The 2nd APEC Seminar on Best Practices and Applications of Digitalization and Innovation in Food Supply Chain

APEC POLICY PARTNERSHIP ON FOOD SECURITY

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WORKSHOP SUMMARY REPORT

APEC Policy Partnership on Food Security

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THE 2ND APEC SEMINAR ON BEST PRACTICES AND APPLICATIONS OF DIGITALIZATION AND INNOVATION IN FOOD SUPPLY CHAIN

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Workshop Summary Report

I. Introduction

From October 21 to October 24, ***"The 2nd APEC Seminar on Best Practices and Applications of Digitalization and Innovation in Food Supply Chain"*** was held by the Academy of National Food and Strategic Reserves Administration (NAFRA) in China. The project was led by China and co-sponsored by Peru, Singapore, Thailand, and United States. More than 200 industry representatives from 13 APEC economies including Australia; Canada; China; Indonesia; Japan; Malaysia; Peru; The Republic of the Philippines; The Russian Federation; Chinese Taipei; Thailand; United States; Viet Nam, the United Nations World Food Programme (WFP), and 12 non-APEC member economies such as Republic of the Congo, Central African Republic, and The Republic of Benin attended the conference.

The objective of ***"The 2nd APEC Seminar on Best Practices and Applications of Digitalization and Innovation in Food Supply Chain"*** was to share best practices of digitalization and innovation in APEC food supply chains, and further to support the *APEC Putrajaya Vision 2040*, the *Food Security Roadmap Towards 2030*, and to realize the *Implementation Plan of the Food Security Roadmap Towards 2030* targets. Through sharing information, experiences and practices, APEC member economies can learn from each other and work together to promote the digital transformation of the food supply chain, thus ensuring the sustainability, inclusiveness, and responsibility of agriculture and fostering the development of digital agriculture.

II. Background

The APEC region is facing risks of food insecurity due to climate change, resource constraints, as well as other emergencies and uncertainties.

Digitalization and innovative technologies and related policies have the potential to enhance food security throughout the food supply chain. In recent years, the research, development and promotion of smart agricultural technologies and equipment have been accelerating, including the application of technologies such as the Internet of Things, big data, cloud computing, and artificial intelligence in the agricultural sector. Digital agriculture can improve the quality of agricultural products through various means, such as precision agricultural management, intelligent control for pest and disease, traceability of agricultural product quality, early warning systems, intelligent irrigation and fertilization systems, big data analysis in agriculture, and the innovation and transformation of digital technology. These technologies help to increase agricultural land productivity, labor productivity, and resource utilization rates, while also enhancing the digitalization and intelligent level of industry management services. Compared to developed economies, the penetration rate of the digital economy in agriculture in developing economies is at a relatively low level, but it is still growing, showing the potential for development and the room to catch up in digital agriculture.

This project is aligned with two economic drivers of *APEC Putrajaya Vision 2040*, 'Innovation and Digitalization' and 'Strong, Balanced, Secure, Sustainable and Inclusive Growth', as well as the *Aotearoa Plan of Action*. The project contributes to the implementation of the *Food Security Roadmap Towards 2030*. The talks covered digital and innovative technologies on food supply chain, from technology to public policies and private application, from regional to global. Eighteen domestic and international experts shared theoretical achievements and application cases of digitalization and innovative technologies in the field of grain, and provided important references for the digital transformation and promotion of innovative technologies in grain industry in the future. Meanwhile, some of the challenges were pointed out, such as the lacking of enormous investment and mature profit model on digital and innovative technologies, and how to break down digital information barriers between departments, etc. The outcome is expected to contribute to carry out the *Implementation Plan of the Food Security Roadmap Towards 2030*.

Building on the successful outcome of the first Seminar, which was self-funded and held in 2023, the second one was convened with the aim of further deepening

the exchange and cooperation among APEC economies in the field of food. It played an important role in accelerating the digital transformation and promotion of innovative technologies in the grain industry of APEC economies, implemented the relevant action objectives in *the Food Security Roadmap Towards 2030*, promoted food saving and reduction of food loss and waste, and ensured the security of the food supply chain in APEC region.

