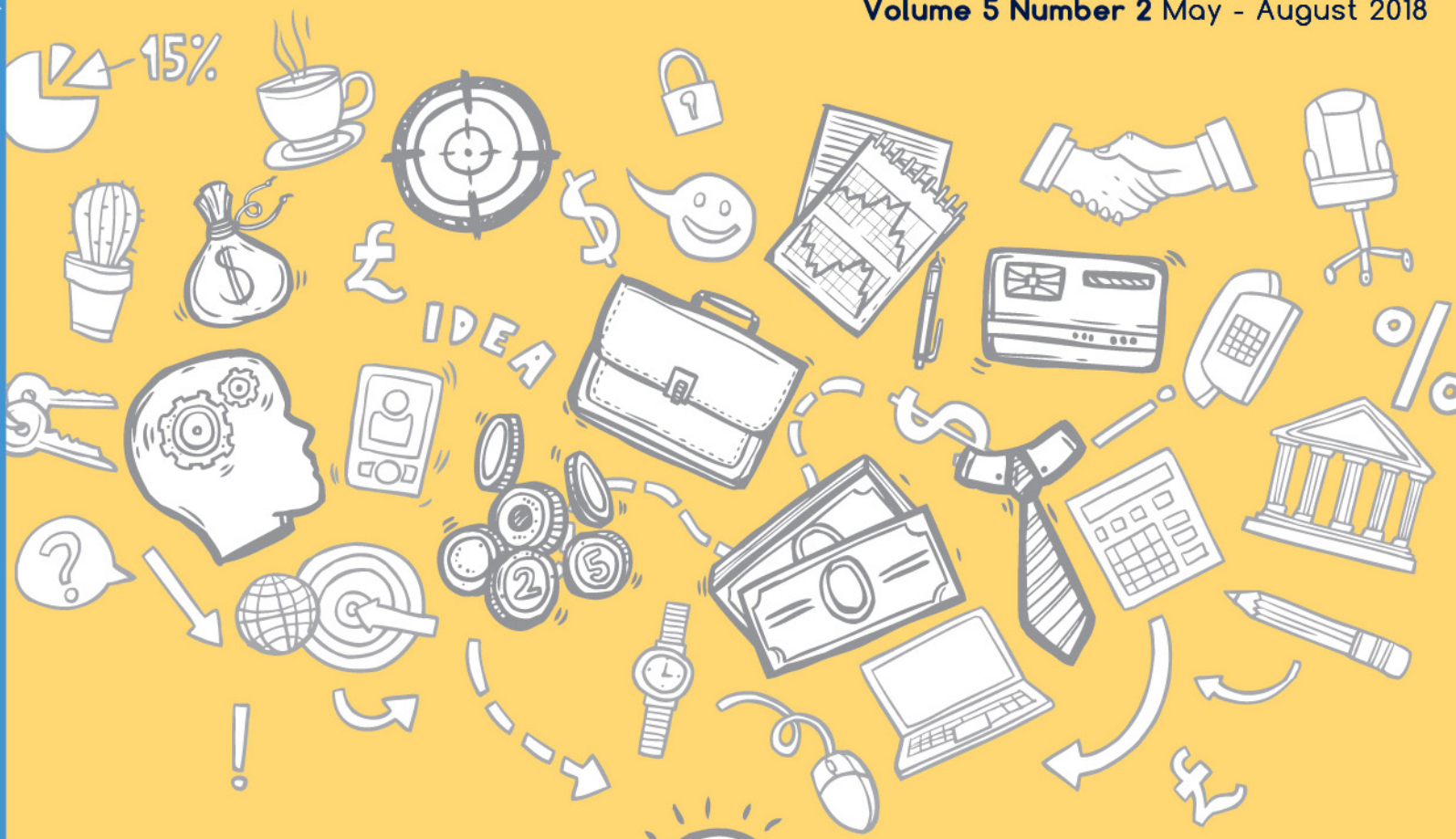
Volume 5 Number 2 May - August 2018

UNISEARCH JOURNAL

Volume 5 Number 2 May - August 2018



Creative Economy

Biotechnology for Production of Value-added Compounds from Plant Biomass Found in Thailand

Water Turbines: Design and Development for Sufficiency Economy in Pongleuk-Bangkloy Villages

Precision Dairy Farming

New Marketing Communications for Building Reliability in Product Storytelling and Buying Decisions

Feasibility Study for Establishing a Biodiversity and Local Wisdom Learning Center for Urban People

Local Cultural Heritage towards International Craftsmanship Enterprise

ISSN 2465-3764

UNISEARCH JOURNAL

Think of... Academic Services

Think of...CHULA UNISEARCH

Academic services,
and special projects

Academic services,
research and development,
and consultancy

Human resource development
and event organization

Our highly experienced
professional team
offers academic and
project management
services tailored
to clients' needs

"We strive to bring
practical benefits to society"

Chula Unisearch, Chulalongkorn University

254 Chulalongkorn Research Building, 4th Floor, Phyathai Road, Pathumwan, Bangkok 10330

Tel : 0-2218-2880 Fax : 0-2218-2859 : www.unisearch.chula.ac.th

Editor's note

UNISEARCH JOURNAL

With global development increasingly focusing on developing knowledge-based economies, Thailand is pursuing a national transformation towards a connected, digital economy under the Thailand 4.0 policy, as part of the 20-year National Strategy (2017-2036) and also contributing to the 12th National Economic and Social Development Plan (2017-2021).

The Creative Economy concept aims to harness knowledge, research, creativity and intellectual property linked to local wisdom to use in the production of goods and services that can create economic value added. The concept carries profound implications for Thailand's economic structure and the goods and services we will be producing in the future.

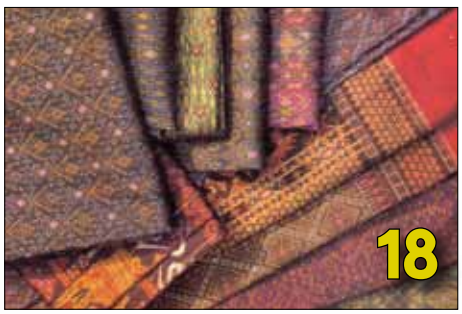
Thailand is rich with natural biodiversity and enjoys a unique and ancient cultural heritage, embracing diverse fields such as architecture, religion, music, arts and crafts, textiles, herbal and Thai medicine, and Thailand's renowned natural resources support the country's thriving tourist industry. These form the core of Thailand's *'cultural capital'*. If we are to further drive development, we need to link this cultural capital with new technologies and markets in order to enhance the value of goods and services in both domestic and global markets.

This can only be achieved through greater prioritization of education and investment in research and innovation across all industry sectors- industry, agriculture and services. Most of all, new policy, strategic and organizational reforms will be critical to incentivize change at all levels towards establishing Thailand as a true *'Creative Economy'*.

The Editorial Board

Vol. 5 No. 2 May - August 2018
Published by
Chula Unisearch, Chulalongkorn University

Contact Enquiries
Chula Unisearch, Chulalongkorn University
254 Chulalongkorn Research Building,
4th floor, Phayathai Road, Pathumwan,
Bangkok 10330
Tel: 0-2218-2880
Fax: 0-2218-2859
E-mail: unisearchjournal@gmail.com
www.unisearch.chula.ac.th



New Marketing Communications for Building Reliability in Product Storytelling and Buying Decisions

Assoc. Prof. Worawan Ongkrutraksa, D. Arts.
Department of Public Relations, Faculty of Communication Arts, Chulalongkorn University

Introduction

A pilot study was initiated to develop a new body of marketing knowledge, using an enhanced understanding of the changing dynamics of marketing communications to build innovative business models based on emerging marketing platforms such as social media. The purpose of the research is to study models, methods and platforms suitable for new marketing communications in this era of social media and to highlight new approaches to building knowledge and understanding of applying new marketing communications for business. The research results may be applied to develop new marketing communication strategies through creative storytelling. Storytelling normally aims to associate the product with creative and compelling narratives, influencing the buying decision and adding value to the product. Storytelling builds consumer loyalty by communicating key facts and emotionally engaging consumers, triggering awareness, recognition, and attraction towards the product. Storytelling is also an important skill that contributes to the concept of the creative economy.

Research methodology

The research team used qualitative methods to obtain data for this study, reviewing all available secondary data from the extant literature as well as generating primary data via selected group interviews. The data collection methods are described below.

1) Literature sources

1.1) Statistics and trends in use of social media in Thailand, information perception via social media and social media usage for marketing communications.

1.2) Theory and literature related to marketing communications and emerging approaches.

1.3) Theory and literature related to consumer behaviour, psychology of buying decisions and product reliability.

2) Focus group interviews

Participants for the focus group interviews were selected by purposive sampling. The interviews aimed to gain a better understanding of consumer behaviour and their social media communications. Sex, age and religion segmentation was also used to select participants, divided into two groups of consumers (students and professionals) who use social media and reside in the Bangkok area.

https://financialtribune.com

Results

1) Literature review

1.1) Statistics indicate increasing social media usage in Thailand year-on-year. Unsurprisingly, the most popular platforms in Thailand are Facebook, Twitter, Instagram and YouTube. Users' behaviour including likes, sharing, check-ins, status posts and video posts were analyzed.

1.2) Social media have emerged as new and powerful tools for business, offering innovative ways to interact with consumers to build brand-awareness, escaping the limitations of traditional mass media, whose costs are often prohibitively high, and impact ad return on investment are often hard to evaluate accurately.

1.3) Social media are effective tools for brand-building since they foster interaction with consumers, allowing real-time evaluation of the impact of any campaign or message.

1.4) Marketing communication strategies must be constantly adjusted to ensure optimal positioning in a fast-moving and competitive environment. New approaches to marketing communications help us understand consumer motivations and behaviours that contribute to customer satisfaction and brand attachment. Such approaches aim to stimulate consumer demand and stimulate word-of-mouth or peer-to-peer marketing among friends. Marketing communication by social media are increasingly recognized as more efficient than traditional channels such as advertisements, public relations or the brand owner's self-communications. Therefore, factors affecting consumer motivation in communicating by sharing content or showing satisfaction or dissatisfaction by clicking "Like" affect group behaviour and thus merit further study.

1.5) Essential factors to motivate consumer communications and content sharing (Puriwat, 2013).

(1) Emotional interactions between consumers and the brand. It is not necessary for the product content be business-related. The main goal is to build an emotional relationship between the consumer and the product(s).

(2) Providing products or services beyond the consumer's expectation

(3) Identifying influential figures to communicate with mass consumers

(4) Creating content related to consumers.

However, consumer attachment or impression towards the brand are themselves insufficient. The marketer must also take into consideration the consumer's buying decision, which are influenced by four essential factors:

(1) Culture, including ways of life, race, religion, skin color, gender and social status.

(2) Sociality, including family dependence

(3) Individuality, including age, career, economy, educational background and lifestyle

(4) Psychology, including motivation, perceptions, learning, beliefs, attitudes, personality and ideas.

There are also 9 sub-factors as follows

(1) Level of consumer's desire for product

(2) Type of product that match consumer's needs

(3) Income, career, social role and status of consumers

(4) Price, taste and quality of products

(5) Belief and attitude towards brand

(6) Seller or agent

(7) Buying quantity

(8) Time

(9) Payment.

Building product reliability through storytelling is a marketing tool to enhance consumer demand through sharing accurate product information. Storytelling impacts on consumer buying decisions by enhancing product awareness and recognition, and stimulating consumer interest. Storytelling can be categorized into three types; 1) product history, 2) product qualification and 3) special production process. Today, social media play an essential role in marketing communications. With increasing cross-media convergence, normal storytelling is replaced by trans-media storytelling, with users serving as the content and media producers sharing their own experiences. Human experiences are increasingly recognized as the most compelling source of information. Daily routines, memories, emotions, social attitudes, social interactions, image and identity can be communicated and shared via social media.

2) Data were collected from two sample groups: a worker group and a student group; both were segmented by sex and religion. These results were used to study patterns, methods and platforms for new marketing communications via social media. Three sample products were selected; toothpaste, mouth cleansing foam and toothbrush. The sample groups were differentiated by sex, religion and age showed differentiated interest in different product characteristics of the sample products as shown in Table 1.

Conclusion

The results of the research can be applied according to the target sampling consumers, both students and workers, who shared similar recommendations concerning the target consumers and locations. These recommendations are listed below.

1) Storytelling should highlight the product's ingredients, for example special herbs or sakura extracts that refresh the mouth or keep maintain oral health. Storytelling can be expressed through impression or comedy, according to Chuastapanasiri (2015).

2) Products should be sold at drug stores, herbal stores, dental clinics, booths or events for

Table 1 Group Interviews

Segment	Preferences
Sex	
Female	Preference for products relating to physical appearance- focus on colours, shapes and attractive packaging design
Male	Strong brand loyalty
LGBT	Preference for products relating to appearance or image
Religion	
Buddhism	No issues due to general products
Christianity	No issues due to general products
Islam	No prohibited ingredients such as lard oil
Age	
Student Group	Preference for innovative and colourful products; sometimes influenced by family
Worker Group	Focus on quality and product utility

Source: Adapted from Ongkrutraksa (2014)

product exhibition. Sample products should be given out for target consumers.

3) Products should be packaged as a set for special persons and occasions.

4) Sales promotion should be communicated via TV direct and local radio where target consumers are workers and those who love herbal products. Word of mouth marketing methods should also be considered.

5) Sales promotion should also be communicated via social media such as Facebook, Instagram, web boards and YouTube. The target consumers are those who prioritize their health and love herbal products, and who also have oral problems. Popular public figures should be hired to communicate with, and appeal to, key target groups.

The value of this study is limited by its small size and the use of focus group interviews with relatively small sample size, so that the findings may not be reliably extrapolated to other situations. To increase accuracy and reliability of findings for new market communications programmes in the future, the researchers suggest the need for a higher number of sampling groups and more differentiated segmentation. However, the researchers have accumulated all of suggestions concerning marketing communication issues applied from the works of three groups of the students. Their works are creative and fascinating and show high potential to be applied for marketing success.

Acknowledgements

This article is part of the research projects entitled ***"New marketing communications for building reliability in product storytelling and buying decision"*** funded by Lion (Thailand) Co., Ltd.

References

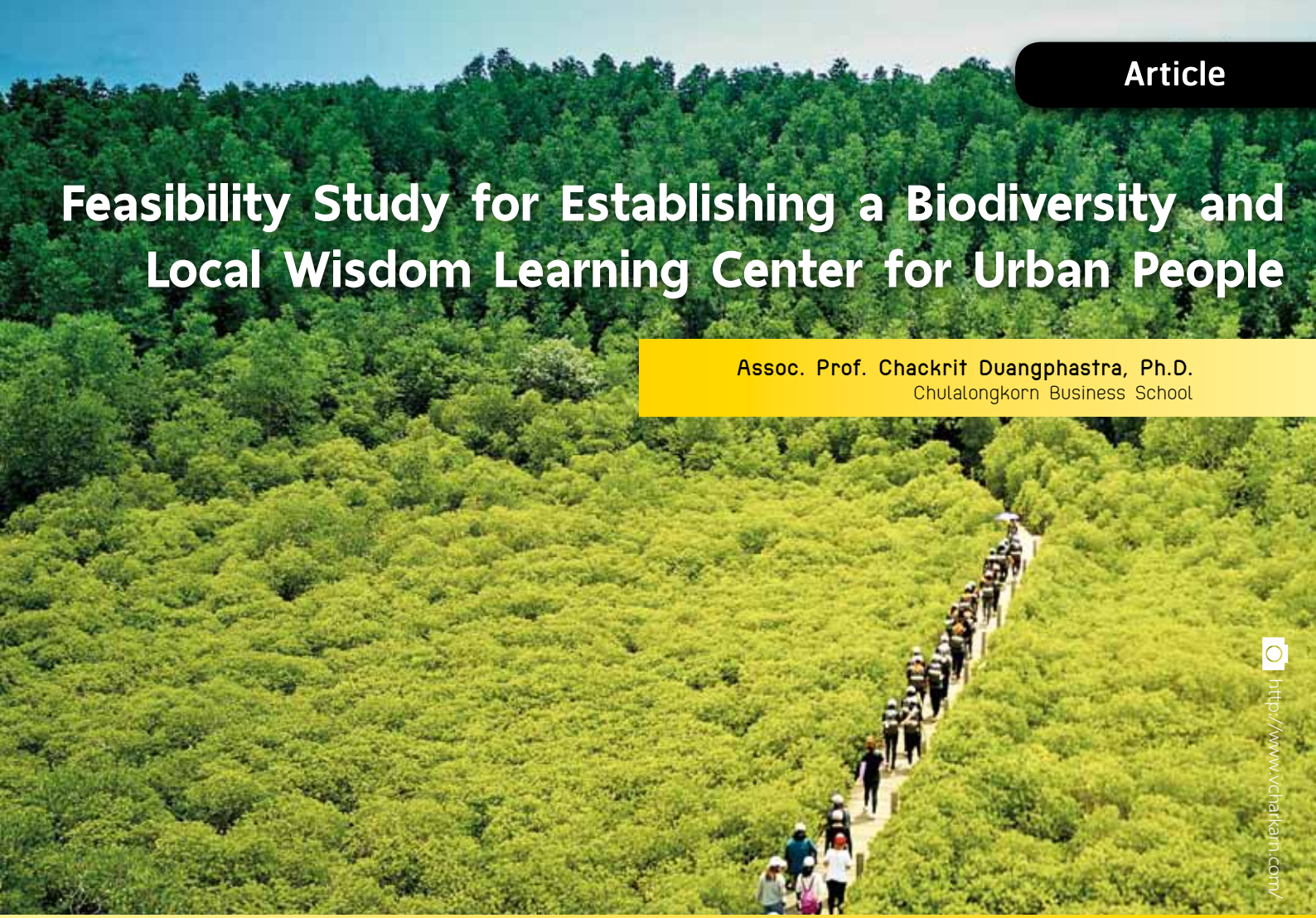
Chuastapanasiri, T. 2015. Transmedia: story-telling. **Journal of Communication and innovation NIDA** 2 (1): 59-88.

