Annual Report 2021

Content

Message from the Governor

2021 was a year of challenges for the Thailand Institute of Scientific and Technological Research (TISTR) due to the severe situation caused by the COVID-19 pandemic. However, in the midst of a crisis, TISTR, as a state enterprise in research, development, technology transfer, industrial services, and innovation under the Ministry of Higher Education, Science, Research and Innovation (MHESI), has successfully made the most of Science, Technology and Innovation (STI) to support the growth of Thailand's local economy under the framework of the Government's policy. TISTR has placed emphasis on the public involvement and inclusive growth & wellness of future lifestyles, the development of targeted S-Curve industries and small and medium-sized businesses, energy and environmental management, business continuity, and the corporate good governance through the global crises. The spotlight on TISTR's achievements in 2021 was on the development of research, technology and innovation in the context of BCG (Bio economy, Circular economy, Green economy), that focused on integration with large business sectors, the agricultural sector, and the communities to generate the growth of agroindustry, food industry, medical industry, and energy. These performances could upgrade the entire economy of the nation as the gross domestic product was increased and the local people's income was widely distributed, thus strengthening the community with an environmentally friendly concern. Examples of important projects were:

- Development of biotechnology production processes. The innovative product such as "Palatyne Sugar" sweetener for balance control of blood sugar level was obtained and transferred to Rajburi Sugar Co., Ltd., with a capacity of 60 tons per year, an economic value of 10 million baht per year, and the company has a plan to achieve in global markets in the near future.

- Development of bio-methanol from waste materials. This research will lead to the construction of the first bio-methanol plant in Thailand by BLCP Power Limited in the near future that can reduce by 100% of imported methanol from abroad.

- Waste management for the community The value addition of waste for recycling according to the circular economy was undertaken in 4 regions of Thailand and the results showed that it could generate income for local authorities over 10,000,000 baht per year. Currently, TISTR has extended its capacity by collaborating with Dow Thailand Group to conduct the project on value addition of community plastic waste for sustainable development in the long run.

- Development of microbial pesticides. This product can be used safely for living things and the environment as no toxic residues have been left while carbon was also reduced. Moreover, the import volume of chemicals from abroad has decreased. TISTR has already transferred this production technology to the western central provinces, namely Kanchanaburi, Suphan Buri, Nakhon Pathom and Ayutthaya, resulting in cost reduction of 172.5 million baht for farmers and reduction of 241.5 million baht in agricultural chemicals imports.

- Development of the local economy for a farmer cluster of ornamental plants in Loei province. The pilot projects were undertaken for 124 groups of farmers in order to increase their income earning and the results showed that planting technology could increase economic value of 90 million baht per year. The sustainable technology transfer was also promoted collaboratively with the public / private sectors in Loei province to establish "Flowers Academic Institute", so called Malai Witthaya Sathan for the benefit of local economy development, natural and cultural attractions, as well as market of ornamental plants and products in each area.

- Development of a model community for growing cash crops together with mycorrhizal cultivation in Ban Boon Chaem community, Phrae province, under the project of community woodlots. In the area, the bio-based technology was transferred to strengthen the community's economy and the project's success was evidently proved as the community won the 1st prize award of the northern region and 1st runner-up at the national level in Udomsuk Community Contest according to the BCG Model.

- Development of an advanced laboratory for the analysis and testing of cannabis/hemp extracts for medical use, covering 5 sample types: cannabis plants, Thai pharmacopeia, hemp oils, hemp extracts, and medicinal products from cannabis/hemp oil. Having been operated under the ISO 17025, the laboratory's capacities could support local entrepreneurs in medicine, and create value addition of cash crops from domestic resources. Moreover, the laboratory is also accredited in accordance with OECD GLP standards from the Bureau of Laboratory Standards, Ministry of Public Health, which is 1 of 5 accredited laboratories in Thailand.

Last but not least, in 2021, it was a great pride as TISTR's performance was obviously shown in various outstanding awards received, for instance,

- The Outstanding State Enterprise Award 2020 in the category of "Outstanding Cooperation Award for Development in Strategic Cooperation". In this regard, the cooperation was initiated between Thailand Institute of Scientific and Technological Research (TISTR), Bank for Agriculture and Agricultural Cooperatives (BAAC) and Export-Import Bank of Thailand (EXIM Bank). In addition, TISTR has received 3 awards for government services for the year 2021 from the Public Sector Development Commission (OPDC) as follows:

- Government Service Award in the category of "Service Innovation Award", Outstanding class, from the project of Tan Diao Model – from waste to energy and income earning for sustainable community.

- Government Service Award in the category of "Service Development", Outstanding class, from Innovative Centre for Production of Industrially used micro-organisms (ICPIM).

- Government Service Award in the category of "Service Development", Good class, from the project innovation for productivity increase and value addition of banana (Kluai Khai) for agro-economic development.

In terms of stakeholder focus, TISTR also received outstanding awards and assurance in many fields that can build up confidence for customers and consumers on the quality of TISTR's performance. Those were "Excellent Agricultural and Food Product Certification Body" 2021; TISTR laboratories - Soil Analysis Laboratory in compliance with OECD GLP Test for Toxicological Testing, Fertilisers and Plants, which has been certified according to international standards; Human Rights Model Organisation Award 2021 from Rights and Liberties Protection Department, Ministry of Justice; and Green Office Award which has passed the assessment for another one more year since 2020. TISTR also worked collaboratively with educational institutions in the region such as Rajabhat Universities across the country and various organisations in order to drive the local economy. We also had a good opportunity to join hands with Chaipattana Foundation and Napa Foundation in the project of value addition for local resources. In the global aspect, the research funding from international organisations was granted such as the SOILGUARD project under financial support of the European Union under the Horizon 2020 framework.

From the aforementioned performance and achievements, it can be stated that TISTR has put colossal effort to combat with the COVID-19 pandemic that definitely has some effects on our operations. Concerning this, TISTR's strategy in striving towards a Digital Trans-formation organization has been substantially successful as our goals have been achieved with no disruption.

This is a commitment that we all TISTR are proud of and will maintain this operational quality standard to be even better in this crisis, both the New Normal and Next Normal, and to bring research, development, services and innovations initiated by TISTR to create maximum benefits for the nation's prosperity.

Dr.Chutima Eamchotichawalit

Governor

Board of TISTR

Mr. Pasu Loharjun
Board Chairman

Dr. Wiparat De-ong
Board Member

Ms. Duangjai Asawachintachit
Board Member

Mr. Danucha Pichayanan
Board Member

Mr. Permsuk Sutchaphiwat
Board Member

Flight Lieutenant Kanok Thongpurk
Board Member

Mr. Tien-ake Tiyapongpattana

Board Member

Ms. Kanittha Sahamethapat

Board Member

Miss Nisakorn Jungjaroentham

Board Member

Dr. Chutima Eamchotchawalit

Board Member and Secretary

TISTR Executives

Dr. Chutima Eamchotchawalit
Governor

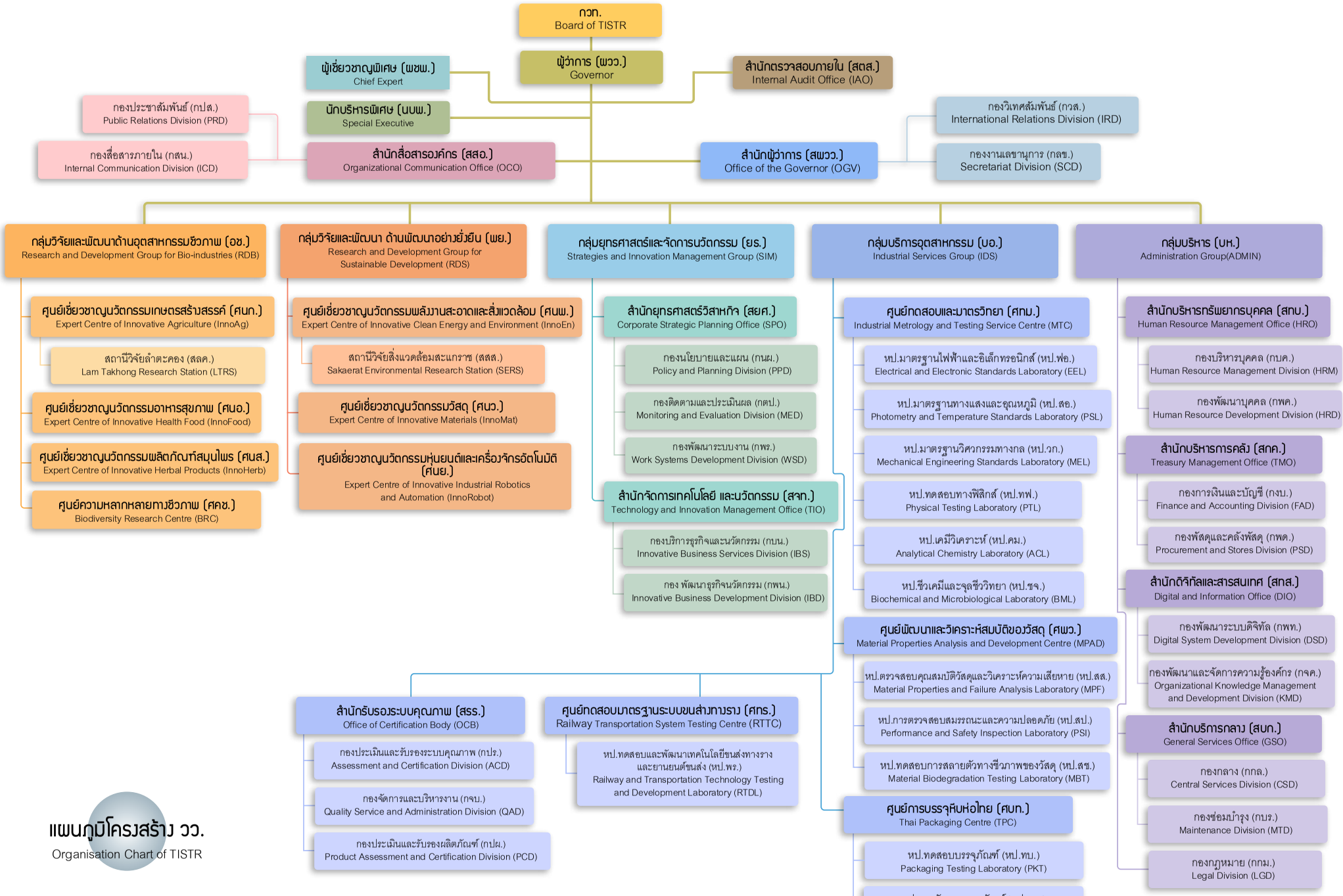
Dr. Pratip Vongbandit
Deputy Governor Research & Development Group for Sustainable Development

Mr. Sayan Tanpanich
Deputy Governor Research & Development Group for Bio-industries

Dr. Pattra Maneesin
Deputy Governor Industrial Services

Dr. Jittra Chaivimol
Deputy Governor Administration Group

Dr. Apakorn Supanya
Deputy Governor Strategies and Innovation Management Group



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Organisation Chart of TISTR

Operational Risks

In 2021, there was a new wave of coronavirus disease 2019 (COVID-19) outbreak in Thailand. The pandemic began to spread rapidly at the end of 2020 and intensified again in April 2021. The government has announced strict control measures to limit the spread of the pandemic. In addition, the personal data protection law in Thailand has come into force since June 2021, Thailand Institute of Scientific and Technological Research (TISTR) has to face various risks, both strategically and operationally such as financial and legal compliance, including rules and regulations. From the above situations, TISTR has analysed and assessed the risks that may occur and affect the operations of TISTR's main activities as follows:

- The risk of that provision of services to the industrial sector may not meet the goals because customers are affected by the economic crisis caused by the pandemic of COVID-19, both directly and indirectly. Some of the industry sectors needed to halt operations, resulting in lower business revenues and jobs, especially the business groups that are in maximum controlled areas.

- The risk that the transfer of knowledge in science, technology and innovation in various provinces across the country may not be carried out according to plans because of the government measures on travel in and out of controlled areas. This causes delays and damages in various projects and negatively affects entrepreneurs and stakeholders. If TISTR is unable to communicate properly, it may affect reputation and image.

- The risk that TISTR's operational systems and processes may be interrupted. This may affect the effectiveness and efficiency of operations as well as reputation, credibility including loss of revenue and operational opportunities. This risk may occur when the government imposes measure to stop the spread of the virus the Work from Home measure as much as possible. TISTR has also encouraged employees to work from home according to the government's measures.

- The risk that the number of customers who request services from TISTR may be less, resulting in a decrease in income. Business patterns have changed due to the COVID-19 epidemic. This led to the adoption of digital technology to support more online operations, resulting in higher business competition which related to TISTR's mission in providing analysis, testing, calibration, quality system certification, training and consulting.