In this seminar, eighteen speakers from APEC economies including Australia; China; Indonesia; Japan; Malaysia; Peru; Thailand and United States, as well as United Nations World Food Programme and non-APEC economy, Swiss Confederation, shared technologies, policies and application cases of digitalization and innovation on food supply chain. A panel discussion was also involved with 4 topics.

III. Key Issues

1. Digital and innovative technologies on food production, processing and distribution

"History of Carbohydrate Research and New Thoughts on Starch Processing". Dr JIN Zhengyu, Professor of School of Food Science and Technology, Jiangnan University, Academician of Chinese Academy of Engineering: Carbohydrates are the main source of energy intake for the human body, and are also one of the three major nutrients that maintain the basic metabolism and normal physiological functions of the human body. Carbohydrates are the main components of grains with a complex and diverse structure. The advent of industrial sucrose production in the 18th century and the commencement of industrial starch production in the early 19th century marked seminal developments in the annals of carbohydrate history.

The speaker conducted starch processing innovative research from two perspectives, based on the further processing of grains: high-value starch components and the industrialization, facilitation, and nutritionization of staple foods. The research on high-value starch components mainly focused on the efficient creation of new high value-added starch derivatives. The speaker's research on the industrialization, facilitation, and nutritionization of staple food

mainly focused on the improvement of quality and nutrition enhancement of starch-based staple food products. The research put forward the matching relationship between the thermal stability and bioavailability of different crystalline forms of starch, discovered the structure–activity relationship between the distribution of water molecules and the crystalline form of starch, clarified the laws and regulatory mechanisms of the formation of ordered crystalline complexes of starch, and proposed theories and techniques such as new methods for the functional utilization of crystallization from both preventing crystallization and utilizing crystallization.

The speaker, in view of the fact that plastic pollution has become a global focus and presents great challenges to the sustainable development of humanity, carried out research on plastic substitutes, specifically biodegradable starch-based packaging materials, and achieved the large-scale production and multi-scene application of starch-based degradable food packaging materials.

The speaker put forward new thoughts on the starch processing industry. Firstly, to explore new starch resources from plants other than grain, including alga, leaves and baobab, as well as Starch customization based on biological breeding. Secondly, to develop new food processing technology by Synthetic biology, 3D-6D printing and precise nutrition. Thirdly, to create new starch derivatives based on processing requirement (fat substitut, anti-retrogradation *et. al.*) and special need for particular groups(infants, athelets and group with chronic diseases...). Fourthly, to expand new application fields involves the creation of new opportunities in the fields of materials/environment, energy supply in extreme environments, and biomedicine. Fifthly, to intelligentize the equipment from product design and process optimization to equipment manufacturing, aim to achieve intelligent control over the entire process.

"Engineering Innovations that Accelerate Breeding and Quality Gains in the Cereal and Grain Industry". Dr. Paul R Armstrong, Former Senior Research Engineer and Lead Scientist with the United States Department of Agriculture, Center of Grain and Animal Health Research in Manhattan, the USA: Corn occupies a pivotal position as a cereal crop in many economies, serving as a principal feedstock for livestock and a critical component in the generation of animal protein and a myriad of other animal-derived products. The

corn kernel, stands as a vital raw material for a broad spectrum of industrial processes, exerting a significant influence on our daily lives. In 2023, the global corn production scaled to an impressive 1.17 billion metric tons, underscoring its importance in the agricultural and industrial sectors.

The genesis of inbred lines is a cornerstone in the breeding of hybrid maize. Traditional methods for producing corn inbred lines demands 6-8 generations of maize self-pollination. A haploid is an organism that looks like a sporophyte, but has the chromosome complement of a reduced gamete, which can produce a double haploid (DH) individual and form an inbred line in 2-3 generations. However, haploids occur in a minuscule proportion of seeds, presenting a challenge in their manual segregation from the vast array of hybrids. Haploid inducer lines are meticulously breed not only to elicit the formation of haploids but also to enable their differentiation from diploids through the utilization of the R1-nj color marker, thereby enhancing the efficiency of maize breeding programs.

