Green Technology and Sustainable Agricultural and Food Production

by Ms. Suvarna Ooi

Dato' Zohadie's visit to Japan during the Cherry blossom season

Emeritus Dato' Ir. Prof. Muhamad Zohadie Bardaie, Ph.D., P.Eng. Dato' Zohadie holds a Ph.D. degree in Agricultural/Environmental Systems Engineering from Cornell University, USA. He retired as a professor in engineering from Universiti Putra Malaysia (UPM) in December 2006. In 2009 he was conferred the 'Emeritus Professor' in Bio-systems Engineering by the Faculty of Engineering, Universiti Putra Malaysia of Selangor.

FOOD prices have been increasing in recent years. Between March 2007 and March 2008, global food prices increased by an average of 43% as reported by the International Monetary Fund. According to the National Inflation Association in the United States, the average American family currently spends only 13% of their total annual expenditure on food.

However, it is projected that Americans will spend as much as 40% of their annual expenditures on food by 2015. The World Watch Institute concluded that the growth of biofuel, the impact of climate change and the rising prosperity of developing nations are all driving retail food prices to their biggest annual increase in 30 years.

Closer to home, international aid agencies are increasing worried by the recent dramatic rise in food costs in Asia, particularly the price of rice. World stocks of grain are at their lowest for more than 20 years and international rice supplies are at their lowest since 1976. To make matters worst, many of the world's leading rice exporting countries are limiting the sale of rice or banning them altogether.

With the world population ever increasing, estimated by the United Nations to reach 10 billion by 2050, food production will become even more critical as time goes by. As such, JURUTERA sought out Emeritus Prof. Dato' Ir. Muhamad Zohadie Bardaie, Chairman and Director of Perunding Bakti Sdn Bhd and former Vice Chancellor of Universiti Putra Malaysia (UPM), for his thoughts on how we should address some of these issues.

According to him, one possible solution could come from green technologies in agricultural and food production. This would involve the use of innovative technologies that have the potential to steer agriculture along a sustainable path, while at the same time contribute to the advancement of the economic and efficient production of safe and high quality food. This also includes sustainable agriculture, the practice of farming using principles of ecology, which can be defined as an integrated system of plant and animal production practices having a site specific application that will last over the long term.

Dato' Muhamad Zohadie pointed out that several research institutions and universities in Malaysia have carried out studies on some of the green technologies that are available in the country. One of the more interesting R&D initiatives in agricultural and food production that he has encountered is the concept of "vertical farming". This refers to the cultivation of plant or animal life within skyscrapers, or on vertically inclined surfaces.

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He said, "The strongest proponent of vertical farming is Dr Dickson Despommier, a professor of environmental health sciences and microbiology at Columbia University in the United States. He argued that vertical farming is legitimate due to environmental reasons and claimed that the cultivation of plant and animal life within skyscrapers will produce less embedded energy and toxicity than plant and animal life produced on natural landscapes."

Vertical farming promotes the mass cultivation of plant and animal life for commercial purposes in skyscrapers. In theory, the latter could also produce fish, poultry, fruit and vegetables using advanced greenhouse technology such as hydroponics and aeroponics. And unlike traditional farming, indoor farming can produce crops year-round. All-season farming multiplies the productivity of the farmed surface by a factor of four to six depending on the crop.

Furthermore, the crop would not need to be transported between production and sale as it would be sold in the same infrastructure in which it is grown. This will result in less spoilage, infestation and energy required compared to conventional farming. Vertical farming would also reduce the need for new farmland due to overpopulation, thus saving many natural resources currently threatened by deforestation or pollution.

Dato' Muhamad Zohadie said, "Dr Despommier argued that the technology to construct vertical farms currently exists and also stated that the system can be profitable and effective. Developers and local government from various cities in the world, including South Korea, United Arab Emirates, United States, Canada, France, India, and China, have expressed serious interest in establishing vertical farms. In fact, the Illinois Institute of Technology is now crafting a detailed plan for Chicago."

He added, "However, it has been suggested that prototype versions of vertical farms should be created first, possibly at large universities interested in the research of vertical farms, in order to prevent failures. Perhaps one of our local research universities would consider the suggestion with a grant from the federal government."

SUSTAINABLE AGRICULTURE

The most important factors for a farm site are sun, air, soil and water. Of the four, water and soil quality and quantity are most amenable to human intervention through time and labour. As such, when farmers grow and harvest crops, some of the nutrients from the soil are removed. Without replenishment, however, the land suffers from nutrient depletion and becomes either unusable or suffers from reduced yield.

Dato' Muhamad Zohadie explained that, "Sustainable agriculture depends on replenishing the soil while minimising the use of non-renewable resources, such as natural gas or mineral ores. Some of the practices which can replenish the soil with nutrients includes recycling crop and livestock waste, growing legume crops and forages that form symbioses with nitrogen-fixing bacteria, genetically engineering (non-legume) crops to form nitrogen-fixing symbioses or fix nitrogen without microbial symbiont, long-term crop rotations, and returning to natural cycles that annually flood cultivated lands and return lost nutrients."

He pointed out that, while some areas have sufficient rainfall for crop growth, many other areas require irrigation. Thus, for irrigation systems to be sustainable, it needs proper management and this includes, among others, improving water conservation and storage measures, providing incentives for selection of drought-tolerant crop species, using reduced volume irrigation systems, and managing crops to reduce water loss.

As soil erosion is fast becoming one of the world's greatest problems, he also recommended several soil management techniques such as no-till farming, growing wind breaks to hold soil, incorporating organic matter back into the field, avoiding the use of chemical fertilisers which contain salt, protecting soil from water runoff, and incorporating Keyline design which is a technique for maximising the use of water resources on a piece of land.