- The risks to the image and credibility of TISTR, provided that the risk of TISTR will be sued as TISTR may not be able to operate in compliance with the Personal Data Protection Act B.E. 2562 (PDPA), effective on June 1, 2021. It is because TISTR has to collect personal information of service applicants and employees. However, if TISTR employees perform actions that are inconsistent with the legal provisions, TISTR will be guilty according to the law under both civil, criminal and administrative penalties.

Business Environment, Plan and Strategy

TISTR is a national leading organisation having competence and resources in research, development, technology transfer, and industrial service. There are over 500 researchers of TISTR and more than 2,000 articles which are evidently shown as a result of its collective experiences in research and development expertise, and knowhow or technology throughout 58 years. With the availability of manpower and infrastructure, TISTR is ready to provide services in research, development, technology, and innovation. The laboratories and certification body have been accredited by international standards. TISTR has a network of cooperation from government sectors, educa-tional institutions and private sectors both inside and outside the country. The main services of TISTR are research, consultation, technology transfer, analysis, testing, quality system certification, and training, covering multidisciplinary areas of industry, and in line with demands of the economic sector and society. TISTR has determined its targeted customers into 2 groups :

1. Commercial Customers:

- Government organisations e.g. central administrations/local government agencies/state enterprises/public organisations/universities
- Private sector e.g. large enterprises, small and medium enterprises (SMEs)

2. Social Customers : Community enterprises, farmers, general people

Business operations of TISTR are in accordance with the customer demands and expectations, including market trends by utilising technology, innovation, and digital technology to leverage its competence of science and technology (S&T) services. It is a mechanism to drive strategic plans on marketing and customer and link to national strategies, ministerial policies, TISTR's strategies, and business conditions of agencies that have similar missions to TISTR. Marketing opportunity consists of these following strategic plans:

Strategy 1 : Development of communities and area-based economy through innovative infrastructure. TISTR focuses on driving the utilisation of science, technology and innovation (STI) developed by TISTR toward commercialisation through its innovative infrastructure, and through the mechanisms of technology transfer to potential entrepreneurs in various economic fields. Proactive public relations will help to disseminate the results of technology transfer via new media and channels to raise up a positive image, public recognition and awareness of TISTR to the targeted groups. This strategy will result in leveraging the competitiveness of potential entrepreneurs

in the industrial and service sectors, including the public and education sectors. TISTR will continue to push forward the area-based projects under the economic development plan for communities and area-based with innovative infrastructure, consisting of research and development activities to be carried out to achieve our goals.

Strategy 2 : Development of digital platform and online database for customers. TISTR focuses on leveraging its digital potential for providing better services to customers. the Voice of Customer (VoC) online system was developed to receive feedback from customers. Database management was also arranged to meet customer demand and satisfaction. Moreover, TISTR Biz, a ready-to-use technology database, was also set up to help in achieving our indicators and goals in serving both new and existing customers.

Strategy 3 : Promote the utilisation of technology and innovation. The commercialisation of technology/innovation developed by TISTR to be transferred to potential entrepreneurs in various economic groups is also one of TISTR's main focus. Proactive public relations and dissemination of technology transfer activities through various media and channels are conducted to raise awareness and public image of TISTR. This strategy enhances the competitiveness of entrepreneurs who have potential in industries and services. The activities carried outcould make a strategy into implementation in order to achieve its goals.

However, TISTR has competitors from private sectors, government agencies, educational institutes that provide research, analysis, and testing services similar to TISTR's, thus requiring TISTR to adjust its business models with a focus on business networking, not competition in order to achieve joint development research and creating more customers together. In conclusion, TISTR has strengths in research, development and science services. The threat on competitors is not high, but TISTR needs to be well-managed and adjust business models to turn competitors into partners.

The situation of Coronavirus Disease 2019 (COVID-19) pandemic is one factor affecting the economy, investment, manufacturing and service sectors, as well as rapidly changing behaviour trends of producers and consumers. The trend of global supply chain has decreased and switched to domestic production (Deglobalisation). Location of production and raw materials have moved closer to consumers. Manufacturers or producers have relied on local suppliers or local content in their regions to avoid problems and impact of product distribution caused by country lock down. Besides, the trend of Work from Home and Learn from Home with digital transformation has caused digitisation of business models and education. New norms of consumers (New Normal) on hygiene and health standards have caused customers to be concerned about hygienic products and services. Paying attention to social distancing measures has caused the rising of e-commerce markets or online purchases.

From the aforementioned trends, TISTR has turned crisis to market opportunity by adaptation of its research and services to meet the needs of customers. TISTR

has presented its achievement to the targeted customers together with an established network of cooperation with government agencies, private sectors, educational institutions both inside and outside the country. TISTR has created a digital platform and online systems to support customers and receive voice of customers. According to the Customer Service Charter and Service Standard, TISTR has created CSR activities, knowledge management programs, consultancy services for customers through various media and channels. These activities will help us in gaining customers' trust and understanding customer touchpoints. Our tools to drive commercialisation and technology transfer consist of marketing mechanism development to engage new customers and those existing ones. It begins by listening to the customers, using business matching, providing technology transfer and after-sales service. In addition, TISTR has driven the main mission of transferring technology into utilisation both commercially and socially by using proactive and passive marketing communication channels, intellectual property management system, business administrative system to work with marketing networks and financial partners. TISTR also helps develop entrepreneurship on local and area-based innovation and community enterprise (OTOP), and works on S&T to support the needs of area-based problems and provincial strategic plans. Moreover, the employees of TISTR understand their roles and duties to treat customers aligning with the standards organisation at all contact points (Touch Points) of business.

Research Highlight

1. BCG policy

TISTR successfully developed STI and collaborated with big firms, agricultural sector and local communities, in order to build a growth of agro-industrial sector, food, medical and energy development, enhance national economic, increase GDP, distribute incomes to communities, strengthen communities, and to be environmentally-friendly, for examples:

- Development of biotechnological production processes, such as sugar innovation products to control and balance sugar levels. TISTR has transferred technology of 'Palatyne Sugar' production to Rajburi Sugar Co., Ltd., with a capacity of 60 tons per year, economic value at 10 million baht per year. An export business plan will be launched in the near future.

- Development of local herbs. TISTR tested the quality and efficacy of the herbs to support community enterprises in Nan pro-vince, enabling them to produce herbal extracts and supply to Lion Corporation (Thailand) Limited. The company used the extracts to produce 'Triphala Toothpaste' which is highly effective in oral and dental health care. It has market values at 50 million baht per year. Triphala herb has also been developed into hair care products. Besides, other unique herbs such as *Litsea glutinosa* (Lour.), and *Clausena wampi* (Blanco) or wampee were also considered to be developed into various health products.

- Development of biomethanol from wastes. TISTR aims to develop biomethanol from waste for the further development of the first biomethanol pilot plant in Thailand. This is to reduce the import of biomethanol from abroad by 100 percent. BLCP Power Limited is TISTR's business partner that has a plan to bring this research outcomes into domestic and international commercialisation.

- Development of microbial pesticides. TISTR developed and transferred the technology of microbial pesticides which were environmentally friendly as there were no toxic residues and reduced carbon dioxide emissions. It also reduced the amount of chemical imports from abroad. Production technology of microbial pesticides was initially transferred to farmers in the western central region – Kanchanaburi, Suphan Buri, Nakhon Pathom, and Ayutthaya. This could

reduce agricultural costs up to 172.5 million baht and reduce the import of agricultural chemicals by 241.5 million baht.

- Municipal waste management and value creation from waste for recycling under the Circular Economy (CE) principle covering the 4 regions of Thailand, namely Saraburi, Chonburi, Chiang Rai and Nong Khai. 'Tan Diao Model', located at Tan Diao Sub district, Kaeng Khoi District, Saraburi province, was a demonstration plant for municipal waste and environmental-problem solving in the local community for its integrated sustainability. It successfully created income to local authorities of more than 10,000,000 baht per year and was ready for technology transfer to other provinces in Thailand.

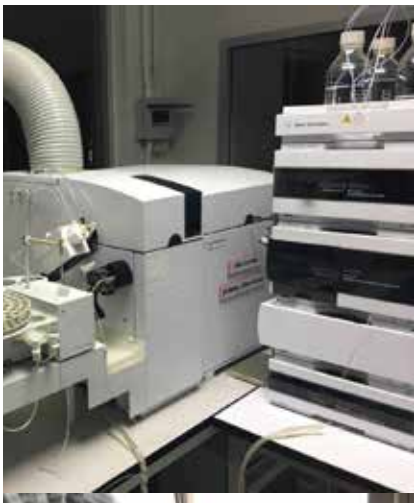
- Development of the local economy of ornamental plants. TISTR launched a pilot project in Loei province by gathering 124 entrepreneurs into the clusters and increasing farmers' income calculated into economic values at 90 million baht. Besides, those entrepreneurs have collaborated with public and private sectors in Loei province and have established 'Malai Wittaya Sathan Model' to provide technical knowledge in planting, local economic development, natural tourist and cultural attractions, including ornament plant and its product market.

2. Anesthetic product from *Acmella oleracea* extract

TISTR by Expert Centre of Innovative Herbal Products (InnoHerb) successfully conducted research and development of clear gel product from *Acmella oleracea* extract of 'AcAnes', applying externally for anesthetic. It passed the safety assessment on laboratory animals. It is safe to numb sensation in certain areas of the body. It can be used as a substitute for internal anesthetic drugs (or injections) which cause different side effects and complications to the users. This external anesthetic gel product from *Acmella oleracea* extract can reduce side effects from injections and can be used for patients who are afraid of injections, such those who need minor cosmetic surgery (ticking warts, moles or freckles) or children who need to have injections or vaccines.

3. Green packaging prototypes from bagasse for safety food delivery to patients in hospitals

- TISTR by Thai Packaging Centre developed green packaging prototypes from bagasse for safety food delivery to patients in hospitals under green packaging concepts. It is clean and hygienic, compact in size, suitable to serve, light-weighted, easy to transport and degradable in nature. It provides alternative ways to reduce plastic waste, food waste, water usage and wastewater, and is flexible in use, as it can be used to contain all kinds of foods, and can be applied for ready-to-eat food containers or commercial catering.



4. Laboratory to extract, test and analyse cannabis/hemp for medical usages

TISTR responds to the government's urgent policy to allow cannabis/hemp usages for medical purposes in order to build medical security of the nation and prevent monopoly on medicine as well as to promote local economic crop. TISTR, as one of the national research institutes under MHESI, specialised in testing and analysing medical plant properties, research and development of new health products from herb extract has establishes a laboratory for extraction services, study and test of efficacy and safety usages of cannabis/hemp extract for medical purposes. The laboratory studied and tested 5 sample types of cannabis/hemp which were: cannabis plants, Thai pharmacopeia, cannabis extract, cannabidiol (CBD) oil and products from CBD oil, under the ISO 17025 standard.

Highlight Activities in 2021

TISTR Research Showcase on Driving BCG Model: The New Sustainable Growth Engine at Royal Thai Government House

H.E. General Prayut Chan-o-cha, Prime Minister of the Kingdom of Thailand, and Cabinet visited TISTR's exhibition on BCG in Action: The New Sustainable Growth Engine for national sustainable development, held on 9 February 2021 at Royal Thai Government House. In this event, Prof. Dr. Anek Laothamatas, Minister of Higher Education, Science, Research and Innovation (MHESI), Prof. Sirirurg Songsivilai, M.D., Ph.D., Permanent Secretary of MHESI, Mr. Samran Rodpetch, Adviser to Minister of Higher Education, Science, Research and Innovation (MHESI), Dr. Chutima Eamchotchawalit, Governor of TISTR, and Mr. Sayan Tanpanich, Deputy Governor Research & Development Group for Bio-industries welcomed and gave a presentation on BCG's works to the Prime Minister. Consequently, Thai entrepreneurs who receive technology transfer and commercialise TISTR's work, such as Rajburi Sugar Co., Ltd., BLCP Power Limited, and Lion Corporation (Thailand) Limited, attended the event to showcase the BCG model's concrete adoption through the integration of public and private operations to lead to Thailand's sustainable development.

The Minister of MHESI visited Lamtakong Research Station (LTRS) and Sakaerat Environmental Research Station (SERS) in Nakhon Ratchasima

Prof. Dr. Anek Laothamatas, Minister of Higher Education, Science, Research, and Innovation (MHESI), and a delegation visited Nakhon Ratchasima province on November 8, 2020, to follow up on TISTR's operations, which included the Lamtakong Research Station (LTRS) and the Sakaerat Environmental Research Station (SERS). In this connection, the Minister of MHESI witnessed the signing of an agreement for academic cooperation in space technology and geoinformatics between Dr. Chutima Eamchotchawalit, Governor of TISTR, and Mr. Pakorn Apaphant, Executive Director, Geo-Informatics and Space Technology Development Agency (GISTDA). The goals of the collaboration are to provide knowledge and enhance careers in academic work, as well as to be a reference source for both national and worldwide academic works.

