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**The Establishment of the First Bull,
Goat and Ram Semen Production Center
in Thailand**

Antibacterial PLA/Nanoclay
Composite Film for Food Packaging

**Possibility of Using Biochar In
Agricultural Areas In High-Rise Buildings**

Readiness and Impact of Greenhouse Gas
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Using Multi-Criteria Analysis

**Carrying Capacity Assessment In
Natural Attraction**

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Each year, researchers in Thailand publish many academic works in local and international journals; some of them have been recognized through global awards for research excellence. However, despite their clear contributions and value to society and the nation, these accomplishments all too frequently do not receive the acknowledgement they deserve, in terms of further development or integration e.g. into commercial products or as tools for social policy. At present, Thailand is addressing this challenge by promoting the publication of valuable research as well as its adoption and commercial exploitation. There is a strong focus on holistic approaches to research in both technology and the social sciences, which are both critical to the country's future development.

Transforming research, technology and innovation from laboratory to utilize in commercial application is key to economic growth and to the country's social and national development. It requires close and long-term cooperation among universities, research institutions industry and funding bodies in both public and private sectors. It also requires an enabling policy framework to incentivize cross-sectoral collaboration as well as to encourage major investment projects at national level. Such investment will help kick-start markets for new products, services and business models arising from research, and contribute through building a strong foundation for the country's long-term sustainable development.

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The Establishment of the First Bull, Goat and Ram Semen Production Center in Thailand

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Introduction

The business of bull and goat semen trading has been developed by importing and domestic production. The Department of Livestock Development (DLD), Ministry of Agriculture and Cooperatives is responsible for domestic production. There are three main bull semen production centers as Lam Phraya Klang Center, Khon Kaen Center, and Doi Inthanon Center. Semen produced at these three centers is distributed nationwide for local artificial insemination. According to data, collected at September 2018 about 900,000 doses per year of dairy and beef cattle were produced. Meanwhile goat semen is produced at Pak Chong Center and Songkhla Center; however, as yet there is no ram semen production in Thailand. Most of the semen production is aimed for domestic use. While the semen from different breed were imported by private (Figure 1). From 2014 to October 2018, the total bull semen of 834,619 doses were imported it is about 170,000 doses a year were imported.



Figure 1 The example of beef and dairy bull semen with a high genetic were imported

Source: Techakumphu et al. (2018)

According to the data above, DLD has the potential to produce semen for domestic use, but is not possible to sell, except under contractual support agreements with neighboring countries. Government regulations limit exports; and producers in Thailand are reluctant to export elite bull semen to potential competitors in other countries. Semen production needs to be certified under the DLD's production standard and comply with relevant laws.

by the National Science Technology and Innovation Policy Office (NSTIPO), Ministry of Science and Technology and the Office of Higher Education Commission.

The project covers semen production of high genetic bulls under the DLD semen production standard, hence to improve competitiveness in domestic and export markets. In future, the semen will be sold to other countries in ASEAN.

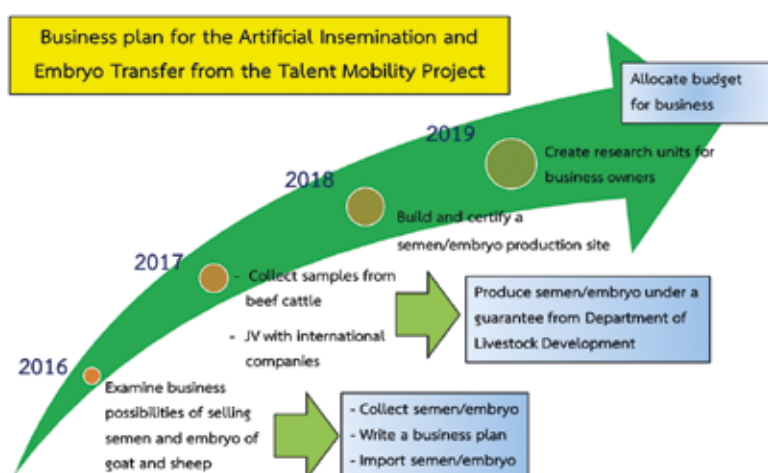


Figure 2 The 3-year framework of the Talent Mobility Project
Source: Techakumphu et al. (2018)



Figure 3 The research and development of the business of artificial insemination and embryo transfer in cow, goat, and sheep project (phase 1 in 2016) won the TM Innovation Award in the Talent Mobility Fair 2017
Source: Techakumphu et al. (2018)

From research to application to the development of the first private bull, goat, and ram AI center in Thailand

In 2016, a project entitled *“Development of the First Private Bull, Goat, and Ram Semen Storage Center in Thailand”* was launched based on the expertise of a research team led by Prof. Mongkol Techakumphu, DVM., DEA, Doctor at 3e cycle and Pornchai Intertrade Limited Partnership, a medium-sized livestock business operator.

The project is in the program of Talent Mobility (TM) aimed to develop the potential of entrepreneurs and to transfer the expertises from universities and government research institutes to private in order to increase the competitiveness. This project is supported

In the first year (2016-2017) of the project's four-year duration (Figure 2), the project aimed to develop the business model of goat and sheep semen and embryo trading, which was funded by the Agricultural Research Development Agency (Public Organization, ARDA). In the second year (2017-2018), the project will conduct experiments on the storage and freezing of beef cattle embryos and explore the feasibility of establishing the country's first private sector semen production center. In the project's final year (2018-2019), the project will motivate the private sector to invest in research until they can ultimately transition from importer of livestock technology to innovator.

The first phase of the project *“The Research and Development of the Business of Artificial Insemination and Embryo Transfer in Cow, Goat, and Sheep Project”*

Flowchart of a private bull, goat, and ram semen production center

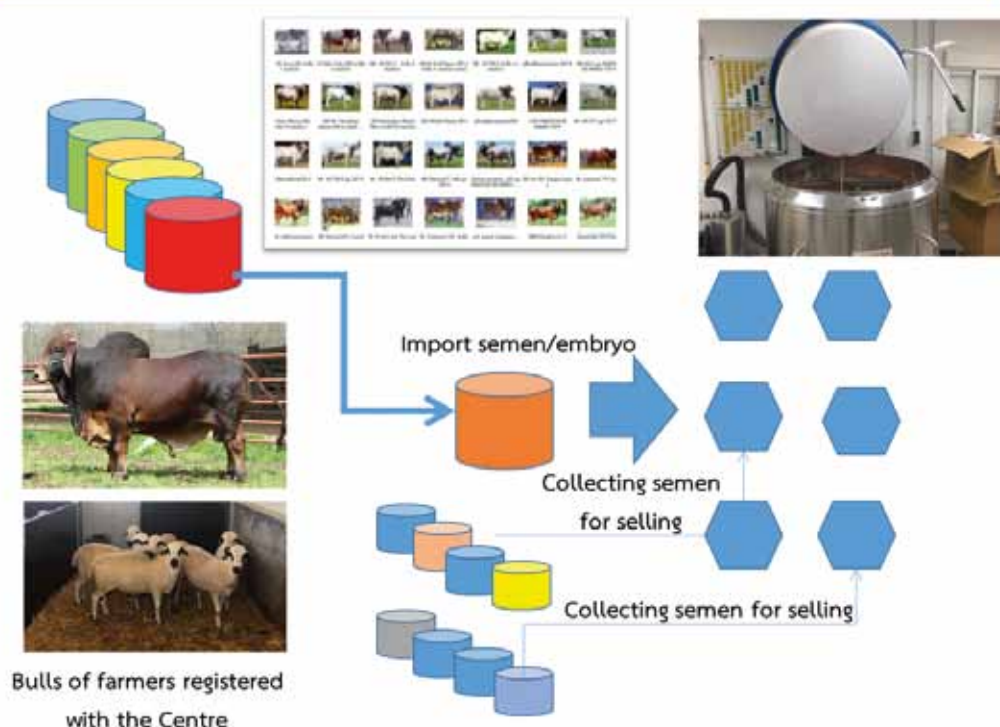


Figure 4 The concept of building a private bull, goat, and ram semen production center
Source: Techakumphu et al. (2018)

under the Talent Mobility Project in 2016 won the Outstanding Project Award by the NSTIPO and the Office of the Higher Education Commission (OHEC) (Figure 3). From that success, the researchers and the business operator continued with the second, development phase of the project, with the goal to establish a business based on frozen bull, goat, and ram semen by creating a cattle semen production center certified under the DLD standard. Business activities included import and export of the animals, disease control, semen storage and production using high-end technology (Figure 4).

The pyramid of Talent Mobility

With a long experience in research and working with the private sector, the research team applies the principle of Chulalongkorn University-Talent Mobility Team (OGR CU-TM Team) to create the model for service research. This is because working as a team can improve the efficiency of research and TM service (Figure 5).

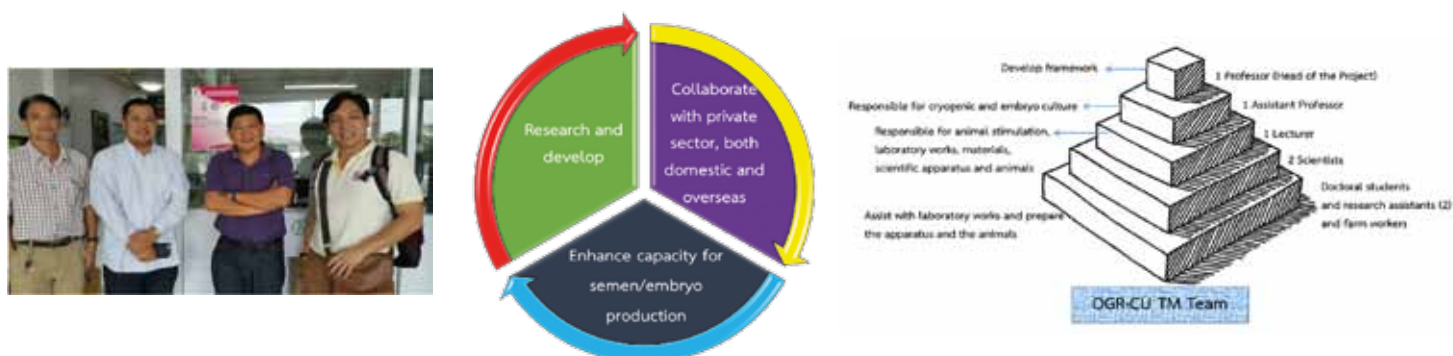


Figure 5 OGR CU-TM Team and Mr. Sanya Suphaphonchai, managing director of Pornchai Intertrade Limited Partnership
Source: Adapted from Techakumphu et al. (2018)

How to transfer technology to the business

The steps and action plans are as show in Figures 6-8.

Steps	Actions
Hold a meeting with the business operator, consultant and company engineers to develop a plan for building a bull, goat, and ram semen storage center	- Select elite bulls, goats, and rams and conduct fertility test before including them in the project and study the regulations on building the semen production system according to the DLD standard. - Visit DLD semen production facilities - Meet with OGR CU-TM Team and private sector project partners to develop a plan for building a bull, goat, and ram semen storage center - Select location and develop a design for the semen production center together with the business operator
Hold a meeting with the team from animal science company and staff who will collect the semen	- Import the bulls, goats, and rams into the project - Semen collection test and quality inspection
Knowledge transfer by individual training for the company staff and group training in the form of academic seminar for farmers and customers of the business	- Test the management of semen storage unit and frozen semen production unit by introducing the actual bulls, goats, and rams in the laboratory to produce real semen (mock-up process) - Establish the standard management criteria - Provide training for private artificial insemination personnel and educate them about the standard of semen production and artificial insemination
Construct and modify the frozen semen storage center as recommended by veterinary staff of the Department of Livestock Development	- Construct and modify the frozen semen storage center as recommended by veterinary staff of the Department of Livestock Development
Apply for the semen production center standard by the Department of Livestock Development	- Apply for the semen production center standard by the Department of Livestock Development - Organize academic seminar for domestic and foreign customers e.g. ASEAN countries
Hold a meeting to summarize the project implementation and make a marketing plan	- Project evaluation and marketing plan



(a) Hold a meeting and select the location for the semen storage center between the OGR CU-TM Team and the private sector joining the project



(b) A visit by veterinary staff of the Department of Livestock Development to give recommendations for building the semen production center

Figure 6 Planning and surveying the location for building a bull, goat, and ram semen storage center between the OGR CU-TM Team, Department of Livestock Development, and the private sector joining the project

Source: Adapted from Techakumphu et al. (2018)



Figure 7 Biotech-Industrial Link Unit co-invested by the private sector in the project of ARDA at Center of Learning Network for the Region, Chulalongkorn University, Kaeng Khoi District, Saraburi Province
Source: Adapted from Techakumphu et al. (2018)



Figure 8 Health condition examination for the sheep herd and semen collection from ram
Source: Adapted from Techakumphu et al. (2018)

After the modification as advised by DLD, DLD conducts an audit and certifies the first private goat and sheep semen production center in Thailand. (Figure 9)

In addition, this project also provides training for farmers and the company staff (Figure 10) as a way of knowledge transfer and create the network of livestock service in the future.