Ongkrutraksa, W. 2014. **New Marketing Communications for Building Reliability in Product's Storytelling and Buying Decision**. Report. Funded by Lion (Thailand) Co., Ltd.

Puriwat, W. 2013. **You are what you like, you are what you share**[Online]. Available from:http://library.acc.chula.ac.th/PageController.php?page=FindInformation/ArticleACC/2556/Wilert/BangkokBiznews/B2403131[March 28, 2018].

Feasibility Study for Establishing a Biodiversity and Local Wisdom Learning Center for Urban People

Assoc. Prof. Chackrit Duangphastra, Ph.D.
Chulalongkorn Business School



http://www.vcharkarn.com/

Introduction

This study aimed to explore possibility of establishing an exhibition unit to raise awareness of connectivity between biodiversity and local wisdom for Bangkok residents. Nowadays, urban residents tend to rely more on technology and imported goods and resources, which affects the environment. Moreover, because local wisdom is no longer passed on to the younger generation and not valued, Thailand is fast losing its renowned biodiversity and rich local wisdom. The establishment of a Learning Center will play an important role in enabling urban residents to understand the broad-ranging benefits of biodiversity and local wisdom. It also creates a creative learning space that is easy to access, interesting and relatable. The Learning Center was designed to pass on knowledge that can be utilized in everyday life.

The Biodiversity-Based Economy Development Office (Public Organization) with its mission to support and add value to biodiversity and local wisdom as well as businesses that were inspired by them. The Office supported the goals of the Learning Center and appointed **Chula Unisearch** to conduct a feasibility study including conceptual design, appropriate content, possible locations and benefit-cost analysis.

Conceptual design and methodology

In developing the conceptual design of the Learning Center, the research team recognized the need for both permanent and temporary exhibitions. Permanent Exhibitions normally need to be on display for more than five years at a fixed location. The management team must, therefore, be certain that the exhibition will be able to attract a large number of visitors and remain popular for a long enough period of time. In contrast, temporary exhibitions can be highly mobile and can be moved among different venues for limited periods of time. Such exhibitions must, therefore, be easy to store, transport, set up, dismantle and transport.

The research team analysed primary and secondary data obtained from target participants in highly populated spaces including department stores, commercial areas, as well as visitors to the National Science Museum, Natural History Museum, Biodiversity-Based Economy Development, Bangkok Butterfly Garden and Insectarium, Thailand Creative & Design Center (TCDC), conservation centers and other learning centers located in Bangkok and nearby areas. The data analysed included behaviour of the population, their perspectives on architectural design, content appropriate for the Learning Center, types of media used, display period, accessibility and convenience of the location, and the surrounding area. The research team also interviewed management teams of the department stores and exhibition staff responsible for the local biodiversity and wisdom exhibitions in the Bangkok area. The data were analyzed to identify target audiences, define appropriate communication for the establishment of the Learning Center and evaluate the costs and benefits.

Identifying location for the Learning Center

Behaviour analysis of the target audience (Bangkok residents interested in biodiversity and local wisdom) indicated that residents prefer visiting a learning center located in a department store (in the city) rather than within a science park or museum (which are located outside the metropolis). Department stores located in the city are easy to reach, with sufficient parking space and convenient for combining a visit to the Learning Center with dinner. However, the cost of establishing a Learning Center within the department store is high, especially if located in the city center. Comparing five different locations - Central Plaza Grand Rama 9,

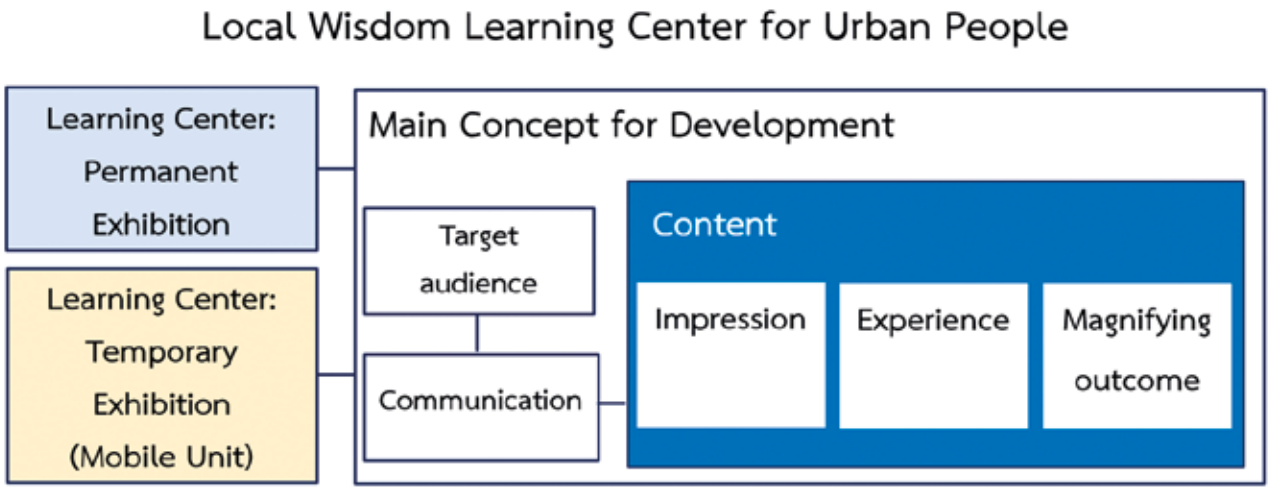


Figure 1 Conceptual design for the Local Wisdom Learning Center for Urban People
Source: Duangphastra et al. (2014)

Figure 2 Architectural design for the Learning Center
Source: Duangphastra et al. (2014)

Central Plaza Chaengwattana, CentralWorld, Thailand Creative & Design Center (TCDC) and Chamchuri Square, the analysis revealed that Chamchuri Square was the most feasible location, followed by Thailand Creative & Design Center (TCDC) and CentralWorld, respectively. The analysing factors were visitor density, population density in surrounding areas, accessibility, rental fees, and space available for setting up the Permanent Exhibition.

Architectural design for the Learning Center: temporary and permanent exhibitions

Studying the preferences of the target audience, the components of the area, and review of literature such as Ott (2014) and Shone and Parry (2010), the analysis revealed that the Learning Center should be designed to encourage the audience to learn about their local biodiversity. It should also encourage visitors to make use of the knowledge to create new wisdom that can be passed on to the younger generation. The wisdom created should add value and enhance quality of life or even become a source of income. The audience should be able to remember the knowledge and apply in their daily life (Figure 2).

The data obtained from participants living in Bangkok revealed that the exhibition content should relate to food, health, clothing, living space, daily tools, traveling, 3Rs, energy conservation, reducing waste and pollution, conservation of plants and animals, and introducing new materials for construction or designing new products.

Figure 3 The Learning Center displaying a permanent exhibition
Source: Duangphastra et al. (2014)

The Biodiversity and Local Wisdom Learning Center for Urban People – permanent exhibition is shown in Figure 3 and 4.

The service pathway of the exhibition (Figure 5) began at the Public Relations area, where visitors are welcomed to the Learning Center; they then continue to an Introductory Area where videos and photographs related to the exhibition are screened. The visitors proceed to a room showcasing biodiversity and local wisdom; though these are presented in different zones, they are well linked together to show the connectivity of the themes. The visitors then enter an Experimental Area, which displays different ways to utilise and adapt local wisdom

Figure 4 Components of the Leaning Center for permanent experiment
Source: Duangphastra et al. (2014)

Figure 5 Service pathway for the Learning Center showcasing permanent exhibition
Source: Duangphastra et al. (2014)

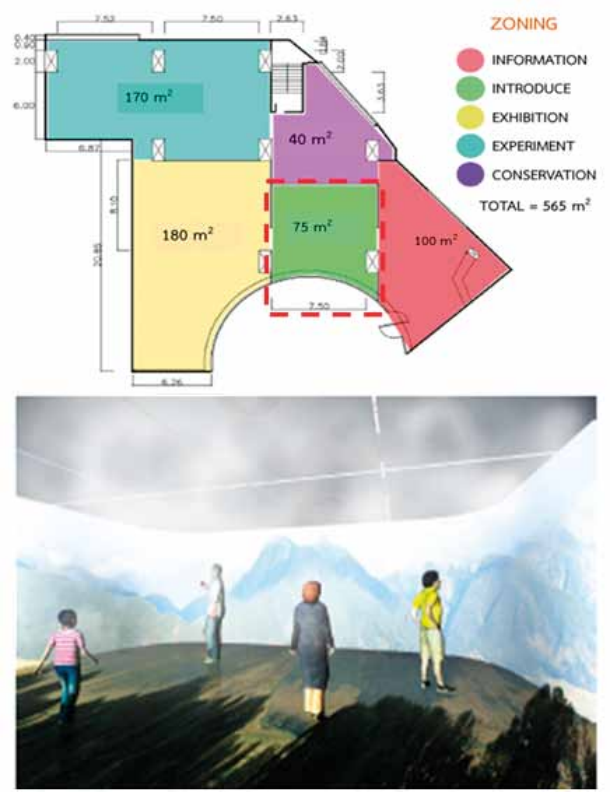


Figure 6 Introductory area of the Learning Center
Source: Duangphastra et al. (2014)

in our daily lives. This room demonstrates how easy it is to apply passed-on wisdom to good use and raises awareness and understanding of the two themes (biodiversity and local wisdom), their inter-connectedness and relevance to our daily lives.

The service pathway then leads visitors to the Conservation Area where the importance of conservation of biodiversity and local wisdom are emphasised. After visiting this final part of the Exhibition, visitors can rest in designated waiting areas (Figure 6).

The Temporary Learning Center (Figure 7) was designed to be set and displayed in front of a conference room or promotional area inside a department store. The size varied from 2 m to 8 m in width and from 2 m to 8 m in length (i.e. from 2-64 m^2).

Benefit-cost analysis of the Learning Center

Setting up the Learning Center at a mall in Bangkok (Chamchuri Square) as shown above required seven exhibition staff. The estimated cost is as follows:

1) Cost

The cost of the exhibition is divided into construction cost and operation cost. The construction and interior designing cost 14 million baht. The operation cost was estimated at 9.8 million baht per year: rental and utilities 6.1 million baht; human resources 1.6 million baht; learning resources and materials 1.5 million baht; public relations, advertisement and other expenses 0.6 million baht.

2) Income

The revenue of the Learning Center was divided into three categories. 1) income from visitors (300 visitors a day/80 baht per person) which was estimated at 6.3 million baht per year. 2) rental fees from exhibitors showing innovative ways to produce products from local wisdom was 0.4 million baht per year. 3) income from the Learning Center Shop and souvenirs was 4.5 million baht per year.

The rate of return on investment was calculated over a 5-year period at 10% discounted rate. The calculation revealed that the net present value (NPV) was 1.51 million baht and the internal rate of return (IRR) was at 17.12%. Under these assumptions, the break-even point would be achieved within 3 years and 9-months. The risks of the program are based around cost management, especially rental and utility fees which are the most important cost elements. Income management was also important, especially in designing activities and content to attract visitors as well as selecting the optimal location.

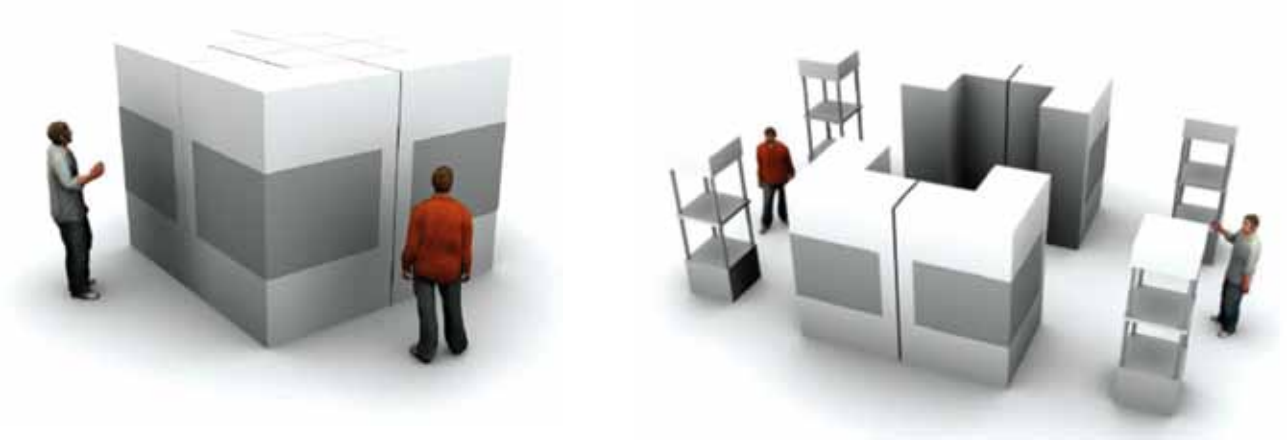


Figure 7 Different sizes of Temporary Learning Center
Source: Duangphastra et al. (2014)

Conclusion

The ***"Feasibility Study for Establishing the Biodiversity and Local Wisdom Learning Center for Urban People"*** aimed to explore possibility of establishing an exhibition where visitors from urban areas can learn about biodiversity and local wisdom. This is important to bridge a widening disconnect between urban citizens and the environment, and to revive the tradition of passing on local wisdom to younger generations, thus conserving ancient heritage and biodiversity. Therefore, the Learning Center is a crucial channel for urban residents to learn about biodiversity and local wisdom in a creative and compelling way, that enables them to use the knowledge in everyday life.

The research team submitted the proposal to Biodiversity-Based Economy Development Office (Public Organization) for consideration. The proposal contained both types of learning centers. 1) The permanent Learning Center is most suitable to be established at Chamchuri Square or at Thailand Creative & Design Center (TCDC), and 2) the temporary Learning Center (mobile unit) that can be transported and display at different areas is proposed to be between 4 m^2 and 54 m^2 in size. Risk management of establishing the learning center should take into account cost management, especially in regard to rental and utility fees, as well as income management, especially in creating attractive exhibitions to reach the targeted number of visitors, and in selecting optimal locations with convenient visitor access.

Acknowledgements

This article is part of the research project entitled ***"Feasibility Study for Establishing the Biodiversity and Local Wisdom Learning Center for Urban People"*** funded by the Biodiversity-Based Economy Development Office (Public Organization).

References

Duangphastra, C. 2014. **Feasibility Study for Establishing the Biodiversity and Local Wisdom Learning Center for Urban People**. Report. Funded by the Biodiversity-Based Economy Development Office (Public Organization).

Ott, A. 2014. **Museums, Learning Centers and Education for Sustainable Development**. Master's Thesis. Culture, Environment and Sustainability. Center for Development and the Environment, University of Oslo, Norway.

Shone, A., and Parry, B. 2010. **Successful Event Management: A Practical Handbook**. Hampshire: Cengage Learning.

Water Turbines: Design and Development
for Sufficiency Economy in Pongleuk-Bangkloy Villages

Assist. Prof. Suphannee Boonpeng, Ph.D.
Department of Dance, Faculty of Fine and Applied Arts,
Chulalongkorn University

Introduction

Pongleuk (Moo 2) and Bangkloy (Moo 2) villages are located at Huai Mae Phriang, Kaeng Krachan district, Phetchaburi Province, Thailand. The villages are about 50 km away from Kaeng Krachan National Park and are located next to the Phetchaburi River at 150 m above mean sea level (Department of National Park, Wildlife and Plant Conservation, 2017). Residents in these villages are Skaw Karen who moved from the upper Bangkloy (known as the Heart of the Earth). They have simple lifestyles, work as farmers and believe in ghosts, tree nymphs, guardian spirits, Buddhism and Christianity.

The Phetchaburi River is very important to Pongleuk-Bangkloy's residents. One of the most challenging problems for the residents is that their freehold accommodation and agricultural areas (CN area) are located at a high elevation above the river, and so water diversion from the river to the villages for consumption and agriculture is problematic. Moreover, the villagers can only plant and cultivate their crops during the rainy season due to the lack of water or electricity mains supply to the villages. As a result, the net income per household is rather low, and consequently many villagers have moved to cities for work. Notwithstanding the difficult economic and physical conditions, more than 100 households still reside in the villages and rely on the land for their livelihood, thus requiring a reliable source of water for both consumption and agricultural irrigation. Using mechanical water pumps to divert the water from the river into the villages requires petrol or diesel, which are expensive. Most villagers have to use a communal water pump, with only a few private households having their own machines.

Currently, the villagers mainly use solar cell powered water pumps, which are supported by sectors. Using a solar cell water pump is dependent on the amount of sunlight each day, and on low sunlight days there is insufficient power for the water pump to operate effectively. In addition, there are frequent problems with the submersible pump due to unstable mechanical problems and breakdowns. Together, these issues, coupled with the fact that the solar cells are expensive and difficult to maintain, lead to insufficient water diversion from the river to meet the demand of the villagers, and negatively affect the ability of the farmers to cultivate their rice paddy fields. Water turbines represent an alternative approach to providing water without the complexity and cost of electrically-powered pumps to aid agriculture in the area.