Prof. Dr. Anek Laothamatas, Minister of MHESI, followed Up on TISTR's Research Operation in Krabi, Thailand, in accordance with the BCG Model

On 2 November 2020, Prof. Dr. Anek Laothamatas, Minister of Higher Education, Science, Research, and Innovation (MHESI), and a delegation visited Sri Phong Farm, Goat Farming Demonstration, Krabi Provincial Education Council, Ban Namjaan Krabi Noi, Mueang Krabi District, Krabi, to track TISTR implementation of integrating research on technology, science, and innovation to drive entrepreneurship and goat farming communities in Krabi. Dr. Chutima Eamchotchawalit, Governor of TISTR presented TISTR's research results derived from local raw materials in the southern region and developed into creative innovations using the BCG Model such as goat hair perfumes, goat milk cosmetics, cosmetics from saline hot spring, production process design and improvement for commercial pasteurised

goat milk beverages, cultivation of Bamboo mushroom (Phallus indusiatus I) in plantations, probiotics for livestock, and identity fruit processing in Southern Economic Corridor: SEC.

Participating workshop on "Innovation for Thai Society, Modern Youth Leadership Roles to the Good Thai"

Prof. Dr. Anek Laothamatas, Minister of MHESI presided over the opening ceremony and special lectured on the concept of community development work with student roles in the workshop "Innovation for Thai Society, Modern Youth Leadership Roles to the Good Thai", held on 5 November 2020 at National Science Museum, Khlong Ha, Pathum Thani. On this occasion, Dr. Chutima Eamchotchawalit, Governor of TISTR, participated in a special talk on the roles and missions of TISTR in leading science, technology, and innovation and strengthening entrepreneurs and industry capacities to drive sustainable economic growth.

TISTR Exhibition on "TISTR BCG ... Being the Better Life"

TISTR jointly organised Thailand National Science and Technology Fair 2020 during 13 – 23 November 2020 at Challenger Hall 2, IMPACT Exhibition and Convention Center, Muang Thong Thani. At the event, TISTR showed an exhibition on "TISTR BCG ... Being the better life" to educate youth with science knowledge, technology, and innovation through research and development on the Circular Economy from beginning to end, resulting in economic value added for the country's long-term prosperity.

Driving Local Economy with TISTR Shared Service "Nan Identity Development, Sustainable Creation of Shared Values"

Prof. Dr. Anek Laothamatas, Minister of MHESI, and Prof. Sirirurg Songsivilai, M.D., Ph.D., Permanent Secretary of MHESI, along with a delegation, visited Nan province on 2 December 2020 to follow up on TISTR's work progress on Shared Service "Nan Identity Development, Sustainable Creation of Shared Values'' at Local Enterprise, Nam Kian, Phu Phiang District, Nan. On this occasion, the Minister officially opened the "Nan Pun Suk'' building as well as TISTR's shared service "Community level herbal extraction machine." Dr. Chutima Eamchotchawalit, Governor of TISTR, Mr. Viboon Weawbundit, Deputy Governor of Nan province, and Mr. Banthoon Lamsam, Co-Chairman of Nan Provincial Area Operations Committee, welcomed and presented the success of bringing Science, Technology, and Innovation (STI) to add value and strengthen local communities and SMEs in Nan and surrounding areas at the event.

MoU Signing between TISTR and Nabha Foundation, Suratthani Rajabhat University, Udon Thani Rajabhat University

Prof. Dr. Anek Laothamatas, Minister of MHESI together with Asst. Prof. Dr. Duangrit Benjathikul Chairungrueng, Secretary to the MHESI engaged in honoring and witnessing the signing of a memoradum of collaboration to promote research studies and commercial development based on Thai herbal plant extracts among Mr. Eakkapop Dechkriangkraisorn, Vice Chairman of Nabha Foundation, Dr. Chutima Eamchotchawalit, Governor of TISTR, Dr. Pathom Sawan-panyalert. M.D., Director General of Department of Science Service (DSS), Asst. Prof. Dr. Wattana Ratanaprom, Acting for the President Suratthani Rajabhat University and Prof. Charoon Thawornchak, President of Udon Thani Rajabhat University. The three-

year agreement aims to employ local resources to add value to unique products. The ceremony took place on 9 March 2021 at the Ministry of Higher Education, Science, Research and Innovation (MHESI).

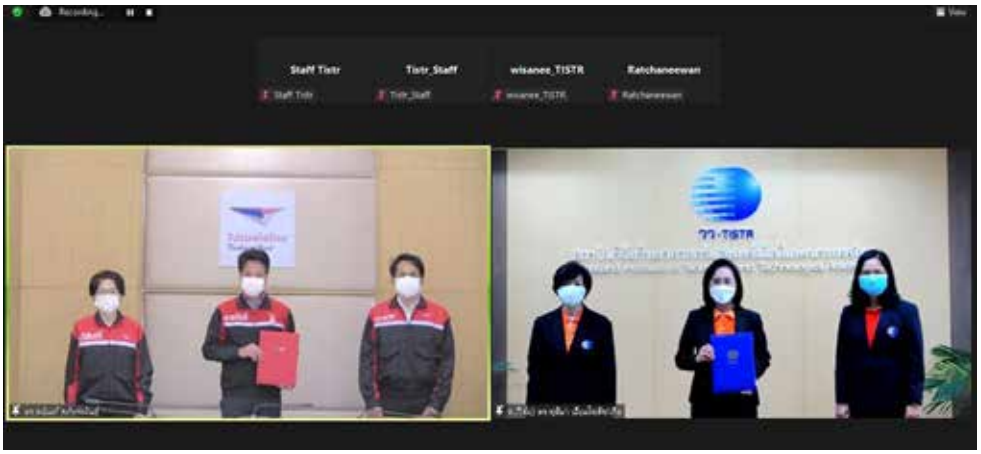
TISTR in Cooperation with 'Dow Group Thailand' on Solving the Plastic Waste Problem with Science Technology and Innovation

On 8 September 2021, Dr. Chutima Eamchotchawalit, Governor of TISTR and Mr. Chatchai Luanpolcharoenchai, President of Dow Thailand & Managing Director of SCG-Dow Group signed the Memorandum of Understanding via Video Conference System under the project "Science, Technology and Innovation Leads to Sustainable Development of Plastic Waste Quality in Communities". The collaboration seeks to establish a model of the "Waste Sorting Hub" by communities in the Eastern area and to expand the results to communities across the country to drive the country's BCG strategy by managing plastic waste in the community and the environment in a sustainable way.

Workshop on Liquid Biomass Expansion Using a Basic Fermentation Tank

On 1 April 2021, Advisor to the MHESI Minister Assoc. Prof. Dr. Jak Punchoopet, presided over the opening ceremony of Workshop on "Liquid Biomass Expansion Using a Basic Fermentation Tank" and handed over microbial fermentation tank to Sustainable Tung Thong Organic Farming Community Enterprise. The workshop was jointly organised by TISTR and Plant Protection Service Group, Suphanburi Provincial Agricultural Extension Office, Department of Agriculture Extension at Sustainable Tung Thong Organic Farming Community Enterprise, Chorakhe Sam PhanU Thong District, Suphan Buri.

TISTR and Thailand Post Collaboration in Raising Packaging Standards to Serve the Needs of E-commerce Businesses.



Asst. Prof. Dr. Ake Pattaratanakun, Capital Management Committee, TISTR and Thailand Post Committee presided over the signing ceremony between Dr. Chutima Eamchotchawalit, Governor of TISTR and Dr.Dhanant Subhadrabandhu, Managing Director of Thailand Post through the video conference. The partnership proposes studying, researching, and developing new packaging for use in all types of shipping via Thailand Post channels that is sturdy, durable, meets specifications, and prevents product damage. Furthermore, the expected goals were to lower costs and create customer trust to support existing and future e-commerce firms, as well as to improve and expand distribution channels for OTOP entrepreneurs, community enterprises, and SMEs to function in a COVID-19 crisis situation. The Memorandum of Understanding was signed on August 8, 2021, for a period of two years.

Seminar on "Study the Past, Learn the Present, and Fight COVID-19 with Thai Science"

Prof. Dr. Anek Laothamatas, Minister of MHESI, presided over a seminar organised by the Department of Science Service (DSS), titled "Study the Past, Learn the Present, and Prepare for the Future with Thai Science to Fight COVID-19". A special lecture on "Learning History to Build the Future" was given by Asst.Prof. Dr. Predee Phisphumvidhi of Mahidol University. Furthermore, Dr. Chutima Eamchotchawalit, Governor of TISTR, took part in a special talk titled "Study the Past, Learn the Present, and Fight COVID-19 with Thai Science" with Dr. Pathom Sawanpanyalert, M.D., Director General of the Department of Science Service (DSS), and Dr. Narong Sirilertworakul, President of the National Science and Technology Development Agency (NSTDA). The event was held on August 26, 2020, at the Minister of Higher Education,Science,Research,andInnovation(MHESI).

Achievement Awards in 2021

State-Owned Enterprise (SOE) Award 2020

H.E. General Prayut Chan-o-cha, Prime Minister of the Kingdom of Thailand, presided over the ceremony of State-Owned Enterprise Award 2020, and presented the "Outstanding Development Cooperation Award" to Dr. Chutima Eamchotchawalit, Governor of TISTR. This award is a cooperation award for outstanding development in the field of strategic cooperation, which is a cooperation between TISTR, Bank for Agriculture and Agricultural Cooperatives (BAAC) and the Export-Import Bank of Thailand (EXIM Bank). The event was held on 16 November 2020 at Santi Maitree Building, Government House of Thailand.

Public Sector Excellence Awards

TISTR received 3 awards of PSEA presented by Mr. Wissanu Krea-ngam, Deputy Prime Minister to Dr. Chutima Eamchotchawalit, Governor of TISTR on 16 September 2021 via Zoom video conferencing as follows:

- Government Service Award in the category of "Service Innovation Award", Outstanding class, from the project of Tan Diao Model – from waste to energy and income earning for sustainable community.

- Government Service Award in the category of "Service Development", Outstanding class, from Innovative Center for Production of Industrially used microorganisms (ICPIM).

- Government Service Award in the category of "Service Development", Good class, from the project innovation for productivity increase and value addition of banana (Kluai Khai) for agro-economic development.

Human Rights Award 2021

Mr. Somsak Thepsutin, Minister of Justice presented the Human Rights Award 2021 hosted by the Rights and Liberties Protection Department, Ministry of Justice, to Dr. Chutima Eamchotchawalit, Governor of TISTR via Zoom video conferencing on 29 September 2021.

Green Office Award 2020

TISTR receviced 3 awards of Green Office Award 2020 presented by the Department of Environmental Quality Promotion (DEQP), Ministry of Natural Resources and Environment (MNRE).

- The trophy of G-Green at Excellent Level (Gold Level) was given to Algal Excellent Centre (ALEC)

- The trophy of G-Green at Very Good Level (Silver Level) was given to Admin Building at TISTR Technopolis, and Industrial Metrology and Testing Service Centre (MTC)

Thailand Energy Awards 2020

TISTR won Thailand Energy Award 2020 for promotion of energy conservation and renewable energy, in the category of associations, organisations, and government agencies. The Award was provided by the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy.

Award of Honor in Excellent Certification Body for Agricultural Products and Food in 2021

TISTR by the Office of Certification Body (OCB) won an Award of Honour in Excellent Certification Body for Agricultural Products and Food of the year 2021 from National Bureau of Agricultural Commodity and Food Standards.

Accreditation of TISTR Laboratories on International Standards

- TISTR by the Soil, Fertiliser, and Plant Analysis Laboratory (SFP Lab) of Expert Centre of Innovative Agriculture (InnoAg) was audited by the Bureau of Laboratory Accreditation, Department of Science Service (BLADSS) in the scope of soil pH and electrical conductivity.

- TISTR by its Expert Centre of Innovative Herbal Products (InnoHerb) received Certificate of Compliance to OECD Principles of GLP for toxicity testing provided by the Department of Medical Sciences, Ministry of Public Health.

Governor of TISTR received Certificate and Academic Pin of "Research Professor"

Prof. Dr. Anek Laothamatas, Minister of Higher Education, Science, Research and Innovation presided over the Hand-over Ceremony of Certificate and Academic Pin to Dr. Chutima Eamchotchawalit, Governor of TISTR in her appointment as "Research Professor" of Rajamangala University of Technology Phra Nakhon (RMUTP) on 18 January 2021 at Faculty of Industrial Education, RMUTP.

Governor of TISTR was appointed as Chairperson of State Enterprise Society

Dr. Chutima Eamchotchawalit was elected by the representatives of 51 state enterprises, members, and advisors, to be Chairperson of State Enterprise Society to drive actions on Corporate Social Responsibility (CSR) on 14 October 2020.

Governor of TISTR received Outstanding Thai Government Scholarship Student 2021

Dr. Chutima Eamchotchawalit received Outstanding Thai Government Scholarship Student 2021 presented by Associations of Thai Government Scholarship Student on 30 September 2021.

Awards of Academic Achievement

Dr. Siriporn Larpkiattaworn, Director of Expert Centre of Innovative Materials (InnoMat) and her team received award from WAITRO Innovation Award 2020 on the project titled "COVID-19 Challenge : Phytotechnologies to clean water in small community" by the selection of Scientific Advisory Board of WAITRO.