Problems and challenges during implementation

Establishing a private semen production center in Thailand is a complex undertaking. During the process, a range of problems and challenges were encountered, as listed below.

1) Relatively few customers buy from the private semen production center because free semen for dairy and beef cattle are provided by government agencies

(DLD). Farmers with limited resources therefore prefer to obtain semen from that source. The private semen production center will serve a target group of medium and large farmers with purchasing power and prefer semen from imported bulls which they believe to have a better genetic than domestic produced semen. Some farmers prefer another breeds which do not presents by government agencies such as Angus, Brangus, Hereford or Jersey etc. Moreover, the private semen production center can even evolve to produce sexed semen by collaborating with oversea private sector companies.

2) The location of the private semen production center needs to be suitable, and construction is expensive. The private sector should have a clear business plan that takes into account economic value, profit and loss, unlike the agencies sponsored by the government which do not focus on profit and loss.



Figure 9 The certification audit of goat and ram semen production by staff from the Department of Livestock Development on 10 September 2018 at Saraburi
Source: Adapted from Techakumphu et al. (2018)



Figure 10 Training provided for farmers and staff of private sector joining the Talent Mobility Project
Source: Techakumphu et al. (2018)

3) Production of semen requires compliance with and certification by the DLD Standard to ensure quality and pathogen-free semen that transmits to the offspring.

4) In case of accommodating bulls from the farmers in the semen production center, the business contract needs to have clear terms and conditions, including the number of doses, bull insurance, price, and a trade secret clause. This could be done by means of consignment or selling by the owner, depending on the contract provisions.

5) The certification process for the semen production center by DLD takes a long time and is expensive.

6) The government is unable to serve the high demand for goat semen. It was also found that artificial insemination for goat and sheep is not widely adopted. Therefore, it is important to provide training on cervical artificial insemination in order to promote sales. There may also be different breeds or sexed semen to attract buyers.

Conclusion

Implementation of the project *“The Development of the First Private Bull, Goat, and Ram Semen Production Center in Thailand”* under the Talent Mobility Project 2017 has led to a range of benefits, as follows:

1) A strong service research team now exists for Talent Mobility, concrete collaboration and technology transfer with the private sector.

2) The goat and ram semen production center at Kaeng Khoi District of Saraburi is going to be certified as compliant with the DLD standard, and has elite quality goats and rams. Semen collection and storage techniques have been improved. The semen has also been used for laparoscopic artificial insemination.

3) The private sector understands the importance of investing in the technology in Thailand instead of importation and resale.

4) Knowledge has been transferred to farmers and researchers from Thailand and other countries.

5) Staff from private companies are now trained to provide services to local farmers.

6) Veterinarians, animal scientists, and farmers have gained more knowledge and are better able to solve problems on the farm.

7) Collaborative networks have been established, both domestically and internationally (Figure 11).

8) Five research projects have been established in collaboration with the private sector and nine research projects presented at academic conferences and publications in academic journals

Readiness and Impact of Greenhouse Gas Mitigation Technologies for Energy and Industrial Process in Thailand Using Multi-Criteria Analysis

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Introduction

Assessment of the readiness and significance of Greenhouse Gas (GHG) mitigation technologies provides a knowledge database to support a national strategy to meet Thailand's target to reduce GHG emissions by 20-25% from current levels by 2030. Such a database also makes important contributions to formulation of research policy and the country's broader technological development. A strong technological base is vital to enable Thailand to meet its national policy targets and international obligations for GHG mitigation as well as to reduce social and environmental impacts of economic activity and create additional value added. This study aimed to assess and analyse the readiness and importance of key GHG emission technologies using multi-criteria analysis (MCA).

Multi-criteria analysis

Multi-criteria analysis (MCA) (Subash et al., 2015) is a method that combines assessment of multiple criteria in a single analysis process. The analysis facilitates identification and prioritization of the most feasible technologies as well as key constraints to each available

option. Moreover, MCA also aids with reducing the complexity of the analysis by converting data into quantitative criteria or weighted scores. The MCA method uses weighted scores for each criterion to compare and prioritize different GHG mitigation technologies. In this study, each criterion and its score were taken

from the Climate Change Technology Needs Assessment (TNA) report published by the National Science Technology and Innovation Policy Office in cooperation with the United Nations. The report was accompanied by a focus group session during which participants agreed that the most important priorities were 1) technology readiness and 2) impact of the technology. The results of brainstorming among experts and stakeholders, the criteria, weight and score for the MCA are shown in Table 1. The analysis covered 11 criteria for technology readiness and 4 criteria for impact, with a 60:40 distribution of weighting between readiness and impact.

In this study, the criteria were adapted to broaden the scope of analysis. In terms of readiness, additional criteria for financial support (R2), human resources and expertise/institution (R5) and technology database (R6) were added. Economic and technology criteria each were

given the highest weighting (15%) while political and social criteria were each given a 5% weighting.

In terms of impacts, criteria on economy, society and environment were classified and given clearer definitions. Economic criteria focussed on competitiveness and value creation, while social criteria emphasized local employment, income distribution and equity. Environmental impact criteria focused on pollution generated by each technology option. An equal weighting of 15% was given for each criterion.

This study reviewed existing GHG technologies commercialized in Thailand as well as pre-commercial technologies with high potential. However, new technologies must be able to reduce further GHG emission in comparison to conventional technologies currently in use. A list of key mitigation technologies is shown in Table 2.

Table 1 Criteria, weight and score for the Multi-Criteria Analysis (MCA)

Criteria		Weight	Score				
Readiness		40.0%	5	4	3	2	1
R1	Political	5.0%	Have strong policy and regulatory support, officially announced as national agenda	Have policy and regulatory support, officially included in the plan	Consistent with current policy direction under consideration of regulatory support	Consistent with current policy direction without any regulation support	Inconsistent with current policy direction
R2	Financial support	15.0%	Have strong direct financial support from any sources of funding	Have direct financial support from any sources of funding	Have indirect financial support from any sources of funding	Have discontinuous financial support	No financial support from any sources of funding
R3	Benefit and cost		Technology has a very high return in investment without any mechanisms	Technology has a very high return in investment with some mechanisms	Technology has a return in investment in all levels with some mechanisms	Technology is not cost effective in some levels	Technology is not cost effective in all levels
R4	Social and stakeholder acceptance	5.0%	Stakeholders in all sectors accept this technology	Government and local stakeholder accept this technology	Government and public stakeholder accept this technology	Only government accepts this technology	Stakeholders in all sectors do not accept this technology
R5	Human resource and expertise/institution	15.0%	Have network of experts for sharing experiences and expertise on technology	Have group of experts and expertise on technology	Have some experts and expertise on technology	Lack of expert and expertise on technology	No expert and expertise on technology
R6	Technology database		Have complete technology database and open widely for public	Have complete technology database and can be accessed by limited users	Have some technology database	Have some information on technology	Have no information on technology
R7	Short-term trend		Very high possibility/trend of implementing this technology in Thailand within five years	High possibility/trend of implementing this technology in Thailand within five years	Possibility/trend of implementing this technology in Thailand within five years	Low possibility/trend of implementing this technology in Thailand within five years	No possibility/trend of implementing this technology in Thailand within five years
R8	Management infrastructure		There exists a very good management infrastructure systematically supporting this technology	There exists a good management infrastructure supporting this technology	There exists a fine management infrastructure supporting this technology	There exists a some management infrastructure supporting this technology	No management infrastructure is supporting this technology
R9	Possibility of domestically based production	15.0%	Very high possibility of domestically based production of this technology	High possibility of domestically based production of this technology	Possibility of domestically based production of this technology	Low possibility of domestically based production of this technology	No possibility of domestically based production of this technology
R10	Current technology situation in Thailand		Situation of the technology in Thailand is fully diffused in all related sector	Situation of the technology in Thailand is diffused in all related sector	Situation of the technology in Thailand is diffused in limited areas	Situation of the technology in Thailand is diffused in limited areas with problem(s)	Situation of the technology in Thailand is in the beginning stage
R11	Current technology situation in other countries		Situation of the technology is fully diffused in all related sector in all developed countries	Situation of the technology is diffused in all related sector in some developed countries	Situation of the technology is diffused in limited areas in some developed countries	Situation of the technology is diffused in limited areas with problem(s) in some countries	Situation of the technology in developed countries is in the beginning stage
Impact		40.0%	5	4	3	2	1
I1	Competitiveness and value creation	15.0%	Enhance national competitiveness with possibility of very high value-added creation	Contribute national competitiveness with possibility of high value-added creation	No significant impact on national competitiveness with slightly value-added creation	Have some negative impact on some economic sectors	Have large negative impact on national economy
I2	Social: Local employment/income distribution/equity	15.0%	Increase employment immensely	Increase local employment	No significant impact on local employment	Have slightly negative impact on local employment	Have large negative impact on local employment
I3	Environment: Pollution (air, water, contamination and etc.)	15.0%	Have positive environmental impact / reduce pollution in broad area	Have positive environmental impact / reduce pollution in limit area	No significant impact on environment / No additional pollution	Have a negative environmental impact and polluting in limited areas	Have a negative environment impact and polluting in broad area
I4	Estimated GHG reduction	15.0%	This technology can dramatically reduce GHGs	This technology can significantly reduce GHGs	This technology can reduce GHGs	This technology can reduce GHGs in low figure	This technology can reduce GHGs in very low figure

Source: Adapted from the National Science Technology and Innovation Policy Office (2012)

Table 2 Key mitigation technologies specified by categories

Categories		Key mitigation technologies										
		Management/ System	Energy efficiency	Fuel switching / Mode shift	Heat and Power recovery	Material efficiency and recycling	CCS	Renewable energy				
								Bio-energy	Waste	Solar	Wind	Hydro
1A1a	Power	Smart grid, Storage for RE integration	Coal, NG, Nuclear power plant	Fuel cell	Combined Heat and Power (CHP)	-	CCS for Coal-fired power	Biomass, Biogas, Energy crop	MSW	Solar PV	Wind	Hydro
1A3a	Transport	Smart mobility and management	Internal combustion engine (ICE)	Road-to-Rail, Electric vehicle, Fuel cell	-	-	-	Biofuel, CBG	Waste-to-oil	-	-	-
1A2	Manufacturing	Process efficiency	General equipment (e.g. Motor, Boiler, Burner) + Specific (e.g. EAF, Kiln and etc.)	-	Reuse heat + Absorption chiller, Waste- heat recovery	Material recycle	CCS	Biogas, Biomass	RDF	Solar thermal	-	-
1A4	Others (Commercial, Residential, Agriculture)	Building and envelope design, Energy management in building, District cooling	Electric appliances (e.g. Air- condition, Absorption chiller, Heat pump) + Other equipment (e.g. stove and etc.)	-	-	-	-	Biogas	-	PV rooftop, Solar heat	-	-
2A1	Cement production	-	-	-	-	Clinker substitution	CCS	-	-	-	-	-
1B2	Oil and NG	Vent / Flare	Enhance oil injection	-	-	-	CCS	-	-	-	-	-
6A1	Solid Waste Disposal on Land + Landfill	Waste management and utilization	-	-	-	Reduce, Reuse, Recycling (3R)	-	-	Waste-to-energy, RDF	-	-	-

Source: Compiled from reports from the Office of Natural Resources and Environmental Policy and Planning (2017) and Ministry of Energy (2016)

Results

The results of the MCA study are presented in four categories as proposed by the Intergovernmental Panel on Climate Change (IPCC): public electricity and heat production, road transport, manufacturing industries and construction/other sectors. The results are as follows.