The speaker noted that haploids inherently have a lower oil content than hybrids. Consequently, the research focus was on creating significant oil differences between hybrid and haploid kernels, which can then be sorted using Near Infrared Spectroscopy (NIR). A single-kernel NIR platform was capable of processing three kernels per second. The preference for NIR stemmed from its ability to meet the demand for rapid and efficient identification and separation of haploid seeds, a task that other methods failed to accomplish. The USDA-ARS Single-Kernel Near-Infrared Reflectance spectroscopy (skNIR) could be employed to identify haploid kernels. This device utilizes a three-way classification system to distinguish and separate haploid kernels, hybrid kernels, and defective kernels. The speaker stated that the first approach to sorting haploid kernels was to simply use oil measurement and sort based on thresholds. The second approach employs adaptive sorting, which aims to separate a specified percentage of kernels into high and low oil content categories. This was achieved by adjusting oil thresholds during sorting based on the measurements of preceding kernels. Typically, haploid/hybrid ratios were 10%/90%. Adaptive sorting requires continuous monitoring of oil measurements to ensure accuracy and efficiency in the sorting process.

The speaker provided a summary of his report. Firstly, sorting based on oil content effectively eliminated a significant portion of hybrid seeds without losing any haploids. Secondly, adaptive sorting proved to be highly effective at removing an even larger proportion of unwanted hybrid kernels. However, when employing Near-Infrared (NIR) technology to distinguish and separate haploid kernels, dealing with defects can present a challenge. Lastly, future work should focus on the development of inducer lines that create more pronounced oil differences between hybrid and haploid kernels. This is currently being pursued concurrently by the Iowa State University Doubled Haploid Facility.

"Digital Journey of WFP on Food Systems Transformation". Dr. JIA Yan, Program Policy Officer, United Nations World Food Programme: The seminar highlighted the World Food Programme's (WFP) global mission to enhance food security and rural development through digital technology. It reviewed WFP's digital initiatives, their role in transforming food systems, and the prospects for digital food systems.

WFP views digital innovation as crucial for modernizing agriculture and transforming food systems. The agency is dedicated to integrating advanced technologies like data analytics, UAVs, and blockchain, aligning with humanitarian principles. The key digital initiatives include: 1) Satellite Earth Observation: For comprehensive food security analysis; 2) Digital Drone Technology: For monitoring and risk prediction; 3) Hunger Map LIVE: For real-time hunger monitoring and decision-making.

WFP utilizes drones and satellites to rapidly assess disaster damage, predict food security risks, and support data-driven decisions. It also implements smart agriculture and digital platforms like Farm2Go and MANO to connect farmers with markets and facilitate grain sales.

WFP's digital South-South Cooperation involves field needs analysis, knowledge exchange, and a cloud school for broader digital outreach. The agency explores digital applications in e-commerce, information services, and smart agriculture to reduce disaster risks.

Looking ahead, WFP is committed to scaling digital solutions for innovation and sustainable development in food systems. Dr. Jia Yan's presentation emphasized WFP's significant strides in using digital tech to revolutionize food systems and modernize farming, enhancing humanitarian efforts and global food security.

"Integration of the Internet of Things and Machine Learning for Food Logistics 4.0/5.0 and Loss Reduction in Indonesia". Dr. Sari Intan Kailaku, Researcher, National Research and innovation Agency of Indonesia (BRIN), Indonesia: Indonesia, with a population of over 282 million, is a diverse economy with more than 1,340 ethnic groups and 710 local languages spread across 17,500 islands. The economy faces significant food loss, estimated at 22-48 million tones per year, which equates to 115-184 kg per capita per year. The seminar emphasized the importance of the Food Rescue Movement to combat this issue. The seminar highlighted that the distribution process is critical as it is the longest phase where products are unmonitored, leading to potential negative impacts on product quality and quantity. Factors such as environmental condition changes and repetitive handling could damage the products. The presentation introduced advanced digital technologies such as IoT, AI, Blockchain, Big Data, and Cloud Computing, each playing a distinct role in sensing, thinking, recording, storing, and hosting/processing data respectively.