Dr. Rujira Deewattanawong, Expert Centre of Innovative Agriculture received funding granted by the 26th Science and Technology Research Grant, Thailand Toray Science Foundation (TTSF) on research area of agriculture & biology. Her topic was "Interaction of Arbuscular Mycorrhizal Fungi and Trichoderma in Controlling Root Rot and Stem Rot of Durian Trees".

Dr. Witchapong Sochu, Railway Transportation System Testing Centre (RTTC) won Runner-up of Best Paper Award on the article entitled "Resonant Frequency and Modal Analysis of Rail Clip" at the 35th Conference of the Mechanical Engineering Network of Thailand 2021 (ME-NETT 2021).

Dr. Yoothana Thanmongkhon, Senior Research Officer, and the team of Expert Centre of Innovative Clean Energy and Environment (InnoEn) received Best Speaker Award on the topic of High Quality Solid Biofuel from Woody Biomass using Torrefaction Technique during the Forestry Conference 2021.

Dr. Sujitra Kosol and research team of Expert Centre of Innovative Clean Energy and Environment (InnoEn) in cooperation with Maejo University Phrae Campus achieved the Best Oral Presentation Award in the given topic of Integrated-Forest Plantation Model for Food Security and Sustainably Household Economic Development, at the 10th Thai Forest Ecological Research Network Conference at Maejo University Phrae Campus.

The Product of Expert Centre of Innovative Health Food (InnoFood) and Expert Centre of Innovative Agriculture (InnoAg) namely 'Lady Finger Banana Juice' was the winner of the Contest of Knowledge-Based OTOP : KBO in year 2021 hosted by Community Development.

Probiotic Herbal Tea, the product of research and development project on innovative functional products "Pro-Herb" by Dr. Prapaipat Klungsupya, research expert of TISTR, to control diabetes and high blood pressure of the aging population was the Healthy Drink Award Winner of Food Ingredients Asia 2021.

Flagship Projects

1. Project on the Bio-Circular-Green (BCG) for Central-Western Economic Corridor

TISTR has implemented the Project on Bio-Circular-Green (BCG) for Central-Western Economic Corridor, which aims to mitigate and recover the economy and society from the impact of COVID-19 situation. The Coronavirus has affected people's daily lives and employment, especially in the agricultural sector. With the ready-to-use agricultural technology and innovation, TISTR is prompt to transfer the appropriate technology for commercialisation purposes, as well as supports the expansion of industrial production by utilising the complete infrastructure. For example, the Food Innovation Service Plant (FISP) is a food and beverage production plant, which is well equipped with the latest technological machines. It has received the certification and approval from the Thai Food and Drug Administration (Thai FDA) in the production of food products.

As a result of the project implementation, TISTR obtained to upgrade the smart process of agricultural crops, increase production capacity, reduced costs of production, and mitigated environmental impact for 58 farmers, with 5 production technologies, and 6 agricultural inputs transferred. The production inputs created value addition to agricultural products along the production chain according to the BCG model for 190 farmers, 6 R&D entrepreneurs. For these target groups, processed product prototypes, and developed 2 environmentally-friendly prototypes were developed. The success of the project generated the total economic impact of 98.0248 million baht, which was a result from a decrease of production cost of 8.9173 million baht, an increase of investment of 4.4332 million baht, an increase of domestic income of 64.3814 million baht, profit generation of 0.7949 million baht, and the value of knowledge dissemination of 19.4979 million baht.

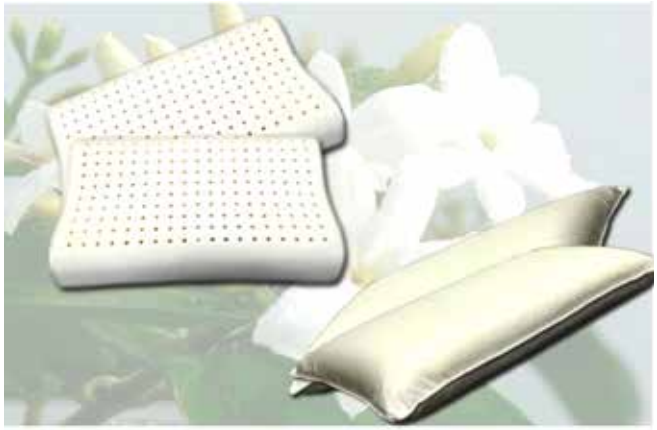
2. Project on the Excellence Centre of Probiotics and Microorganism Production for Food Industry

TISTR recognised the urgency of economic and social recovery from the effects of COVID-19 situation. Therefore, it implemented the Project on the Excellence Centre of Probiotics and Microorganism Production for the Food Industry that effectively met the needs of manufacturers and simultaneously fulfilled the demands of consumers. The ready-to-use technology was applied to create the opportunities and strengthen the country's competitiveness in the ASEAN region in the field of biotechnology, and innovation; such as, probiotics, prebio-tics, synbiotics, and intellectual property protection. The Innovative Centre for Production of Industrially used Microorganisms (ICPIM) has been firstly established in Thailand with specialised expertise in the comprehensive technologies for probiotics and microorganism production used in the food industry. ICPIM possesses 12 probiotic strains from a total of 24 strains that have been approved according to the standards of the Thai Food and Drug Administration (Thai FDA). It also has a semi-industrial (25,000 liters/year) microbial production system that is a complete production line for probiotics and microorganisms in the food industry. As a result of the project, there were 41 entrepreneurs who gained the benefits of TISTR's microbial technology and innovation, 42 people were employed to work in the project and upskilled and reskilled programmes. The success of the project created the GDP value of 166.8668 million baht from a decrease in the import of probiotics and microorganisms equaled to 0.0707 million baht, an additional investment of 6.1285 million baht, an increase in domestic income of 146.7155 million baht, and an increase in export income of 13.9521 million baht.

3. Project on the Circular, Bio-based Innovative Materials for Healthcare

The Expert Centre of Innovative Materials (InnoMat) under TISTR enhanced the ability to further apply research results into innovative products, which were the concrete outputs from the laboratory to product commercialisation in order to create value-added, innovative materials for entrepreneurs who are interested in producing innovative products for health. The InnoMat is a learning centre for training, dissemination of production knowledge, and technology transfer. Moreover, it promotes the access to infrastructure for production trials in order to build technology and market confidence before the expansion of commercial production. Its infrastructure has been improved, aiming to upgrade and add value to innovative products for healthcare, which were made from bio-based and renewable materials in order to maximise the use of natural resources and agricultural waste. The infrastructure development would be beneficial in terms of providing research, development, and service.

In 2021, the InnoMat focused on the preparation of research related to materials for healthcare at the la-boratory level, development of 3 innovative material product prototypes for healthcare, training, dissemination of production knowledge, and technology transfer on production process, product development, reduction of production cost, and value creation to material products for healthcare. The project could create an economic and social impact value of 29.4225 million baht. The infrastructure consisting of a production section at the factory level has continuously improved in order to support training and transfer of science, technology, and innovation, promote the production, as well as build a network of entrepreneurs in the year 2024 onwards.



4. Project on the Potential Promotion of One-stop Packaging Service to Upgrade Small and Medium Enterprises (SMEs)

The Thai Packaging Centre (TPC) under TISTR implemented the project and focused on packaging design to help promote product sales and market expansion, eliminate the obstacles on a lack of science, technology and innovation data, stimulate the investment in infrastructure for material and/or packaging testing and analysis services, and product shelf-life assessment. The project helped build confidence in product quality and safety along with the packaging design that was beautiful and attractive, and enhanced the product image.

The project results represented the development of packaging structures and graphics by presenting three packaging development guidelines per product to 30 entrepreneurs, online and offline training courses to search for Brand DNA in terms of marketing and design under the topic "BRAND DNA ADVANCE New Normal", and knowledge dissemination for 340 entrepreneurs. Moreover, the project could create significant economic and social impacts of 144.9524 million baht. The SMEs had an increase in income earning of 271.88%. There was an increase in export value from packaging development or packaging testing of 18.74 million baht with higher employment of 7 persons/year. The entrepreneurs had a 100% lower cost of production from the proper selection of packaging. In addition, the project contributed to an increase of choices and reduction of the testing time by 50 percent for entrepreneurs.

5. Project on the Development of Ornamental Plant and Flower Clusters to enhance the Small Medium Enterprises (SMEs) Competitiveness

TISTR together with the networks from government and private sectors; such as, the Department of Agricultural Extension, Department of Agriculture, Provincial Commercial Office, and universities under the research funding sponsorship by the Office of SMEs Promotion (OSMEP), have carried out the flowering and ornamental plant cluster development activity under the project on support and development of SME clusters in 2021. The objective of the project was to promote the collaboration and connection among SMEs, ranging from farmers to targeted clusters that would meet the market demand throughout the production chain. Furthermore, the project emphasised on the comprehensive ornamental plant development, for instance, breeding and cultivation system based on the principle of sufficiency Economy, application of technology and innovation to improve production process, product quality standard, management system, and creative product and service design, as well as the Micro-SMEs (MSMEs) development in order to create value addition to products and services, increase the competitiveness, and create a cluster development plan to be used as the work guidelines for future cluster operations.

The development of flowering and ornamental plant SMEs clusters has been operated since 2020 in Chiang Mai, Loei, and Nakhon Ratchasima provinces. Additionally, it has expanded the new cluster areas into a full development and network in 2021 in Suphan Buri, Nakhon Nayok, Bangkok and its vicinity. The success of a pilot project in Loei province helped more than 885 entrepreneurs to increase their incomes and created an economic value of 90 million baht per year. TISTR in cooperation with both public and private sectors in Loei province, have established the Malai Wittaya Sathan Model to strengthen local economy for flower and ornamental community with the utilisation of innovative agriculture. This project has benefits in development of bioeconomy, natural and cultural tourism attractions, together with flower markets and products.

Research and Development Projects Completed in Fiscal Year 2021

Thailand Institute of Scientific and Technological Research (TISTR) has its mission to conducts research and development following the new economic model "BCG" and the Sufficiency Economy Philosophy which focuses on inclusive growth and will not leave anyone behind in order to move towards sustainable development of the country. The BCG model consists of Bio economy – focusing on efficient use of resources, Circular economy – maximising reuse of materials and Green economy – focusing on pollution problem solutions. In fiscal year 2021, there were 33 research and development projects completed by the Innovative Expert Centres, namely, Biodiversity Research Centre (BRC), Thai Packaging Centre (TPC) and Railway Transportation System Testing Centre (RTTC) as follows:

1) Expert Centre of Innovative Agriculture (InnoAg)

InnoAg aims for excellence in community agro-culture technology, integration with R&D, technology and innovation, according to actual problems of the country for both social and commercial use, as well as, technology transfer and infrastructural development for providing service to economic and social sectors. InnoAgr has the expertise in organic agriculture, R&D and cultivation, promotion herb, indigenous plants and new economical plants, strain improvement of mushroom, factors on plant production, biocontrol fertiliser technology, microorganisms and bio-products for agriculture, post-harvest technology, plant improvement and tissue culture, plant genetic conservation, and plant protection. In fiscal year 2021, there were 2 completed projects as follows:

1.1 Research and development on the production of Hom Thong banana seedlings to reduce genetic variation from tissue culture.

1.2 Research and development on post-harvest technology of Hom Thong banana and curing chamber by visual control system.

2) Expert Centre of Innovative Health Food (InnoFood)

InnoFood focuses on research and development for adding value to domestic raw materials, functional food and dietary supplement. InnoFood aims to create a complete range of health food innovations and healthy food products as well as to develop infrastructure to help entrepreneurs improve their products for a commercial purpose and gain competitiveness in the world market. InnoFood specialises in food and beverage products, functional food supplements, essential substances in natural food, and design of machine tools for food production. In fiscal year 2021, there were 8 completed projects as follows:

2.1 Research and development of technology for producing peptide hydrolysate from rice bran as a natural preservative for the food industry

2.2 Research and development of food products from peptide hydrolysate in rice bran for exercisers

2.3 Development of technology for producing peptide hydrolysate from rice bran at the pilot plant scale

2.4 Research and development of sugarcane wax for dental purposes

2.5 Enhancing activities on bone formation and bone resorption of bioactive polysaccharides and glycosides in plants

2.6 Research and development of probiotic products for people with irritable bowel syndrome

2.7 Research and development of relaxation snacks for the elderly

2.8 Technology transfer on processing for value adding of local fruits and vegetables in 5 provinces of the southern regional area

3) Expert Centre of Innovative Herbal Products (InnoHerb)

InnoHerb focuses on expertise in cosmeceutical and herbal medicinal products in order to be an internationally recognised centre for integrating research and development services and being able to create innovations for comprehensive herbal health products. In addition, the centre conducts further research to add value to products and help entrepreneurs to commercial production. InnoHerb has expertise in extraction technology of active natural substances and studies their pharmacological and toxicological effects. In fiscal year 2021, there are 9 projects as follows:

3.1 Research and development on health strengthening products from important substances in Inca peanut (*Sacha inchi*)

3.2 Research and development of herbal dietary supplements for the relief of acid reflux and infectious esophagitis

3.3 Research and development of herbal dietary supplements to reduce uric acid levels in patients with gout

3.4 Research and development of herbal products to balance emotions and relieve depression for people in a self-reliant society

3.5 Research and development on innovative functional products from probiotics for skin health and beauty for the pre-elderly population

3.6 Research and development of innovative functional products "Pro-Herb" for the control of diabetes and hypertension in the pre-elderly population

3.7 Research and development on cosmetic products from low-grade Hom Thong banana and waste of banana processing process

3.8 Thai cosmetopoeia

3.9 Potential and standard development of cosmetics manufacturing facilities in accordance with ASEAN Guidelines for good manufacturing practice of cosmetics (ASEAN cosmetic GMP)

4) Expert Centre of Innovative Clean Energy and Environment (InnoEn)

InnoEn focuses on excellence in renewable energy and environmental management to create a sustainable green economy and society of the country by developing infrastructure as well as transferring knowledge and innovative technologies. InnoEn specialises in clean energy from biomass, environmental management and energy-related resources, climate change, biodiversity, and measures in terms of carbon footprint and water footprint.