In the past, water turbines driven by a piston pump were used to divert water from the Phetchaburi River to the Pongleuk-Bangkloy villages by the Royal Irrigation Department in 2008. The piston pump was able to pump water to a height of 25 m. In 2014, Assistant Professor Ruengwit Bunjongrat brought the idea of using a piston pump back to the villages and hired Mr. Sanchai Joopleng, a mechanic in Kaeng Krachan district, to build a piston pump water turbine as an experiment to determine if the villages could use such devices to help become economically self-sufficient. This was based upon the area's context that the use of petrol and electricity is prohibitively expensive and wastes natural resources and thus is not suitable for these areas. Preliminary results from using the piston pump water turbine showed that the turbine could pump water into the villages, but only at a low rate of water transfer and for a very short distance from the river. The pump could not transfer water to the center of the community nor could it work continuously.

Despite the above limitations, the possibility of using a water turbine in Pongleuk-Bangkloy villages was established. As a result, the requirement for a functional water turbine in the area was surveyed and a water turbine project was established to find grants to design and develop suitable water turbines that could be used in the two areas. To involve the community in the project, villagers with knowledge of mechanics were invited to help with the design, development and building of another water turbine. Therefore, this project is a collaboration between the head of the project, water turbine mechanics and members of the two communities. Some of the initial problems and solutions are summarized in Table 1.

Figure 1 Water turbine Chula-Pidthong 8 (the latest development model). Experimental turbine installed at The Kaeng Krachan National Park Ranger 10 (Huai Mae Saliang)
Photographed by: Boonpeng, March 2017

From the installation and test results, the redesigned water turbine was found to be more stable and could pump more water for longer and higher distances from the river, to a level sufficient to support agricultural use for some, but not all, groups of farmers. In addition to installing and testing the water turbine, the project organized a workshop for the villagers to teach them how to use, maintain and repair the water turbine, thus enabling them to operate and solve future problems by themselves. Materials and parts will deteriorate due to use and time, and training will enable the villagers to fix and change some parts that are not too expensive. Even though the water turbine provided greater volume and more consistent delivery of water to the villages, the initial design was clearly insufficient to provide enough water to all the villagers there for consumption and agricultural use. However, this was just the first step in developing a better one. There are still many problems to solve, with new designs being developed to match the geological environment and life styles of each community. This is because the agricultural areas in each village and between villages are diverse, such as the elevation and distance from the river to the residence and agricultural areas. Thus, a better system and installation still needs to be developed using more efficient and durable materials matched to the different areas, bearing in mind the need to reduce the production cost and complexity of the turbine and to make it lighter, easier and safer to use. The development of the water turbine can be summarized as follows.

1) Increase the turbine stalks from 8 to 10 pieces, adjust the pitch degree and increase the size

Table 1 Problems and solutions from testing the water turbine's system (I) and test results after solving the problems

	Problem	Solution	Result
1	Unstable structure of the water turbine, so it cannot sustain a strong water current	Increase thickness of the angle steel structure	Stronger structure
2	The pump is small with a low rate of water diversion	Change to a bigger pump with a larger power cylinder	Higher rate of water diversion
3	Swollen and broken rubber tube	Change rubber tube to PVC and HDPE	New tubes allow a higher water pressure
4	Turbine cannot spin properly because of a rusted chain and fast system force reducer, due to constant water contact	Adjust structure at the base of the pump, move chain and conveyor system higher above the turbine blade	Turbine moves better, chain and conveyor work better and can be used for a longer period of time
5	Water flows back into the pump (booster broken) preventing its operation	Install a check valve to let water flow in the same direction and prevent water flowing back	Water does not flow back
6	Transfer water only for short distance	Install airways to increase water pressure	Transfer water for a longer distance

of the turbine blades so that they can penetrate into the water further and increase the spin force.

2) Adapt the front of the turbine to have a longer wing to enable a wider inlet to receive more water.

3) Match the size of the pump to deliver the required volume of water given the distance and elevation from the river in each area.

4) Alter (reduce or increase) the size of the force reducer materials to decrease the amount of pumping.

5) Change from a conveyor to a chain system for increased strength and to solve the problem of a lax conveyor that resulted in the turbine not pumping water.

6) Increase the number of pumps from one to two so that the water turbine can pump twice the rate of water but use only one set of water turbines.

7) Increase the chain lock, once the chain is strained, so the system will work better.

8) Install suitable structure to prevent water entry into the pump and other details of the water turbine's structure, such as delete sharp parts and apply two coatings of rustproof treatment (Figure 2).

Materials for building the water turbine

The required materials for building the water turbine are divided into four parts as follows.

1) Structure is made from angle steel, iron plate, zinc (20-30 litres).

2) Force reducer is composed of shaft, chain, conveyor, chain lock and nut.

3) Pump and tube systems are composed of the water pump (piston pump), check valve, adaptor brass, foot valve, suction line and high density polyethylene (HDPE) piping that can withstand high pressure. HDPE pipes have been proven to be more durable than rubber and other PE alternatives and are more convenient than polyvinyl chloride (PVC). The bushing PE has one side smaller than the other so the outlet water is at an increased pressure and can transfer water for a further horizontal and vertical distance.

4) Materials for making the airway to increase the water pressure are a PVC tube (size 3-4 in, length 0.5-1 m), PVC cover lid, three-way adaptor joint, adaptor joint, duct tape and glue for the water pipe. The airway should be installed every 20 m.

Apart from the above materials, other tools are needed for the installation and on-going maintenance, such as wrenches, locking pliers, screwdrivers, duct tape, engine oil, grease, pipe clamps, paints and thinner, can be found at any hardware store. The structure of the turbine was redesigned and developed taking account of the indigenous knowledge to solve installation problems, such as how to attach the turbine (using bamboo to connect the water pipe and PE instead of an adaptor joint), using wood instead of the straight pipe joint for the pipe covering, arranging river stones to make the watercourse wide enough to install the turbine and to let the water flow inside and make the turbine spin stronger, and building a bamboo raft to transport the turbine, given that cars and people have no access to the installation area (Figure 3).

The project has already built and developed eight water turbines that can transfer water as high as 40-50 m vertically above and approximately 450 m horizontally away from the river at a rate of 10-19 litres per minute. Note that water is mostly needed in the area at 20-30 m above and 200-450 m away from the river. However, it depends on the slope, distance and type of water turbine. The budget for constructing a water turbine is approximately 18,000-28,000 baht (transportation expense is not included). Each water turbine can pump water for 24 h/day, so it can supply enough water for the current demands of the villages for consumption and agricultural use, giving them more options for farming, a better economy and eventually a better quality of life (Figure 4). This is especially the case for people who live and farm away from the village's plumbing system, who now have access to water without having to use petrol or diesel based pumps.

However, this type of pump is expensive and will require on-going maintenance due to the deterioration of the components from constant use. Key components that will need to be repaired (or replaced) on an on-going basis include broken pump springs, torn and brittle rubber pumps, leaking rubber gaskets, rusted support structures, broken turbine blade restraining rods, blocked foot valves due to sand, leaves and garbage get stuck onto the turbine, and broken chains and / or lax conveyors. These problems can be solved by the local villagers, and there is already a group of villagers who maintain the turbine, understand and make the rules for using the communal water turbine in the community.

Conclusion

To design and develop a water turbine for sufficiency economy in Pongleuk-Bangkloy villages, the researchers hold to the principles of the sufficiency economy theory by His Majesty King

Figure 2 Water turbine driven the piston pump (Chula-Pidthong 6)
Photographed by: Boonpeng, March 2017

Figure 3 Water turbine transport (Chula-Pidthong 4), showing the incorporation of indigenous knowledge using a bamboo raft to transport the turbine
Photographed by: Boonpeng, April 2016

Figure 4 Water from using water turbine (Chula-Pidthong 5)
Photographed by: Boonpeng, February 2017

Bhumibol Adulyadej to organize the activities, using his work motto of **understanding, accessibility and development**. Many sectors have collaborated to help develop the service areas, such as Kaeng Krachan National Park, Pidthong Foundation according to a Royal Initiative (due to working in the area under the responsibility of the Kaeng Krachan National Park, the main area of the Pidthong Foundation to do activities for community development). Recognizing that the most important aspect of any such development is cooperation from the community, the researchers have worked with the community to build and experimentally test water turbines for almost 4 years in the villages, which has enabled the use of many more natural resources of the area. Accordingly, there are plans to develop other aspects of the community, such as the social environment, life styles, culture, activities outside classroom, volunteer activities and academic services. Using appropriate technology to solve the community's problems will lead to an improved and sustainable economy, social and education benefits.

The rural development plan, in accord with the Royal Initiative of Pongleuk-Bangkloy villages, has led to on-going workshops and other activities in the area that have helped the design and development as a community, leading to the well-planned work. Moreover, learning from real in situ problems and collaborating with the villagers, using the knowledge and specific skill sets of each individual, has helped solve problems in the community and will eventually lead to innovation that could be used in the community.

Acknowledgements

This article is part of the research project entitled ***"Design and development of water turbine for sufficiency agriculture"*** funded by the Chulalongkorn University strategic plan to develop society and The Royal Initiative Discovery Foundation. (Pidthong Foundation)

References

Boonpeng, S. 2016. **Report of water turbine build and development project.** The Strategic University for Social Studies, Chulalongkorn University.

Bucci, A., Sacco, P. L., and Segre, G. 2014. Smart endogenous growth: cultural capital and the creative use of skills. **International Journal of Man Power** 35 (1/2): 35-55.

Department of National Park, Wildlife and Plant Conservation. 2017. **Kaeng Krachan National Park**[Online]. Available from: http://nps.dnp.go.th/parksdetail.php?id=130&name=อุทยานแห่งชาติแก่งกระจาน[February 2, 2018].

Howkins, J. 2001. **The Creative Economy: How People Make Money From Ideas**. London: Allen Lane. Cited in Farmakis, E. 2014. **Fostering the Creative Economy**[Online]. Available from: https://ssir.org/articles/entry/fostering_the_creative_economy[February 2, 2018].

Newbigin, J. 2014. **What is the creative economy?**[Online]. Available from: https://creativeeconomy.britishcouncil.org/guide/what-creative-economy[February 2, 2018].

van der Pol, H. 2007. **Key role of cultural and creative Industries in the economy**[Online]. Available from: https://www.oecd.org/site/worldforum06/38703999.pdf[February 2, 2018].

Article

Local Cultural Heritage towards International Craftsmanship Enterprise

Assoc. Prof. Patcha Utiswannakul, D.F.A.
Department of Creative Arts, Faculty of Fine and Applied Arts, Chulalongkorn University

Introduction

Given the Thai government's policy to build a creative economy to drive added value, the focus of development brings together six types of capital: natural, physical, social, human, financial and cultural. Cultural capital often serves as the core that connects all capital types. When the ASEAN Economic Community (AEC) came into being in 2015, one of Thailand's goals regarding the AEC's second pillar - the Socio-Cultural Community, focusing on economic, social, and cultural development - was set in harmony with the 11th National Social and Economic Development Plan (2012-2016). The Plan encouraged greater leverage of cultural capital and innovation in an integrative fashion to create new knowledge and strengthen competitiveness in a fast-changing global and regional economy (Klankamsorn, 2012)

Cultural capital describes values, knowledge, wisdom, and creative works produced by local intellectuals (Pattamasiriwat et al., 2004, quoted in Pinkaew, 2011). Throsby defines cultural capital as *"an asset which embodies, stores or provides cultural value in addition to whatever economic value it may possess."* Accordingly, cultural capital can exist in tangible goods such as buildings, museums, and paintings, as well as in intangible normative concepts such as techniques, ideas, beliefs, and customs (Throsby, 2001). Intangible cultural capital is also defined as *"a set of attitudes, beliefs, mores, customs, values, and practices which are common to or shared by any group, including rituals, performing arts, music, literature and the like"*.

Greater awareness of Thailand's cultural capital has led to its harnessing as a resource to develop the nation and strengthen its culture. It should be noted that such development needs to be planned and implemented in combination with and with respect to other forms of capital, against the backdrop of rapid changes in contemporary culture.

A study on textiles from the northeastern part of Thailand, or Isan textiles as an example of cultural capital, found that specialized weaving techniques are passed on from one generation to another among females and that these techniques express a clear identity of local beliefs, customs and rituals, expressed through pieces of art that come with a great deal of utility. In addition, it was found that the sharing of knowledge regarding textiles and weaving techniques has been widespread in the region. Textiles in the Isan region can be divided into three groups according to the locality of production: (1) Northern Isan, including Loei and Udon Thani provinces, which is home to a cotton textile industry; (2) Central Isan, including Nakhon Ratchasima and Khon Khaen provinces, which are the heart of the silk industry; and (3) Southern Isan, including Surin, Srisaket, and Buriram provinces, where the Khmer weft ikat industry is located. Data collected on-site regarding *"One Tambon, One Product" (OTOP)* community enterprises in the textile and clothing industry in Isan region revealed that upstream,

Figure 1 On-site visit at Ubon Ratchathani province for collection of data on textile development
Source: Utiswannakul (2013)

midstream, and downstream enterprises are active throughout the region, and that the challenge in developing textiles from existing cultural capital lies in a relatively limited market demand for the textiles, whose patterns and designs are often outdated. Isan textiles can benefit greatly by modernizing designs and the incorporation of local identity into products that better respond to market demand, particularly among the younger generation.

It is therefore important to identify new approaches to unlock the potential of Isan textiles as an example of cultural capital. The objectives of this study are to identify appropriate ways to incorporate cultural capital and local wisdom into Isan textile products, and to develop new Isan textile products with universal appeal for the fashion industry. These will pave the way to the wider application of cultural capital and local wisdom in the fashion industry that is giving increasing recognition to cultural capital. Increased market demand will lead to lower product prices, making these products more accessible to a wider market, while offering a basis for public agencies, educational organizations and communities to learn and make further use of knowledge to improve their livelihoods and sustain their communities.

A study of local cultural heritage towards international craftsmanship enterprise

This study was conducted in collaboration with the One Tambon, One Product Ubon Ratchathani Initiative, which typically produces Isan textiles and clothes. A qualitative study was combined with the creation of artworks as part of the research and development program to design and produce Isan fashion and textile products making use of cultural capital.

Primary data were collected during on-site visits to Ubon Ratchathani province through in-depth interviews with 15 experts and academics, including local experts in Isan textiles. The interviews aimed to learn about traditional patterns and weaving techniques and learn about challenges and market requirement. The interviews also sought the perspectives of local academics on how to sustain the development of knowledge for entrepreneurs in the region. During the visits, data were also collected regarding local context, culture and way of life, for use in identity analysis and in developing new textile patterns.

In addition, secondary data regarding local textiles, arts, culture and customs in the Isan region were collected from relevant literature, and at the same time, an analysis of current fashion trends was conducted to gain insight into future demand for the most iconic patterns, designs, shadows, colours, and decorating styles that would emerge in the Spring-Summer 2016 season. The findings of this analysis were then used as a basis for designing the new collection (Figure 1 and Figure 2).

Textile development in the Isan region

The data collected from the interviews with experts and academics indicated that the development of textile and culture wear involves three groups of people: upstream entrepreneurs (textile producers), midstream entrepreneurs (sewing businesses) and downstream entrepreneurs (distributors), with the upstream entrepreneurs or textile producers as the largest group. In the Isan region, textiles are produced manually within households and only rarely are new patterns are developed to meet today's market needs. Midstream entrepreneurs or sewing businesses lack the design knowledge needed to develop new

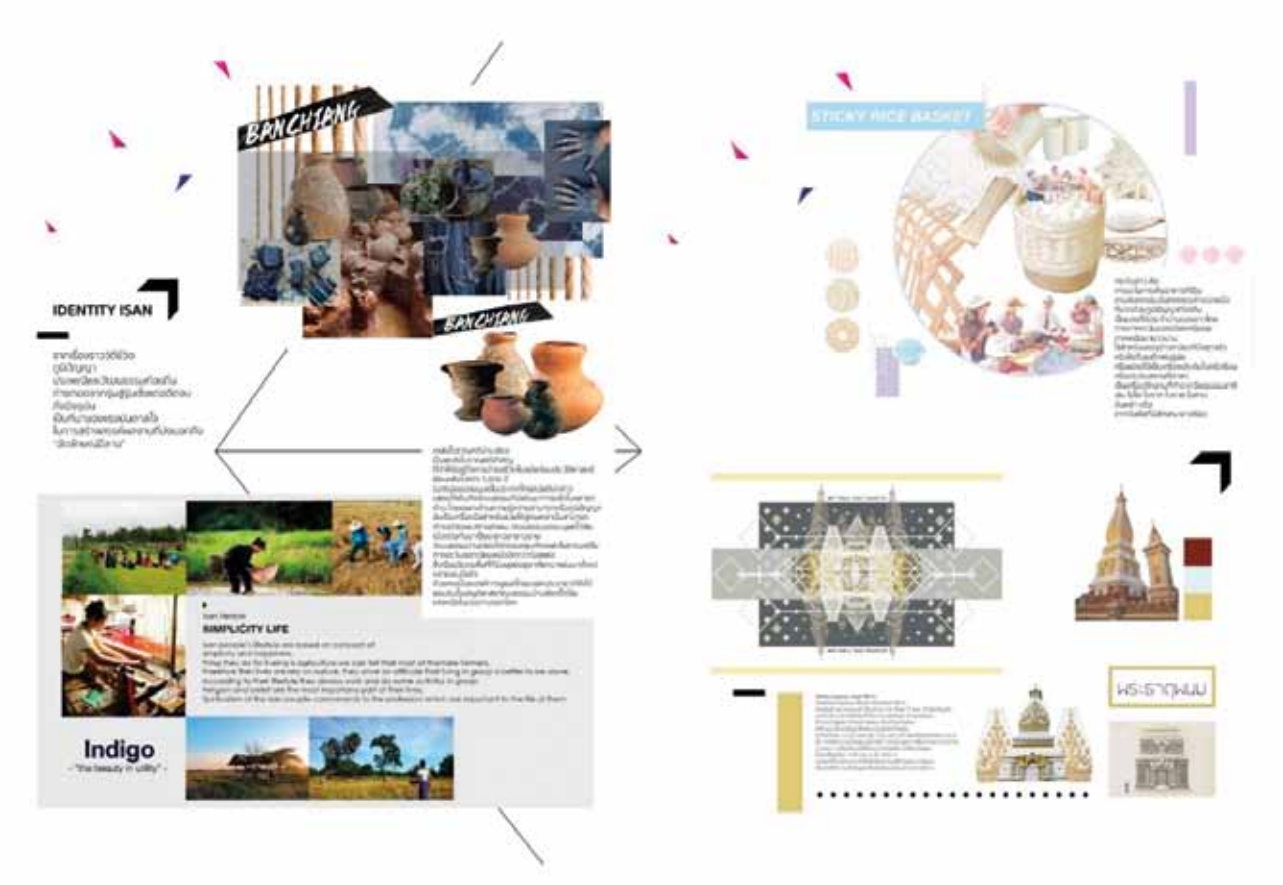


Figure 2 Examples of data and analyses of data collected from Isan region
Source: Utiswannakul (2013)

patterns, which hampers expansion of their pattern pools to meet the demand of the younger generation. Though downstream entrepreneurs have been consistently supported by government agencies, they nevertheless lack the branding knowledge that will allow them to compete in international markets.