The presentation delved into the application of ML for quality prediction, particularly for climacteric fruits like mangoes, which continue to ripen after harvest due to ethylene production. The importance of temperature management during transport and the optimal timing for harvesting and shipping to ensure quality were discussed. ML algorithms, such as K-Means Clustering for maturity level categorization and Deep Learning for predicting maturity level changes, were highlighted for their accuracy in real-time logistics decision-making. The architecture of IoT was presented, emphasizing the benefits of big data analysis in cloud environments for logistic operations. The IoT-based framework allows for continuous monitoring and immediate response to changes in transportation conditions. The seminar also showcased a web-based application for recording and triggering predictions, as well as a mobile application for monitoring shipments.

The presentation concluded with a discussion on AIoT-based logistics decisions for food loss reduction, emphasizing real-time and predictive analytics for better visibility, control, and timely delivery. The implementation road map outlined opportunities such as growing digital infrastructure and government support, as well as challenges like high initial investment and data security concerns. Dr. Sari Intan Kailaku's seminar provided a comprehensive overview of how IoT and ML could be integrated to revolutionize food logistics in Indonesia, reducing food loss and improving efficiency. The seminar underscored the potential of these technologies to transform the food supply chain, ensuring that more food reaches consumers in a safe and timely manner.

"Targeted Modification of Key Enzymes Involved in Biosynthesis of Methionine from Corn Starch". Dr. MIN Weihong, Professor, Zhejiang A&F University, China: The global market for industrially produced amino acids, primarily derived from corn fermentation, has been a compound annual growth rate (CAGR) of 7% for lysine, 12% for threonine, and 7% for methionine between 2011 and 2023. Methionine, also known as Met, is an essential sulfur-containing amino acid that cannot be synthesized by humans or animals and is the first limiting amino acid in poultry feed. The global demand for methionine in 2023 is projected to be approximately 1.71 million tons, making it the second largest animal nutritional amino acid globally.

Methionine biosynthesis is a complex, multi-branched, and highly regulated pathway. The efficient accumulation of methionine for industrial production presents significant challenges due to its strict regulatory mechanisms. To achieve efficient methionine accumulation, Prof. Min's team employed metabolic engineering strategies, including: releasing feedback regulation; weakening competitive pathways for L-methionine synthesis;□enhancing the supply of the key co-factor NADPH;□global regulation to enhance the carbon flow in methionine synthesis. Through physical and chemical mutagenesis, the team selected auxotrophic and structural analog-resistant mutant strains, achieving the highest methionine yield of 2.103g/L.

Prof. Min's research made significant strides in enhancing methionine production through targeted enzyme modification and metabolic engineering. The strategies employed have the potential to revolutionize the industrial production of amino

acids, offering more efficient and sustainable solutions for the feed and food industries.

2. Public policies including relative standards

"Advances in the Implementation of Policies on Food Loss and Waste in APEC". Dr. Christiam Méndez Lazarte, Professor-Researcher, Universidad de lima, Peu: Dr. Christian Méndez Lazarte introduced the APEC project PPFS 01 2023, an initiative designed to survey and workshop the prevention and reduction of food loss and waste (FLW), with the goal of achieving sustainable food systems across APEC economies.

Dr. Méndez Lazarte described the two-phase methodology used to survey APEC member economies on their FLW reduction policies. Phase 1 involved distributing a survey to 21 APEC member economies, while Phase 2 utilized a rubric to rate their progress. He presented the survey results, which detailed the progress of APEC member economies in strategy and planning, leadership and governance, and policy instruments.