1) Public electricity and heat production

Evaluation of impacts of public electricity and heat production indicated that technologies in this category that have high potential impact on Thailand's economy, society and environment also demonstrate the highest

levels of readiness (Figure 1). The five highest ranked technologies were 1) biogas for power; 2) municipal solid waste (MSW) for power; 3) biomass for power; 4) combined heat and power (CHP); and 5) solar power. Criteria for economic value added, value creation and cost efficiency for the country were the main criteria for the analysis, which resulted in prioritization of these five technologies. On the other hand, new technologies such as smart grids, energy storage and fuel cells for power still lacked readiness and were not yet able to make significant contributions to public electricity and heat

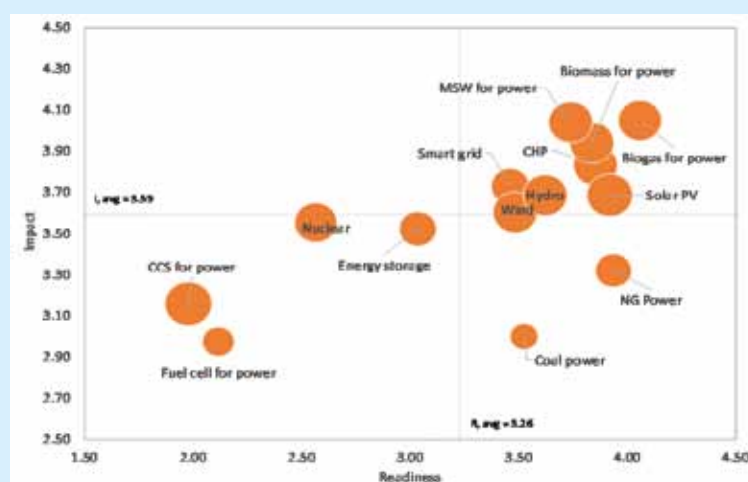


Figure 1 Prioritisation of technologies in the 1A1a public electricity and heat production sector

Source: the project's brainstorming session on 18 July 2017

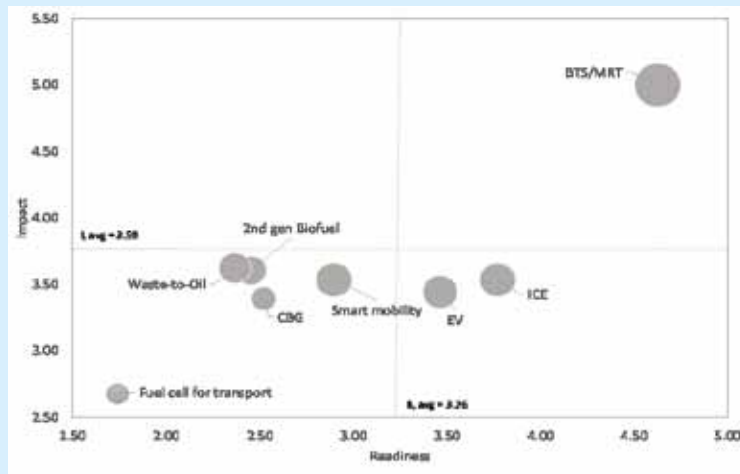


Figure 2 Prioritisation of road transport technologies (Category 1A3b)
Source: the project's brainstorming session on 18 July 2017

production supply. These technologies require further development and monitoring.

2) Road transport

The results of the prioritisation of road transport technologies (category 1A3b) ranked rail transportation as the highest priority (Figure 2). At present, Thailand's rail transport policy is being implemented with strong government support. However, electric vehicles (EV) still lack infrastructural support, particularly in terms of number and network of recharging stations; clarity is also needed in terms of policy support and incentives. As for alternative fuels, second generation biofuels, compressed biogas and waste-to-oil technologies are still not cost-effective, with high production cost hampering their competitiveness.

3) Manufacturing industries and construction: cement production and oil & natural gas production

The prioritisation of technology readiness in manufacturing industries and construction, cement production and oil and natural gas production (Figure 3) identified five high impact technologies for Thailand's economy, society and environment: 1) carbon capture and utilization (CCU); 2) biomass for thermal use; 3) biogas for thermal use; 4) process improvement; and 5) higher efficiency equipment such as burners, boilers and steam turbine generators. The MCA analysis indicated that the highest ranked technologies were in energy-intensive industrial thermal processes. Thailand aims to improve its thermal performance and already possesses commercialised thermal technologies. However, further

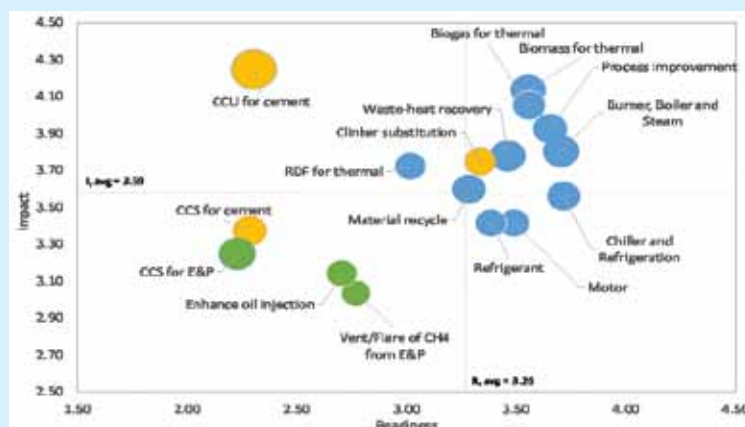


Figure 3 Prioritisation of technologies in the 1A2 manufacturing industries and construction sector (blue), the 2A1 cement production (orange) and the 1B2 oil and natural gas production (green)
Source: the project's brainstorming session on 18 July 2017

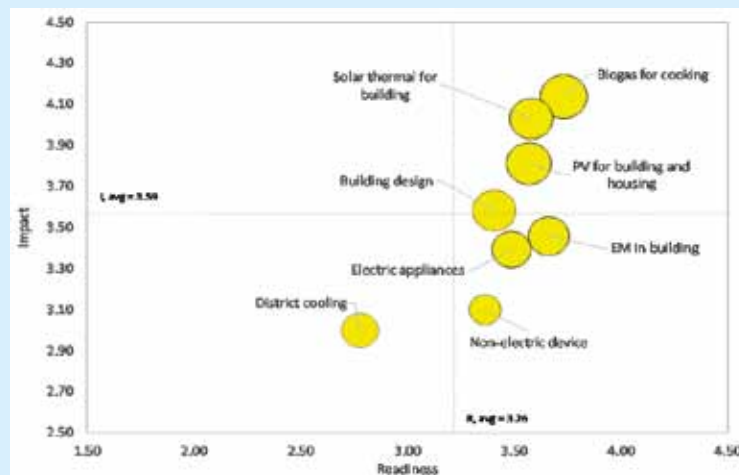


Figure 4 Prioritisation of technologies in the 1A4 other sectors
Source: the project's brainstorming session on 18 July 2017

development of the technology is needed to encourage its wider adoption. Due to high demand, the most important factors affecting the biomass and biogas technology in Thailand are supply chain management and cost of raw materials.

4) Household and other sectors

The MCA of technology in household and other sectors (Figure 4) indicated that the five high impact technologies that Thailand possess readiness for were 1) biogas for cooking in place of LPG; 2) solar thermal for hot water production; 3) solar photovoltaic (PV) rooftop; 4) energy efficient building design; and 5) energy management (EM) in buildings. Using biogas for cooking not only reduces LPG usage, but is also

an efficient option for household bio-waste management. Unutilized household bio-waste releases methane (CH_4), which possesses a global warming potential (GWP) 21 times higher than that of carbon dioxide (CO_2) (Intergovernmental Panel on Climate Change, 2006). Moreover, household use of solar energy for thermal use (e.g. producing warm water and electricity) is increasing.

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Antibacterial PLA/Nanoclay Composite Film for Food Packaging

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Introduction

Exponential growth in the global plastics industry over the past decades was the result of their versatility, low cost, light weight and seemingly unlimited range of applications. However, petroleum-based plastics are non-biodegradable and are increasingly causing widespread environmental properties. To address the twin problems of dependence on fossil fuels and persistence in the environment, research is increasingly focusing on biodegradable plastics as a possible alternative to replace conventional plastics in certain applications.



Polylactic acid (PLA) is a polyester bioplastic synthesized from lactic acid obtained from renewable resources such as corn and sugar cane, and is currently the most widely used in packaging applications. However, PLA suffers from several drawbacks such as low flexibility and a brittle structure, which restrict its broad application. Consequently, additives are necessary

to improve the material's properties; plasticizers are used to enhance flexibility, while nanocomposite preparation improves PLA's mechanical and gas-barrier properties.

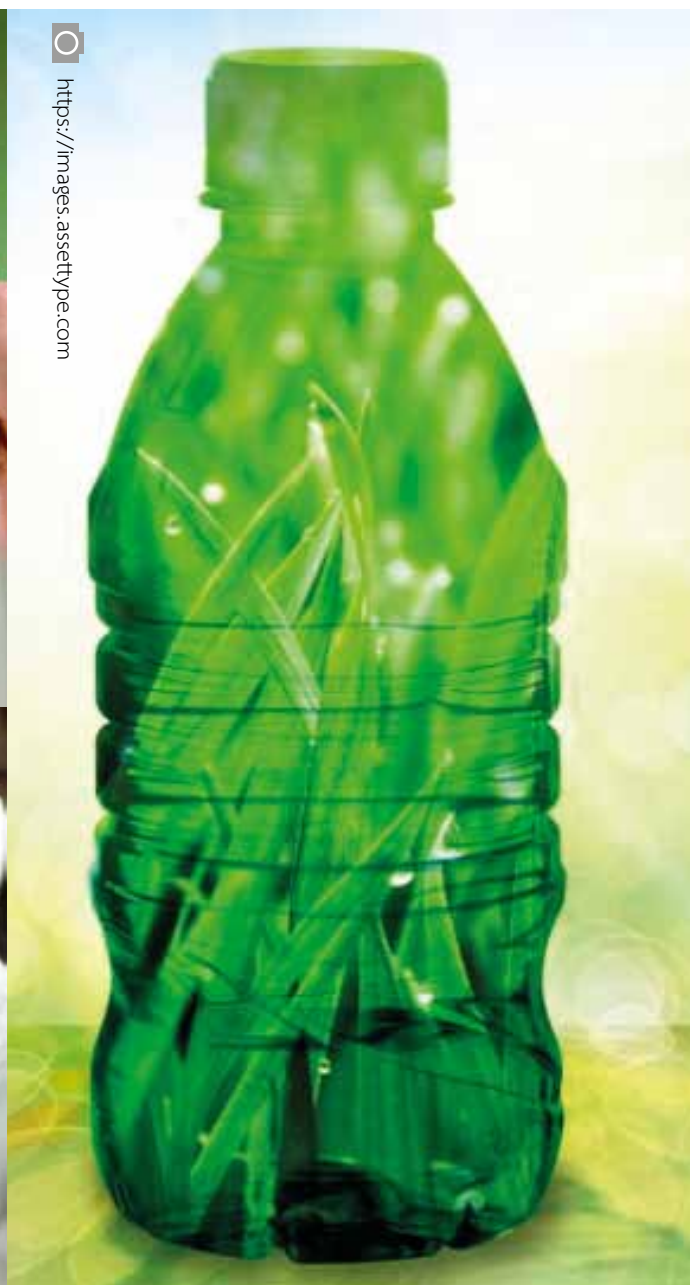
Polyethylene glycol (PEG) is suitable as a plasticizing agent for PLA due to its compatibility, biodegradability and lack of toxicity for food contact applications. Among the various categories of inorganic



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nanoparticle types, layer-silicate clay minerals such as montmorillonite (MMT) and bentonite are widely used due to their abundance in nature, low cost and non-toxic. Processing is simple and results in significant improvement in material properties.

Mangosteen peel extract has recently come under the spotlight for its potential antimicrobial properties- in this case to enhance the antimicrobial efficiency of PLA-based packaging. Mangosteen peel contains high levels of xanthone derivatives, which are responsible for the antimicrobial activity.

In this study, biodegradable antimicrobial nanocomposite packaging was prepared by melt-mixing PLA, PEG and nanoclay via melt-extrusion, and follow by blow film-extrusion. The nanocomposite film was coated with mangosteen

peel extract to create an antimicrobial bilayer film; using a hot rolling process, the bilayer film was then covered with a sheet of nanocomposite film to produce a multilayer film. Finally, the prepared multilayer films were prepared into the required biodegradable antimicrobial nanocomposite packaging forms and used to extend shelf-life of fresh meat in low-temperature storage.