The data collected on Isan textiles revealed that textiles represent a cultural heritage that has been passed on for many generations, and is highly diverse, considered as pieces of art that revolve around the local way of life. Isan textiles are worn both as daily wear and as religious clothing. Isan hand-woven textiles are passed on from generation to generation, expressing a clear identity of craftsmanship, beliefs, customs, and rituals of the northeastern people, and are a mixture of both artistic beauty and practical utility. Isan textiles can be categorized into three groups by their weaving technique (Figure 3) as follows.

- **Kaab Bua fabric** (Figure 3A) is mentioned in much of the local literature of the northeastern region. *"Kaab"* means the outer bark of a tree. Kaab Bua fabric can be made from silk or cotton with ends of at least two different colours and a *"Sin Tiew"* pattern that has been widespread in Ubon Ratchathani province until present times. Weft styles are mub mai, mudmee, and khid.
- **Mudmee fabric** (Figure 3B): The fabric's pattern is decided before wefts are dyed with the parts that are to remain undyed being wrapped prior to the weaving process. Mudmee fabric is commonly seen with a herringbone pattern; its signature trait is the weft dyeing before weaving.
- **Prae Wa** (Figure 3C) is a two-meter-long silk fabric made with any of the following techniques: continuous supplementary weft, discontinuous supplementary weft, or tapestry weaving. It is often worn as Sabai (breast cloth), headwear, or scarf, only on special occasions to express one's social status.
- **Twill fabric** (Figure 3D) represents a mixture of Thai traditional patterns, ancient Royal Thai patterns, and local weaving wisdom.

Figure 3A Kaab Bua Fabric
Source: The special commission to write an academic book to commemorate the Candle Festival, Ubon Ratchathani province (2000)

Figure 3B Mudmee Fabric
Source: Plookpedia (2017)

Figure 3C Prae Wa Fabric
Source: Hall of Fame (n.d.)

Figure 3D Twill Fabric
Source: Vipthaisilk (2017)

Figure 3E Indigo Dyed Fabric
Source: Still_khram (2017)

Figure 3 Examples of Isan textiles and fabrics

- **Indigo dyed fabric** (Figure 3E) is a silk or cotton fabric that draws its colour from indigo, a natural dye. The fabric is soaked in the dye for a period, then exposed to the air.

Developing and producing textiles and prototype collections

1) From new pattern creation to production of prototype collection

Based on primary and secondary data collected on arts and culture, customs, beliefs and ways of life of people in the northeast, textile design experts used feedback from focus groups as a basis for analysis, including line, colour, patterns and textures. Different combinations of these components were tested until conclusions could be reached. There are three 2-D patterns that most clearly reflect and resonate with Isan cultures (Figure 4):

1.1) *Khao Phun Gon* (One Thousand Pieces of Rice, Figure 4A) was inspired by the One Thousand Pieces of Rice Parade in the northeastern region, where 1,000 pats of cooked sticky rice were brought as offerings to the Triple Gem at the temple, as part of Boon Phawhet Festival, reflecting the community's ancient and strongly-held faith in Buddhism.

Figure 4A Textile Prototype (Khao Phun Gon Pattern)

Figure 4B Textile Prototype (Tri Nathee)

Figure 4C Textile Prototype (Mae Fon)

Figure 4 Fabric patterns developed from Isan cultural capital
Source: Utiswannakul (2015)

Figure 5 Prototype Collection
Source: Utiswannakul (2015)

1.2) *Tri Nathee* (Triple River, Figure 4B) was inspired by three arterial rivers in the northeastern region: the Mun, Chi and Mekong rivers. As well as serving as the economic lifeblood of Isan, these three rivers also give life to cultures, traditions, values, and beliefs throughout every corner of the region.

1.3) *Mae Fon* (Mother Rain, Figure 4C) was inspired by the way of life of the northeastern people that has always been closely related to water. Rain is considered not merely materially, as a source of water, but also a mother to local cultures, traditions and beliefs. The Rain Ritual offers an example. Weaving the Mae Fon pattern is therefore symbolic of a rain ritual that attempts to invoke seasonal rain.

2) Inspirations behind the collection

Economic, social, and technological changes have played a crucial role in changing ways of life and cultures around the globe, challenging the world to integrate their cultural values into the modern way of life, or lose them forever. The creation of the collection *'Modern Isan'* is inspired by the Post-Modern concept, that is, the craftsmanship, local wisdom and artistic values seen in Isan textiles and fabrics that tell of the local way of life, beliefs and rituals, as examples of cultural capital, are developed into modern fashion-conscious products through creative design and processes.

3) Consumers (Urban/Business Wear/Confident/ Modern/Up to date)

The target group comprised females aged 24-34 (Generation Y), living and working in the city, amidst rapid economic, social, cultural and technological change. They were self-confident, technology-literate, with their own styles and preferences for creative works and quality brands. The analysis concluded that the common characteristics of their fashion styles were as follows:

3.1) Silhouette

From an analysis on what shape the silhouette should be in considering fashion trends during the Spring-Summer 2015 season, it was found that there are three groups of silhouettes as follows.

(1) Casual wear: trendy silhouettes, A-line and biker jacket

(2) Business wear: trendy silhouette, silhouette from the 50's that illustrate their confidence, pencil skirt, oversized jacket

(3) Party wear: trendy silhouette, princess line, and mermaid

3.2) Colours and tones

Colours and tones used in the collection come in two major tones:

(1) Colours representing the Isan identity, based on an analysis of Isan identity in terms of arts and cultures, customs, ways of life, beliefs and geography, predominantly earth tones and tribal colours.

(2) Colours that were in trend during the Spring-Summer 2015 season include pastel colours and basic colours such as navy blue and black.

3.3) Decorations and materials

Local fabrics such as Mudmee silk and twill fabric that represent Isan cultural capital are used together with trending fabrics such as lace, to create a balance between local culture and modern utility.

Figure 6 Fashion set
Source: Utiswannakul (2015)

4) Developing and producing prototype fabrics

First, the most suitable weaving technique was selected from those available. Second, the material was prepared: the silk was dyed as planned. Third, the loom was prepared, as well as ends and picks. The pattern was analyzed and the weaving process was planned, given the chosen technique, and then tested. If the resulting pattern came out as planned, then the product would be worked on until finish.

5) Testing and developing prototype collection

A study was conducted to analyze fashion trends and inspirations from cultural capital in modern-day fashion, with the aim of designing cultural textile products that blend with modern lifestyles and meet market needs, the prototype was sketched and produced using raw fabrics to establish the best composition before the design and textile selection were finalized and the actual prototype products were made.

Marketing and measurement

Following creation of the prototype collection using the fashion manufacturing process, it was publicized through marketing using modern techniques such as photoshoots, fashion sets and exhibitions to assess the level of customer satisfaction (Figure 6 and Figure 7).

1) An exhibition *"Modern I-san"* under the cluster OTOP and category *"Northeastern Textiles and Clothing"* at the Contemporary Art Gallery, Ratchadamnoen Avenue, Bangkok, 12-15 February 2015.

2) Fashion set featured in Dichan Magazine (Year 38 Issue 915: April, 2015) to introduce to the public the collection developed from fashion thinking processes and local cultural capita.

Conclusion

This research ***"Local Cultural Heritage Towards International Craftsmanship Enterprise"*** was conducted under the concept of the creative economy that leverages creation of economic added value to local products, and helps communities to sustain themselves by developing unique cultural products to meet modern market trends. The findings indicate that in developing products using cultural capital, two key aspects need to be considered together:

1) A clear identity and specific and understanding of cultural capital should be found, with an aim of preserving the body of knowledge and local wisdom on which it is based;

2) This identity should be used to help entrepreneurs in developing new products for domestic and international markets, taking into account the latest modern fashion trends among key demographics and modern lifestyles.

Figure 7 An exhibition at Contemporary Art Gallery, Ratchadamnoen Avenue
Source: Utiswannakul (2015)

Figure 8 Dissemination of knowledge to upstream, midstream, and downstream entrepreneurs in Ubon Ratchathani province
Source: Utiswannakul (2015)

The findings of this study have been shared with the communities involved. The knowledge that was developed and shared with the enterprise cluster includes methods for identification of cultural identity, branding techniques and fashion trends to enable communities to work together to design with fashion trends in mind, and to help them work systematically as a team. To be specific, this research will help upstream entrepreneurs (textile and fabric producers) to improve their patterns, weaves, and colours, help midstream entrepreneurs (sewing businesses) to develop new patterns and silhouettes and help downstream entrepreneurs (distributors) to enhance product presentation. These processes exemplify the development of cultural capital using an industry mindset that values cultural assets and how to produce products at lower cost that are accessible to a larger market. This approach will ultimately enhance livelihoods that help sustain communities (Figure 8).

Moreover, this study has demonstrated the viability of a method to integrate bodies of knowledge from different domains to preserve cultural capital and local wisdom and to bridge such local cultural capital with the creative economy to secure the longer-term sustainability of local culture, economy, and the community itself.

Acknowledgement

This article is part of the research project entitled ***"Cultural Heritage towards International Craftsmanship Enterprise"*** funded by the OTOP cluster and development program in the northeastern textile and clothing category, Department of Industrial Promotion, Ministry of Industry, and the Fashion and Creative Arts Research Unit, Faculty of Fine and Applied Arts, Chulalongkorn University.

References

Hall of Fame. n. d. **Khamsorn Srathong, the national artist, 2010**[Online]. Available from: http://www.sacicthalloffame.com/th/person/detail/21/คำสอน-สระทอง[March 20, 2018].

Klankamsorn, S. 2016. **Cultural Industry**[Online]. Available from: http://lib.dtc.ac.th/article/others/0008.pdf[March 10, 2018].

Pinkaew, K. 2011. Creative economy, cultural capital and business opportunity. **Journal of Executives** 31 (1): 32-37.

Plookpedia. 2017. **Thai Textiles**[Online]. Available from: www.trueplookpanya.com/knowledge/content/58308/-artfin-art [March 20, 2018].

Special commission to write an academic book to commemorate the Candle Festival, Ubon Ratchathani province. 2000. **Beautiful Lotus, Ubon City, and Candle Festival**. Ubonratchathani: Document Production and Service Center, Office of the Academic Resources, Ubonratchathani University.

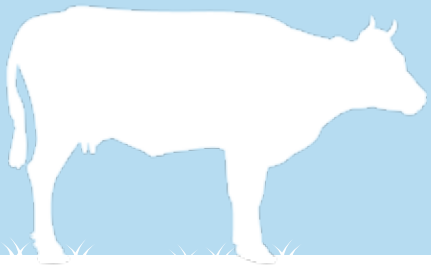
Still_khram. 2017. **Indigo dyed**[Online]. Available from: https://gramrix.com/tag/ผ้าฝ้ายย้อมครามเข็ญมือ[March 20, 2018].

Throsby, C. D. 2001. **Economics and culture.** Cambridge: Cambridge University.

Utiswannakul, P. 2015. **Report of the OTOP cluster and development program in northeastern textile and clothing category**. Department of Industrial Promotion, Ministry of Industry.

Vipthaisilk. 2017. **Lamphun's twill fabric**[Online]. Available from: https://gramrix.com/tag/ผ้าหรู[March 20, 2018].

Precision Dairy Farming



Assist. Prof. Chaidate Inchaisri, DVM., Ph.D.
Piyanat Prasomsri
Epidemiology and Animal Health Economics Group,
Department of Veterinary Medicine,
Faculty of Veterinary Science, Chulalongkorn University

Introduction

In 2025, dairy products will become tax liberalised, that is tax free for both imported and exported products, leading to both potential advantages and disadvantages to Thailand. For the advantage, Thailand would potentially have a chance to export dairy products to larger markets, while the disadvantage is that the Thai dairy products industry cannot currently compete with the others in the global markets, and so many dairy farmers would likely have to give up their dairy farm career because their current production efficiency is quite low in terms of both product quality and quantity. There is a shortage of labours, which is compounded by the previous practice of using cheap unskilled foreign workers who are moving back to their home countries, a lack of young generation farmers to continue the family's farm and to whom labour work is not attractive, and also Thailand is becoming an aging society.

However, Thailand is located in the centre of Southeast Asia and currently exports dairy products to neighbouring countires to a value of more than 10 billion Thai baht per year (300 million $USD) (0.08 % of the GDP), so there might be an opportunity to increase the level of exported dairy products to the neighbouring countires, including both larger markets, like China, and other countries that have the potential to buy dairy products from Thailand, such as Singapore, Brunei, Malaysia and Hong Kong. Because the Thai dairy farms' situation is under threat, both to the dairy industry and dairy farm careers, then the Thai dairy industry must improve its ways to farm and manage dairy farms so as to increase both the quality and quantity of its products, and this needs to be done soon in order to be able take advantage of the opportunity of the impending tax liberisation.

Since the beginning of this decade, from 2011, the dairy industry in many developed countries, including western Europe and North America, have started to change their practices to use precision technology in the management of dairy pastures. These include monitoring and evaluating the growth of pasture and to control the watering and fertiliser addition to the pasture. Smart farming technology has also been applied to manage dairy farming indoors, such as the control of feeding, dung management and temperature control in animal housing. Moreover, using precision technology to manage cows individually, such as equipment to monitor the cow's health, digital technology

equipment to manage their reproductive performance and monitor the milk quality on each milking (Figure 1) is being implemented.

Dairy farm management has changed very quickly during the last three years, especially with the application of precision techniques to manage cows individually. Many types of digital equipment are sold on the market (Figures 2 and 3) for precision techniques on dairy farms and cow management to increase the production quality and efficiency which allow the ability to house more cows for milking per farm. Farmers will then have more time and a happier and more productive working environment. However, some of the currently available digital equipment is not suitable for current Thai dairy farms because of its high investement cost and that Thai farmers are not ready for the new technology for managing their dairy farms. That is they lack the required skills and knowledge to use these systems to manage their farms, such as how to apply the data collected from digital equipments to farm management to optimize the dairy production quality and quantity.

Precision technology for cow management

Thai dairy farm management, especially for larger farms, involves a large number of cows for milking and correspondingly uses a large labourforce, but these labourers are unskilled and lack management experience and relevant skills. This, especially in small to medium dairy farms, leads to a low quality of raw milk. In contrast, to become competitive, large farms need new technology to increase their production efficiency, including raw milk quality, and need to change from the use of many low-skilled labourers to high quality, experienced and skilled labourers.