In fiscal year 2021, there were 2 completed projects as follows:

4.1 Cassava waste pretreatment technology for cellulosic ethanol production

4.2 Integration processes of biogas production from high sludge and anaerobic phased solids (APS) to develop and support biomass power generation demonstration centre

5) Biodiversity Research Centre (BRC)

BRC is the centre for collecting, conserving and conducting research on the sustainable utilisation of bioresources to enhance the country's bio-industry and bio-economy capabilities at the regional and global levels. BRC specialises in collecting, maintaining and managing databases of biological resources including microbial, plant and animal species. It also focuses on research and development of science, technology and innovations in biological substances and bio-based products.

In fiscal year 2021, there were 8 completed projects as follows:

5.1 Research and development on polysaccharide production for healing skin wounds and pressure ulcers in the early stage

5.2 Research and development on polyunsaturated fatty acids from marine microalgae to promote the growth and survival rates of larval shrimp

5.3 Research and Development on carotenoids from marine microalgae to enhance the growth and survival rates of white shrimp larvae

5.4 Research and development on ß-glucan supplement products from microalgae to enhance the growth and survival rates of aquatic animals

5.5 Research and development on phycocyanin products from blue green algae as high-value ingredients

in aquatic animal feed

5.6 Research and development on carboxymethyl cellulose (CMC) biopolymers production from sugarcane bagasse for the food industry

5.7 Research and development of innovative functional products from probiotics to enhance immunity for pre-elderly population

5.8 Research and development on the use of probiotic yeast to enhance health, feed efficiency and growth for heat-stressed calves

6) Thai Packaging Centre (TPC)

TPC is the national agency in a complete range of packaging technology that complies with international standards. TPC provides services to help maintain product quality, reduce product loss due to poor packaging. The centre also helps develop packaging products that can increase the value of the product and the efficiency of exports. TPC has the expertise in packaging development and packaging testing.

In fiscal year 2021, there were 3 completed projects as follows:

6.1 Research and development of easy-to-open packaging for dietary supplements and rejuvenating products for skin wounds and pressure ulcers

6.2 Research development on fresh Hom Thong banana packaging and chain products

6.3 Project on strengthening capability in a complete range of packaging services for leveraging small and medium enterprises (SMEs)

7) Railway Transportation System Testing Centre (RTTC)

RTTC is the national central agency for testing, certifying, and developing product and technology standards for transport operators covering both rail and land transport connections. RTTC provides services in compliance to transport authorities and international standards, ensuring rail system quality and increasing operational safety while also reducing the risks and losses from lower standard rail systems. In addition, the centre also contributes to the promotion and development of domestic entrepreneurs in order to produce standard rails by developing rail equipment and technology in accordance with the needs and context of the country as well as providing knowledge on rail technology to the general public.

In fiscal year 2021, a project completed was the is testing and analysis services on safety standards of transportation systems.

Patents and Petty Patents

Note: TISTR's patents and petty patents are domestically registered in Thailand; therefore some items are not identified in foreign languages when applying for registration. However, only specialised terms or technical terms are mentioned in foreign languages by the applicants.

1. Patents-25 items	
No	Title
1.	Infrared radiation reflective dye pigments from laterite soil
2.	2-piece odor lock box
3.	Odor lock box (CS2)
4.	Odor lock box (CS1)
5.	Track and Trace box (TP2)
6.	Track and Trace box (TP1)
7.	Grip opener Globe Type
8.	Grip opener Type 5
9.	Grip opener Type 4
10	Grip opener Type 3
11.	Grip opener Type 2
12.	Lid of odor lock box
13.	Three-stage methanol production process from hydrogen or methane or glycerol in combination with power plant waste gas
14.	Carbon dioxide concentration from coal power plant emissions with multistage adsorption process for methanol production
15.	Modified dental implant containing sugarcane wax
16.	Tree packing box
17.	Biomass charcoal briquetting machine
18.	Ethylene gas incubation chamber using visual control
19.	Ethanol Productivity Enhancement Method for High Concentration Fermentation
20.	Biomethanol production process using waste carbon dioxide from the biogas power generation process
21.	PM 2.5 dust meter: direction identification and information collection with IoT
22.	Silicon carbide nanowire synthesis (SIC) process coated on biochar

23.	Registered plant species: Magnolia family/ *Magnolia liliifera* x *Magnolia x alba* (DC.) Figlar "Champi Srimontha" species
24.	Registered plant species: *Ficus microcarpa* L.f. / Sai TISTR 1
25.	Registered plant species: *Mitrephora*/ Phrom TISTR 13

2. Petty patents - 41 items

No	Title
1.	Formula and production process of probiotic dip products
2.	Production process of fermented vinegar and ready-to-drink fermented vinegar from Takraw (*Schleichera oleosa* (Lour.) Merr)
3.	Formula and production process for bio-based polymer nanocapsules
4.	Formula and production process of encapsulated metal oxide particles in polymer capsules by suspension polymerisation synthesis
5.	Process of preparing the Cuprous oxide film and the development of photoelectrocatalytic cells to produce hydrogen gas and remove the dye at the same time
6.	Magnesium potassium phosphate slow dissolving fertiliser and production process
7.	Magnesium ammonium phosphate and production process
8.	Formula of perfumes and fragrance products from goat hair extract
9.	Concrete block from expanded clay pellets
10.	Multi-channel liquid dispenser with nitrogen gas pressure system of separate containers
11.	Bamboo splitting machine (Thin type)
12.	Longkong (*Lansium parasiticum*) juicer with seed separator
13.	Serum formula from Dahlia flower extract and production process
14.	Cultivation of *Thalassiosira* sp. in water tanks for the production of polyunsaturated fatty acids
15.	Formula and production process of concentrated cocoa mixed with extracts of Chayote (*Sechium edule*) and Kohlrabi (*Brassica oleracea*)
16.	Sugar-free pudding recipe from Bengal Currant and Indian gooseberry extract and production process
17.	Process of extracting and separating important chemical constituents from Chiang Da (*Gymnema inodorum* (Lour.) Decne) herbal tea that has properties to inhibit the synthesis of intracellular lipids
18.	Formula and production process of water hyacinth control agent from medicinal plants by spray drying technique for water hyacinth removal

19	Automatic ultrasonic and ozone fruit and vegetable washing machine
20.	Process of increasing the stability of Astaxanthin with microemulsion technology as an active ingredient in inhibiting melanin production
21.	Single process for producing carotenoid pigments from *Coelastrum* algae
22.	Recipes and methods for utilising fermented pig placenta
23.	Formula and production process of herbal products to reduce uric acid levels from peppermint extract
24.	Recipe for tissue culture of Phuang Java (*Campanomoea javanica* Blume subsp. Javanica) and Bong Yai Bamboo (*Dendrocalamus brandisii*) Kurz
25.	Formula and production process of cattle feed from fermented ready-mixed cashew nuts
26.	Formula and production process of hard candy from basil extract to reduce the need for smoking
27.	Nano-capsule formulation containing coconut oil for use in cosmetic products and production processes
28.	Plastic garbage bag continuous washing machine
29.	Photocatalytic fluid purification device with metal surface of titanium dioxide nanotube in the photocatalytic reactor chamber
30.	Recipe and production process of seasonings from malt and roasted wheat
31.	Biomass furnace for steam and hot air production
32.	Process of adding inorganic substances to biochar
33.	Formula and production process of herbal products from young betel nut extracts for mood enhancer
34.	Recipe and production process of dark chocolate fortified with probiotics
35.	Formula and production process of ready mixed yogurt from chickpeas fortified with probiotics
36.	Production process of active ingredients from probiotic microorganisms -TISTR strain, to be used in cosmetic products
37.	Formula and production process of amino acid gel drink from Inca nuts (*Plukenetia volubilis* L.)
38.	Spiral labour-saving durian cutting machine
39.	Formula of rose fragrance products from goat hair extract
40.	Formula and production process of flat sheet fiber cement from natural fibers
41.	Formula and process for forming cement pipes mixed with natural fibers

National and International Publications in 2021

1. National publications -28 articles		
No	Article Title	Journal
1.	Characterization of Biodegradable Packaging Film Based Riceberry Rice	KKU Research Journal (Graduate Studies) Vol. 20 No. 4, October-December 2020, p.81-93
2.	Morphological Diversity of Some Wild Orchid Seeds in Thailand	Songklanakarin Journal of Plant Science Vol. 7, No. 4 October-December 2020, p.264-282
3.	The Effect of Planting Media of Vermicompost on Growth of Banana (*Muso* sp. Cv. Namwa Mali-Ong) and Teak (Mahaesak) Plantlets from Tissue Culture	Songklanakarin Journal of Plant Science Vol. 8, No. 1 January-June 2021, p.28-33
4.	Development of Essential Oils-based Microemulsion Larvicide Product for Control of Insecticide-resistant Strain of Aedes aegypti Mosquito Larvae	Bulletin of the Department of Medical Sciences Vol. 62, No. 4 (October – December 2020, p. 352-371
5.	Analysis of Mixing Capability in Stirred Tank Reactor Using Computational Fluid Dynamics	Engineering Journal Chiang Mai University) Vol.28, No 1, January-April 2021, p.30-44
6.	Comparison of Solvents to Separate Aluminum Foil and Polyethylene plastic from UHT Beverage Packaging	Udon Thani Rajabhat University Journal of Science and Technology Vol.9, No.1, January-April 2021, p.1-18
7.	Morphological and Agricultural Characteristic Variability of T9 Pigeon Pea Native Lines	Agricultural Science Journal Vol.51, No.3, September-December 2020, p.221–231

8.	Food Packaging Design for Elderly People	Agricultural Science Journal Vol.52, No.1(Suppl.), May-August 2021, p.201-204
9.	Effect of Seed Enhancement on *Gymnocalycium* sp. with Light Emission Diode and Hormones Gibberellins	Agricultural Science Journal Vol.52, No.1(Suppl.), May-August 2021, p.261-264
10.	Extraction of Aloe Polysaccharides Using Ionic Liquid Based Aqueous Two-Phase System and Determination of the Monosaccharide constitutes in Aloe Polysaccharides by HPLC-ELSD	Agricultural Science Journal Vol.52, No.1 (Suppl.), May-August 2021, p.365-368
11.	Effect of Various Pretreatment Conditions on Enzymatic Hydrolysis and DPPH Free radical Scavenging Activity of Spent Yeast	Agricultural Science Journal Vol.52, No.1 (Suppl.), May-August 2021, p.369-372
12.	Efficiency of Crude Extracts from Potato Peel Fermented with *Rhizopus oryzae* Against the Activity of HMG-CoA Reductase)	Agricultural Science Journal Vol.52, No.1 (Suppl.), May-August 2021, p.373-376
13.	Study on the Optimum Irrigation Time for Riceberry Rice Cultivation Affecting the Growth and Yield	Agricultural Science Journal Vol.52, No.1 (Suppl.), May-August 2021, p.385-388
14.	Effect of Dairy Manure Compost Applications on the Growth and Yield of Riceberry Rice	Agricultural Science Journal Vol.52, No.1 (Suppl.), May-August 2021,, p. 389-392
15.	Sugarcane Wax Contents Obtained from Byproducts in the Sugar Production Process	Agricultural Science Journal Vol.52, No.1 (Suppl.), May-August 2021, p.393-396
16.	Influence of BA and Duration Times of Feeding in Temporary Immersion Bioreactor on Micropropagation of *Alocasia sanderiana* Bull. In vitro)	Thai Journal of Science and Technology Vol.9, No. 5, September-October 2020, p.642-649