He highlighted the differences in progress among economies and analyzed the heterogeneous progress of APEC member economies in designing and executing FLW reduction policies. This analysis provided insight into the specific areas where each economy stands in terms of FLW reduction policies, allowing for a nuanced understanding of the challenges and successes within the region. He concluded that while some economies have made progress, there is a need for more concrete milestones and baseline measurements to effectively track and drive further improvements.

He recommended the design of policy instruments, programs to improve food storage, and the introduction of technological solutions to enhance measurement and management of FLW. These recommendations aimed to provide a roadmap for APEC member economies to reduce food loss and waste more effectively, ultimately contributing to more sustainable food systems.

"Empower Food Supply Chain Digital Transformation: Status quo and Roadmap of the Standard System". Mr YANG Lifei, Senior Engineer,

Standards and Quality Center, National Food and Strategic Reserves Administration, China: The report offered a comprehensive analysis of the digitalization status and challenges within the food industry, emphasizing the pivotal role of standardization in this transformation. It was structured as follows: The digital economy, with its innovative, penetrating, and broad-reaching characteristics, is identified as a new economic growth point and a fulcrum for industry transformation. Digital technology applications have shown initial success in business scenarios such as grain supervision, storage, processing, trading, and quality inspection.

The report outlined the existing standards related to digital transformation in the food industry, analyzed their impact, and proposed a roadmap for future standard development. As of the current date, there are over 700 domestic and industrial standards in the grain sector, with 51 standards related to digitalization already issued and 40 in development. These standards are categorized into various objects, including information classification and coding, terminology, data elements, and information systems.

Recommendations included the establishment of a digital standardization technical committee or sub-technical committee for the grain industry to better address the specific needs of the food industry in its digital transformation journey. The report emphasized the need to distinguish between "digital technology standards" and "industrial digitalization standards," as well as between "enterprise digitalization standards" and "industry digitalization standards." It also highlighted the importance of "standard digitalization," which involves the development of machine-readable standards and open-source standards to promote the transformation of standardization work towards digitalization, networking, and intelligence.

The digital transformation of the food industry is a complex systems engineering challenge that requires a concerted effort in standardization to ensure data connectivity, interconnectivity, and effective sharing. This report provided a clear roadmap for the future development of standards to empower the digital transformation of the food supply chain, emphasizing the need for a more integrated and comprehensive approach to standardization to unlock the full potential of digitalization.

"Industry Driven & Managed". Ms. Rosemary Richards, Trade & Market Access Manager, Grain Trade Australia, Australia: The report provided a comprehensive overview of the Australian grain supply chain, highlighting the opportunity for digital and innovative technologies and modernization of supply chain practices to support efficiency, safety and sustainability outcomes. The report delved into the digitalization and innovation practices within the Australian grain supply chain, highlighting the role of Grain Trade Australia (GTA) in facilitating trade through self-regulation. It examined the current state of grain production, the benefits of digital tools, the challenges faced, and the drivers propelling the industry forward. The report also outlined GTA's technology roadmap and a case study on the Visual Image Standard (GATS) project, concluding with the significance of digital technology in supply chain modernization. GTA is a not-for-profit industry body that works to facilitate trade within a self-regulatory framework, focusing on trading standards, contracts and trade rules, dispute resolution, trade policy and market access, and industry stewardship and capability. The Australian grains industry is characterized by a stable planted area, production efficiency, and increasing farmer scale.

The largest crops include wheat, barley, canola, and sorghum. Crop production, industry value, domestic demand, and exports are detailed with data from ABARES 2024. Digital and innovative technologies are being integrated across the grain supply chain to improve traceability, farm management, trust, transparency, and efficiency. The digitalization in the grain industry brings numerous benefits, including enhanced traceability, improved farm management, increased trust and transparency, better commercial outcomes, and support for global marketing and ESG initiatives. However, challenges such as data governance, technical challenges to data operability, and logistical complexities may hinder rapid and effective application of digitalization. Drivers for change include the recognition of digital agriculture's potential, technology adoption, advancements in data collection, the industry's strong R&D investment and innovation, data sharing, and a growing focus on environmental sustainability.