Dairy farm management technology has developed from the herd to the individual cow ("tailor made") level, which allows each cow to reach its highest potential milk production and also

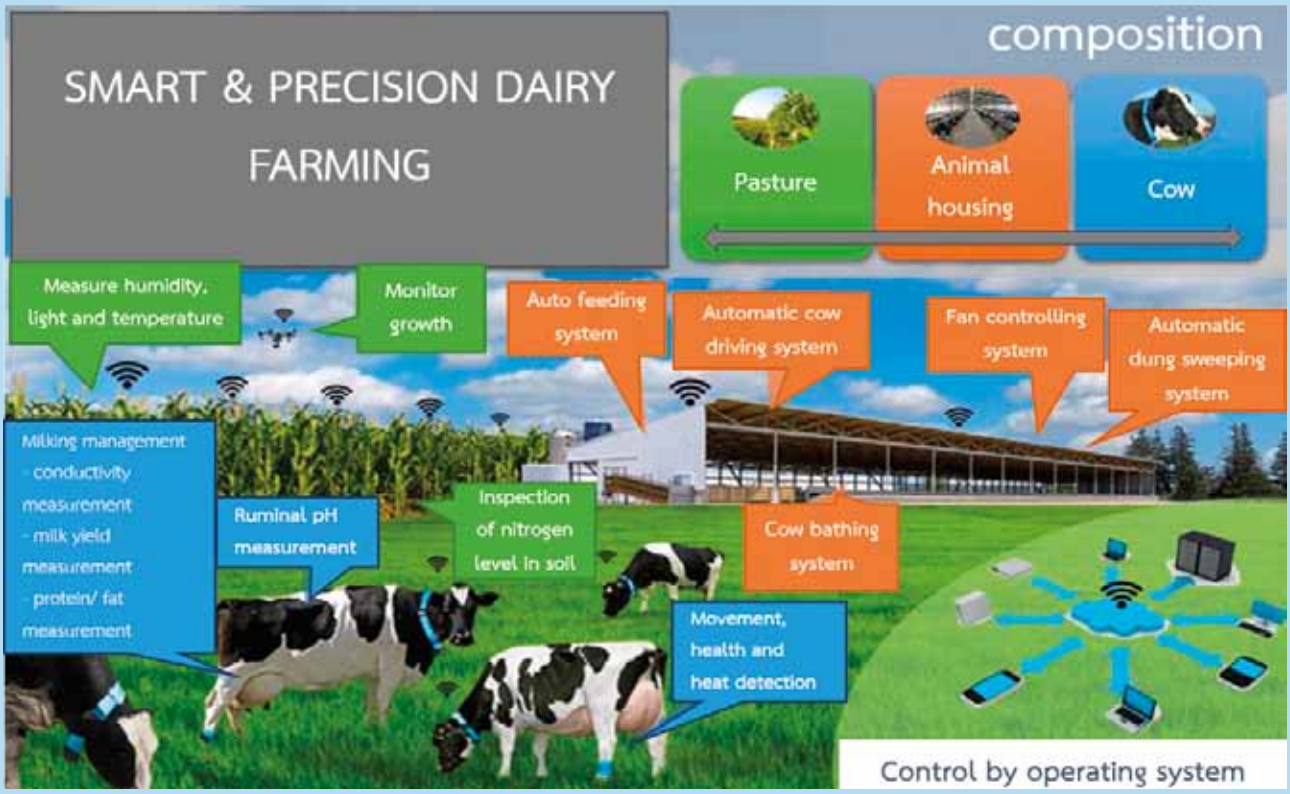


Figure 1 Principal composition and precision dairy farm management system
Soure: Kamta, designed in September 2017

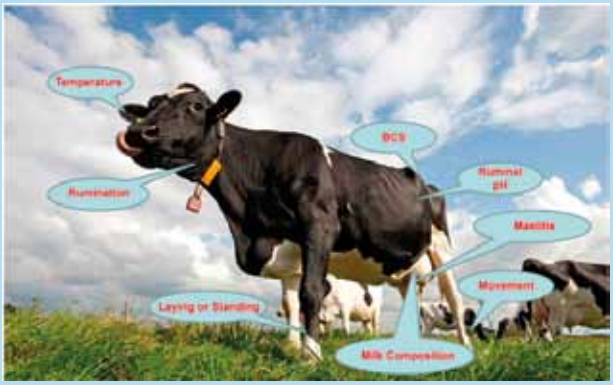


Figure 2 Precision technology for detecting the health, milk composition and other physiological aspects of the cows.
Soure: Inchaisri, designed in September 2017

Figure 3 Examples of digital equipment for cow management on sale in the market
Soure: Hogeveen, designed in July 2017

to monitor the loss that occurs during the production process for each individual cow. The main problems in dairy farming are the reproductive system (timing of estrus), mastitis and lameness. Using modern managing technology, such as pedometer and temperature probes, the detection of estrus and health monitoring, including for diseases and lameness, can be detected and treated before they develop into a severe injury or disease state. Using the electrical conductivity of milk to detect subclinical mastitis and monitoring the temperature of each individual cow to check its health, allows the detection of a sick cow at the early (often asymptomatic) stages and so allows prompt treatment before it becomes a serious illness and the cow has a decreased milk yield or milk quality.

The pedometer is developed from the two principles of (1) a movement sensor, which works by a small hammer that completes an electric conduction every time the pedometer vibrated vertically and is then registered by the internal electronic circuit and (2) a stationary sensor or accelerometer, which is a small horizontal tube with a pendulum at one end. When the pendulum is accelerated by a change in movement it creates pressure on the other end that is registered as an electric signal (high or low wave depending on the pressure received), which is then registered by the electronic circuit inside that processes and analyses whether each wave was similar to the refrence wave or not. If the wave was different then the pedometer does not count the step, but if it was similar then the step count is increased by one.

The pedometer is often used for detecting the onset of the estrus phase (on heat) and gives a better result than traditional methods using human observation because the pedometer will show the actual steps of an individual cow throughout each and every day. From studies of cow's behaviour, it is known that when cows enter the estrus phase (on heat) they take more steps than cows not in estrus, and so this method can more accurately detect the onset of estrus. Indeed, it has been reported to have an 80-85% rate of accuracy (Hockey et al., 2010, Kamphuis et al., 2012) compared to only 55% by human labour (Steeneveld and Hogeveen, 2014). An example of estrus phase detection from a digital equipment is shown in Figure 4.

However, the pedometer is normally used together with rumination monitoring equipment for greater accuracy, since as a cow enters estrus the rate of rumination is decreased whilst the rate of movement is increased. In addition, the data from the pedometer can be used to detect lameness,

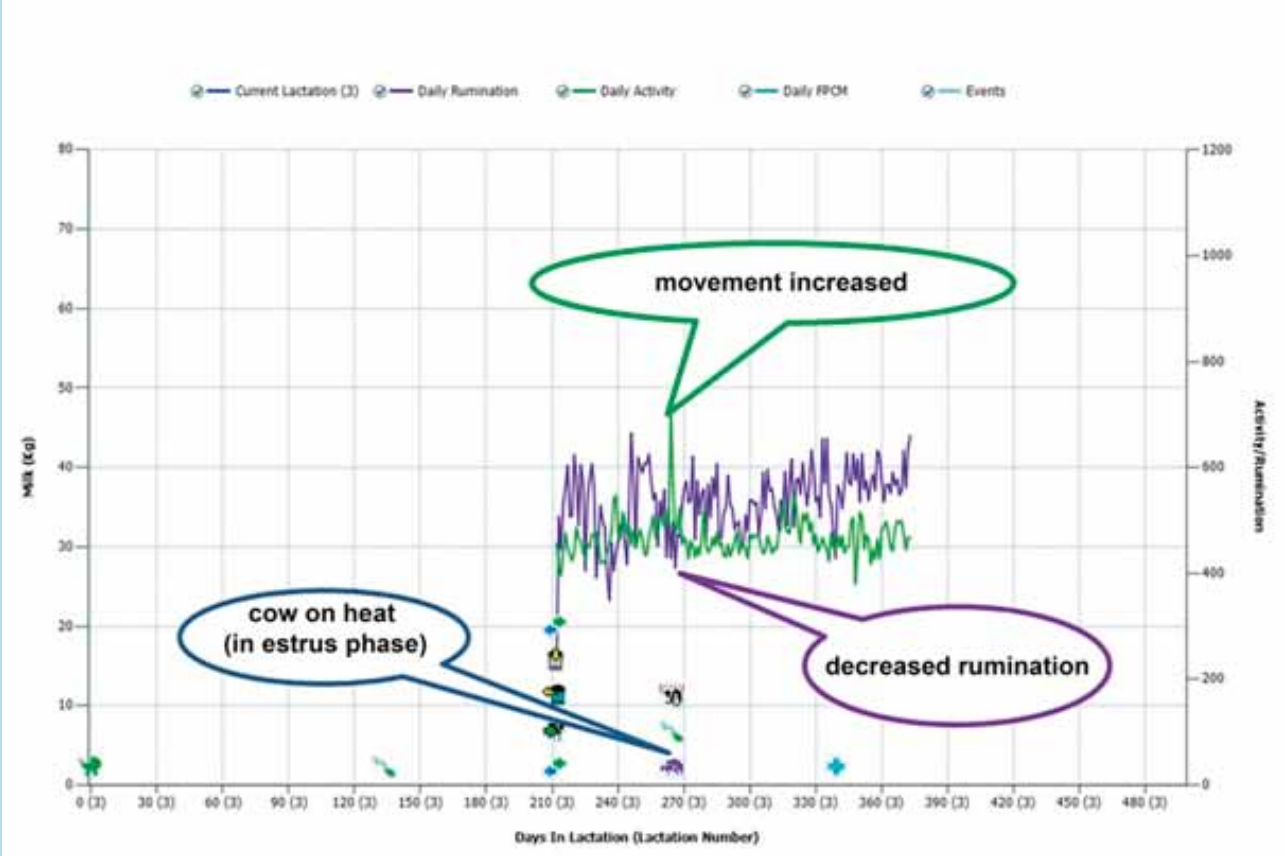


Figure 4 Data from monitoring the increased rate of movement and decreased rate of rumination from an individual cow to determine the onset of estrus.
Soure: Inchaisri, designed in April 2018

allowing the lameness to be diagnosed in the early stages (Alsaaod et al., 2015), which can decrease the loss of milk yields and improve the welfare of the cow, including a better response to the treatment and decreased severity or frequency of chronic diseases (Alsaaod et al., 2015). Edwards and Tozer (2004) reported that the walking and movement data collected from a pedometer showed a lameness signal some 7-10 days before it became symptomatic, while Thorup et al. (2015) found that a pedometer could detect lameness in a cow with only minor symptoms and a locomotion score at level 2 from a 5 score system.

Electrical conductivity of an aqueous solution measures the ability of that solution to transfer electricity by inorganic compositions dissolved in the water, such as Cl^-, NO_3^-, SO_4^{2-}, PO_4^{3-}, Na^+, Mg^{2+}, Fe^{2+}/Fe^{3+} and Al^{3+} ions. Millisiemens (mS) is the standard unit of electrical conductivity and is measured by applying a voltage across two electrodes in the probe that is dipped into the liquid. The measured current is used to calculate the electrical conductivity per centimetre (μmhos/cm).

The relevance here is that in both clinical and subclinical mastitis the milk composition is changed, including the levels of Na^+ and Cl^- that are increased dramtically (Kitchen, 1981), and this can be detected during milking. For example, milk from subclinical mastitis cow had a 184% increased Na^+ level (and so increased electrical conductivity) compared with milk from healthy cows and this increased electrical conductivity can be detected before detection of any other abnormality in the milk. Thus, each individual cow can be monitored each milking as a health check, whilst low quality milk can be detected prior to pooling (Norberg et al., 2004).

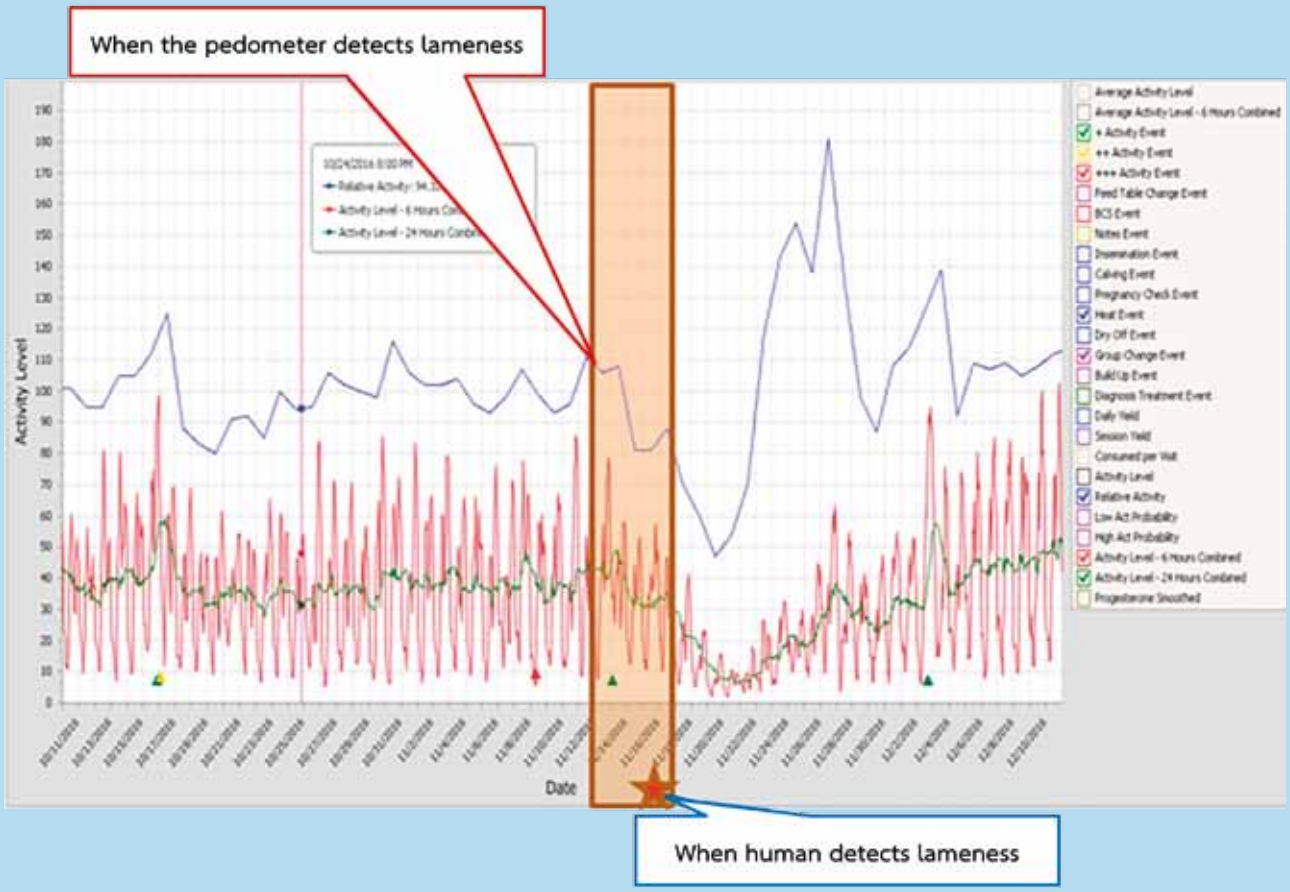


Figure 5 Data report showing lameness detection from monitoring the locomotion of an individual cow, where the amount of movement is decreased 5 days before the cow was symptomatic.
Soure: Inchaisri, designed in April 2018

For example, changes in the electrical conductivity of milk could detect mastitis with a sensibility and specificity, respectively, of 86.9% and 91.4% (Samarasinghe and Jago, 2010), 92.9% and 93.9% (Cavero et al., 2006), and 80% and 99.2% (Kamphuis et al., 2008). In conclusion, the early (asymptomatic) detection of mastitis prior to a decrease in acceptable milk quality can be detected by monitoring the electrical conductivity of the milk, which would also aid in the provision of a fast effective treatment.

Moreover, the detection of the milk quality, such as the proportions of fat, protein, lactose and somatic cells, can be monitored by near-infrared spectroscopy (NIRS). This measures the light quantity at a wavelength of 800-2500 nm, and is installed at the milking system so, as with the electrical conductivity, it can detect the milk quality fast and accurately. Previous studies have established that the milk composition derived from NIRS analysis is more or less similar to those obtained by the standard method (Tsenkova et al., 2006; Kawamura et al., 2007), but it is quicker and performed in the milking parlour. Accordingly, NIRS assessment of milk should increase the efficiency of milk production and quality by isolating undesirable milk before pooling. The in situ NIRS analysis of milk is applied alongside the monitoring of the electrical conductivity to more accurately and sooner detect subclinical mastitis in cows (Maltz, 2010), as well as detect metabolic disturbance online every milking time (Heuer, Schukken and Dobbelaar, 1999).

Body temperature is also a good index of health in animals, and can predict physiological and health problems as well as the precise prediction of the time for a mother cow to give birth (Piccione, Caola and Refinetti, 2003). Impema et al. (2008) found that the body temperature gradually decreases from 20 hour before giving birth until delivery time. In addition, the cow's body temperature is increased 1.3 °C at estrus (Piccione, Caola and Refinetti, 2003), while the rumen's temperature is significantly decreased before birth and rises duing estrus (Cooper-Prodo et al., 2011).

Moreover, body temperature can be used an index for body abnormalities, such as a cow with milk fever, which would have a low body temperature and blood calcium levels, or hypovolemic shock from water and dietary mineral loss, or septic shock. Whereas a high body temperature cow may well indicate the onset of infections, such as blood parasites, pneumonia or non-infectious disease, such as heat stroke (Drivers and Peek, 2008).

A high body temperature in cows can be either continuous or intermittent depending on the disease (Drivers and Peek, 2008). Therefore, it is essential to monitor the body temperature continuously so the disease can be diagnosed and the cow will receive appropriate treatment as soon as possible so as to reduce milk production loss and improve the animal's welfare. Wireless equipment has been used to monitor the body temperature continuously, which is not possible otherwise. For example, Beatty et al. (2008) measured the rumen and core temperature continuously for 25 days and found that the body temperature changes showed the same pattern as that of the rumen during the study time. Rose-Dye et al. (2011) studied the changes in the rumen's temperature (recorded directly inside the rumen by sensor) and found that the rumen's average temperature was related to but 0.13 °C lower than the anus's temperature (r = 0.89). Moreover, cows challenged with bovine respiratory disease and bovine viral diarrhea had a continuously significantly higher temperature than healthy cows, allowing this data to be used for early diagnosis. This study is supported by that of Small, Kennedy and Kahane (2008), who used a sensor to measure the temperature of the rumen and could diagnose the effects of lipopolysaccharide endotoxin from the increased rumen's temperature.

Summary

Due to the fast development of computers and IT in Thailand, the application of digital technology equipment in dairy farms would generate many databases that, along with smart farm management, would lead to the installation of automatic programmes to control the farm, recording data from an individual cow, each dairy farm, raw materials and milk production from farms. These data would support decisions on how to optimally manage dairy farms efficiently, including for further research and study. Therefore, researchers and Thai dairy farmers need to study and understand current and emerging digital technologies for application in dairy farms, to develop and expand the current dairy farm industry and effectively use farm resources to the highest benefit. These changes will aid Thai dairy farmers to produce high quality raw milk competitively for export and so compete with global markets in the future.