17.	Effects of 1-Methylcyclopropene to Atemoya Fruits (*Annona atemoya* Hort. cv. Petchpakchong) Postharvest Quality	Thai Journal of Science and Technology Vol. 10, No. 1, January-February 2021, p.42-53
18.	Control of anthracnose in "Kluai Hom Tong" banana (Musa (AAA group)) using mangosteen pericarp crude extract)	Thai Journal of Agricultural Science 2020, V.53(4), pp. 228-235
19.	The Effects of Silica/Carbon Black Hybrid Filler Contents on Natural Rubber Composite Properties Using Conventional Vulcanization System	International Journal of Science and Innovative Technology V.3(2), (July-December 2020), pp.13-23
20.	Cost reduction of glucoamylase in the Ethanol Production Process from Cassava by Saccharomyces cerevisiae MGT1/1	Journal of Science and Technology, Ubon Ratchathani University Vol.23, No. 2, May-August, 2021, p. 35-46
21.	SnO_2 Coatings on Porous LiAl5O8 by Simple Thermal Evaporation Process	Progress in Applied Science and Technology. V. 11(2), (May - August 2021), pp. 50–54
22.	Diversity and Distribution of Invasive Ant Species in Urban Ecosystem Case Study: Talat Thai Market, Pathum Thani province and Bangkok Port	The 13th UDRU National Graduate Research Conference (NGRC 2020) Microsoft Teams Online Conference, 31 October 2021, p. 4411-4418
23.	Diversity and food preference of invasive ant species, in dry evergreen forest at Sakaerat Biosphere Reserve, Nakhon Ratchasima province	The 13th UDRU National Graduate Research Conference (NGRC 2020) Microsoft Teams Online Conference, 31 October 2021, p. 4419-4427

24.	Plant Diversity and Income Assessment from Plant Productivities in Integrated-Forest Plantation Model for Food Security and Sustainably Household Economic Development	The 10th Thai Forest Ecological Research Network Conference (T-FERN) 4-5 February 2021, at Mae Jo University -Phrae campus, Phrae province, p. 499-507
25.	The role of *Astraeus odoratus* on biomass, carbon storage and CO_2 uptake in *Dipterocarpus alatus* Roxb. ex G. Don	The 10th Thai Forest Ecological Research Network Conference (T-FERN) 4-5 February 2021, at Mae Jo University -Phrae campus, Phrae province, p.509-516
26.	Source Apportionment of PM2.5 around the North Bangkok Power Plant using PMF Model	The 20th National Environmental-Conference and the 10th International Conference 12-14 May 2021, at Pullman Khonkaen Raja Orchid Hotel, Khonkaen province, p. 379-386
27.	The Study of Effect of Impact Particle Velocities on Solid Particle Erosion Behavior of AISI 410 Martensitic stainless steel	The 39th Conference of Industrial Engineering Network 2021 5-7 May 2021, at Faculty of Engineering, at Rajamangala University of Technology Srivijaya, Songkhla province, p.126-130
28.	Physical Therapy Equipment for Arm Muscle Weakness	The 13th International Conference ECTI-CARD 2021 28-30 April 202, at Fortune River View Hotel, Nakhon Phanom, p. 410-414

2. International publications - 52 articles		
No	Article Title	Journal
1.	Characteristics of rice starch film blended with sugar (trehalose/allose) and oil (canola oil/coconut oil): Part I – Filmogenic solution behavior and mechanical properties	Journal of Food Science V. 85(10), (October 2020), pp. 3372-3379
2.	Anti-cancer effect of engineered recombinant interleukin 18	Advances in Clinical and Experimental Medicine, V. 29(10), (October 2020), pp. 1135 -1143
3.	Solar/photoelectrocatalytic cell development for H_2 production and simultaneous organic dye degradation	Materials Science in Semiconductor Processing, V. 24(105597), (March 2021), pp.1-9
4.	gcType: a high-quality type strain genome database for microbial phylogenetic and functional research	Nucleic Acids Research, V. 8(49), (January 2021), (D1): D694–D705, pp.1-12 Published online: 2020 Oct 29. doi: 10.1093/nar/gkaa957 . Online ahead of print
5.	The leaf extract of *Coccinia grandis* (L.) voigt accelerated in vitro wound healing by reducing oxidative stress injury	Oxidative Medicine and Cellular Longevity, V. 2021, Article ID 3963510, pp.10 Online: https://doi org/10.1155/2021/3963510
6.	Morphological characterization and phylogeny of pythiumand related genera in Rayong province, Thailand	Current Applied Science and Technology V. 21(1), (January-March 2021) pp.132-153
7.	Preparation and characterization of gamma oryzanol loaded zein nanoparticles and its improved stability	Food Science & Nutrition, First published: 30 December 2020, (Open Access) DOI: 10.10022fsn3.1973, pp.1-9
8.	Study on organic acid and anti-oxidant properties of *Elaeagnus latifolia* L. Acta Hortic	Acta Horticulturae, 2020, V. 1298, pp.551-556 DOI: 10.17660/ActaHortic. 2020.1298.75

9.	Influence of geographical and genetic variation on GABA content in Annona muricata grown in Thailand	Acta Horticulturae, V. 2020 (1298), pp. 523-528 DOI: 10.17660/ActaHortic. 2020.1298.71
10.	Comparative assessment of fertilization of marigold (*Tagetes erecta* L.) development, yield, quality and residual soil chemical properties	Acta Horticulturae, V.1, (June 2021), pp.401-408 DOI: 10.17660/ActaHortic. 2021.1312.58
11.	In vivo anti-Inflammatory activity of derris reticulata ethanol extract	Tropical Journal of Natural Product Research, V. 5(10), (January 2021), pp.100-104
12.	Neuroprotective effects of apium graveolens against focal cerebral ischemia occur partly via antioxidant, anti-inflammatory, and anti-apoptotic pathways	Journal of the Science of Food and Agriculture, First published: 2, (October 2020), pp. 1-8 online: https://doi.org/10.1002/jsfa.10846
13.	Photoelectrocatalytic H_2 evolution enhancement over CuO-decorated TiO_2 nanocatalysts and promoting *E*. coli degradation	Journal of Alloys and Compounds, V. 859(157818), (5 April 2021), pp.1-9, online: https://doi.org/10.1016/j.jallcom.2020.157818
14.	Suppressing Cdk5 activity by luteolin inhibits MPP+-induced apoptotic of neuroblastoma through Erk/Drp1 and Fak/Akt/GSK3β pathways	Molecules, V. 26(5), 1307, (28 Feb 2021) pp. 1-18, online: https://doi.org/10.3390/molecules 26051307
15.	Native Burmese pythons exhibit site fidelity and preference for aquatic habitats in an agricultural mosaic	Scientific Reports, 2021, V. 11(7014), pp. 1-13 online: https://doi.org/10.1038/s41598-021-86640-1
16.	Production of bio-jet fuel through ethylene oligomerization using NiAlKIT-6 as a highly efficient catalyst	Fuel, V. 287, (119831), (1 March 2021), pp.1-9 online:https://doi.org/10.1016/j.fuel. 2020.119831

17.	Thermal decomposition of biomass wastes derived from palmoil production	Journal of Analytical and Applied Pyrolysis, V. 155(105069), pp. 1-11
18.	Characterization and comparative genomic analysis of gamma-aminobutyric acid (GABA)-producing lactic acid bacteria from Thai fermented foods	Biotechnology Letters online: 17 May 2021 https://doi.org/10.1007/s10529-021-03140-y
19.	Characterization and comparative genomic analysis of gamma-aminobutyric acid (GABA)-producing lactic acid bacteria from Thai fermented foods	Biotechnology Letters, 2021, V. 43, pp. 1637–1648 online: https://doi.org/10.1007/s10529-021-03140-y
20.	Preliminary responses of some Thai rice cultivars to simulated acid rain stress during seed germination	ScienceAsia, 2021, V. 47(3), pp. 303-311 doi: 10.2306/sciencesia1513-1874.2021.037
21.	Plant growth and soil microorganisms treated by waste-water from Upflow Anaerobic Sludge Blanket (UASB) of ethanol manufacturing	Solid State Technology, 2020, V. 63 (6), pp. 23803-23816
22.	Supposed snake specialist consumes monitor lizards: diet and trophic implications of king cobra feeding ecology	Ecology, V. 101(10), (October 2020), pp. 1-4
23.	The design of experimental production of briquette solid fuel from oil palm fiber and kernel meal residual	Engineering Journal, V. 24(6), November 3 2020, pp. 31-42
24.	Stress analysis of 48 kg LPG cylinder	Journal of Physic: Conference Series, 2021, V. 1719, pp. 1-5

25.	Preparation of transparent alumina thin films deposited by RF magnetron sputtering	Journal of Metals, Materials and Minerals, 2021, V. 31(2), pp. 96-103
26.	Biodegradable hydrogels of cassava starch-g-polyacrylic acid/natural rubber/polyvinyl alcohol as environmentally friendly and highly efficient coating material for slow-release urea fertilizers	Journal of Industrial and Engineering Chemistry V.101 (September 2021), pp. 237-252
27.	Novel reusable pH-responsive photocatalyst polymeric microcapsules for dye treatment	International Journal of Energy Research, V. 45(5), (April 2021), pp. 7535-7548
28.	A novel iron aluminate composite polymer particle for high-efficiency self-coating solar heat reflection	Solar Energy Materials and Solar Cells, V. 230 (111248), (September 2021), pp. 1-13
29.	Influence of malposition on the performance of elastic rail clip: Toe load, stress, and friction	Structures V.28, (December 2020), pp. 2661–2670
30.	Fouling behavior in a high-rate anaerobic submerged membrane bioreactor (AnMBR) for palm oil mill effluent (POME) treatment	Membranes, 2021, V. 11(9), 649, pp. 1-15 online: https://doi.org/10.3390/mebranes 11090649
31.	Nonchalant neighbors: Space use and overlap of the critically endangered Elongated Tortoise	First published, (15 June 2021), online: https://doi.org/10.1111/btp.12981
32.	Functional differentiation among 12 dipterocarp species under contrasting water availabilities in Northeast Thailand	Botany, V. 99(6), (June 2021), pp. 321–335 online: https://doi.org/10.1139/cjb-2020-0155

33.	Colchicine Determination in *Gloriosa* spp. by HPLC	Science & Technology Asia V. 26(2), (April - June 2021), pp. 120-127
34.	Enhancement propagation of protocorms in orchid (*Cymbidium tracyanum* L. Castle) by cold atmospheric pressure air plasma Jet	Plasma Chemistry and Plasma Processing 2021, V. 41, pp. 573–589, online: https://doiorg/10.1007/s11090-020-10148-1
35.	Preparation of nanostructured lipid carriers (NLCs) loading vlolacein extract for anti-acne products	Key Engineering Materials, 2021, V. 901, pp. 129-136
36.	Effects of simulated acid rain on morphological traits of Thai rice cultivars	Agriculture and Natural Resources, V. 5(4), (August 2021), pp.692-702 DOI: https://doi.org/10.34044/j.anres.2021.55.4.20
37.	Mulberry fruit extract alleviates the intracellular amyloid-β oligomer-induced cognitive disturbance and oxidative stress in Alzheimer's disease model mice	Genes to Cells, First published: 12 August 2021, pp. 1-13 DOI : 10.1111/gtc.12889
38.	Terrefaction of wood chips and wood pellets to enhance solid fuel qualities and hydrophobicity	Proceedings of The 32nd Annual Meeting of the Thai Society of Biotechnology and International Conference (TSB 2020), 26 November 2020, Online Conference, Bangkok, Thailand, pp. 330-346
39.	A preliminary study on evaluation of the estrogenic activity of Sa-Tri-Lhang-Klod remedy extracts in variectomized rats	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp.2-5
40.	Anti-inflammatory activity of Litopenaeus vannamei shell extract on carrageenan-induced rat paw edema	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021) June 23-24, 2021, Online Conference, pp. 6-8

41.	Beneficial effects of stinking passionflower on relieving depressive-like symptom mice	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp. 13-17
42.	Development and validation of HPLC method for the determination of rosmarinic acid in *Mentha cordifolia* leaf extract for gout relief product	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp. 23-27
43.	Effects of alkaline extraction of Durio-Mon-Thong on melanin production	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp. 46-48
44.	Glycosaminoglycan characterization and acute oral toxicity study of Litopenaeus vannamei shell	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp. 53-56
45.	In vitro antioxidant and cytotoxic evaluation of the tamarind seed coat extract	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp. 62-65
46.	Micronucleus assay and radioprotective effect of tamarind seed coat extract in human peripheral lymphocytes	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp. 71-74

47.	Stimulation of dermal fibroblast collagen synthesis in vitro by alkaline extract of *Durio zibethinus* Murr.	Proceedings of International Conference and Exhibition on Phamaceutical Sciences and Technology 2021 (PST 2021), June 23-24, 2021, Online Conference, pp.101-103
48.	Total phenolic content and antioxidant activity of five mushroom species	Proceedings of 36th International Annual Meeting in Pharmaceutical Sciences (IAMPS36) & Herbal and Traditional Medicine 2021 (HTM2021), Friday 28, May 2021, pp. 1-4, Via Zoom video conferencing
49.	Comparative study on the antiacne potency of Indian gooseberry extract and fingerroot extract	Proceedings of 36th International Annual Meeting in Pharmaceutical Sciences (IAMPS36) & Herbal and Traditional Medicine 2021 (HTM2021), Friday 28, May 2021, pp. 14-16, Via Zoom video conferencing
50.	Formulation of terpene composited nanostructured lipid carriers for dermal delivery of silymarin	Proceedings of 36th International Annual Meeting in Pharmaceutical Sciences (IAMPS36) & Herbal and Traditional Medicine 2021 (HTM2021) Friday 28, May 2021, pp. 21-24, Via Zoom video conferencing
51.	Assessment of Isomalto-oligosaccharides as cryoprotectant for survival of freeze dried lactobacillus fermentum and *Bifidobacterium longum*	Proceedings of Thai Society for Biotechnology International Conference Online, April 2, 2021, Bangkok, Thailand, pp. 466-470.
52.	Screening of Potential Probiotic Lactic Acid Bacteria from Cattle	Proceedings of The 32nd Annual Meeting of the Thai Society for Biotechnology and International Conference (TSB2020), November 26, 2020, Online Conference, Bangkok, Thailand, pp. 511-519.