Preparation of PLA/Nanoclay composite film

PLA/Nanoclay composite was prepared from PLA pellets blended with nanoclay using a co-rotating twin screw extruder (Figure 1). The extruder was operated using temperature profile from hopper to die at 180–200°C respectively and a rotation speed

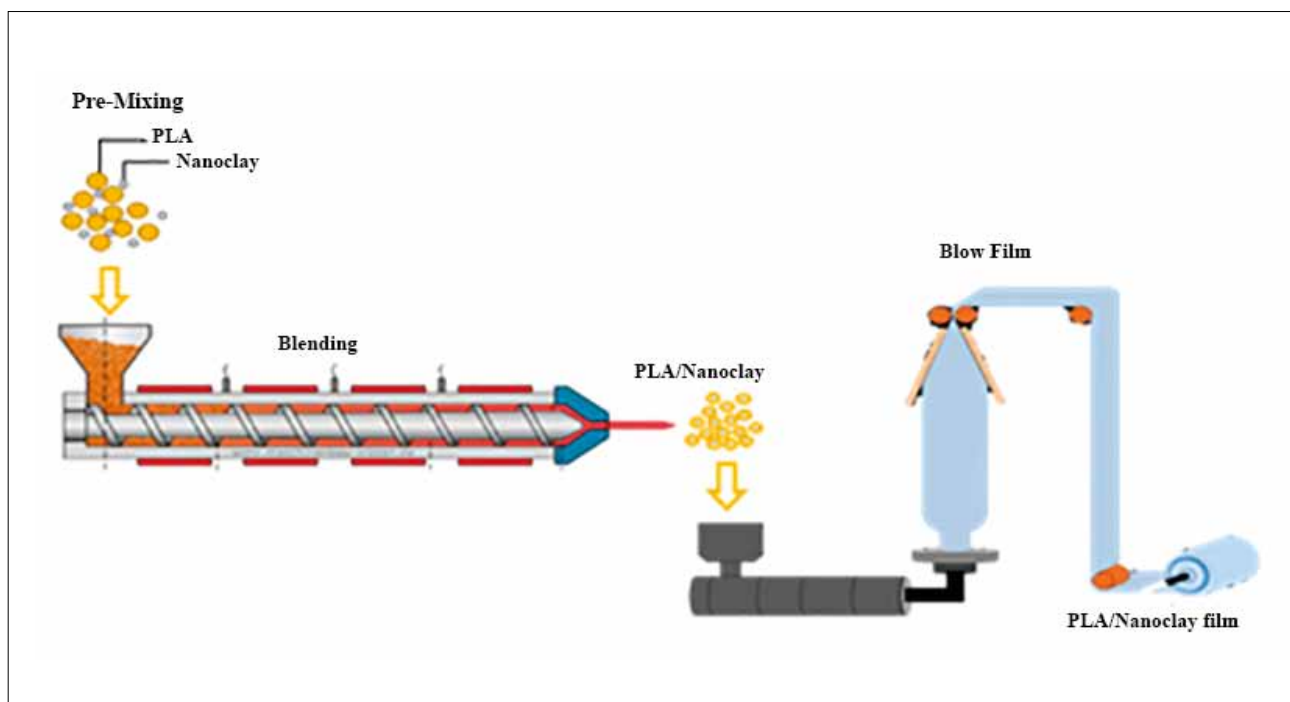


Figure 1 Preparation of PLA/nanoclay film
Source: Nithitanakul (2019)



of 40 rpm. The PLA/nanoclay pellets obtained were used to prepare PLA/nanoclay film via a blown film extruder. PLA/nanoclay composite film was prepared with a thickness of 0.05 mm and 15-18 cm in diameter.

To add the antimicrobial property to the material, a solution casting process was introduced to coat the prepared nanocomposite bioplastic film with mangosteen peel extract. 1 ml of peel extract solution was cast on 25 cm² of PLA/nanoclay composite film and left to dry at room temperature for 48 h. The resulting bilayer film was then covered with another PLA/nanoclay composite film by a hot rolling process, resulting in a multilayer PLA/nanoclay composite film (Figure 2).

Antimicrobial properties of PLA/nanoclay composite film coating with mangosteen peel extraction

The antimicrobial activity of PLA/nanoclay composite film was tested using Gram-negative bacteria using the well diffusion agar method. The antibacterial activity was determined according to the JIS L 1902 standard and evaluated by measuring the width of the zone of inhibition (clear) in comparison to a control of reference standards. The results are presented in Figure 3. The *Escherichia coli* isolate tested was sensitive to PLA/nanoclay composite film with inhibition zones of 3.00, 1.33, 1.33, 1.00, 0.83, 0.83 and 0.83 mm from day 1 to day 7, respectively. The inhibition zone for *E. coli* of 3.00 ± 0.65 mm on

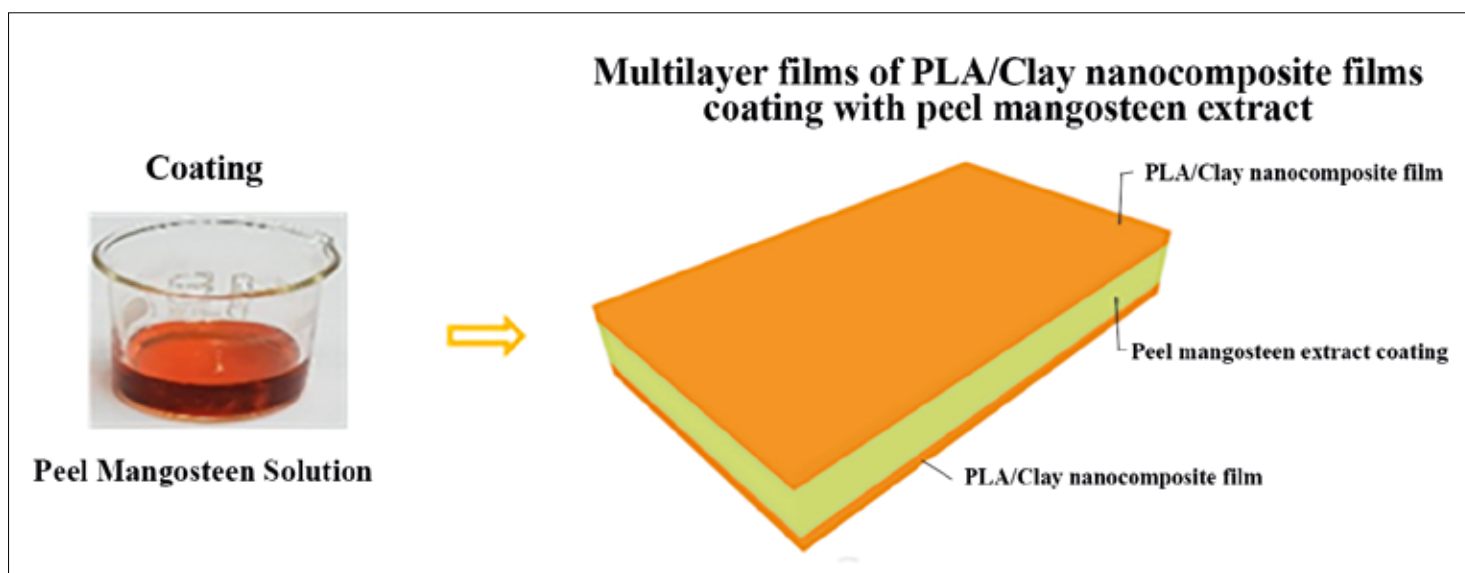


Figure 2 Solution casting of PLA/nanoclay composite film
Source: Nithitanakul (2019)



Day 1 was found to be the most sensitive, followed by Day 2 and Day 3 which were found to be more sensitive to PLA/nanoclay composite film than Day 4 to Day 7.

Evaluation of fresh meat samples in multilayer PLA/nanoclay composite bag

The fresh meat (pork) samples were evaluated by color, texture and odor. 100 g samples of fresh pork were taken as reference samples. The fresh meat

samples were kept in multilayer PLA/nanoclay composite bags at 4°C and evaluated every day for 7 d.

The meat sample pictures during storage at 4°C for 7 d are shown in Figure 4. The meat sample at 0 d was not affected by the multilayer PLA/nanoclay composite bag, indicating that the multilayer PLA/nanoclay composite bag had no adverse effect on meat quality. Meat quality from 1 d to 6 d storage also showed no sign of deterioration; the samples retained their red color and original texture, and emitted no odor. This indicates that the multilayer PLA/nanoclay composite

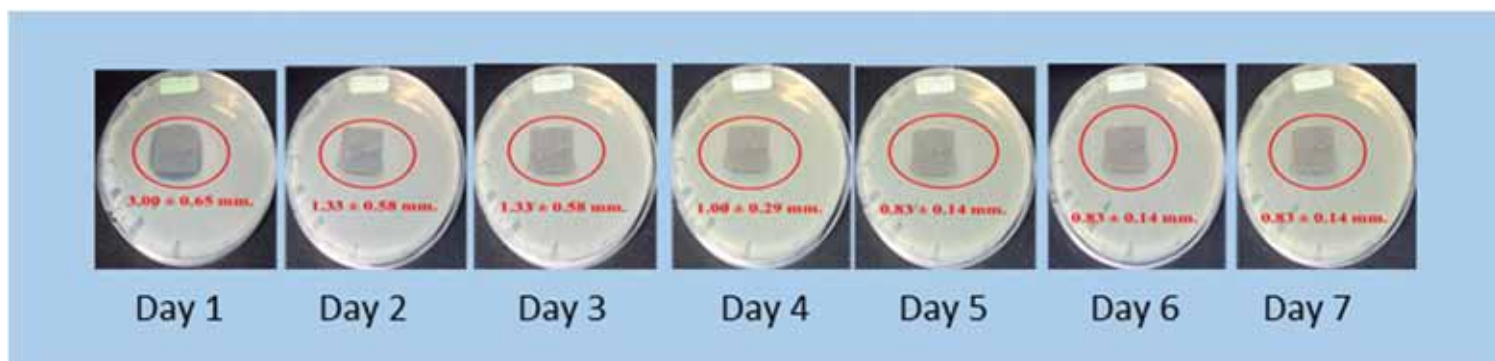


Figure 3 Clear zones of inhibited growth of a wild-type *E. coli* isolate around PLA/nanoclay composite film

Source: Nithitanakul (2019)

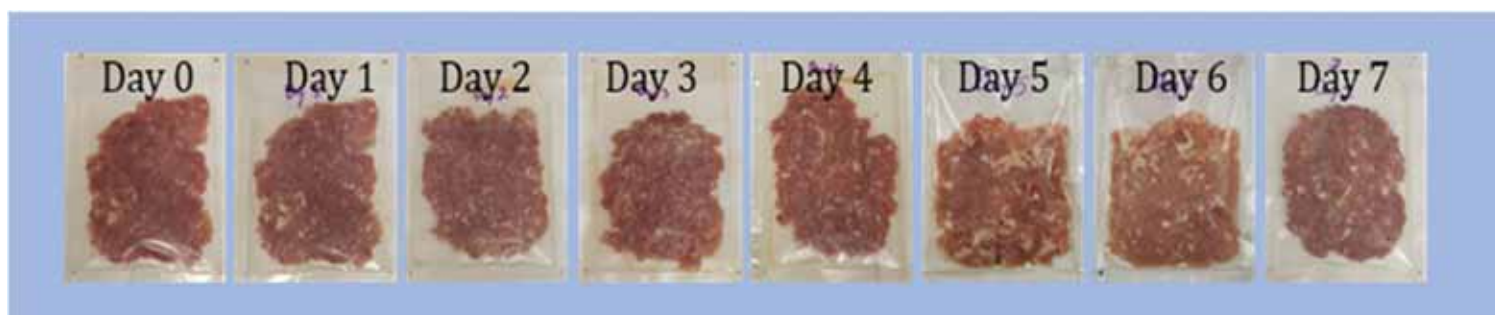


Figure 4 Fresh pork samples during storage at 4°C for 7 days

Source: Nithitanakul (2019)



bag could indeed inhibit microbial growth; moreover, the antimicrobial properties were enhanced when mangosteen peel extract was incorporated into the film. The % weight loss between 1 d and 6 d were 0.14, 0.28, 0.53, 0.65, 0.65 and 0.68%, indicating that the samples lost very little moisture over this period. After 6 d the meat samples began to show signs of deterioration, with a brown color, foul odor, and watery exudate. The red color of fresh meat is due to hemoglobin; fresh meat also contains lipids that readily oxidize on exposure to air, leading to discoloration (Suman & Joseph, 2012). Discoloration is considered as a major indicator of quality deterioration in fresh meat.

Conclusions

Multilayer PLA/nanoclay composite film showed strong antimicrobial activity and extended the shelf life of fresh pork during storage at 4°C for 6 d. A multilayer PLA/nanoclay composite bag containing fresh pork in the absence of oxygen led to longer shelf-life in terms of both color and odor stability as a consequence of low oxidation permeation rates.

Food packaging such as polyethylene and polypropylene is often disposed of as waste since it is frequently contaminated and unsuitable for cleaning for reuse or recycling. Such packaging can persist for





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many years in landfills, leading to adverse environmental impacts. Their replacement with biodegradable alternatives made of PLA/nanoclay composite films from mangosteen peel extract could help reduce the environmental impacts of non-biodegradable food packaging waste.

Acknowledgements

This article is part of the research project entitled ***“The Development of Antimicrobial Nanocomposite Bioplastic Film from Polylactic Acid and Mangosteen Peel Extract for Fresh Food Packaging”*** funded by Plastics Institute of Thailand. The research was conducted and supported all necessary facilities by the Petroleum and Petrochemical College, Chulalongkorn University.

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Carrying Capacity Assessment in Natural Attraction

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Introduction

Thailand welcomes increasing numbers of tourists each year, and tourism revenues represent an important pillar of the national economy. Many natural attractions are suffering from multiple problems resulting from excessive numbers of tourists. These include tourism safety, natural resource conservation and management, irreversible physical damage to unique natural features and inadequate public utilities and facilities. These challenges result in health and environmental problems, particularly in regard to waste management and pollution, often overwhelming the capacity of local facilities at the site. Overcrowding at tourist destinations also causes environmental degradation, affecting local communities and surrounding areas as well as quality of life. Degradation of pristine natural attractions reduces the value of the site itself, and also impacts on the image of Thailand as a dream destination.