Acknowledgements

This article is part of the research project entitled ***"Developed a centralized management system prototype for multi dairy farm units with high technology"***, funded by Office of the Higher Education Commission and National Science Technology and Innovation Policy Office and Green Dairy Farm Co., Ltd.

References

Alsaaod, M., Niederhauser, J. J., Beer, G., Zehner, N., Schuepbach-Regula, G., and Steiner, A. 2015. Development and validation of a novel pedometer algorithm to quantify extended characteristics of the locomotor behavior of dairy cows**. Journal of Dairy Science** 98: 6236–6242.

Beatty, D. T., Barnes, A., Taylor, E., and Maloney, S. K. 2008. Do changes in feed intake or ambient temperature cause changes in cattle rumen temperature relative to core temperature? **Journal of Thermal Biology** 33: 12–19.

Cavero, D., Töllea, K. H., Buxadéb, C., and Kriete, J. 2006. Mastitis detection in dairy cows by application of fuzzy logic. **Livestock Science** 105: 207–213.

Cooper-Prado, M. J., Long, N. M., Wright, E. C., Richards, C. J., and Wettermann, P. 2011. Relationship of ruminal temperature with parturition and estrus of beef cows. **Journal of Animal Science** 89 (4): 1020-1027.

Drivers, T. J., and Peek, S. F. 2008. **The clinical examination. In Rebhun's diseases of dairy cattle**, pp. 3-15. 2nd edition. Missouri, USA: Saunders Elsevier.

Edwards, J. L., and Tozer, P. R. 2004. Using Activity and Milk Yield as Predictors of Fresh Cow Disorders. **Journal of Dairy Science** 87: 524–531.

Heuer, C., Schukken, H., and Dobbelaar, P. 1999. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. **Journal of Dairy Science** 82: 295-304.

Hockey, C. D., Morton, J. M., Norman, S. T., and McGowan, M. R. 2010. Evaluation of a neck mounted 2-hourly activity meter system for detecting cows about to ovulate in two paddock-based Australian dairy herds. **Reproduction in Domestic Animal** 45: e107-e117.

Ipema, A. H., Goense, D., Hogewerf, P. H., Houwers, H. W. J., and van Roest, H. 2008. Pilot study to monitor body temperature of dairy cows with a rumen bolus. **Computers and Electronics in Agriculture** 64: 49–52.

Kamphuis, C., Pietersma, D., van der Tol, R., Wiedemann, M., and Hogeveen, H. 2008. Using sensor data patterns from an automatic milking system to develop predictive variables for classifying clinical mastitis and abnormal milk. **Computers and Electronics in Agriculture** 62: 169-181.

Kamphuis, C., DelaRue, B., Burke, C. R., and Jago, J. 2012. Field evaluation of 2 collar-mounted activity meters for detecting cows in estrus on a large pasture-grazed dairy farm. **Journal of Dairy Science** 95: 3045-3056.

Kawamura, S., Kawasaki, M., Nakatsuji, H., and Natsuga, M. 2007. Near-infrared spectroscopic sensing system for online monitoring of milk quality during milking. **Sensing and Instrumentation for Food Quality and Safety** 1: 37–43.

Kitchen, B. J. 1981. Bovine mastitis: Milk compositional changes and related diagnostic tests. **Journal of Dairy Research** 48: 167-188.

Maltz, E. 2010. Novel Technologies: Sensors, Data and Precision Dairy Farming, pp. 1-15. **The First North American Conference on Precision Dairy Management, 2010**.

Norberg, E., Hogeveen, H., Korsgaard, I. R., Friggens, N. C., and Lovendahl, P. 2004. Electrical conductivity of milk-ability to predict mastitis status. **Journal of Dairy Science** 87: 1099-1107.

Piccione, G., Caola, G., and Refinetti, R. 2003. Daily and estrous rhythmicity of body temperature in domestic cattle. **BMC Physiology** 3 (7): 1-8.

Rose-Dye, T. K., Burciaga-Robles, L. O., Krehbiel, C. R., Step, D. L., Fulton, R. W., Confer, A. W., and Richards C. J. 2011. Rumen temperature change monitored with remote rumen temperature boluses after challenges with bovine viral diarrhea virus and Mannheimia haemolytica. **Journal of Animal Science** 89: 1193-1200.

Small, J. A., Kennedy, A. D., and Kahane, S. H. 2008. Core body temperature monitoring with passive transponder boluses in beef heifers. **Canadian Journal of Animal Science** 88: 225–235.

Steeneveld, W., and Hogeveen, H. 2014. Characterization of Dutch dairy farms using sensor systems for cow management. **Journal of Dairy Science** 98: 709–717.

Tsenkova, R., Atanassova, S., Morita, H., Ikuta, K., Toyoda, K., Iordanovad, I. K., and Hakogic, E. 2006. Near infrared spectra of cows' milk for milk quality evaluation: disease diagnosis and pathogen identification. **Journal of Near Infrared Spectroscopy** 14: 363–370.

Thorup, V. M., Munksgaard, L., Robert, P. E., Erhard, H. W., Thomsen, P. T., and Friggens, N. C. 2015. Lameness detection via leg-mounted accelerometers on dairy cows on four commercial farms. **Animal** 9: 1704–1712.

Article

Biotechnology for Production of Value-added Compounds from Plant Biomass Found in Thailand

Wichanee Bankeeree, Ph.D.[1], Assist. Prof. Pongtharin Lotrakul, Ph.D.[1], Prof. Hunsa Punnapayak, Ph.D.[1,2], Assoc. Prof. Sehanat Prasongsuk, Ph.D.[1]
[1]Plant Biomass Utilization Research, Department of Botany, Faculty of Science, Chulalongkorn University
[2]Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia

Introduction

Advancement in our knowledge of technologies for utilization of plant biomass forms an important contribution to Thailand's development. As an agriculture-dominated economy, large amounts of plant waste are generated in agro-industrial processing and must then be disposed of after processing. Burning has always been the main means to either eliminate waste or recycle the energy. However, open field burning pollutes the environment and valuable complex compounds are not utilized to their full potential. Plant biomass contains a wide range of complex biopolymers with economic value for production of a wide variety of value-added products as well as for renewable energy. Therefore, it is important to conduct research on plant biomass utilization in order to unlock this potential to make use of different categories of plant biomass in new and innovative industrial processes, while minimizing impact on the environment.

Production of bioenergy and value-added compounds from the major components of plant biomass such as cellulose and hemicellulose require more complicated technology and processes compared to those when starch is used as a raw material. Consequently, continuous improvement in production technology, especially biotechnology with low environmental impact, is needed. In general, the basic process for the utilization of plant biomass consists of a minimum of three major steps: pretreatment, saccharification and bioconversion, as shown in Figure 1. The importance of each step is described as follows:

Pretreatment of plant biomass

Pretreatment is the process of extracting the components of plant biomass by degradation of the structure of lignin so that the cellulose and hemicellulose fibers are unbound. It also increases porosity and lowers cellulose crystallinity so that it is easier for chemicals or enzymes to degrade cellulose or hemicellulose to access their substrates. Pretreatment can be divided into 4 main types: physical, chemical, chemical-physical and biological methods. Combinations of more than one method are also applicable with plant biomass with high lignin content. Each method has its advantages and disadvantages. For example, pretreatment using concentrated acid at low temperature and pressure potentially produces more sugars than those using dilute acid or alkali. Moreover, the acid used in this process can be reused after repeated evaporation. However, concentrated acid pretreatment has disadvantages due to its toxicity to the system and the formation of compounds that may inhibit microbial growth during the fermentation process (Singh et al., 2015).

Biological pretreatment of plant biomass is based on microorganism activity, especially white rot fungi that can produce enzymes such as lignin peroxidase, manganese peroxidase, laccase, and polyphenol oxidase to oxidize

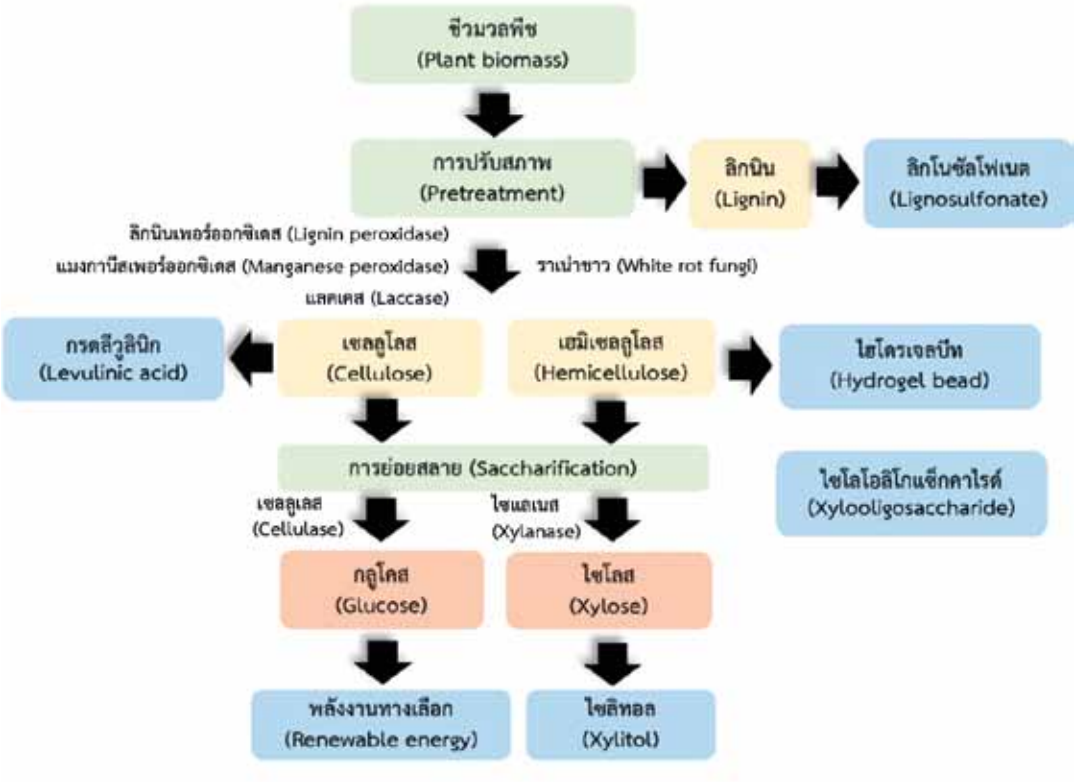


Figure 1 Flow chart of biotechnological production of value-added compounds from plant biomass
Source: Bankeeree, Lotrakul, Punnapayak, and Prasongsuk, designed on May 24, 2018

lignin. This method has advantages as it requires low energy consumption and is processed under mild conditions, i.e. at room temperature and neutral pH. Therefore, it has little impact on the environment and does not create toxins in the system. Researchers at the Plant Biomass Utilization Research Unit at Chulalongkorn University have successfully isolated white rot fungi that efficiently degraded lignin from several natural habitats in Thailand. There were 13 isolates that could produce various enzymes (Table 1). *Phanerochaete sordida* PBU 0057, isolated from Nakhon Ratchasima, produced the highest lignin peroxidase activity, while *Perenniporia tephropora* PBU 0053, PBU 0054 and *Perenniporia* sp. PBU 0055 produced high laccase activity (Permpornsakul et al., 2016). *P. sordida* PBU 0057 was then selected for pretreatment of eucalyptus wood chip at room temperature (25±3 degrees Celsius). After 10 days, the amount of lignin in the pretreated wood was reduced by 75%, with the remaining lignin content at 6.68±0.12 % compared to the untreated control at 26.93±1.01% (Sripat, 2013).

Enzymes for saccharification of plant biomass

Individual components in plant biomass released through pretreatment are mainly cellulose, linear glucose polymers, and hemicellulose, a branched polymer of many pentose sugars such as xylose and arabinose. When these polymers are saccharified, they release monosaccharides that can be used as substrates in several fermentation pathways. Saccharification of cellulose and hemicellulose can be achieved by both chemical and enzymatic methods. Enzymatic saccharification has many advantages over the chemical method, including high reaction specificity that prevents toxic compound formation. However, it is limited in industrial application due to high cost and low enzyme stability. In order to reduce the cost of imported enzymes, isolation of efficient microorganisms for domestic enzyme production is important.

Cellulases, the cellulose degrading enzymes, comprise 3 main enzymes that work together. Endoglucanase (endo-1,4-β-D-glucanase) breaks the glycosidic bonds at the beta-1,4 position within the cellulose chain at the non-crystalline areas. It cuts the bonds randomly, thus releasing many products. Exoglucanase (exo-1,4-β-D-glucanase) breaks the beta-1,4-glycosidic bonds from the non-reducing ends, yielding cellulobiose sugar that are degraded by the enzyme betaglucosidase (1,4-β-D-glucosidase) yielding glucose as the final product. Cellulase enzymes, in addition to the saccharification

Table 1 Production of lignin-degrading enzymes by white rot fungi isolated from natural habitats in Thailand.

Isolate of white rod fungi	Source (province)	Efficiency in enzyme production		
		Lignin peroxidase	Manganese peroxidase	Laccase
Bjerkandera adusta PBU 0047	Nan	+	++	+
Ceriporia cystidiata PBU 0048	Roi Ed	-	+	++
Irpex lacteus PBU 0049	Kanchanaburi	++	++	+
Junghuhnia crustacea PBU 0050	Kanchanaburi	++	+	++
Macrohyporia dictyopora PBU 0051	Kanchanaburi	++	+	+
Macrohyporia sp. PBU 0052	Kanchanaburi	-	+	++
Perenniporia tephropora PBU 0053	Nakorn Ratchasima	-	++	+++
Perenniporia tephropora PBU 0054	Nakorn Ratchasima	-	++	+++
Perenniporia sp. PBU 0055	Chon Buri	-	+	+++
Phanerochaete sordida PBU 0057	Nakorn Ratchasima	+++	-	++
Phanerochaete sp. PBU 0056	Bangkok	++	+	+
Phanerochaete sp. PBU 0058	Chon Buri	++	+	-
Phanerochaete sp. PBU 0059	Kanchanaburi	++	-	+

Remark: - = no activity of the enzymes.
+ = ratio between the activity zone of the enzyme and colony growth is less than 1.5
++ = ratio between the activity zone of the enzyme and colony growth equal to 1.5-2
+++ = ratio between the activity zone of the enzyme and the colony growth > 2
Source: Permpornsakul et al. (2016)

of plant biomass, are also important enzymes in many industrial processes such as alcohol, single cell protein and organic acid production, animal feed, recycled paper production and textile fiber cleaning and modification to soften the cotton fibers and reduce the amount of strong acid and alkaline required.

The hemicellulose saccharification process is based on the xylanase enzymes such as endoxylanase that randomly breaks down the β-xylosidic bonds in the main chains and β-xylosidase that hydrolyzes the short chain xylooligosaccharides from the non- reducing ends and releases xylose as the major product. The β-xylosidase expresses very low catalytic activity on long chain xylans, and the activity of the enzyme decreases as chain length increases.

Cellulase and hemicellulase can be produced both from fungi and bacteria, which differ in their action, products and efficiencies. For example, the purified endoglucanase from the bacterium *Lysobacter enzymogenes* isolated in Thailand is a bifunctional enzyme, capable of degrading both cellulose and chitosan (Saraihom et al., 2016). However, most bacterial enzymes are intracellular or bind to the cell wall, while fungal enzymes are extracellular. Therefore, harvesting fungal enzymes is relatively easier. Each fungal enzyme has different properties depending on the isolate produced. For example, the properties of the β-xylosidase enzyme (Table 2) that, in general, the commercial enzymes catalyze well at temperatures between 40 and 60 degree Celsius, while some fungal enzymes catalyze better at high temperature, which makes them suitable for plant biomass saccharification. This is because the heat renders the plant fibers soft and swollen, allowing the enzymes to penetrate further, resulting in more complete hydrolysis. Moreover, plant biomass that has been subjected to industrial chemical pretreatment has a temperature above 60 degree Celsius (Datta et al., 2010). The use of such

Table 2 Characteristics of β-xylosidese enzymes produced from each fungal isolate

Fungal isolate	The molecular mass of the enzyme (kDa)	Optimal conditions		Specific activity (U.mg-1)
		pH	Temperature (°C)	
Aureobasidium pullulans CBS 135684	145.0	6.0	70	163.3
Aureobasidium pullulans ATCC 20524	88.5	3.5	70	288.0
Aspergillus japonicas	120.0	4.0	70	42.6
Aspergillus niger GS1	111.0	5.0	60	386.7
Aspergillus oryzaea	84.7	4.5	55	150.0
Fusarium proliferatum	91.2	4.5	60	53.0
Humicola grisea var. *thermoidea*	87.0	6.5	55	19.6
Penicillium sclerotiorum	144.0	2.5	60	31.1
Trichoderma reesei	80.0	3.5	60	16.0
Talaromyces amestolkiae	200.0	3.0	70	47.1

Source: Bankeeree et al. (2017)

thermotolerant enzymes would reduce the cost of the temperature control system between different processes. It also reduces the amount of enzyme used because its activity is not lost at high temperature. Therefore, isolation and screening of fungi that produce thermotolerant enzymes at high quantity is still ongoing. In particular, isolation of fungi in Thailand, a tropical country with high biodiversity, has the advantage and great potential to exploit fungi that produce diverse enzymes from the vast native microorganism resources. Some examples of Thai fungi that produce thermotolerant cellulases are *Aspergillus fumigatus*, *Humicola lanuginosa* (Kitpreechavanich et al., 1984), *Chaetomium* sp. MCT 794 (Limtong et al., 1990) and *Acrophialophora nainiana* (Punnapayak, Kuhirun, and Thanonkeo, 1999). Xylanase and betaxylosidase enzymes that catalzye well at high temperature are produced by *A. pullulans* CBS 135684 (Bankeeree et al., 2014; 2016b; 2017).