Technology transfer for Commercialisation

TISTR is an innovation organisation that respond to the needs of the country under TISTR 4.0 policy by focusing on R&D in science, technology and innovation (STI) of multidisciplinary subjects. In fiscal year 2021, TISTR conducted contract research services and consultancy projects for a total of 114 projects. Examples of TISTR's commercialised technologies and innovations from 4 group can be summarised as follows:

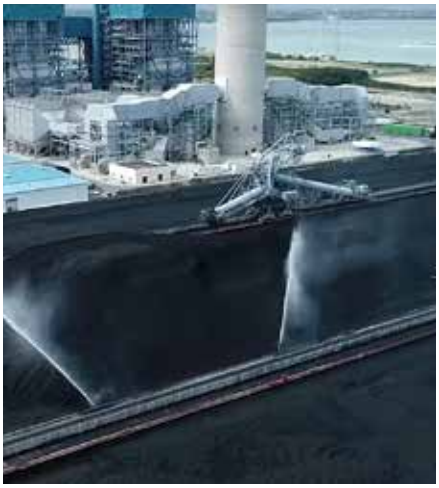
Research and Development Group for Bio-Industries

Project on research and development of protein products from bio-based plants for creating functional foods commercialised to Thai Foods Group Public Company Limited

With the growing trend of plant-based protein consumption along with the increasing growth of healthy food, this project was initiated to enhance innovative knowledge and produce safe and effective products that meet the requirements of the Ministry of Public Health and comply with the BCG policy. In addition, the project aims to strengthen Thai entrepreneurs in driving the basic economy, increase the potential for food industry development, generate income for the people and help the people to them accessgood food for a better quality of life. This project was developed under the Expert Centre of Innovative Health Food (InnoFood) by applying knowledge from the patent on the process of extracting protein isolate from peas (*Cicer arietinum* Linn.) (Ms. Maneerat Meeploy et al., Request number 1701005504, Date of submission 21/ 9/2017).

Research and Development Group for Sustainable Development

Value-added project on combining carbon dioxide extracted from coal-fired power plant emissions with alternative hydrogen products to produce 100 litres of methanol per day (Phase 3) for BLCP Power Co., Ltd.



This research is ongoing through Phase 3 to combine carbon dioxide extracted from coal-fired power plant emissions with alternative hydrogen products to enhance the potential and stability of methanol production trials at a capacity of 100 litres per day. The goal of the project is to reduce CO_2 emissions by 28 tons per year and achieve methanol output of 28 tonnes per year. The results of this research could obtain a prototype at a semi-pilot scale. This project, carried out by the Expert Centre of Innovative Clean Energy and Environment (InnoEn), has marked the beginning of a significant reduction in carbon capture utilisation and storage (CCUS) from the environment.

Industrial Services Group

Rubber Innovation Education Project for Safety and Loss of Life and Property of Road Users for the Department of Rural Roads

Road accidents are one of the major causes of deaths and injuries of Thai people each year. The results of various studies have shown that drivers will drive exceed the speed limit on the types of road with raised median and depressed median while driving more slowly and less than speed limit on the roads having concrete barriers as a median. It is assumed that the concrete barrier could help reduce accidents. However, accidents that drivers crash with a concrete barrier can be fatal. Therefore, the research and design of the Rubber Fender Barrier was carried out in order to reduce the severity of accidents. The study on Rubber Fender Barrier has progressed to Phase 2, where the performance of rubber sheeting was evaluated in the laboratory and the safety performance of the Rubber Fender Barrier was tested by crash testing. This project is operated under the Railway Transportation System Testing Centre (RTTC).

Strategies and Innovation Management Group

Project on voucher for product development of small community enterprises for the Office of SMEs Promotion (OSMEP)

Product development is an essential tool for entrepreneurs during the growth period of business. As current demand patterns of products and services of buyers are diverse, product development will help entrepreneurs meet the demand of consumers at different levels. So far, government agencies have paid attention to product development and services of entrepreneurs for quality, standard and value addition. Therefore, this project is conducted in order to support entrepreneurs in their products and services to meet quality standards. Product or packaging design with value creation will increase competitiveness and market opportunity for entrepreneurs. This project is operated under the Technology and Innovation Management Office.

In addition to the projects mentioned above, TISTR also has a network and cooperates with government agencies, state enterprises as well as the private sector to promote of research and development and technology transfer in compliance with the international standards. This cooperation will lead to potential enhancement of small and medium-sized enterprises (SMEs) in Thailand. In doing so, plans will be made together with systematic tools and facilities for technology transfer and commercialisation of STI works. The aforementioned operations consist of 18 projects as follows:

No.	Project	Technology transfer recipient
1.	Permission to use yeast strain as ingredient in production of animal food product	Bioman Company Limited
2.	Technology transfer on coffee bean sorting machine	Jittatana Consultant Company Limited
3.	Permission to use fungi strain for eradication of stem and root rot diseases of tomato	Natural Farm Company Limited
4.	Technology transfer on production of nutraceutical product for nourishing brain, enhancing memory “Braini-Tab”	Healthy Kingdom Company Limited
5.	Technology transfer project for the development of 3 flavours of drinking powder products	Palee 168 Company Limited
6.	Technology transfer on culture dispensing machine for mushroom cultivation	FN Advance Limited Partnership
7.	Project on testing, research and data collection for technology transfer of methanol production process from flare gas of coal power plant at the scale of 100 litres per day (Phase 3)	BLCP Power Company Limited
8.	Technology transfer on production process of avocado oil	Kow Rang Food Company Limited
9.	Technology transfer on production of herbal cosmetic product from *Etlingera elatior*	Terry24 Company Limited

10.	Technology transfer on production of instant beverage powder product from longan extract for enhancing immunity, reducing sleepiness and nourishing connective tissues	Super Good 89 Company Limited
11.	Development and technology transfer project of probiotic production as a prototype product	Chiang Mai Bioveggie Company Limited
12.	Research and development on productivity improvement of high-value astaxanthin from *Haematococcus* sp. algae for commercialisation	Nature Benefit Company Limited
13.	Appropriate technology transfer for producing mushroom spawn	Ban Po Prom Jit, Prom Jai agriculture community enterprise
14.	Technology transfer on the production of massage oil from local herbs	Ban Salamai mushroom cultivation group community enterprise
15.	Technology transfer and development of frozen steak products from Phon Yang Kham beef	Fish and beef cattle food processing community enterprise
16.	Technology transfer on oil-free drying of agricultural products	Ban Kud Nam Sai food processing community enterprise
17.	Permission to use the patent of research and development of packaging boxes	Safer Pac (Thailand) Company Limited
18.	Technology transfer on fragrant charcoal from mangosteen peels	Neo Factory, Company Limited

Technology Transfer for Society

Innovative identity community development project under cooperation with government agencies and key private sectors in the area

TISTR pays attention to area-based development by focusing on the needs of communities and people in various areas, resulting in the creation of the "Innovative Identity Community Project" which help bringing knowledge in science, technology and innovation (STI) to create a product identity and community innovation in order to add value to the original products. This project is carried out in collaboration with government agencies and key private sectors in the area. In 2021, TISTR conducted research and applied research and development results from each specialised centre to develop the potential of community enterprise entrepreneurs and farmers to transform communities into innovative communities and be able to connect to the bio-industry or tourism industry. In addition, it also takes advantage of the resources that are unique in the area, and creates a fair distribution of income back to the upstream producers, creating employment, creating a career, as well as conserving sustainable resources. There are a total of 32 Innovative Identity Development Projects (31 communities) in 22 provinces as follows:

No.	Project	Innovation community	Benefit area
1.	Project on research and development of *Biocellulose* mask sheet product	Jelly mask supplier community enterprise, Amphawa, Samut Songkhram	Samut Songkhram province
2	Project on research and development of prototype cosmetic products from longan flower honey	Highland farmer groups, Ban Mae Sa Noi	Chiang Mai province
3	Research and development project of anti-inflammatory cosmetics from Bua Tong (Mexican sunflower)	Farmers in provincial area of Mae Hong Son	Mae Hong Son province
4	Biological evaluation project of Lanna Kura herb (*Sapium indicum* Willd.) extract on skin effects	North Hongya community enterprise	Nan province
5	Project on development of perfume products with unique smell from goat hair waste	International goat academy	Krabi province

6	Project on formula development of prototype cosmetic from red lotus extract from Udon Thani province	Chiang Wae conservative homestay community	Udon Thani province
7	Project on development of pineapple extract for cosmetics	Huai Khot agriculture cooperative	Uthai Thani province
8	Project on development of cosmetics from mangosteen peels	Phetkiri homestay community enterprise, Phetkiri brand	Nakhon Si Tham-marat province
9	Project on development of extract and product for oral health from chrysanthemum flowers	Ban Pak Karn flower group	Loei province
10	Project development on extraction process of lutein from marigold flowers	Dao Rueang, Phu Rua community enterprise	Loei province
11	Project on the development of instant coffee products using Arabica and Macadamia for community enterprises as a volunteer community at Ban Dong Mafai	Arabica coffee and macadamia, voluntary community enterprise, Ban Dong Mafai	Nakhon Ratchasima province
12	Agricultural technology promotion project of OTOP Tourism Community, Nawat Withi, Pathum Thani province	OTOP Nawatwithi tourism community, Pathum Thani province	Pathum Thani province
13	Project on development of prototype cutting machine for Ling Zhi mushroom	Farmers network under the Chaipattana foundation	Chiang Mai province
14	Project on research and development of prototype wax from avocado	Plank Yai avocado, Saliang Hang 3 community enterprise	Phetchabun province
15	Project on development of processed coconut products, Prachinburi province	Coco Inter Prachin community enterprise	Prachinburi province
16	Project on development of tamarind cyder as health beverage	Phetchabun sweet tamarind growers community enterprise	Phetchabun province

17	Innovation and technology development project to utilise and create added value of raw materials in the area of Uttaradit province	Tha Pla forest park farmer cooperative limited	Uttaradit province
18	Project on bio-activity study of extract from Miang tea leaves for developing bio-active substance in skin nourishing product	Fermented tea leaves Suri farmer groups	Chiang Mai province
19	Technology transfer project and product development from shang Mon bamboo	Bamboo product processing career group and Chang Nuea community	Mae Moh, Lampang province
20	Technology transfer project and product development from duck eggs	Bang Phasi eggs production and processing career group	Bang Len, Nakhon Pathom province
21	Technology transfer and coffee machine development project	Mae San coffee production group and Ban Dong community	Mae Moh, Lampang province
22	Technology transfer project and product development of dragon fruit soap	Tambon Rong Chik farmer group and Rong Chik community	Tambon Rong Chik, Amphoe Phu Ruea, Loei province
23	Project on technology transfer of products from kai algae for Ahi Subdistrict Administrative Organisation, Ahi Community Tourism Community Enterprise and Moo 1, Baan Ahi	A Hi tourism community enterprise	Loei province
24	Project on development of artificial coral products from oyster shells	Ban Mueang community	Chon Buri province
25	Product development project of the Zodiac herbal candle from residual candle wax	Nong Pung community	Chiang Rai province

26	Product development project for paper flowers from rice stubble	Hat Khum community	Nong Khai province
27	Project on development of coffee beans	Bua coffee group	Nan province
28	Project on design and development of paddy steaming process for the production of germinated rice (Hang rice)	Ban Huai Hai agricultural produce processing community enterprise	Nakhon phanom province
29	Nipa Palm leaf container development project in Chachoengsao and Ang thong areas	Chachoengsao province community enterprise and Ang Thong province community enterprise	Chachoengsao province and Ang Thong province
30	Fabric dyeing project from natural pigments of Muang Loei flowers	Dao Rueng, Phu Ruea community enterprise	Loei province
31	Lampang's identity ceramic coating project (Ancient ceramic glaze, Wang Nuea furnace)	Lampang province community enterprise, Lampang Ceramics Association	Lampang province
32	Project of natural rubber plant pots in Loei province	Loei province community enterprise	Loei province

Project on development of the potential innovative health products and services in the Southern Economic Corridor area.