The report then provided a case study example of the opportunity for technology to supplement the subjective human elements in grain assessment for sale with digital imagery, a move that aligns with the broader goals of modernization and

efficiency. It discussed the challenges inherent in assessing, approving, and integrating emerging digital imagery grain assessment technologies. To address these challenges, GTA is faciltating the development of an industry standard/ procedure for a uniform system of technology assessment, approval, and maintenance. This approach will support the creation of an harmonized framework that ensures product and data integrity, as well as quality assurance intelligence, which are key components of a modernized supply chain.

"Digital Transformation: Pathway for Modernizing Malaysia Agrofood System". Ms. Izzatul Fardiah Othman, Senior Principal Assistant Secretary, Ministry of Agriculture and Food Security, Malaysia: The presentation covered various aspects of Malaysia's agro-food sector, including its cultural significance, statistical data, policies for modernization, the impact of digital transformation, and the pathway towards modernizing the agro-food system.

The presentation outlined several policies aimed at modernizing the agro-food sector in Malaysia: 1) the National Food Security Policy Action Plan (2021 - 2025); 2) the Sustainable Development Goals (2015 - 2030) ; 3) the Malaysian National Agrofood Policy (2021-2030); 4) the Malaysian Digital Economy Blueprint; 5) the Malaysian National 4IR Policy, focusing on increasing the use of 4IR technologies, IoT, Artificial Intelligence (AI), and Big Data Analytics in the agro-food sector. 6) the Farm-to-Table concept was introduced as a means of enabling digital marketing in the agro-food industry.

The presentation introduced digital agriculture applications in Malaysia, emphasizing the implementation of IoT systems and presenting smart farming use cases that highlight the economy's advancements in this arena. It culminated in a strategic roadmap for the modernization of Malaysia's agrofood sector. It emphasized the importance of strategic initiatives and the steps Malaysia was taking to cultivate a contemporary and efficient agrofood system. The focus was on leveraging digital technologies and innovative practices to enhance productivity, sustainability, and the sector's global competitiveness. To gain a deeper understanding of Malaysia's approach to modernizing its agrofood sector, the report recommended further action. It suggested a more in-depth analysis of statistical data and policy implementations to fully comprehend their impact on the agro-food industry. Moreover, it advised a closer examination of digital

transformation initiatives and their influence on the agriculture sector's value chain, beneficial for industry stakeholders. Ultimately, the report called for the development of a detailed roadmap for the "DX" pathway, providing clear guidance and direction for the sector's modernization. This report served as a high-level summary, indicating that a more detailed exploration of each part is vital for a comprehensive understanding of Malaysia's strategy in advancing its agrofood sector.

"Analysis on the Role and Pathway of Digital Technology in Reducing Food Loss and Waste". Dr. LIN Hai, Associate professor, China Agricultural University, China: The presentation emphasized the importance of reducing food loss and waste (FLW), a critical global issue with significant economic and environmental implications. It discussed the current situation and challenges of application of digital technology in food supply chain, including inadequate digital infrastructure, room for improvement in scientific and technological innovation, and the low digital literacy of farmers. The presentation highlighted how digital technology can address these challenges and improve the efficiency of the food supply chain. Presents a logical framework linking key problems of FLW with digital technology solutions and process objectives. It discussed the use of crop/livestock monitoring systems, drone technology, and agriculture apps for pest, disease, and weed control, and precision agriculture. It detailed intelligent warehousing systems, sorting systems, automated guided vehicles, and cold chain logistics for efficient food transportation. It explored intelligent inventory control and e-commerce platforms to optimize the distribution and sale of food. It advocated for establishing a concept of food saving among consumers.