Successive governments in the past decades have stressed the significance of development programmes to conserve and promote the country's natural attractions. Tourism organisations such as the Tourism Authority of Thailand and the Department of Tourism, Ministry of Tourism and Sports are responsible for the development of major tourist attractions. These agencies aim to promote sustainable, quality tourism in order to ensure continuing long-term revenues and benefits to local communities as well as the national economy.

The Department of Tourism conducts in-depth research into natural attract and has set tourism standards to provide benchmarks for different types of tourism, both natural and manmade. The Department of Tourism requires tourism organisations responsible for different types of natural attractions to survey, identify and ensure that attractions under their scope of responsibility

comply with the established standard. Tourism standards apply to multiple types of natural attractions including beaches, islands, waterfalls, caves, rapids, thermal springs, fossil sites and areas with special geographic and topographic features.

Identifying basic parameters for the carrying capacity assessment of national attractions

Research into area management in tourism indicates that responsibility for managing tourist attractions is shared among multiple agencies, categorized by their area management responsibility as follows:

1) Natural attraction areas managed by government agency including national parks, forest parks, wildlife sanctuaries, non-hunting areas, botanical gardens, arboretums and forestry plantations.



Figure 1 Natural attraction - Ao Patok, Racha Island, Phuket
Source: Department of Tourism (2018)

2) Natural attraction areas as designated public spaces managed by local administrations.

3) Natural attraction areas managed by public agencies.

Apart from perceived recreational values that attract tourists, identifying parameters for natural attractions must also take into account other criteria relating to appropriate tourism management in order to prevent or mitigate adverse effects on the fragile ecosystems associated with natural attractions. In assessing the standard of any tourism site, three major parameters are considered, as follows:

Parameter 1 Perceived values and vulnerability

The perceived value of an attraction results from multiple judgements, subjective and objective, including its value to the local ecosystem and to humans who

benefit from its resources, as well as educational and sentimental value. The perceived value parameters can be assessed using 3 major criteria: biological value, physical value and societal value.

The vulnerability or destruction risk is defined as an environmental change resulting from external factors such as unpredictable natural disasters or reckless human activity. Adverse impacts on the environment include destruction of coral reefs resulting from rising ocean temperatures, coral picking for commercial use, anchoring of ships, inshore fishing and uncontrolled underwater tourism.

The perceived value and vulnerability standard comprises four key parameters:

- 1) Biological value (4 criteria)
 - 1.1) Ecological system diversity



Figure 2 Tourism safety introduction for tourists on Racha Island

Source: Department of Tourism (2018)

1.2) Abundance of natural resources

1.3) Unique environment for unique and endangered species or habitats

1.4) Unique ecosystems

2) Physical value (4 criteria)

2.1) Numbers of different natural sources within the attraction

2.2) Size of the natural attraction

2.3) Physical beauty and landscape

2.4) Physical uniqueness of the area

3) Societal values (2 criteria)

3.1) Importance for local livelihoods and communities

3.2) Historical, traditional and cultural value

4) Vulnerability and destruction risk (2 criteria)

4.1) Risk of destruction by humans

4.2) Risk of destruction by natural disasters

Parameter 2 Tourism capacity development

Tourism capacity development refers to features contributing to the attraction's tourism potential. For example, attractions that possess some qualities

contributing to a unique natural beauty but lacking safe accessibility tend to be less popular among tourists. There are 5 criteria for tourism capacity development.

1) Capability for tourism activities

2) Accessibility

3) Tourism safety

4) Capability for basic tourism facility development

5) Potential for tourism development from external factors

Parameter 3 Natural attraction management

Natural attraction management refers to the ability to operate and manage a tourist attraction, including:

1) Tourism management for sustainability includes natural conservation, environmental management and tourism management.

2) Knowledge management and tourism awareness is assessed by responsible observing authorities under their mandate to raise awareness and disseminate relevant knowledge relating to natural resources, ecosystems and natural conservation to local communities, businesses, tourists and local administration offices.



Figure 3 Ao Tue Haven, Racha Yai Island, Phuket
Source: Department of Tourism (2018)

3) Economic and social management is assessed by the level of involvement of local communities in tourism operations. Such involvement might take the form of public hearings, brainstorming sessions, involvement and consultation in decision-making, operating and being made accountable for issues that may impact the local community as well as sharing revenues with the local community.

Management of natural attractions

Natural attraction management in Thailand can be divided into two types according to the organizations responsible.

1) Natural attractions managed by central organization including national parks, forest parks and wildlife sanctuary.

2) Natural attractions managed by local authorities such as subdistrict administrative organizations and municipalities.

Natural attractions managed by central government organizations are supported via policy, plans, guidelines

on environmental conservation, as well as allocation of budgets and human resources. On the other hand, natural attractions managed by the local authorities lack such long-term plans and support for environmental management, leading to more rapid degradation of tourism assets and surrounding natural resources. However, locally-managed natural attractions do allow local communities to step in and take ownership of their area, and tourism activities also generate revenues to local communities.

Unfortunately, tourism development frequently occurs exploitatively without assessment of tourism capacity, resulting in severe long-term impacts. Therefore, the Department of Tourism has commissioned research on approaches to assess tourism carrying capacity for key areas in accordance with local strategic area development plans. The assessment ensures that development plans are appropriate and do not over-stretch the locality's human and environmental carrying capacity. Moreover, responsible staff are also receiving training to provide them with the latest knowledge relating to systematic tourism development and area management. These approaches

to tourism development will enhance Thailand's image and generates income through sustainable tourism. It also follows the Sufficiency Economy Philosophy (SEP) and Thailand's 20-year National Strategy.

Tourism carrying capacity assessment project

The tourism carrying capacity assessment project aims to study, explore and analyze capabilities and drivers contributing to tourism carrying capacity of tourism sites, covering economic, social and environmental aspects. The data will be used to create a tourism carrying capacity model and an assessment handbook following the area development policy.

Thailand is endowed with a large number of tourist attractions that are also diverse in type and requiring extensive data collection. Data on tourism demand for specific tourist attractions, tourism time and length of stay must also be collected. Therefore, before undertaking any tourism carrying capacity assessment using our team's methodology, users should first conduct a pilot study and tailor the assessment to local needs. In order to interpret the data, users should possess basic tourism management knowledge, understand the area's physical features and understand the needs and habits of tourists.

The most crucial key for any kind of tourism development is the involvement of local residents. Involvement and understanding of local communities enhance the effectiveness and relevance of planning for sustainable tourism. Approaches to tourism management will vary according to local needs, depending on multiple factors such as the site's physical features, responsible organizations, budgetary support, etc.

Conclusion

The tourism carrying capacity assessment project for natural attractions developed by the authors follows a strategic spatial development policy and provides an objective benchmark to determine tourism carrying capacity. This facilitates a strategic approach by planners

to improve the area to meet the needs of both tourists and local communities. It can also assist in safeguarding unique and vulnerable attractions, thus preserving their continuing value and attraction for tourists in the future.

Even though the assessment model may not be fully suitable for all types of natural attractions, the assessment model database was designed to hold all relevant local data for easy access by area management executives. Preliminary assessment can then take into account factors such as ongoing problems in the area and the general physical features, seasonal water scarcity patterns etc. Based on this preliminary assessment, the model can then be used to test impact scenarios resulting from proposed changes such as the impact of addition of new buildings or facilities to accommodate more tourists on tourism capacity and resource use. The tourism capacity may increase or decrease as a result. Reducing capacity may bring benefits in terms of site conservation and environmental protection. On the other hand, the model may show possible positive ways to increase carrying capacity while minimizing adverse environmental impacts. Therefore, adapting the assessment model to suit the needs of the local area allows management executives to decide on effective long-term plans for sustainable development of Thailand's natural attractions.

With fast-growing numbers of tourists visiting all parts of the country, it is essential to assess tourism capacity for all significant natural attractions as a basis for long-term sustainable tourism development. The assessment plan not only helps preserve the local area and the unique features of the attraction; it also better prepares responsible organizations to manage facilities to accommodate tourists. Typically, such facilities will include access roads, bathrooms, parking spaces and souvenir shops. It also includes safeguards to mitigate safety and security risks to tourists from accidents or man-made risks.

Thailand's tourism industry has developed extremely rapidly, and tourist numbers continue to rise year on year. The organizations responsible for supporting and managing tourism need new methods and systems to



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assess tourism carrying capacity, without which exploitative tourism poses serious threats to the environment and local communities as well as to the longer-term viability of the attraction itself. Gradual degradation of the quality of tourism attractions in general will adversely impact on the economy and society both at local and national levels.

Acknowledgements

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Possibility of Using Biochar in Agricultural Areas in High-Rise Buildings

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Introduction

Biochar is a substance rich in aromatic carbon which renders it highly stable (Schmidt & Noack, 2000; Lehmann, 2007; Glaser et al., 2002) and resistant to decomposition (Preston & Schmidt, 2006; Gul et al., 2015). It is produced by a process of slow pyrolysis of biomass at 350-700°C in an airless or nearly airless kiln (Wijitkosum & Jiwonok, 2019; Sriburi & Wijitkosum, 2016a; Brassard et al., 2016; Liu et al., 2014; Lehmann & Joseph, 2009). The quality of biochar depends on types of feedstock and the parameters of the pyrolysis process (Cao et al., 2017; Sriburi & Wijitkosum, 2016a; Graber et al., 2014). The biomass feedstock contains organic carbon (Wijitkosum & Kallayasiri, 2015; Yooyen et al., 2015; Qambrani et al., 2017). In this study, agricultural wastes such as rice husk, woodchips and cassava stems are locally abundant and are frequently used as feedstock for biochar production.

Researchers have conducted continuous experiments in both production and field application of biochar. In terms of application, the research team incorporated biochar into soils as a soil amelioration in areas with problematic soils, e.g. hard and compacted soil, (Pituya et al., 2017a; 2017b), infertile soils (Sriburi & Wijitkosum,

2015a; Wijitkosum & Kallayasiri, 2015; Yooyen et al., 2015) and saline soils (Sriburi & Wijitkosum, 2016b).

Rapid urban development is impacting on the availability of land for farming, in the face of a fast-growing demand for food. A secondary impact is the increasing phenomenon of urban heat islands. Urban farming is





a widely acknowledged concept to mitigate both these challenges (Safayet et al., 2017; Smit et al., 2001). Urban farming provides multiple benefits in regard to diverse functions of the city such as its production, ecological and cultural functions. Urban farming is also being referred to as “*Multifunctionalized Agricultural Land*” (Lovell, 2010). Considering the benefits, the research team carried out an experiment by incorporating biochar in an urban farming area on the roof of a high-rise building. An edible crop was used in this experiment to observe biochar’s effect on productivity, plant biomass and carbon sequestration in the form of biomass, when used in a high-rise farming area. The study contributes to effective area management in urban zones for food security and sustainable environmental management. However, this paper focuses only on biochar research on a high-rise building. This article was part of the research project entitled “*Effect of Biochar on Chinese Kale and Carbon Storage in an Agricultural Area on a High Rise Building*” (Wijitkosum & Jiwnok, 2019).

Biochar and its production

This research used rice husk biochar produced using the Controlled Temperature Rice Husk Biochar Retort for Slow Pyrolysis Process (patent number: 1601001281). The rice husk biomass was converted into biochar during the slow pyrolysis process at a controlled temperature of 400-500°C, resulting in a high-quality biochar (Figure 1). The retort was invented and designed to be easy to build, inexpensive and to produce high quality biochar at an adequate volume for farming.

The rice husk biochar possessed a large surface area (41.43 m²/g) and high porous volume (0.034 cm³/g). It contained 47.67% of total carbon (TC), most of which was highly stable total organic carbon (TOC) with little to zero inorganic carbon. The rice husk biochar possessed several important characteristics which made it suitable as a soil ameliorant and as a growth enhancer. Its characteristics were pH 7.90, electrical conductivity (EC) 0.35 dS/m, cation exchange capacity (CEC) 17.34 (cmol/kg) and organic matter (OM) 13.06%. It also contained 0.51%

total nitrogen (Total N), 0.29% total available phosphoric acid (Total P₂O₅) and 1.02% potassium oxide (Total K₂O) (Wijitkosum & Jiwnok, 2019).

Farming experiment on the rooftop of a high-rise building in an urban area

Chinese kale (*Brassica oleracea* var. *alboglabra*), a popular leafy crop, was used in this experiment due to its short duration. Chinese kale seedlings were planted in 0.3 m x 0.8 m x 0.3 m wooden rectangular planting plots. The experimental design was a complete randomized design (CRD). There were eight treatments: pure soil as a controlled treatment (TC) without any soil ameliorant, soil with vermicompost at 20% by weight (TM20), treatments consisted of biochar at 1.5% (TB1.5), 2.0% (TB2.0) and 2.5% (TB2.5) by weight and treatments with 20% vermicompost by weight and incorporated with biochar at 1.5% (TMB1.5), 2.0% (TMB2.0) and 2.5% (TMB2.5) by weight. Each treatment had four replications. The experiment with Chinese Kale was at a pilot scale and was conducted on the 14th floor of Chulalongkorn Research Building (Figure 2).