The production of value-added compounds from plant biomass

Previously the utilization of plant biomass was focused on the energy production from glucose obtained from cellulose saccharification. Other biomass components attained after the saccharification process were disposed as organic waste. Nowadays, interest in utilizing these saccharification wastes is increasing due to the development of technology, either for direct use of hemicellulose and lignin or the use of monosaccharides derived from hemicellulose hydrolysis for production of value-added compounds. Such compounds can be categorized according to the production process, as follows:

1) Compounds or products directly produced from each plant biomass component

1.1) Levulinic acid (Boonjan, 2015)

Levulinic acid is a substance that can be used in many industries, such as manufacturing of pharmaceutical products, herbicides, fuel additives, scenting agents and substrates for polymer production. Our research on production of levulinic acid from Thai weeds found that *Mimosa pigra* L. which has a high cellulose content could be used as a raw material for the production of levulinic acid. After pretreatment of *M. pigra* wood by a biological method followed by heat and chemical treatment, the yield of cellulose extracted from wood was increased to 70.15% (w/w). When the pretreated cellulose from *M. pigra* was subjected to hydrothermolysis using aluminosilicate such as ZSM-, 5.68 % (weight per plant biomass weight) of levulinic acid was obtained.

1.2) Hydrogel Beads from Hemicellulose for Enzyme Immobilization (Bankeeree et al., 2016a)

By altering the functional groups of hemicellulose via esterification, it was found that the modified xylan or hemicellulose could absorb more moisture from the air. When bonding with polyvinyl alcohol (PVA), a novel polymer with hygroscopic mesh structure similar to hydrogel was formed. The pore size of the mesh was less than 1micron, making it efficient in trapping substances such as the enzyme laccase. The immobilized laccase enzyme in this modified polymer was more stable and reusable more than 10 times in wastewater treatment systems. Therefore, it is commercially feasible to develop this polymer for various immobilization applications.

1.3) Prebiotics from Hemicellulose (Patipong, 2015)

Hemicellulose, with xylose as a main chain, a pentose sugar, is generally known as xylan. When xylan is partially digested by a xylanase enzyme from *A. pullulans,* several types of xylooligosaccharides (XOs) were formed. The XOs could strongly stimulate growth of *Lactobacillus brevis* and *L. casei* when compared to glucose, indicating prebiotic activity. When the XOs were partially purified, it was found that xylobiose and xylotriose had higher prebiotic activity than those of the other XOs. In addition, the xylobiose and xylotriose produced in this study were readily water-soluble thus making them more easily adsorbed in the body, and could potentially be used as health enhancing substances.

1.4) Lignosulfonate from lignin as a plasticizer in concrete (Chatpapamon, 2012)

Lignin and derivatives formed during pretreatment of plant biomass are often burned to produce heating energy for the production system. When lignin was structurally modified to lignosulfonate that was subsequently applied to the concrete production process, it was found that this compound could improve the concrete's bleeding properties, which made the concrete more liquid. As a result, the water volume required in the concrete mixtures could be reduced, giving the concrete a denser texture, more durability and water resistance. This lignosulfonate-containing concrete could also bear higher pressure than normal concrete. Therefore, it is of interest to commercially produce lignosulfonate as a component in concrete.

2) Production of xylitol from xylose obtained from hemicellulose saccharification

Xylitol is a sugar alcohol with a sweetness level similar to that of regular sugar, but it does not cause tooth decay. This is because xylitol does not promote the growth of oral microorganisms and it is very slowly absorbed by the human body. Moreover, the body cannot utilize xylitol, thus it does not affect blood sugar levels of diabetic patients. Xylitol can be produced from the fermentation process using xylose as the substrate. Prasongsuk et al. (2016) reported that when the extracted xylan from black liquor, an effluent from the pulp production process in the pulp and paper industry, was digested with xylanase enzyme produced by *A. pullulans* CBS 135684, a maximum xylose yield of 0.71 gram per gram of xylan was obtained. When the xylan hydrolysate was used for xylitol fermentation by a Thai isolate of *Candida tropicalis* for 72 hours, a maximum xylitol yield of 0.64 gram per gram xylose was obtained, which was higher than those previously reported from *C. guilliermondii* (0.44 g/g after 72 hours) (Sene et al., 2011), *C. tropicalis* CLQCA-24SC-125 (0.67g/g after 120 hours) (Guamán-Burneo et al., 2015) and *C. parapsilosis* NCIM 3323 (0.47 g/g after 72 hours) (Srivani and Pydi Setty, 2012).

Conclusion

The role and importance of plant biomass utilization for commercial purposes depends on the potential in technological development of the country. Thailand has a large source of agricultural raw materials waiting to be utilized to its full potential; however, there is a lack of appropriate technology to unlock this potential. Therefore, it is necessary to focus on technology development to be more efficient and environmentally friendly. Integration of biotechnology at each step, such as in pretreatment of plant biomass

with white rot fungi, enzymatic saccharification of cellulose and hemicellulose and the use of selected native microorganisms to produce important compounds from plant biomass, has been shown to help reduce production costs, resulting in better market competitiveness and environmental benefits through the reduction in use of toxic chemicals. Moreover, it can produce new compounds or products of economic value that respond to specific market demands. Continuing study in scale up production processes to produce these high value-added compounds is essential for future national development.

Acknowledgments

This article is part of the research project entitled ***"Value Added Products to Enhance Ethanol Production from Biomass"***, which was supported by the in-depth research program, the Ratchadaphiseksomphot Endowment Fund, Chulalongkorn University (CU-57-043-EN) (fiscal Year 2014).

References

Bankeeree, W., Lotrakul, P., Prasongsuk, S., Chaiareekij, S., Eveleigh, D. E., Kim, S. W., and Punnapayak, H. 2014. Effect of polyols on thermostability of xylanase from a tropical isolate of *Aureobasidium pullulans* and its application in prebleaching of rice straw pulp. **SpringerPlus** 3 (1): 37.

Bankeeree, W., Prasongsuk, S., Imai, T., Lotrakul, P., and Punnapayak, H. 2016a. A novel xylan-polyvinyl alcohol hydrogel bead with laccase entrapment for decolorization of reactive black 5. **BioResources** 11 (3): 6984-7000.

Bankeeree, W., Lotrakul, P., Prasongsuk, S., Kim, S. W., and Punnapayak, H. 2016b. Enhanced production of cellulase-free thermoactive xylanase using corncob by a black yeast, *Aureobasidium pullulans* CBS 135684. **Korean Chemical Engineering Research** 54 (6): 822-829.

Bankeeree, W., Akada, R., Lotrakul, P., Punnapayak, H., and Prasongsuk, S. 2017. Enzymatic hydrolysis of black liquor xylan by a novel xylose-tolerant, thermostable β-xylosidase from a tropical strain of *Aureobasidium pullulans* CBS 135684. **Applied Biochemistry and Biotechnology** 184 (3): 919-934.

Boonjan, C. 2015. **Optimization for pretreatment of wood from giant sensitive plant *Mimosa pigra* L. for levulinic acid production**. Master's Thesis. Biotechnology, Faculty of Science, Chulalongkorn University.

Chatpapamon, C. 2012. **Utilization of sodium lignosulfonate from lignin in black liquor of eucaluptus kraft pulping.** Master's Thesis. Biotechnology, Faculty of Science, Chulalongkorn University.

Datta, S., Holmes, B., Park, J. I., Chen, Z., Dibble, D. C., Hadi, M., Blanch, H. W., Simmons, B. A., and Sapra, R. 2010. Ionic liquid tolerant hyperthermophilic cellulases for biomass pretreatment and hydrolysis. **Green Chemistry** 12 (2): 338-345.

Guamán-Burneo, M. C., Dussán, K. J., Cadete, R. M., Cheab, M. A. M., Portero, P., Carvajal-Barriga, E. J., da Silva, S. S., and Rosa, C. A. 2015. Xylitol production by yeasts isolated from rotting wood in the Galápagos Islands, Ecuador, and description of *Cyberlindnera galapagoensis* f.a., sp. nov. **Antonie van Leeuwenhoek** 108: 919-931.

Kitpreechavanich, V., Hayashi, M., and Nagai, S. 1984. Production of xylan-degrading enzymes by thermophilic fungi, *Aspergillus fumigatus* and *Humicola lanuginosa*. **Journal of Bioscience and Bioengineering** 62 (1): 63-69.

Limtong, P., Vangnai, S., Sunanthapongsuk, V., and Piriyaprin, S. 1990. Isolation and selection of thermophilic cellulolytic microorganisms for compost production in Thailand. **Kasetsart Journal (Natural Science)** 24 (1): 108-115.

Patipong, T. 2015. **Production of Xylooligosaccharides from weeds using a xylanase from *Aureobasidium pullulans.*** Master's Thesis. Biotechnology, Faculty of Science, Chulalongkorn University.

Permpornsakul, P., Prasongsuk, S., Lotrakul, P., Eveleigh, D. E., Kobayashi, D. Y., Imai, T., and Punnapayak, H. 2016. Biological treatment of reactive black 5 by resupinate white rot fungus *Phanerochaete sordida* PBU 0057. **Polish Journal of Environmental Studies** 25 (3): 1-6.

Prasongsuk, S., Bankeeree, W., Lotrakul, P., and Punnapayak, H. 2016. Xylitol production by a newly isolated *Candida* sp. from enzymatic hydrolysate of xylan from black liquor in pulp and paper industry, **SIMB Annual Meeting and Exhibition,** New Orleans, USA.

Punnapayak, H., Kuhirun M. and Thanonkeo P. 1999. Cellulolytic fungi and the bioconversion of fiber from *Agave sisalana*. **ScienceAsia** 25 (3): 133-136.

Saraihom, S., Kobayashi, D. Y., Lotrakul, P., Prasongsuk, S., Eveleigh, D. E. and Punnapayak, H. 2016. First report of a tropical *Lysobacter enzymogenes* producing bifunctional endoglucanase activity towards carboxymethylcellulose and chitosan. **Annals Microbiology** 66 (2), 907-919.

Sene, L., Arruda, P. V., Oliveira, S. M. M. and Felipe, M. G. A. 2011. Evaluation of sorghum straw hemicellulosic hydrolysate for biotechnological production of xylitol by *Candida guilliermondii*. **Brazilian Journal of Microbiology** 42: 1141-1146.

Singh, J., Suhag, M. and Dhaka, A. 2015. Augmented digestion of lignocellulose by steam explosion, acid and alkaline pretreatment methods: a review. **Carbohydrate Polymers** 117:624-631.

Sripat, V. 2013. **Pretreatment of eucalyptus wood using tropical strains of white rot fungi for kraft pulping.** Master's Thesis. Biotechnology, Faculty of Science, Chulalongkorn University.

Srivani, K. and Pydi Setty, Y. 2012. Parametric optimization of xylitol production from xylose by fermentation. **Asia-Pacific Journal of Chemical Engineering** 7 (S3).

Creative Economy and Thailand's Development

Dr. Kamalinne Pinitpuvadol

International law expert, shares his knowledge about Thailand's international trade and expresses his views on Thailand's potential to leverage the creative economy in global markets.

Thailand's international trade – an overview

"...Thailand's international trade started with the export of agricultural products.
Later it developed an import and export industry.
Now it is a trading nation both at a regional and global level..."

Thailand's international trade policy was formally articulated through during its first National Economic and Social Development Plan. The country's first exports were food and agricultural products, but as Thailand built its industrial base and service sector, the country diversified to

become a regional and global trading nation. The globalization of trade in the 1990s was a key factor in liberalizing trade in Thailand. International trade agreements such as the General Agreement on Tariffs and Trade (GATT) were sealed, and the World Trade Organization (WTO) was founded to promote a new trade ideology and reduce international trade barriers. GATT was later expanded to cover services, triggering additional agreements such as the WTO General Agreement on Trade in Services (GATS), the ASEAN Framework Agreement on Services (AFAS), the ASEAN Trade in Services Agreement (ATISA) and the Free Trade Agreement (FTA). Today, Thailand's national policy promotes cross border trade, and encourages SMEs to trade with and invest in neighboring countries such as Cambodia, Lao PDR, Myanmar and Vietnam (CLMV bloc). Thailand views trade and investment as key to development and the establishment of a vibrant creative economy.

A historical review reveals a lack of policy coherence among the world's trading nations, including Thailand, particularly in regard to domestic and foreign investment. A harmonized system and common institutional framework is needed among the numerous organizations affiliated with trade and investment, in order to facilitate international trade through improvement in legal and regulatory frameworks, particularly in regard to issues such as business registration and alien workers. The United Nations Conference Trade and Development (UNCTAD) has created a trade and investment policy that aims for efficient development in the field of science, technology and innovation, to serve as a guideline to assist trading nations in reforming trade and investment policies. Thailand faces a particular challenge in regard to its education system, which has long been in need of reform in order to drive future research, investment and establish a strong foundation for a creative economy, in line with the government's ambition for an innovation-led *'Thailand 4.0 model'*. Thailand will urgently need to leverage its many comparative advantages, including its skilled labour, services, hospitality and tourism, if it is to strengthen its competitiveness and achieve this goal.

Adapting to the creative economy in a global market

"...To compete in the world market, Thailand must pay more attention to protecting intellectual property and update its commercial law to meet today's needs..."

Since the 8th National Economic and Social Development Plan, the Thai government has set progressive policies to drive the creative economy in all business sectors, aiming ultimately at moving the country's economic base towards the *'Thailand 4.0'* model. However, Thailand is not alone in its focus on creativity, technology and innovation. In other words, Thailand needs to ready itself to compete in the world market. It is true that creative economy already exists in various business sectors of Thailand, in line with UNCTAD's classification of the creative industries. This includes policies, development plans and public agencies established to support the development of the creative economy, including value creation based on knowledge and innovation and Thailand's cultural heritage. These efforts have helped stimulate a wide range of creative industries, including small industries and businesses such as handicrafts, performance and visual arts,

media such (print, broadcasting and film), as well as in the areas of design, fashion, advertisement and architecture. Nevertheless, Thailand needs to focus on protection of intellectual property so that creativity can grow and be rewarded fairly.

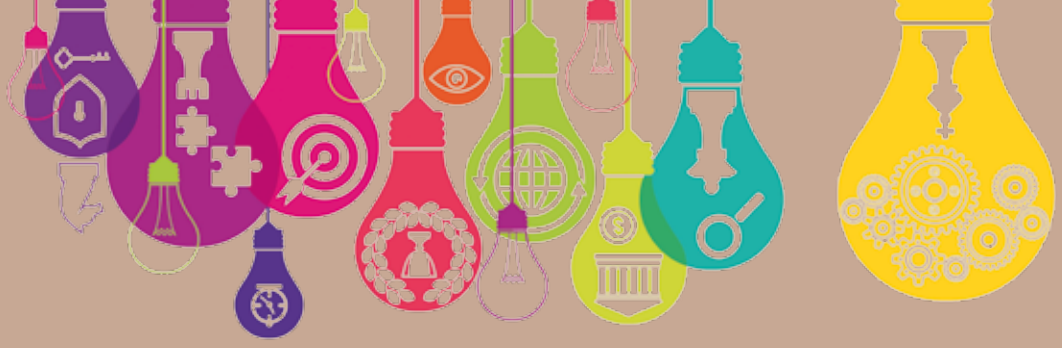
Among the many free trade agreements to which Thailand is a signatory, the four types of services to which Thailand pays most attention are cross-border supply, consumption abroad, commercial presence, and movement of natural persons. However, statistics on the service sector of creative industries shows that Thailand's legal framework still hampers the efforts of foreigners seeking business opportunities in Thailand. Moreover, government agencies responsible for intellectual property protection need to take more effective action to prevent Thai innovation from being patented by foreigners, and, also to prevent violation of existing copyrights, trademarks and other forms of intellectual property. Having already legalized foreigner owned businesses, Thailand should also consider liberalizing current regulations prohibiting foreigners from pursuing careers in certain professions in Thailand, especially in developing innovation and education. Such liberalization will expose Thai professionals in these fields to the latest technologies and professional best practice, enabling them to *'tool-up'* to adapt to the emerging concept of the creative economy, and enhancing Thailand's global competitiveness.

Moving towards the creative economy

"...Education must provide a learning atmosphere and process that stimulate open thought, thus producing creative thinkers and inventors. The educational policy needs to be practical, continuous, and efficient in order to build a firm ground for future development..."

In addition to policy coherence, education is also crucial to achieving a robust creative economy. It must provide a conducive atmosphere and learning process that allows people to think freely, thus producing creative thinkers and inventors. The educational policy needs to be practical, continuous, and efficient in order to build a firm ground for future development. Only through educational reform will Thailand enhance its creativity and capacity for innovation, essential for developing new kinds of goods and services for future generations.

Another trait of Thai people that needs to be improved in the courage to stand out. Because Thai people are often timid, most choose to copy and follow the trend. Thailand needs people who



adopt a mindset that gives them the confidence to be different. This will allow them to develop concepts in a continuous and efficient way. There are many examples from other countries from which Thailand could learn and adapt. Most importantly, His Majesty King Bhumibol Adulyadej's Philosophy of the Sufficiency Economy should also be used as a guiding principle in improving Thailand's economy.

We should also remember the more than 4,000 Royal Projects implemented in Thailand, standing as clear evidence that Thailand has been developing its creative economy for a long time now. It is crucial that the next generation continues with this doctrine. Studying it with seriousness and pragmatism will allow them to understand reality, not only in regard to the country's economy, but in their daily life as well.

