and various other technical training. Moreover, MARDI also provides technical advisory services by the experts and executes continuous monitoring for young agropreneur businesses. MARDI's young agropreneurs were allowed to apply for Young Agropreneur Grant from the MAFI with a maximum value of RM20,000 (US$4,762.00). In addition to this financial assistance, the participants were eligible to apply for business loans with low interest from Agrobank and TEKUN National, the agencies under the MAFI.

MARDI developed young entrepreneurs who are equipped with new technology. MARDI has transferred many technologies to these young entrepreneurs by giving them technical training related to technologies, entrepreneurship, and financial skills. The technologies transferred include new formulation of processed foods, a unique variety of crops and livestock, smart agriculture technology such as precision farming, drones in managing farmland, and AgroCube.

Transfer of AgroCube Technology

In collaboration with the Ministry of Agriculture and Food Industries (MAFI), MARDI has organized a few training on AgroCube technology for young agropreneurs. The program was called "Agora-X: Plant Factory Technology and Fertilization for young agropreneur. The program managed to attract around 120 participants. Agora X refers to an entrepreneurship program for young generations aged between 18 and 40 years old. It aims to encourage youth to involve in entrepreneurship as their career, rather than seeking a job in other industries. It also intends to change youths' perception and involvement in agriculture and agro-based industries. Under this Agora-X program, MARDI develops entrepreneurship through training, guidance, consultation, and packaged technical, financial, and marketing support.

The module for this program consists of two parts: theoretical and practical. The modules for the theoretical part were as follows:

- Introduction to smart agriculture/AgroCube;
- Leafy vegetable planting technique in the plant factory;
- AgroCube infrastructure development;
- Controlled environment and micro-irrigation system by the Internet of Things (IoT);
- LED lighting for crop production;
- Hydroponic planting system in the plant factory;

- Managing pests and diseases;
- Post-harvest handling;
- Operation of the plant factory or AgroCube;
- (Good Agricultural Practice) MyGAP; and
- Marketing strategy.

For practical parts, the participants were provided with seed sowing and transplanting skills and learned about fertilization for the crop in the plant factory. Participants were exposed to hands-on training on operating the AgroCube from the cultivation of crops until the marketing of the produce. Hands-on training aims to make the training environment as realistic as possible. This hands-on training increases the participants' engagement, encourages participants to interact with the researcher, and teaches them to link theory and practice. Since hands-on training is active, not passive, we can expect that the participants retain what they learned.

The participants learned about the marketing aspect of high-value or premium agricultural produce. It includes post-harvest handling (cleaning, sorting, packaging, storing, and transporting the produce from farm to market places). The target markets for premium vegetables are the medium and upper-class population, hotels, and institutional organizations. Generally, premium vegetables are sold at premium supermarkets and specialty grocery stores. In Malaysia, several premium supermarkets are selling premium products. For example, the Food Purveyor Sdn Bhd (TFP) is a full-fledged chain of premium grocers across the Klang Valley and aims to be Malaysia's leading premium supermarket chain. This group of companies has 30 outlets, consisting of three supermarkets, 19 Village Grocers, 7 Ben's Independent Grocer, and one Village Pantry. The participants also learn online marketing, including the advertisement and the delivery of the products. In this regard, the Federal Agricultural Marketing Authority (FAMA) is always ready to provide services and assistance in marketing to these young agropreneurs.

The participants were also introduced to Agrobank, one of the agencies under the MAFI. This bank provides financial assistance such as grants and soft loans for the young agropreneurs to start their ventures. It aims to produce progressive, competitive, creative, innovative, and high-income young agropreneur to build their business. Many young agropreneurs have benefited from the financing, products, and services of Agrobank.

MARDI has trained more than 500 youths to produce high-value vegetables in the AgroCube, until 2021. More than 30 participants have started their venture to grow high-value vegetables and successfully marketed the product in the marketplace. These young entrepreneurs received technical advice and consultation from research officers from MARDI and marketing advice from FAMA.

ISSUES AND CHALLENGES

Technology transfer is a complex and dynamic process. It relates to a method that enables technological knowledge to move from one entity to another. Knowledge can be about know-how, skills, information, technical documents, and many others. Technology transfer involves the technology generator and technology recipients. As technology transfer is a transfer of new knowledge, the ability of the recipient to absorb and assimilate the knowledge is critical. The transfer would fail if the recipient cannot incorporate technology and knowledge from the technology supplier. To assimilate technology transfer successfully, the recipient must be aware of the compatibility of the technology before it is transferred. In other words, the recipient must have similar knowledge that can help them understand the technology and knowledge. Besides the dynamic and complexity of the process of technology transfer, the other issue and challenges of technology transfer are as follows:

Application of technologies

Applying technologies is critical as it could increase productivity and reduce operational costs and labor. Currently, the application of technologies by farmers, breeders, and fishermen in Malaysia is still moderate. One factor that hinders the application of technologies is the cost of purchasing the technologies. Most farmers are small-scale entrepreneurs and cannot afford to buy the technologies, such as machines, automation devices, or new agricultural production systems. At the same time, the old generation of farmers still prefers to use conventional methods or techniques.