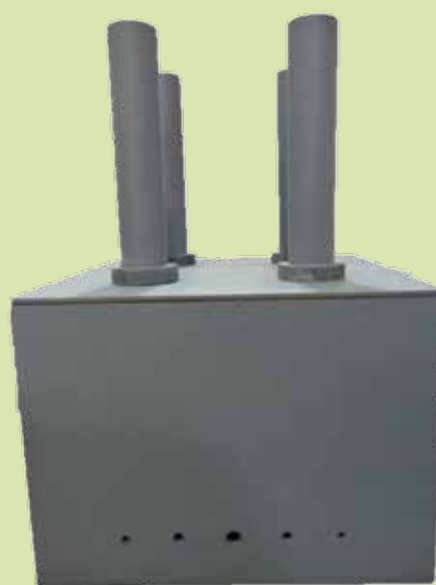


Figure 1 Model of the Controlled Temperature Biochar Retort for Slow Pyrolysis Process
Source: Sriburi & Wijitkosum (2016b)

The soil used in this study was clay (21% sand, 22% silt and 57% clay). It was slightly alkaline (pH 8.10) with soil conductivity of 0.20 dS/m and cation exchange capacity of 67.40 cmol/kg. Its density was 0-15 cm depth, equivalent to 0.90 (g/cm³). It contained 1.21% organic matter, 0.16% total nitrogen, 15.00 mg/kg of available phosphorus and 207.00 mg/kg of exchangeable potassium. The vermicompost used in this study was produced using African nightcrawler earthworms (*Eudrilus eugeniae*) which was highly suitable for producing vermicompost in tropical regions (Dominguez et al., 2001). The vermicompost had pH of 6.37, high in CEC (55.01 cmol/kg) and low in EC (2.63 dS/m). It was rich in nutrients with 39.07% of organic matter, 1.87% total nitrogen, 1.85% available phosphorus (P₂O₅) and 0.47% soluble potassium (K₂O).

Carbon sequestration in the form of plant biomass and in the soil

Data sampling was carried out when the Chinese kale was fully grown (49 d after planting) by collecting data from all parts of the plants (roots, trunks and stems,

and leaves). The Chinese kale product was divided into two parts for two different analyses of carbon sequestrations. Group one focused on carbon sequestration stored in three different parts of the Chinese kale (roots, trunks and stems, and leaves). Group 2 focused on carbon stored in all parts of the biomass. The plants were randomly sampled from each treatment by completely uprooting them. The samples were oven-dried at 75°C for 48 h or until reaching constant weight. The dry weight and moisture content of the samples were measured. An analysis of the carbon stored in each part of the plants and as a whole plant was then carried out (Ponce-Hernandez, 2004).

Carbon sequestration in roots and the upper roots peaked in the TMB2.0 treatment (7.028 tonC/ha) of which 1.542 tonC/ha stored in the roots and 5.486 tonC/ha stored in the upper roots. On the other hand, the controlled treatment (TC) yielded the lowest carbon storage in the roots (1.212 tonC/ha). Moreover, the TMB2.0 treatment revealed a statistically significantly higher levels of carbon storage ($p < 0.05$) than the TC (Wijitkosum & Jiwnok, 2019).



Figure 2 Chinese kale experimental plots on the rooftop

Source: Wijitkosum (2018)



The analysis of carbon sequestered in the soil in the cultivation area (both sequestered in the Chinese kale and in the soil) indicated that incorporating vermicompost and biochar at the highest level (2.5% by weight) yielded the highest level of carbon sequestration (53.490 tonC/ha). The amount of carbon sequestered within the soil in different treatments decreased according to the amount of added biochar (50.890 tonC/ha in TMB2.0 and 44.490 tonC/ha in TMB1.5). Mixing vermicompost with rice husk biochar helped increase the amount of carbon sequestered in the soil. The result was statistically significant ($p < 0.05$) compared to the control treatment (TC) and treatments using only soil mixed with biochar (TB1.5, TB2.0 and TB2.5). The analysis concluded that the amount of carbon sequestered in the Chinese kale cultivation area depended on the amount of carbon sequestered within the soil (Figure 3). The amount of carbon sequestered within the soil and in the Chinese kale cultivation area increased in proportion to the amount of rice husk biochar incorporated into the soil ($TMB2.5 > TMB2.0 > TMB1.5$) (Wijitkosum & Jiwnok, 2019).

Applying biochar to enhance carbon sequestration in agricultural areas

Using biochar for carbon sequestration is an accepted carbon-negative technology (CNT). The biochar technology exploits several important characteristics of the material—especially its porosity, large internal surface area and its high amount of highly stable aromatic carbon content that is resistant to decomposition in the soil. It also possesses a high cation exchange capacity at the surface, enabling it to adsorb nutrients and moderate soil pH levels. These characteristics allow plants to flourish and generate more biomass. On the other hand, highly stable carbon sequestered in the form of plant biomass retains carbon within the soil for an extended period of time (Wijitkosum & Sriburi, 2018; Liang et al., 2006) in comparison to other types of biomass such as plant or animal humus or fertilizers. The other types of

fertilizers decay quickly under warm, moist soil conditions. Large amounts of carbon dioxide are emitted from this decomposition process (Schulz et al., 2013; Qayyum et al., 2012). Biochar, as a highly stable carbon-rich substance, is capable of retaining and slowly releasing carbon back to the atmosphere (Liu et al., 2014; Wu et al., 2013; Schulz et al., 2013; Karhu et al., 2011; Liu et al., 2011; Lehmann et al., 2009).

Thus, carbon sequestration in agricultural areas may be divided into two components: sequestration within the soil itself (Yooyen et al., 2015; Liang et al., 2010; Lehmann, 2007; Wijitkosum & Yooyen, 2014) and bio-sequestration within the biomass via photosynthesis (Timilsina et al., 2015; Lehmann, 2007; Wijitkosum, 2016a; Yooyen, 2013). Plants absorb carbon dioxide from the atmosphere to generate sugars and create biomass both in above-ground parts as well as roots. This process helps reduce carbon dioxide emitted throughout the plant's life cycle (Wijitkosum & Sriburi, 2018; Redondo-Brenes & Montagnini, 2006). The longer the plants' life cycle, the longer the duration of carbon storage. The carbon will return to its cycle when the crop is cut and utilized. However, even though agricultural crops are short-lived, their ability to sequester carbon within the soil is still equivalent to other types of plants or trees.

Conclusion

Applying rice husk biochar at an appropriate amount together with vermicompost in an urban farming area on the rooftop of a high-rise building increased productivity of the crop (Chinese kale). It also increased plant biomass and soil carbon sequestration. This offers a practical alternative to support development of urban farming and benefit urban residents as well at the environment. The use of biochar in urban farming helps boost food production in terms of quality and quantity, reduces greenhouse gas emissions as well as food miles. The carbon will be kept within the soil in the form of

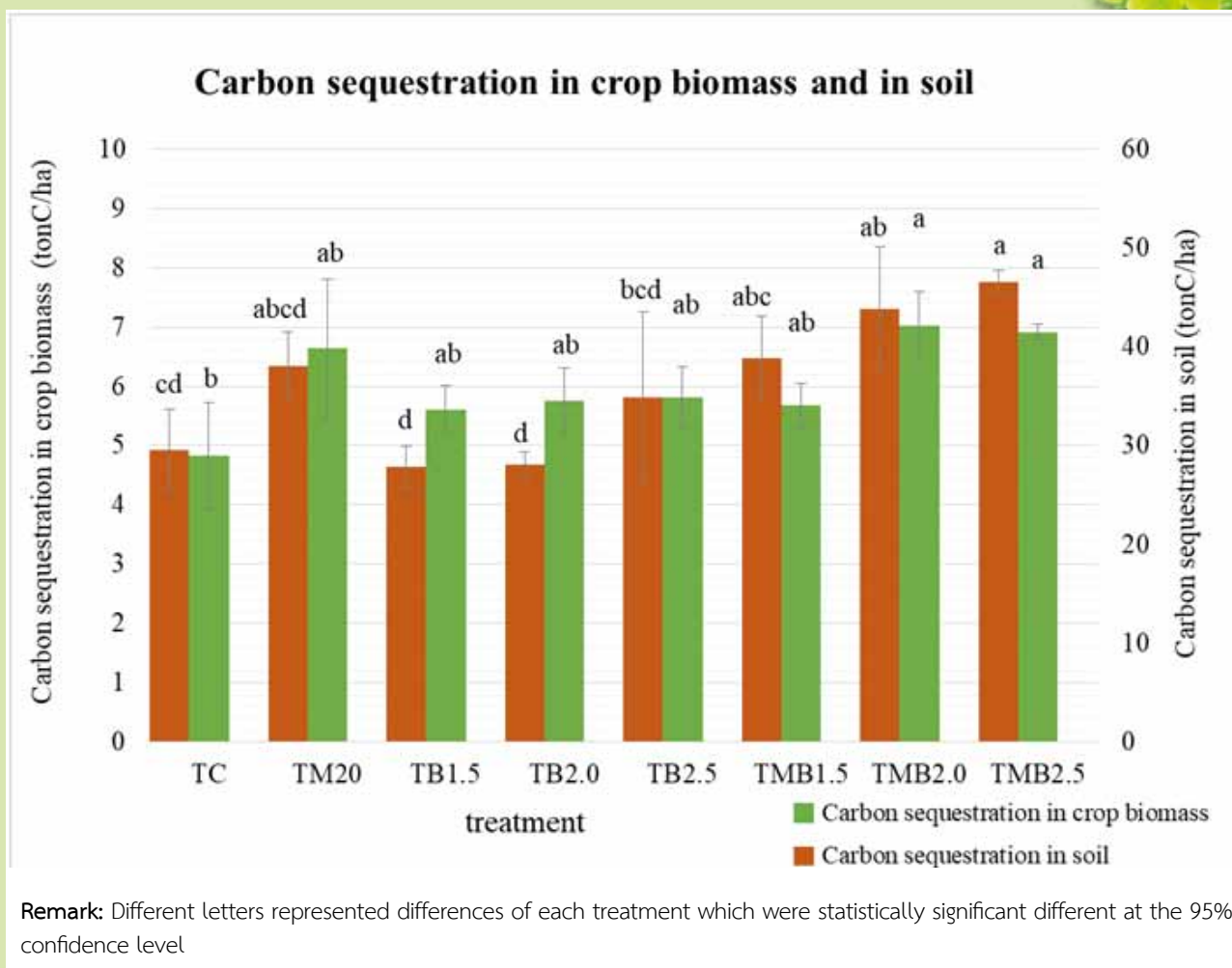


Figure 3 The amount of carbon sequestered in Chinese kale cultivation area
Source: Adapted from Wijitkosum & Jiwnok (2019)

plant biomass and incorporated biochar which directly reduces greenhouse gas emissions from the production process. This leads to effective area management that maximizes the utility of the area for food security and sustainable environmental management for the future.

There are relatively few studies of the uses and utility of biochar in Thailand. However, many research studies conducted by both Thai and international researchers indicated that biochar possesses major potential to store carbon and reduce greenhouse gas emissions from agriculture. Full-scale urban farming on high-rise buildings can also benefit the city by increasing urban green space, reducing the urban heat island effect.

Acknowledgements

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Science and Technology for National Development toward Thailand 4.0

Professor Supot Hannongbua, Ph.D.

Professor Supot Hannongbua, Ph.D., a reputable scientist and researcher who has brought research into commercial application, shares his experience and perspective on the importance of science and technology for national development.



Application of Research for National Development and Direction for the Future

“...We are in the age of applying research for national development and commercial application. It takes time and is not easy to do...”

For over twenty years, Thailand has witnessed the efforts of its universities to transform from an instruction-based to a research-based mindset. In the past, Thai universities prioritized research for publication and teaching students through instruction. Today, research priorities increasingly focus upon national development and applications for commercial real-world application- a shift from pure to applied science. Research nowadays must be ‘marketable’. However, such a change in entrenched philosophy takes time and is not easy to do due to its complexity and the many factors involved, such as institutional policies, budgets and management capability. From the author’s perspective, Thailand in general has been on the right track. In practice, there are a number of obstacles. So far, Thai universities have made strong efforts to apply research for commercial purposes. Research findings have been used for national development according to the direction of each university. The implementation process, however, is making slow progress and needs to be accelerated to achieve real development outcomes for Thailand, as has been seen in other countries. Without prioritizing this under Thailand 4.0, the country’s development will lag further behind its neighbours.



Advantage of Thailand’s education sector

“...Thailand has plenty of research. We hold the advantage of natural resources that can be used and developed toward Thailand 4.0...”



Considering limitations in budget, equipment, and other conditions, Thailand leads its neighbours in terms of academic publications, but only in recent years have begun to shift their attention to more real-world, practical concerns for industrial or commercial applications. Thailand’s strength in research could also therefore be seen as its weakness.

In addition, Thailand’s abundant natural resources offer high potential to exploit its rich biodiversity for commercial applications and national development.