Today, Thailand is moving forward on many fronts, in both public and private sectors. In addition to its ancient cultural heritage that can generate high value added in industries such as services, the performance arts, tourism, food, and many more. When creativity and innovation are integrated with the digital economy and the cultural economy, Thailand will be able to create outstanding goods and services that can compete in the global arena.

Thailand's potential in the global market

"...In regard to services, Thailand needs to offer quality and novelty by mixing technology with tradition...."

In order to enhance Thailand's potential and positioning in global markets, Thailand should showcase its unique strengths such as its cultural heritage, ancient artifacts, food, the arts, services and handicrafts. In terms of cross-border trade between Thailand and its neighboring countries within the CLMV bloc and the Great Mekong Subregion, Thailand should focus on collaboration, due to the region's large population and cultural commonalities. At the same time, Thailand should promote Public Private Partnership (PPPs) in developing the creative economy and penetrating the ASEAN single market, taking advantage of Thailand's ancient culture and skilled labour force, and highlighting the uniqueness of Thai products. Rice offers an excellent example. Thailand has always been renowned as a global leader in rice production and exports. However, its exports face increasing competition, necessitating increasing differentiation based on quality, flavor and aroma. In regard to services, Thailand also needs to offer quality and novelty, mixing technology with tradition.

Today, Thailand's creative sector includes all nine UNCTAD categories of creative industry businesses, with a diverse range of products and services in the realm of cultural heritage, arts, and performance art. However, media, design and creativity services need a boost in order to encourage the younger generation towards independent learning, and to widen their world view. Thai people have to learn more about the world if they are to compete more successfully in the global market.

Knowledge and research as a foundation of the creative economy

"...Thailand needs to create a body of knowledge through academical research that is practically useful for those working in economic development..."

In contrast to many countries that have been successful in creating innovation and building creative industries, Thailand's economic development initiatives have frequently lacked an adequate academic foundation. Thailand needs, therefore, to create a body of research knowledge that can guide economic planners and businesses in driving the creative economy. Researchers and innovators need to be well-supported and have good access to finance, allowing them to create successful commercial products and services. Moreover, such research needs to be closely monitored in its implementation and post-completion in order to learn lessons and understand the contribution to the creative economy. Most importantly, both public and private sectors must take part in supporting these research projects, and especially in providing financial support.

In conclusion, Thailand needs to set long-term policies that are effective and coherent, especially in terms of education and human resources. Each policy needs to be supported, promoted and evaluated, in order to prevent possible complications. The building of the new generation needs to focus more on producing innovative thinkers and inventors, equipped with an academic understanding of history, culture, and philosophy, since this will provide a strong foundation for wisdom and creativity. The use of the Philosophy of the Sufficiency Economy in public and private-led projects offers an excellent example. The question now is how well does Thailand's new generation understand the Philosophy of the Sufficiency Economy? It is necessary to promote this philosophy systematically, as a foundation on which to build Thailand's creative economy.

Dr. Kamalinne Pinitpuvadol

Kamalinne Pinitpuvadol (Docteur en droit) is an Executive Director of the International Institute for Trade and Development (Public Organization) and a member of the Executive Board of Chula Unisearch, Chulalongkorn University.

Thailand Creative Economy

"Around us"

Assoc. Prof. Thavivongse Sriburi, Ph.D.

The terms *'Creative Economy'*, *'Thailand 4.0'* and *'Creative Industry'* are often heard these days, but what do they really mean for Thai people and our society? This article explores how these concepts are changing our attitudes to work and play, and how they relate to each other.

In broad terms, the Creative Economy (CE) refers to economic development based on creative application of either an existing or new body of knowledge. Under the CE, this creates added value through meeting both practical and emotional needs among consumers.

Thailand 4.0 refers to the government's policy to drive national economic development focused on a *'Value-based Economy'*. The policy aims to reform the country's economic base by investing in digital technologies, innovation and connectivity to add value to products and services. The policy prioritizes five core industries:

1) Food, agriculture biotechnology
2) Health, wellness and biomedical applications
3) Smart devices, robotics and electronics
4) Digital and embedded technology
5) Creative, culture and high value services.

The United Nations Conference on Trade and Development (UNCTAD) defines the term *'Creative Industry'* as *"...the cycles of creation, production and distribution of goods and services that use creativity and intellectual capital as primary inputs..."* or *"...that comprise tangible products and intangible intellectual or artistic services with creative content, economic value and market objectives."* The following are defined as creative industries: advertising, architecture, art and antiques, carvings and crafts, design, shows, films and videos, publications, radio and TV, PC software, computer games, electrical and electronic equipment. Even back in 2005 exports of industrial goods and services in these industries were valued at more than 336 billion dollars (UNCTAD, 2008) [1].

Today, the concept of the *'Creative Economy'* is still emerging as it evolves alongside the fast-changing interface between creativity, culture, economics and technology in a contemporary world dominated by images, sounds, texts and symbols. The *'Creative Industry'* refers to a business ecosystem that links creativity, technology to culture, contributing to creation of value added, new intellectual property and enhanced competitiveness.

A recent study (Fiscal Policy Research Institute (FPRI) and Kenan Institute Asia (KI Asia), 2009)[2] since 2010 has concluded that achieving a successful Creative Economy is very difficult without first establishing a rich and robust knowledge economy. Creating a culture of learning organizations is therefore critical to accelerating implementation and in driving private sector investment in knowledge creation. Such investment should not be left only to the public sector; past results have been manifestly disappointing and have failed to resonate with and meet the needs of consumers. So how should the government stimulate and support the private sector to invest more in research and innovation? Research indicates a very low level of investment in R&D within Thai companies, which means those organizations are likely to fail and disappear within the next 40 years.

Intellectual property is at the core of creative economic development because of need to protect entrepreneurial investment in new ideas or new manufacturing or distribution processes. If the entrepreneur does not file a patent, imitation quickly eats into market share. However, patenting products in Thailand is a time-consuming process and the procedures for granting patents can be overwhelming, particularly for small businesses. Even after granting a patent, violations are frequent and patent protection is difficult and expensive to enforce. This means that the genuine product or service often fails in the market because of the higher cost base.

Intellectual property infringement and counterfeiting is a longstanding problem that hampers economic development; the creative economy stands to be greatly impacted, as already seen in the film, music and pharmaceutical industries. As noted by FPRI and KI Asia: *"Intellectual property infringement will reduce the motivation*

---

[1]UNCTAD. 2008. **Creative Economy Report 2008**. New York, NY: UNCTAD.

[2]Fiscal Policy Research Institute (FPRI) and Kenan Institute Asia (KI Asia). 2009. **Study of the economic value from Thailand's creative industry**. Final report.

to create and invest." The same study characterized *"Intellectual property infringement as an organized crime support."* On the subject of drugs, a survey of antimalarial medications in Thailand and Cambodia cited that up to 38% of antimalarial drugs were found to be counterfeit, resulting in treatment failure and drug resistance.

In 2010 FPRI and KI Asia issued the following policy recommendations to drive the creative industries:

1) Creative industry development should be undertaken in parallel with the industrial spatial knowledge, recognizing the inter-dependence between knowledge and creativity.

2) The government should give greater support to help entrepreneurs integrate creativity into value chain development.

3) The government should strengthen protection of intellectual property and the enforcement system, especially the steps and procedures for filing patents, compulsory licensing and copyright enforcement.

4) The government should work to build a more supportive public understanding that intellectual property infringement is a form of theft that impacts negatively on national economic advancement.

5) The Government should set a policy to attract talented people with creative skills to work in Thailand and facilitate employment of professionals in Thailand through reduced administrative hurdles.

6) Delays in bringing the latest IT and telecommunications systems need to be addressed

due to their critical importance to the IT industry and across all industry sectors.

From the above data we can see that the creative economy important to the development of business competitiveness at every level.

Developing competitive capacity at national level requires two development approaches:

1) Science and technology development: Thailand has prioritized S&T by investing in research and operational research on materials and properties used in production, developing improved production processes, equipment and machinery to meet industry needs in the modern era.

2) Arts and design development: A study of the development of the arts and culture in the modern era is needed in order to harness expertise and imagination as well as aesthetic values. By linking Thailand's national culture, heritage and local wisdom to the country's economic and technological development and prosperity, we can ensure that this heritage remains in the public eye and is valued and preserved for future generations.

Although Thailand is globally renowned for its ancient cultural heritage, including traditional crafts such as woodwork, metalwork, masonry, silk and textiles, etc., they are typically not protected by patents or other forms of intellectual property rights. There are also constraints to the growth of the creative economy that have resulted in a weaker than expected generation of value added. Despite a broad commitment to the model by both public and private sectors, progress has been slow and has yet to meet the government's goals and aspirations.

In order to reinvigorate the process, a much stronger focus on innovation will be required. There is a strong domestic demand among consumers for imported innovative products and services, because consumers believe Thailand still does not have sufficient capacity to develop their own innovations. Increased innovative capacity in Thailand will therefore help reduce the import burden.

Whilst large businesses may have the organizational capacity to drive innovation and create new value, small and medium businesses are at a disadvantage. Successive governments have prioritized innovation development at various levels by providing various kinds of infrastructure and other approaches to support SMEs. These include the Thailand Creative and Design Centre, SME Bank, the Office of Small and Medium Enterprises Promotion (OSMEP), Learning Centres, and the One Tambon - One Product initiative, etc. In addition, the Department of Local Government, Department of Industrial Promotion (Ministry of Industry), the Department of Export Promotion (Ministry of Commerce), the Government Savings Bank and Bank of Agriculture and Cooperatives all support both finance and marketing to community-level enterprises. Government and communities must work together to create favourable conditions to ensure the success of SMEs.

For the government, perhaps the most important and urgent challenge today will be to address intellectual property infringement, which impacts all business sectors across the country. Failure to suppress IP theft will result in serious impacts e.g. to health, safety and the national reputation, which will all impact on investor confidence and the appetite for innovation. Patent application processes should be streamlined to prevent and tackle counterfeiting and piracy if the government is to reach its aspirational goal under Thailand 4.0.

Research Development and Industrialization (RDI) Capability of Medium-scale Enterprises

Assoc. Prof. Prasert Reubroycharoen, Ph.D.
Department of Chemical Technology, Faculty of Science, Chulalongkorn University

In accomplishing its goal of reforming the country to escape the middle-income trap and establish itself as a high-income country, development of science, technology and innovation (STI) will play a fundamental and pivotal role. In the long term, an enabling national science policy and regulatory environment will help to foster an effective and sustainable national innovation system (NIS), as well as embed the principles of innovation within communities and Thai society.

In developing countries, innovators need to take into account the lifecycle of new products and services, and their contribution to the organization's core competency and competitiveness. As part of this life cycle, competitors emerge and erode profitability, according to the classic S-Curve of innovation adoption. Saturation and/or technological advances may then render the product or service obsolete. The ever-shorter business life-cycles for innovative products require corresponding agility and responsiveness among organizations to adapt to emerging business realities. The success of new opportunities today relies on breakthrough innovations for the development of new industries (New S-Curve) to ensure that businesses run sustainably.

Recognizing the importance of driving innovation among medium-size enterprises, a project ***"Research development and industrialization (RDI) capability of medium enterprises"*** was initiated jointly by the National Science Technology and Innovation Policy Office (STI) and Chulalongkorn University under a collaborative programme to enhance industry competitiveness. The project aimed to foster the innovation process within industry, as well as build R&D capacity among participating medium-scale companies, linking also to the education sector through a Research Development and Industrialization (RDI) platform. The project creates a new mechanism to provide long-term support for research, development and innovation, and includes a study to upscale the projects through both policy and practice.

The initiative will focus on creating and building system linkages as well as strengthening risk management, in order to establish an industrial base that can consistently and sustainably embrace innovation. Which covering further original industry and systemically, the project is divided into three phases as follows:

1) **Phase 1- Needs Assessment and Gap Analysis:** The project will bring together a multi-disciplinary team comprising executives, technical experts, and specialists in Integrity and Transparency Assessment (ITA) to implement a series of brainstorming and workshop events. By identifying the underlying real needs of companies assessing business risks and conducting a gap analysis, this phase will result in recommendations for further improvements as a basis for development of project proposals for Phase 2.
2) **Phase 2- Pilot project on Cross-Functional RDI Process:** This phase will implement recommendations from Phase 1 through a pilot project based on a cross-functional approach. The selected topic for implementation will be achievable within a timeframe of 6-8 months.
3) **Phase 3- Full-scale project:** Over a 2-year period, this phase will focus on building a full RDI system and build innovation capacity for small and medium enterprises (SMEs). Business growth will be stimulated by supporting new product or process development. Parameters to be prioritized include quality cost and delivery. By modelling the development of industrial process systems and administrative procedures, the company will be categorized under a 5-level risk assessment process in order to empower SMEs to leverage R&D and innovation as a core part of their business models. Support measures may include manpower development to create an RDI platform, facilitation of cooperation linkages both within Thailand and globally to boost technology transfer and expand markets through domestic, regional and global value chains.

Risk 0 : Unattainable product performance generated by the development of the offer
Risk 1 : Failure to deliver expected product performance due to the target model design
Risk 2 : Failure to deliver expected product performance due to the process (5M)
Risk 3 : Failure to deliver expected product performance
Risk 4 : Unattainable product performance generated by the articulation of the offer

Research for Small and Medium Enterprises to leverage and grow with R&D and innovation, this may include the creation of manpower development, to create RDI platform, to cooperate within and outside the country on technology transfer and market expansion in the value of global/regional value chain.

The project is expected to contribute to upgrade management skills on R&D and innovation among Thai SMEs, enabling them to invest in R&D to boost its business growth and competitiveness. Moreover, the project will develop the potential and capacity of government personnel in analysis of research management systems and innovation for companies in order to strengthen the sustainability of SMEs in Thailand. Through these interventions, we expect the project to result in the emergence of innovative services, technology business models and new R&D management processes for SMEs, who will be better equipped to upgrade and grow through R&D and innovation, as a fundamental pillar of Thailand's emerging knowledge-based economy.

NRCT - UNESCO-IOC/WESTPAC International Meeting on "Marine Introduced Species and Marine Debris in Coral Reefs"

Chula Unisearch recently organized an international meeting on ***"Marine Introduced Species and Marine Debris in Coral Reefs,"*** convened by the National Research Council of Thailand (NRCT), Department of Marine and Coastal Resources, UNESCO-IOC/WESTPAC and the Department of Marine Science, Faculty of Science, Chulalongkorn University. The event, held at the Pathumwan Princess Hotel, Bangkok, brought together over 50 researchers and scholars from Thailand and across Asia to share knowledge, create a research network and develop policies, guidelines and concrete plans for prevention of introduced species and marine debris. These recommendations offer an important basis for driving effective broad-scale conservation and management plans to protect our highly vulnerable coral reefs, not only in Thailand, but across the Asian region.

The 9th Conference and Exhibition of "Thai Resources: Enormous Potential to be Seen - RSPG9"

Executives of Chula Unisearch humbly greeted Her Royal Highness Princess Maha Chakri Sirindhorn, who graciously visited Chulalongkorn University's Saraburi Campus on the occasion of the ***"9th Conference and Exhibition of Thai Resources: Enormous Potential to be Seen - RSPG9"***, held from 28 November–4 December 2017. On this occasion, Assist. Prof. Saowanee Wijitkosum, Ph.D., represented **Chula Unisearch** in receiving a certificate of honour from H.R.H. Princess Maha Chakri Sirindhorn as one of the sponsoring organizations for this event. The aim of the conference and exhibition was to showcase the diversity and value of Thailand's resources for students and visitors, and to encourage efforts to conserve the country's unique, precious and irreplaceable resources for future generations.

Exhibition: Coral Hospital

The Department of Marine Science, Faculty of Science, Chulalongkorn University and the National Museum of Marine Biology and Aquarium, Taiwan, recently held the ***"Coral hospital"*** Exhibition at the Mahateerarachanusorn Building, Chulalongkorn University. Assoc. Prof. Thavivongse Sriburi, Ph.D., Managing Director of Chula Unisearch presided over the opening ceremony of the event, which aimed to highlight the causes of coral degradation, techniques for reef rehabilitation and the beauty and diversity of *'coral gardens'* resulting from restoration and conservation efforts.

2018 Staff Seminar

Chula Unisearch held a staff seminar in Nan Province from 27–30 January, 2018, aiming to establish guidelines for the development of academic services and research to expand industry cooperation and enable the organization to work proactively with other institutions and contribute to operational efficiency. On this occasion, Chula Unisearch executives and staff visited the Center of Learning Network for the Region (CLNR), Nan Province, to study aspects on feeding '*Bos javanicus*' and '*Thai buffalo*' for conservation, rearing of frogs and earthworms under organic conditions, and rubber cultivation to increase green areas. Participants together planted 250 '*Syzygium cumini*' trees to maintain plant genetic diversity, under the Plant Genetic Conservation Project Under the Royal Initiation of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG).

32nd Chula Unisearch

Chula Unisearch celebrated the 32nd Anniversary of its establishment on Wednesday 14 February, 2016 at the Chulalongkorn Research Building. The administrators, faculty members, directors of the University's Institutes, Centres and Offices joined the celebration by executives of Chula Unisearch. On this occasion, **Chula Unisearch** arranged an auspicious Buddhist merit-making ceremony, together with giving of alms and food offerings.

MU and KMITL visited Chula Unisearch

Chula Unisearch recently welcomed visiting executives and staff from the Faculty of Engineering, Mahidol University and Research & Innovation Services, King Mongkut's Institute of Technology Ladkrabang. The visitors studied **Chula Unisearch** organizational model and exchanged opinions about their respective approaches to stimulating academic and research services to benefit industry and society.

UNISEARCH JOURNAL