On the other hand, the transfer of technologies from government research institutions is also very low. For example, a Ministry of Science, Technology, and Innovation report revealed that the rate of technology transfer in Malaysia is between eight and nine percent. In other words, out of 100 technologies generated by public research institutions, only between eight and nine technologies are fully transferred or adopted by farmers, breeders, and entrepreneurs.

Investments and financial issues

The agro-food sector is a high risk but has low returns on investments. The investments in the agro-food sector also take time to get back the return. Thus, not many people like to invest in this sector in Malaysia. People prefer to invest in industrial crops such as palm oil that promise higher and more sustainable returns. Small and medium enterprises dominate this sector and always need government support. They lack capital should they want to expand their business. At the same time, no commercial banks are willing to provide a soft loan or financial assistance. Most banks require a guarantor or capital as collateral. Thus, the government offers billions of subsidies and grants to help small and medium enterprises (SMEs) sustain in this industry every year.

Profitability of agriculture-based venture

The perspective of the entrepreneur, on the other hand, looks at business opportunities for firm profitability. The ability to recognize and develop business opportunities from a newly developed technology is influenced by a person’s mental judgment that can predict the potential profitability by venturing into a business. An entrepreneur who has better mental judgment or imagination of the opportunity created from the technological product is likely to have a better chance of succeeding in his business venture than the one who lacks business imagination. A successful entrepreneur is a person who always displays his confidence in any venture. The faith expressed will enhance the chance to succeed in that venture. This perspective suggests that people who have entrepreneurial characteristics, access to information, better social networking, better imagination, and emotion can recognize opportunity better than those who are lacked in business imagery and confidence.

In the case of the AgroCube, several issues that need the government intervention are as follows:

- The AgroCube used a lot of electricity in the production system, including lighting and water supply. The government should provide some incentives regarding electricity tariffs for the agriculture industry. This incentive will reduce the operation cost and subsequently increase the profit margin. The good return on investment will attract more young entrepreneurs to be involved in the industry.
- The production of high-value vegetables requires a big investment, especially for young entrepreneurs. The government should provide special grants for young entrepreneurs interested in being involved in the projects. The government can also encourage the researchers at MARDI to start the business of spin-off the technology. By implementing this project, the researcher could enhance their entrepreneurship skills and apply their technology in the markets.

WAY FORWARD

The transfer of new technology from GRI to private firms is a clear case of how two different organizations with different objectives and cultures can work together to benefit the people and the nation. It is hoped that the higher the number of technologies developed by government research institutions being transferred to private firms will increase the number of new products in the marketplace and finally enhance Malaysia's economic development.

The Malaysian government has been and continues to be supportive of entrepreneurship. It has taken various steps to promote the development of entrepreneurs in general (including providing a conducive economic environment, different financing and funding schemes, tax incentives, and business advisory centers). The government has nurtured entrepreneurs by facilitating and upgrading the industrial structure to create industries for the next generation. For this reason, the government has paid particular attention to the development of young entrepreneurs.

The government was also trying to improve the economic environment conducive to entrepreneurship development and outlined the specific direction that the Malaysian economy will take in the years ahead. The government announced the "Knowledge Economy Master Plan" to transform the economy into knowledge and information-driven. The government has clearly outlined its intention to nurture high-tech, information, and knowledge-intensive ventures to implement this plan. By clearly indicating the economy's future direction, entrepreneurs can channel their energies in a specific direction and minimize the risk of investing in future technologies.

A smart partnership comprising of policymakers, scientists, the private sector, and the farming community is crucial to effect change by allowing the nexus of technological advancement, policy-making decisions, business acumen, and the needs of farmers to coexist and coalesce.

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AUTHORS' CONTRIBUTIONS

Muhd Akhtar and Khairul Anuar were directly involved in the development of AgroCube in MARDI in collaboration with other research officers from the Horticulture Research Center. Rasmuna was responsible for analyzing the financial and business elements, while Rozhan wrote the manuscripts.

COMPETING INTEREST

It is declared that all of us have no competing interest in developing the AgroCube project. While the three authors are still serving as research officers at MARDI, the first author has retired from MARDI.