Obstacles for national development with science and technology

“...The problem is we lack good research projects that can make ‘works on the library shelves and works on the shopping malls’ the same thing...”

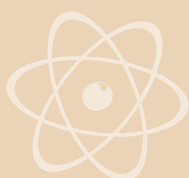
Thailand is certainly not alone in facing the challenge of bridging the academic isolation of university research to meet a burgeoning and fast-moving demand for new technological solutions to drive industrial competitiveness, and there is hardly a need to list the underlying policy, budgetary and cultural factors that constrain the necessary transformation towards





an agile, relevant and responsive research community that embraces the needs and challenges of private sector development. Perhaps the most important issue deserving our attention is cultural; i.e. to have *'people who understand'*. Take for example, the research conducted by our beloved late King Bhumibol. Everything he did begins with the word *"understanding"*. That is to say, before we start doing something, we need to first understand why a new technology is needed, how it can be accessed by the poor, and how it contributes to sustainable national development. If we take a closer look, Thailand's research budget is not essentially low compared to the number of research projects and researchers. The underlying problem is that we frequently do not start our research projects from a development perspective. Collaboration between research and industry is needed to gain such a holistic understanding, which will pave the way for technological solutions that are relevant and appropriate for national development.

Changing attitudes is a challenge for every country. As mentioned above, having *'people who understand'* is a key factor to unlock research to drive national development. *'People'* in this case refers primarily to lecturers, researchers and students. Some lecturers have started while many others, wanting to do likewise, lack the experience. Without proper understanding among academic staff, it will be impossible to fill the gap between research and commercial application; this in turn will lead to failure in transforming the mindset of future leaders through the tertiary educational system. This transformation has been much talked about, and needs to begin with changing teaching styles from rote learning of facts to fostering critical thinking and creativity among young people.





From another perspective, the private sector has paid inadequate attention to university research and its relevance and potential to drive commercial competitiveness. This further widens the gap and represents an additional barrier to building fruitful collaboration between universities and industry. As a result, university lecturers follow their narrow academic interests to serve the purposes of publication and are otherwise not incentivized to reach out to address challenges faced by industry.

Adaptation of universities to drive Thailand 4.0

“...Thai universities need to adjust the mindset of its personnel, learn from external organizations, and strengthen cooperation with the private sector...”

As well as transforming the direction and structure of research towards more collaborative, industry-relevant programmes and themes, universities also have a unique role in preparing the country for Thailand 4.0 by producing new graduates who will move into the private sector as an alternative to an academic career. Thai universities need to understand that “*we have no choice but to do it*” and know how and where to do it. Thai universities need to adjust the mindset of its academic personnel to focus on human resource development. Research proposals should focus more on collaboration with the private sector; such collaboration will lead to mutual learning from external organizations in the private sector. Until then, academics will soon find themselves increasingly isolated and irrelevant to real world needs. Experience in real industrial production environments provides invaluable context for researchers to link their research projects with industry needs.

To make a difference, universities need to change or broaden their attitude, starting with fundamental reform of university regulations to facilitate and incentivize lecturers to collaborate with the private sector and other external organizations. This will necessitate changes to workloads, performance priorities and KPIs. Students should have more opportunity to accompany their lecturers to learn off-campus.

Research and industry need to overcome cultural and organizational barriers to effective cooperation. While researchers focus more on the rigorous and quality of their empirical research, industry’s primary interest will be on applicability, cost-effectiveness and time to market. 90–95% of private sector collaborators do not realize why research studies have to be so in-depth, requiring such large amounts of data, and why they take such a long time. On the other hand, researchers base their stance on the grounds that such a rigorous research foundation is essential in order to develop successful, workable solutions to serve industry’s needs. About 5-10% of large private sector companies have little interest in collaborative research because they have their own in-house R&D capacity.



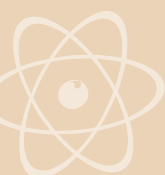


Therefore, it is important, however difficult, to change the way of thinking or the system in Thai universities to support or encourage lecturers to produce research that serves commercial and national development purpose as well as publication needs. There needs to be a process that enhances understanding, so that we can unlock the unused potential of science and technology as powerful tools for national development.

How to apply research for commercial purposes

“...We need to find a way to highlight the importance of ‘understanding, accessibility, and development’ from the perspective of researchers and business executives...”

As discussed earlier, the challenge to bring research into commercial use comes from a lack of mutual understanding. There is therefore a need to promote understanding at all levels and among sectors, especially in relation to the principle of ‘*understanding, accessibility, and development*’. The process can begin with dialogue between universities, government and the private sector in order to help build awareness of the potential of research to drive commercial competitiveness. In other words, while the governmental sector needs to understand the importance of supporting research projects and investing in research for long-term outcomes, universities need a better appreciation of business principles. It is time for Thailand’s University Councils to come together to set a long-term roadmap, and assign





University presidents to implement the roadmap within their own universities. Lecturers and researchers need to be encouraged to be more open in order to gain a better understanding of the outside world. This will help reshape research priorities and budgets to ensure research is more targeted, commercially applicable and marketable as well as useful for academic publication.

Lecturers and researchers need to adapt themselves, be open to learning about business, be able to answer these three questions, and understand the industrial sector. No matter how good the research-based product is, if it is too costly and the quality and standard do not meet market needs, the research will never be used in practice. At the same time, industry needs to understand that research relies on rigorous academic methodology, collection and analysis of empirical data and prototyping in order to develop applied research that will be incorporated as a new product or process innovation, and that the whole process can take a long time.

Bringing research to commercial use in the age of Thailand 4.0 requires much more than producing new and innovative products. It also requires major efforts in design, market evaluation and positioning in order that its technical functionality meets with the market need. We need to accept that Thai people place more importance on emotion than function. For example, a high-quality research-based product supported by scientific data may not be able to compete with another product which makes an emotional connection.

Therefore, in conducting research and developing any new product, it is important to consider both functionality and emotional appeal to the target demographic. There are major cultural differences across markets. Western and Korean consumers, in particular, give up to 80% weighting to product functionality, while Thai consumers giving only 20%. However, this pattern is changing with a growing emphasis on function over form. Researchers need to understand these market factors and adapt their working style to serve business and national development.



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From Research to Revenue



The word “research” has always carried some mystique and has been put on a pedestal by the popular belief that research requires a high level of knowledge, specialized equipment, advanced facilities and big budgets, which are unavailable to ordinary folk. When research is completed, the results or new knowledge gained

may be kept secret or published in a national or international journal in order to seek an academic promotion, or just used in academic circles. However, such preconceptions are no longer relevant in today’s fast-changing world, and it is necessary for the role of research to be better understood and appreciated. Research is not just an abstract activity done by and for scientists; research is essential to everyone who works to conserve and enhance our society and quality of life. Research may be defined as *a systematic process of collecting and analyzing information for any purpose, without specifically referring to research and laboratory level only.*

Although Thailand is blessed with abundant natural resources and human capital, these natural resources are typically sold as raw materials or minimally processed for export- for example rice, rubber, pineapples and other agricultural commodities. Thailand’s agricultural exports carry a relatively low level of value-added; however, importing countries then process these raw commodities, adding considerable value added before reaching downstream markets. Moreover, importing countries use cheap raw materials from Thailand to produce higher-priced goods that are then exported back to Thailand to be sold at a high price to Thai consumers. Clearly, Thailand is losing out economically in its continuing dependence on exports of low-cost bulk agri-food commodities without significant value-added.

Economic development is vital to the country’s stability, prosperity and long-term sustainability. However, the focus of economic development changes over time; in the past Thailand’s economy was driven by the agricultural sector and exploitation of natural resources, with some light industry- all of which relied upon abundant cheap labour. In the 1980s, heavy industry and industrial exports gradually overtook agriculture in their contribution to national GDP. However, this “*Thailand 3.0*” phase of industrial expansion was not accompanied by major advances in GDP or national competitiveness due to lower labour costs in other countries producing similar goods. For many years, Thailand has remained in the ‘*middle-income trap*’, unable to compete in its traditional exports and unable to transform to a new economic paradigm. Inequality has soared in Thailand over this period due to a lack of balanced development. If Thailand is to escape this middle-income trap, it must innovate to create new value-added. A new and strengthened investment in research and development (R&D) will be essential to Thailand’s future economic and social development and its competitiveness in global markets.

Over the past decade, leaders around the world have announced new economic stimuli to boost economic and industrial development in the 21st century. In 2011, President Barack Obama announced a policy to promote the Advanced Manufacturing Partnership (AMP). In 2012, Germany announced a similar industry policy. In 2013, Japan announced the Japan Industrial Policy 4.1, and in 2014, South Korea followed, with a shift in policy focus towards developing an innovative and creative economy 3.0. Then in 2015, China announced its Made in China 2025 policy and the One Belt, One Road initiative to assert and extend its global economic leadership.

The ‘*Thailand 4.0*’ policy aims to transform the national economy, following a vision of economic

development based on “*Stability, prosperity and sustainability*”. By setting priorities to drive broad-ranging reforms, the policy aims to boost national prosperity, escape the middle-income trap and cope with rapidly emerging threats and opportunities over the coming decade. The policy commits to transforming the structure of the economy from a commodity-based economy to *a value-based economy or an economy driven by innovation*. Innovation will play an increasingly important role as an economic driver, with technology and creativity driving a shift in focus from manufacturing to the service sector.

The current government has attempted to free the country from the middle-income trap and reduce social inequality through economic reform. The “*Thailand 4.0*” policy has been widely discussed in various fora as a business system reform based on *technology and innovation* in place of traditional commodity-based systems that have low value added and where Thailand has little or no differentiation or comparative advantage over its competitors. Moving the focus from commodities to innovation will increase R&D expenditure by companies (currently at a very low level) and drive expansion of a new technology-enabled service sector. Thailand 4.0 will leverage R&D to further boost current industry as the ‘*First S-Curve*’, as well as facilitate development of new industries under the ‘*New S-Curve*’. Ten key industry sectors are prioritized under Thailand 4.0.

Research aimed at increasing value added in domestic products gave rise to the term “***From Research to Revenue***”. Today, applied research directed at creating real-world commercial value is supported by multiple government agencies as well as research institutions.

The Government’s policy states: “*Research that is necessary for the country should be commercially oriented in order to increase competitiveness. The primary objective should be to facilitate private sector access to emerging technology and innovation arising from scientific research, enabling technology transfer and commercial utilization of research*”. The policy singles out a number of agencies and key industry sectors to provide a platform for transform research into new revenues; these include the pharmaceutical and cosmetic industries, medical supplies and equipment, food and beverages, gems and jewelry, media learning and agricultural and fisheries sectors. Guidelines for researchers to benefit from this policy were established as follows:

- 1) Publicize the results of completed research work so that they can be adopted by the private sector for commercial application.
- 2) Organize bilateral meetings between researchers and businesses to facilitate cooperation and exchange information relating to research results that will lead to mutually beneficial commercial outcomes for both parties.
- 3) Entrepreneurs are able to commercialize technology by supporting key processes to facilitate investment, generate revenues and create new economic benefits for the country.

In the past, most research was conducted at higher education institutions. Although dedicated to research, technology and innovation, a relatively low proportion of research outcomes are adopted and utilized in the commercial arena. The government’s Thailand 4.0



policy builds on synergies between the public and private sectors to lead the country through the middle-income trap to achieve *stability, prosperity and long-term sustainability*. The policy has stimulated collaboration among relevant government agencies, research institutions and the business community under the “*From Research to Revenue*” policy. Early results are promising and the policy is expected to boost fast-track commercialization of research and drive a shift towards applied research that is geared to the needs of business and industry.

In addition, agencies that support research recently launched the “*Talent Mobility*” initiative to provide opportunities for a new generation of researchers to apply their knowledge and skills within existing institutions, guided by a senior researcher with training experience as a mentor, and to conduct collaborative research with industry. During its early stages, the initiative faced a lack of appreciation and understanding of the critical importance of human resource management in educational institutions. However as we know, in reality, collaboration among researchers and industry is already common, and is frequently undertaken without official institutional knowledge or approval. In consequence, their agencies frequently suffer a shortfall of skilled

researchers personnel available to participate in official institutional collaboration. Researchers are directly compensated by their industry partner without the knowledge of the institution; clearly this can result in serious impacts on the function and capacity of the institution itself.

The “*Talent Mobility*” initiative was officially created with budgetary support from several government agencies. These agencies also collaborated with industry, who provided support for researchers to develop innovative products and solutions. This support boosted income for researchers and also mobilized budgets to boost institutional research capacity. Most importantly, the outcomes of research can be patented by the institution, enabling researchers to continue in their research, and expanding potential revenue streams from patent royalties in the future.