TISTR has applied knowledge in science, technology and innovation (STI) through technology transfer and innovation services, as well as other support services to promote value-added processing in agricultural products, medicinal plants and local resources. TISTR has coordinated with the government agencies of Ranong, Chumphon, Surat Thani and Nakhon Si Thammarat provinces to organise workshops to develop potential health products and services with innovation, and also arranged meetings to promote the processed products development of entrepreneurs in the provinces at the Southern Economic Corridor (SEC). This project is to bring research results to support folk wisdom and increase the utilisation of agricultural products, medicinal plants or various local fruits in the area. In 2021, TISTR has organised workshops for standard product development and in-depth consulting for entrepreneurs with production problems, including entrepreneurs who have ideas for developing standard products for marketing. There were 4 workshops and 356 entrepreneurs participated as follows:

Lists	Participant	Details
1. A workshop on the development of potential health products and services through innovation in the Southern Economic Corridor area in Nakhon Si Thammarat province on Wednesday, March 10, 2021	102	At Grand Ballroom hall, 1st floor, Grand Fortune hotel, Amphoe Muang, Nakhon Si Thammarat province
2. A workshop on the development of potential health products and services through innovation in the Southern Economic Corridor area in Chumphon province on Wednesday, March 17, 2021	84	At Hiranyika hall, 2nd floor, Nana Buri Hotel, Amphoe Muang, Chumphon province
3. A workshop on the development of potential health products and services through innovation in the Southern Economic Corridor area in Ranong province on Thursday, March 18, 2021	88	At Rajavadee hall, 3rd floor, Heritage Grand Convention Hotel, Amphoe Muang, Ranong province
4. A workshop on the development of potential health products and services through innovation in the Southern Economic Corridor area in Ranong province on Wednesday, March 24, 2021	82	At S.Hall, 1st floor, S.22 Hotel, Amphoe Muang, Surat Thani province
Total	**356**	**Goals achieved**

After providing consulting services to entrepreneurs in all 4 provinces, TISTR has selected 18 entrepreneurs and coordinated with researchers from Expert Centre of Innovative Health Food (InnoFood), Expert Centre of Innovative Herbal Products (InnoHerb), Expert Centre of Innovative Agriculture (InnoAg) and Thai Packing centre (TPC) to upgrade product quality, which will lead to the development and upgrading of product standards in the Southern Economic Corridor area as follows:

1. Developing standardised production formulas for 11 products
2. Analysis and testing of products for quality and standard development for 3 products
3. Packaging development for 3 products
4. Development of filling machine for 1 product

Scientific and Technological Services

TISTR by Industrial Services Group (ISG) has focused on providing scientific and technological services to enhance domestic industrial quality up to international standards and support the National Quality Infrastructure (NQI) to strengthen and boost the competitiveness of Thai entrepreneurs to the global market. In fiscal year 2021, TISTR provided scientific and technological services such as analysis, testing, and calibration to the total of 2,843 entrepreneurs. There were a total 299,635 service items while only 478 entrepreneurs passed the assessment and quality system certification. In addition, there were 1,051 participants from industrial and government sectors who received 33 training courses in science and technology from TISTR. Two new standards were also drafted and the design of testing equipment and testing methods were developed to suit the needs of customers.

TISTR provides science and technology to support the manufacturing and service sectors of the country according to international standards, which are ISO 9001, ISO/IEC 17020, ISO/IEC 17021-1, ISO/IEC 17025, ISO/IEC 17043, ISO/IEC 17065 and ISO/TS 22003. The service covers the needs of the industry as follows:

Analysis services for testing raw materials, packaging products and calibration of measuring instruments

TISTR provides services for analysis, testing of raw materials, packaging products, and calibration of measuring instruments as follows:

- Analysis services by testing food and beverage products and cosmetics covering testing for FDA registration, analysis of active ingredients, contamination and nutritional value, as well as safety testing. We also provide testing services for medicinal herbs and herbal products such as hemp, cannabis, *Andrographis paniculata*, Kratom (*Mitragyna speciosa*) etc.

- Analysis and testing services for other industrial products such as PVC pipes and electric lamps and building paint according to TIS standards TIS 272-2549 and TIS 2321-2006. In addition, TISTR has also inspected the product section according to the 5 Bureau of Industrial Standards in various industry standards such as TIS 17, TIS 982, TIS 2321.

- TISTR is an inspection body in accordance with ISO/IEC 17020 in the list of electrical equipment, inspection and evaluation of the remaining boiler life and on-site damage assessment of boiler pipes in power plants.

- TISTR provides testing services for rail, road and water transportation systems and also provides electric vehicle testing services.

- TISTR provides material and packaging analysis services for transportation, retail and hazardous goods. We also provide packaging research and development, shelf life study and packaging design services for food products.

- TISTR provides research services on biodegradation testing of raw materials or environmentally friendly products. We also provide research services for the treatment of residual hazardous substances in the environment using biological processes.

- TISTR provides industrial instrument calibration services covering all fields of measurement including electricity, frequency, sound, light, temperature, humidity, volume, force, torque, mass, pressure, dimensions, flow, and wind speed. We also provide testing and calibration services for medical instruments and equipment such as face masks, medical supplies lockers, plasma storage, cabinet blood locker, as well as providing air quality monitoring services for negative and positive pressure chambers in a hospital.

In fiscal year 2021, TISTR increased the capacity to provide new scope of services to meet customer needs in 8 items for example : preliminary biological decomposition tests in seawater, concrete wall, rubber sheet material and performance test in accordance with special requirements for transportation test (ASTM D4169), assessment of 125% tax reduction for biodegradable plastics.

Quality system certification, products and services certification in accordance with international standards

TISTR is a certification body in compliance with international standards that are accepted both inside and outside the country. TISTR provides quality system assessment, certification services, as well as certification of products and services to entrepreneurs in the government sector, private sector, community enterprises and the general public with integrity and transparency. We are accredited according to international standards ISO/ IEC 17021-1, ISO/IEC 17065 and ISO/TS 22003. International standard audit

and certification services provided by TISTR are as follows:

- Assessment service and system accreditation of international standards, for example: ISO 9001, ISO 14001, ISO 45001, ISO 22000, GMP (codex), HACCP (codex), GHP, TIS 18001, OHSAS 18001
- Site assessment service for food production as TISTR is an certification body that has been registered with the Food and Drug Administration (FDA) in issuing a certificate of production standards in accordance with the rules and food law. The inspection record issued by TISTR can be used as evidence for the renewal of a food production license. In addition, TISTR also provides an assessment of the production process chart and a list of machinery for consideration of approval from the FDA, GMP ASEAN Cosmetic according to the Ministry of Public Health Notification No. 420. We also provide audit and certification services according to GMP, HACCP systems and audit services for plant products that have been registered with the Department of Agriculture.
- Assessment service and system accreditation of agricultural standards in accordance with general standards, for instance, TAS 9023, TAS 9024, TAS 9047 etc. and mandatory standards such as TAS 1004, TAS 9035, TAS 6401, TAS 9046 etc.
- Greenhouse gas reduction verification and inspection service, which TISTR is a certification body that has been registered with the Thailand Greenhouse Gas Management Organization (TGO). The service that we have provided is carbon footprint verification.
- Service and product certification services that TISTR conducts audits and certifications covers services and products in accordance with Good Agricultural Practices (GAP) standards for food crops according to TAS 9001, organic farming according to TAS 9000 Volume 1, biodegradable plastic products according to ISO 17088 and TIS 17088 standards. In addition, TISTR also provides tax benefit assessment services for companies, limited partnerships and juristic persons whereby companies can deduct 25 percent of their expenses from purchasing biodegradable plastic packaging. We also provide certification services for tourist attractions and tourism activities according to the tourist attraction quality standards and tourism activities standards of the Department of Tourism. Incidentally, TISTR is the only certifying agency that has been certified by the TISI.

Other services

In addition, TISTR also contributes to enhancing the capabilities of the government and private sectors in other related areas as follows:

- Proficiency testing provider which was certified according to ISO/IEC 17043 standard in the field of temperature, electricity, and chemistry.
- Collaboration with the Council of Engineers network and help on training and drafting standards, which, in 2021 TISTR drafted a standard for the use of liquid petroleum gas as a fuel in the forklift.

International Cooperation

In fiscal year 2021, TISTR cooperated with international partners in line with organisational direction of Bio-Circular-Green (BCG) for sustainable economy and STI for total solutions. Most bilateral cooperation was in Asia, including China, Japan and Korea. We also participated in the global association and the project under the framework of Horizon 2020 with allocated budget from the European Commission.

Academic and education cooperation in training courses on packaging

TISTR cooperated with Japan Material Handling Society (JMHS) as Japan is specialised in technology and packaging. Japan is also advanced in developing training courses in packaging, materials, material handling and logistics engineering, which could enhance total solutions of TISTR's packaging.

TISTR, JMHS, Japan Packaging Institute (JPI) and King Mongkut's University of Technology North Bangkok (KMTNB), organised a training course on 'Material Handling and Logistics Engineering (Basic Course)' to enhance skills of students, private entrepreneurs and people who were interested, during 19 September 2020 – 28 November 2020 (both online and offline). Training courses on

'Material Handling and Logistics Engineering (Advanced Course)' and 'Corrugated Paper and Cushion Design' will be conducted at the end of 2021 and 2022, respectively.

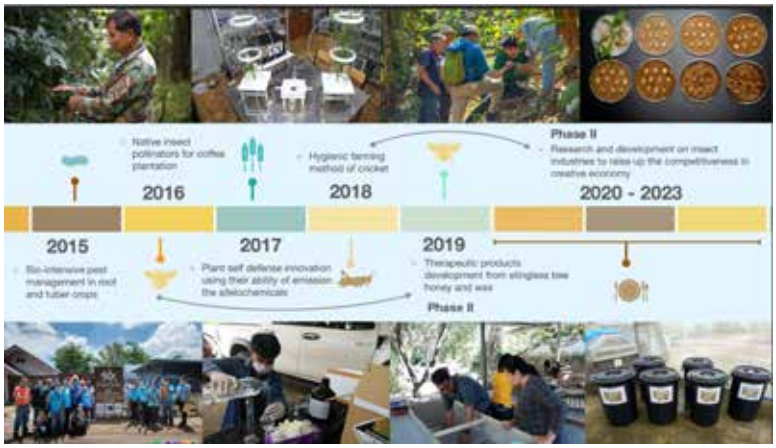
A study of the development of values from rubber biomass

A collaborative project between TISTR and Southwest Forestry University (SWFU) of China on a study of utilisation of rubber seed waste for value-addition was conducted in the line of B (Bio) and C (Circular). In 2021, TISTR studied of synthesis process of epoxidised rubber seed oil with molecular structure improvement and antibacterial properties addition for its utilisation in various purposes, especially development of bio-plasticiser, which could replace traditional products from

petrochemical with contaminants that are harmful to the consumers and affect the environment.

A study and analysis on metal contamination and accumulation in crickets

A collaborative project between TISTR and the National Research Council (NRC) of Canada on a study and analysis of metal contamination and accumulation in crickets, by studying of protein and amino acid contents from crickets and testing its safety and toxicity to body, leading to the establishment of Certified Reference Materials and development of food products from crickets, in order to keep up with the global alternative food trends of edible insects rich protein and benefit body.



TISTR participated in the global association and the project under Horizon 2020 which are as following:

World Association of Industrial and Technological Research Organizations (WAITRO)

TISTR was assigned as WAITRO's Regional Focal Point (RFP) for Asia and the Pacific or a regional representative to coordinate between the secretariat and more than 20 institution members in Asia and the Pacific.

TISTR held 'WAITRO Webinar on Bio-Circular-Green (BCG) in Action', on 24 August 2021. Topics were based on regional hot issues and raised awareness of BCG policy to push forward Thailand's roles internationally.

A project under the EU framework for cooperation on research and innovation (Horizon 2020)


SOILGUARD

Press Release - July 2021

Sustainable soil management to unleash soil biodiversity potential and increase environmental, economic and social wellbeing

Successful Kick-off Meeting for the H2020 SOILGUARD project

25 TRANSDISCIPLINARY PARTNERS WORLDWIDE

17 COUNTRIES

1 GLOBAL NETWORK OF KNOWLEDGE

TISTR participated in the project 'Sustainable Soil Management to Unleash Soil Biodiversity Potential and Increase Environmental, Economic and Social Well Being (SOILGUARD)' 2021 - 2025, with an allocated budget of 6.9 million Euros under the Horizon 2020 framework. The SOILGUARD project was led by Leitat Technological Center (LEITAT) of Spain, in collaboration with 25 research institutes from various countries in Europe, Africa, South America and Asia (Thailand by TISTR). The project focused on the relations of various factors affecting biodiversity conservation.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