The presenter proposed recommendations for FLW reduction, including to improve FLW monitoring and assessment, establish regular investigation systems, and harmonize standards. He suggested strengthening policy guidance, establishing a long-term governance mechanism, and increasing fiscal investment. He emphasized the need to cultivate digital literacy and skills among all supply chain actors to enhance the soft power of FLW reduction management. The speaker encouraged actions at every link of the food supply chain, from production to consumption, to leverage digital technology in reducing FLW, and summarized the critical role of digital technology in reducing FLW and the need

for concerted efforts across the food supply chain. The report underscored the potential of digital solutions to achieve global sustainability goals and improve food security.

"Survey progress on digitalization and innovation of food supply chain in APEC Region". Dr. LI Tengfei, Professor, Academy of NAFRA, China: The report's scope included the entire food supply chain, from production to consumption, with respondents ranging from government agencies to food supply enterprises. The survey covered best practices and applications of digitalization and innovation, policy approaches and outcomes, and gender-specific concerns and benefits within the food supply chain. It established the context for the importance of digitalization and innovation in the food supply chain, emphasizing their role in achieving the APEC Putrajaya Vision 2040 and the Food Security Roadmap Towards 2030.

The survey found that digital and innovative technologies used in the food supply chain mainly include sensors, big data, cloud computing, artificial intelligence IOT and block chain. Digitalization and innovation played an effective role in boosting the safe and sustainable development of the food supply chain, as well as improving the management efficiency and contribution to gender equality.

Case studies, such as Anhui Chaohu rice production and Yihai Kerry Intelligent Processing, demonstrated tangible benefits like reduced costs and increased efficiency. Challenges include insufficient application of digital technology, particularly in real-time monitoring and data analysis, insufficient investment in R&D, lack of standardization, and a shortage of talent supply.

The report concluded that while digitalization and innovation have shown significant benefits in the APEC region's food supply chain, there are challenges that need to be addressed through policy support, investment, standardization, and talent development to fully realize the potential of these technologies for food security.

3. Private application patterns integrating various quality-protection and loss-reduction technologies

"Fish Farming Digital Platform for MSMEs". Mr. Chusak Chuenprayoth, President of KC Fresh Company Limited, Vice Chairman of Thai Chamber of Commerce, Thailand: Food security has become a pressing issue faced by many economies, prompting the implementation of various measures to ensure the survival of their populations due to global changes such as wars and climate change, which have diminished food production capacity. Consequently, the food industry is impacted, food prices increase, and the impoverished people are unable to get adequate food. War-conflict issues, extreme weather events, and economic depression lead to urgent domestic and international investments to address the food crisis and ensure food security. This requires a transformation of fragile food systems and the promotion of agricultural development, such as smallholder food production, providing long-term solutions and expanding humanitarian assistance to all. The Global Food Security Index of 113 economies indicates that Thailand was ranked 64th in terms of food security in 2022. Despite Thailand's reputation as a leading exporter of agricultural products and its abundant natural resources, its performance in terms of access to quality and safe food is less than ideal. Therefore, to address future food shortages, collaboration among the government, private sector, civil society, and the public is required to develop effective strategies and enable people to adapt to change. This includes managing natural resources such as land, water, and forests to promote sustainable agriculture and build resilience to natural disasters, as well as cultivating and transferring these concepts to future generations. The following will showcase examples of actions taken by Thailand to address food security issues – the Fish Farming Digital Platform.

This innovation, " Biofloc", represents an eco-friendly approach to fish farming that offers a novel solution to the challenges of confined-space aquaculture by biotechnology. Water containing wasted organic materials ammonia, which is toxic to fish, will become to be good quality water after treated with microbial activities. For example, utilizing a Biofloc system for tilapia nurseries, the farm is managed efficiently through cloud computing and IoT platform. This system enables comprehensive data collection for fish farming traceability, ensuring

detailed records of resource consumption throughout the process. A robust traceability system is implemented for both fish processing and the utilization of resources. Standard processing procedures are designed to ensure that clean and high-quality products can be delivered to consumers. From farming to processing, consumers can trust that they will receive competitively priced and fresh products directly from the farm. The use of this system contributes to achieving food security and safety, less water and space usage, and zero waste farming.