Today, the majority of higher education across the country have embraced the “*From Research to Revenue*” policy, with each institution implementing according to their capacity and domain expertise in key disciplines. For example, Chulalongkorn University has conducted extensive research aimed at commercial development; the university has long been recognized as a leader





in industry-relevant research and innovation. The University recently initiated and developed the “*Siam Innovation District: SID*”, located in the Siam Square One shopping center, as an extension of the university’s Innovation Hub. SID has defined four key goals:

1) Industry Liaison – linked industries. Connect industry to leverage existing and emerging innovations and find solutions to real-world industry challenges, and manage technology rights to collaborative research to enable commercialization.

2) Marketplace – innovation market. The project makes available a large volume of unutilized research to entrepreneurs as an opportunity to adopt to further develop and expand their businesses. The marketplace will also serve as a meeting point for individuals with initiative and creativity to explore new ideas and co-create innovative solutions leading to new investments and partnerships.

3) Futurium – innovation communities of the future. This is a revolving exhibit, a permanent exhibition of innovation and smart city model to stimulate the general public to imagine and visualize the future.

4) Talent Building – human resources development. The initiative aims to boost human resource development at various levels to build a highly skilled, talented and creative caliber of researchers and innovators, through lectures, training, workshops, competitions and conferences.

Also in the Siam Innovation District, an exhibition space “*Promoting Innovation of Siam, 100 SID*” offers a new generation of innovators space to showcase

their exhibits, knowledge exchange and creative works that will contribute to the country’s economy.

Other leading universities, public and private, are also taking the same approach to science and technology research commercialization, both in Thailand and other countries. These institutions are driving research and innovation based on the proposition, supported by government policies, that research must be linked to commercial application and must create value-added for the national economy. It is also crucial that in parallel, such initiatives also expand the pool of skilled graduates with a creative mindset, who can serve as future leaders to transform the country’s social and economic trajectory.

In addition to educational institutions, the role of key government agencies is also crucial to long-term success. For example, the Department of Industrial Promotion (DIP) provides incentives for new product development to enterprises in the food processing industry and in agriculture and biotechnology. Such support aims to create and strengthen linkages across these sectors to synergize research and boost the value of agricultural products. DIP brings entrepreneurs in small and medium-sized enterprises (SMEs) to meet larger agro-industry operators who are continuously looking for new and innovative products; this follows the government’s policy to develop agricultural products and increase value-added through technological innovation and technology. The aim is to create marketable, differentiated products rather than merely imitate with the aim of undercutting competitors on price alone.

Bringing research to market to create commercial value is important for us all. The “*From Research to Revenue*” initiative must be supported and prioritized by all relevant agencies in their programmes and activities if we are to move beyond export of raw materials by enhancing value-added through relevant research, thereby helping Thailand to escape the middle-income trap. There is an urgent need to promote research across multiple sectors and drive its commercialization by industry. Continuous cooperation among agencies and between public and private sectors will be key to this success.



Co-Creating Rama IV: Urban Vibe

Assist. Prof. Saowanee Wijitkosum, Ph.D.
Deputy Managing Director of Chula Unisearch

Urban development to support economic and social development is transforming our cities in many aspects, including the land use and land cover, topography and the city's environment and image. All these aspects directly impact on quality of life of urban populations as well as the sustainability of continuing urban development. Uncontrolled urbanization has led to major environmental problems, including air, water and noise pollution, loss of green areas, and urban heat islands (UHI). Urbanization also affects the city's social conditions, the settlement patterns within the urban structure, interactions among community residents, crowding and loss of self-identity.

Bangkok's emergence and growth as a primate city since 1947 rapidly led to environmental problems,

especially in the inner district area or the Central Business Districts (CBDs). High population density and uncontrolled economic activities, particularly in the areas of Sathorn, Bang Rak, Rama IV and Sukhumvit resulted in serious degradation of environmental quality, municipal waste and sanitation, quality and visual appeal of the landscape and city, and the identity of local communities. Today these same issues remain as barriers to the city's development and its appeal as a liveable and sustainable city, as well as a destination for investment and tourism.

Rama IV Road is a major arterial road in Bangkok, constructed in 1857 on the recommendation of His Majesty King Mongkut. The road connects several major economic centres and key business districts, each with its own distinct economic role and community



structure. The road's construction catalyzed diverse economic activities as well as growth in residential communities, resulting today in extremely high traffic volumes and associated air and noise pollution. Unfortunately, the road bisected many communities without allowing safe and convenient pedestrian movement across the road. Moreover, some public areas along the road were left abandoned, attracting antisocial and criminal activities, and posing a threat to public safety.

The influence of Rama IV Road is extensive. It is promoting development of large-scale infrastructure projects including the rail transportation system, as well as commercial and residential real estate development. The resulting boost in economic activity creates new jobs and further increases the pressure on the local infrastructure. It is therefore imperative that future development along Rama IV Road be planned, designed and developed with the participation of all key stakeholders, including academic institutions, government agencies, the private sector and communities in affected areas. The objective is to create an enabling physical environment to promote economic growth, adapt to

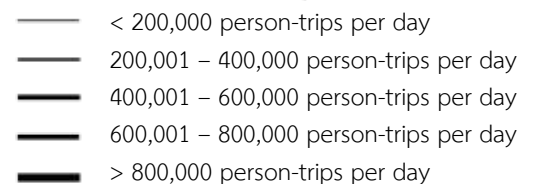
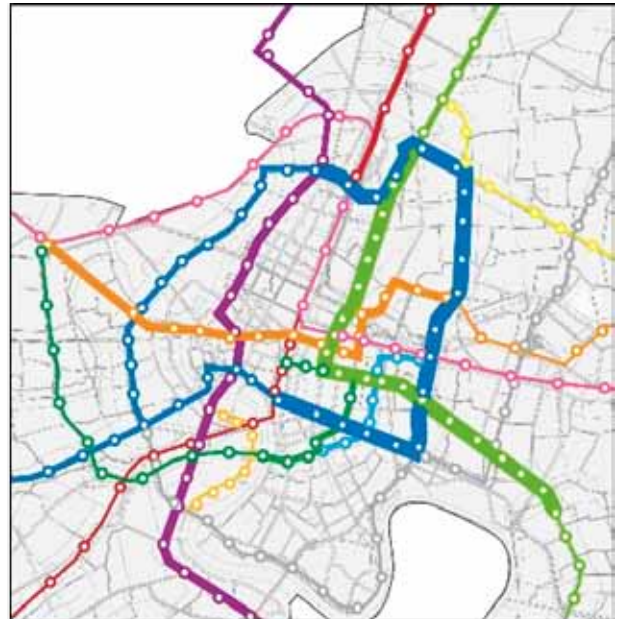
change, and to protect and rehabilitate the environment and urban landscape in a way that will contribute to the city's sustainable development. The “*Co-creating Rama IV: Urban Lifestyle*” project will be a prototype for driving local area development based on best practice and innovation to address the country's development challenges in line with the goals and objectives of the Thailand 20-Year National Strategy.

Implementation guidelines

The “*Co-creating Rama IV: Urban Vibe*” project is planned for a 5-year period, focusing on building a prototype model based on tripartite cooperation among government agencies, universities and the private sector, together with the participation and support of local communities. If successful, such a model for sustainable urban development may then be applied more broadly in Bangkok. The project comprises a number of individual components and activities supporting the main goal to develop area the along Rama IV to feature a beautiful landscape and to connect the metropolitan area with various economic centres in a way that is harmonious



Source: Extract from the Urban Rail Transportation Master Plan for Bangkok and periphery, Office of Transport and Traffic Policy and Planning



and enhances the quality of life for local communities and stakeholders.

The integrated collaborative initiative supports the development of individual projects under the overall framework in four ways:

1) Planning, design, and zoning of local development along Rama IV Road, consistent with Bangkok's overall urban planning goals.

2) Design and improve the landscape and environment along Rama IV Road and adjacent neighborhoods, including design and creation of an emblem to symbolize the local landscape along Rama IV Road and create a unique identity for the area and the local community.

3) Conduct studies into various dimensions of spatial research in the urban context in order to create a prototype for local neighborhood development and sustainable cities.

4) Create awareness, understanding, buy-in and engagement among stakeholder organizations and local communities in order to foster future development along a sustainable trajectory, through activities such as discussion groups, workshops, educational campaigns for school children, etc.

Chulalongkorn University, as a longstanding educational institution along Rama IV Road, will serve as an intermediary to connect and create partnerships among all key stakeholders. Through its faculty members





CU Urban Sandbox



• Innovation

Promoting innovative production, trade and services to boost the country's competitiveness and transformation to the era of Thailand 4.0.



• Community

Fostering citizen participation to improve quality of life, lifestyles and community development, and create a pluralistic multicultural society.



• Environment

Environmental quality management to promote public health, including disaster prevention and mitigation.



• Mobility

Promoting mass transit by rail and complementary modes of transport, e.g. cycling and walking.



• Energy

Promoting renewable energy and improved energy efficiency in buildings, public areas and transportation systems.



• Art and Culture

Preserving and sharing the legacy, creativity and historical values, art and cultural identity of the area to society.

and researchers, the University will leverage and integrate a broad body of multi-disciplinary knowledge and expertise including architecture, urban planning, environmental sciences, history, fine arts, medical and public health, engineering, etc. This body of knowledge will contribute to the elaboration of appropriate local development plans in the form of the CU Sandbox.

Chula Unisearch will serve to coordinate and create links and partnerships among the university's bodies (faculties, colleges, centers and university institutions) in order to collate and integrate relevant knowledge from the university and contribute to preparation of the development plan and its practical implementation through projects and various activities.

12th International Conference “EMECS 12”

Chulalongkorn University, International EMECS Center and partner agencies recently convened the *12th International Conference on the Environmental Management of the Enclosed Coastal Seas (EMECS 12)* under the theme: “*Cooperative stewardship for integrated management toward resilient coastal seas.*” The event was held from 4-8 November 2018 at Jomtien Palm Beach Hotel and Resort Pattaya, Chonburi. The conference was honored by the presence of General Surayud Chulanont, Privy Counsellor, who presided over the opening ceremony. Mr. Toshizo Ido, Governor of Hyogo Prefecture, Japan, Prof. Motoyuki Suzuki, Ph.D., President of the International EMECS Center and Prof. Piamsak Menasveta, Ph.D., Chair of the EMECS Committee and Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch, honored the event with their participation.

This international conference provided an opportunity for participants to present, discuss and exchange academic ideas and technical processes including development of plans for effective integrated management of coastal resources and coastal seas. Over 300 delegates from around the world attended the event.



Building Energy Code (BEC) Awards 2018

On Tuesday 11 September 2018, **Chula Unisearch** attended a ceremony at the Tulip Room, Rama Gardens Hotel Bangkok, to receive the 2018 Building Energy Conservation (BEC) award. The Coordinating Center for Energy Conservation Building Design Management Project issued the award in recognition of the design of the new office building for the National Intelligence Agency (NIA). The Director-General of the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, presided over the event and presented the awards.



The 10th Diploma Award Ceremony, “Nursing Administrators: A new era of effective management”, Ubon Ratchathani province

Chula Unisearch and Sunpasithiprasong Hospital conducted a diploma award ceremony to close the 10th “*Nursing Administrators: A new era of effective management*” training course. A total of 83 trainees from 30 hospitals in Ubon Ratchathani and neighboring provinces were trained at the 50th Anniversary Mahavajiralongkorn Building, Sunpasithiprasong Hospital.

The course aimed to support professional development of junior and mid-level registered nursing administrators to build their knowledge and nursing management skills as future leaders in nursing and hospital administration. In total, 179 hours of training was provided between 3 November 2018 and 28 January 2019.





Embassy of Finland and partner agencies from Finland discuss collaboration with Chula Unisearch

On 12 October 2018, Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch and Supichai Tangjaitrong, Ph.D., Deputy Managing Director of Chula Unisearch, recently welcomed a delegation from Finland. Ms. Susanna Eltivist, Team Finland Adviser (Education) at the Embassy of Finland in Bangkok was joined by several organizations from Finland including Business Finland, the Thai-Finnish Chamber of Commerce (TFCC) and The Synergy Company Finland Ltd. in a consultation to promote academic cooperation in international studies between Thailand and the Republic of Finland.

JAIST visits Chula Unisearch

On 24 October 2018, Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch welcomed Tetsuo Asano, Ph.D., President of the Japan Advanced Institute of Science and Technology (JAIST), who visited **Chula Unisearch** to explore possibilities for future collaboration between the two agencies and to gain insights into how **Chula Unisearch** delivers services to academia and industry, in order to learn lessons in implementing JAIST's own programmes.



Chula Unisearch New Year's Eve party to welcome 2019!

The **Chula Unisearch New Year's Eve Party** to welcome the New Year 2019 was held at Meeting Room 201 of the Chulalongkorn Research Building at Chulalongkorn University, to celebrate the success of **Chula Unisearch** over the past year and further contribute to a wonderful team spirit among academic and administrative staff. Members of the Executive Board, faculty, administrators and staff joined together for a fun-filled evening of food, entertainment and recreational activities. The Board of Directors also presented New Year's gifts to staff in recognition of their hard work, dedication and team work.







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