OPPORTUNITIES IN GREEN TECHNOLOGY

According to Dato' Muhamad Zohadie, the Ministry of Energy, Green Technology and Water is in the process of intensifying the development of renewable energy, particularly biomass, as the "fifth fuel" resource under the country's Fuel Diversification Policy.

The policy has been reinforced by fiscal incentives, such as investment tax allowances and the Small Renewable Energy Program (SREP). This latter encourages the connection of small renewable power generation plants to the national grid. Such initiatives will further encourage the utilisation of green technology in the country.

However, with global warming becoming a global concern, how can Malaysians in general take advantage of opportunities in green technology? Dato' Muhamad Zohadie responded by explaining that the current priority is to mitigate climate

change which the Intergovernmental Panel on Climate Change (IPCC) defines as activities that reduce greenhouse gas (GHG) emissions, or enhance the capacity of carbon sinks to absorb GHGs from the atmosphere.

He said, "Many countries, both developing and developed, are now aiming to use cleaner, less polluting technologies. Use of these technologies aids mitigation and could result in substantial reduction of CO_2 emissions. Policies include setting targets for emissions reduction, increasing the use of renewable energy, and increasing energy efficiency."

He added that there are opportunities available for both the private and government sectors in the country to work on technologies for emission reduction on current processes which utilise fossil fuels, such as power plants, automobile and other industrial equipment.

Other areas of opportunity include introducing and developing technologies for increasing energy efficiency, and the development of renewable energy, such as bio-fuel and hydro-electric generation.

Dato' Muhamad Zohadie pointed out that opportunities may also exist in geo-engineering which encompasses a range of techniques to remove CO_2 from the atmosphere or to reflect incoming sunlight. He said, "As most geo-engineering techniques would affect the entire globe, deployment would likely require global public acceptance and an adequate global legal and regulatory framework, as well as significant further scientific research. On this matter, there might be opportunity for research institutions and universities to propose research projects and sought funding internationally."

Opportunities in green technology could also exist for green factories in the food industries which must have features that conserve the natural environment and resources. Dato' Muhamad Zohadie said, "The energy used in a green factory has to be non-polluting, and preferably renewable. Part of the energy supply could be generated internally by utilising the organic waste from the factory. Methane digesters could be built on site to transform the organic waste into biogas, which could then be burned to generate electricity for the factory."

He added that a water conservation process, which includes a water recycling and cleaning system, should be implemented in a green factory to minimise usage, ensure proper reuse of water, and discharge only clean water into the waterways. An air scrubbing and filtration system should also be installed to ensure that all particulates and harmful gases are trapped and prevent any accidental atmospheric discharge. In addition, waste from the factory needs to be properly processed to ensure there is no detrimental effect on the environment. Any solid waste from the process can be utilised by the farm for soil improvement.

Dato' Muhamad Zohadie said, "Besides all that, the management of the factory should be responsive to any malfunction of the installed systems, be on the lookout for any new technology which can improve the system, as well as organise regular briefings for employees to create awareness on the importance of going 'green'."

HOW CAN AGRICULTURAL ENGINEERS HELP?

Apart from the basic principles of engineering, Dato' Muhamad Zohadie pointed out that agricultural engineers in Malaysia should also be exposed to some of the basic principles of agriculture. The engineers should not only be aware of the availability of green technologies, they also need to be able to provide engineering solutions to most of the agricultural issues related to these technologies.

In fact, he said, "I would like to see one of the agricultural institutions in the country, be it the Agriculture Department or MARDI, create a centre for technological research. The main function of the latter will be to discover and study all the new technologies that are developed around the world with regards to agriculture and its related field. The centre should also have information on these new developments for use by our engineers in solving the agricultural problems in Malaysia."

He stated that agricultural engineers, in particular, needed to understand that they are dealing with living things, namely, plants and animals; thus, their experiences will be different from other engineers. For example, he said, "Once, an orchard owner who faced a serious drought problem wanted to set up an irrigation system for his mango orchard. He called me for advice on the type of irrigation system he should use. The first question I asked him was, 'What is your water source?' Suddenly, there was silence on the phone. A minute later came his reply, 'What water source?' Can you imagine, he was expecting the irrigation system to provide water for his orchard without a water source!"

When it comes to solving agricultural engineering problems, Dato' Muhamad Zohadie strongly believes in adopting a systematic approach. Relating an incident that illustrated this concept, he said, "Some time ago, there was a tomato harvesting issue in California. During the initial production, tomato harvesting was done manually, mainly by foreign labourers from neighbouring Mexico, who would go to the fields and pick ripe tomatoes from the plants. The Tomato Growers Association then decided to approach the University of California for a way to mechanise the operation."

He added that, after several initial studies and trials, the researchers at the university embarked on a systematic approach by bringing together the plant breeder, the agronomist and the agricultural engineer. The plant breeder was tasked with the breeding of a variety of tomato plant which grows upright and have uniform fruit maturity. The agronomist, on the other hand, had to create an appropriate practice in order to allow a machine to go through the field, while the agricultural engineer was tasked with designing the harvester.

After several years, the researchers produced a harvester which goes over the row of upright tomato plants. The machine uproots the plant, strips the fruits, then discharges the stripped plant at the rear. The final design of the machine was sent to a private company for fabrication, resulting in a machine which was named the UC-Blackwelder Tomato Harvester. The resulting harvester revolutionised the tomato industry in California, and was also adopted by other states in the US. ■