"Smart Rice Center™ - New Solution for Farmers by IoT". Mr. Nobuyoshi Ikeda, Deputy head of Sorting System Group, Technical Division, SATAKE Corporation, Japan: The speaker addressed two aspects, including rice production and distribution in Japan, as well as the Smart Rice Center. In the general rice distribution model, field farmers sell paddy to rice mills, which then process the paddy into white rice for consumer sales. In contrast, the Japanese rice distribution model involves field farmers selling paddy to a cooperative drying facility, where rice is processed into brown rice. This brown rice is then distributed and sold to rice mills, which convert it into white rice before it reaches the consumers. In Japan, the distribution of brown rice stems from a 16th-century practice where the tax amount was determined by calculating the yield of brown rice from surveyed farmland. Japan is currently facing a decrease in demand for staple foods year by year, a decline in the number of farmers across all ages, a reduction in the number of agricultural enterprises, and an acceleration in the concentration of arable land. While mechanization technology to reduce work on the cultivation side is evolving, the progress of digital transformation (DX) to improve cultivation is not advancing.

The Smart Rice Center - DX Solution for Rice Farmers. The Rice Center refers to facilities dedicated to drying, hulling, and preparing brown rice, owned by the producer or corporation, whereas the Smart Rice Center enhances these facilities with the addition of IoT machines and automated harvest evaluation. It is capable of performing harvest evaluations, adjusting water management based on last year's weather information, and determining the harvest time based on accumulated temperatures and other factors. The data obtained from the Smart Rice Center enables the Plan-Do-Check-Act (PDCA) cycle for cultivation to

proceed and leads to technology transfer, which in turn provides training for new farmers.

"Building a Low-cost and Accessible Data Infrastructure for Small Stakeholder". Dr. LI Xun, Chief scientist, Special committee for the integration of production and education in smart agriculture, China Agricultural Machinery Distribution Association, China: The speaker presented the initiative "Constructing an Affordable and User-friendly Data Infrastructure for Small-Scale Stakeholders." According to the 2022 FAO report, digital automation technologies are poised to significantly boost efficiency, productivity, sustainability, and resilience within the agricultural sector. When tailored to local requirements and complemented by digital tools, even motorized mechanization can significantly enhance agricultural output. While the uptake of digital automation technologies is increasing, it is largely confined to high-income economies, where the business case is not yet fully realized. The United Board for Digital Agriculture embarked on an ambitious plan last year to extend the reach of digital agriculture across China's economy. Unlike many previous projects that focused on large-scale farms, this plan designed an integrated framework aimed at serving small stakeholders across the entire region, dubbing it the "Pilot Zone for Smart Agriculture."

The new data infrastructure to support this initiative encompasses several key components: Data services should be affordable and accessible via smartphones, with IoT being a critical component. DJ UAVs or similar aerial remote sensing vehicles are frequently deployed to gather data from small farms, equipped with multi-spectral sensors to collect information on NDVI, plant population, and crop nutrition status, among other things. Aerial remote sensing data supports practical applications such as fertilization and routine field scouting. The Beidou navigation system has been extensively utilized to upgrade agricultural machinery for more precise guidance and variable rate applications. Yield mapping is increasingly being applied to small farms to facilitate better decision-making and insurance claims. Climate change is prompting small stakeholders to make data-driven decisions, and disease warnings based on numerical forecast models are disseminated by government agencies during extreme weather events. A variety

of data sources must be integrated using cloud computing platforms to help farms comprehend the digital landscape.

Currently, there are still numerous challenges, including the analysis of vast data sets, data-driven decision-making, and the education and training of the next generation of farmers. The commercialization of digital agriculture services and the effects of climate change will be pivotal in propelling the development of digital agriculture. Furthermore, collaborative efforts across various economies will be crucial in surmounting these challenges and nurturing the expansion of digital agriculture.

"Practice in Development of the Database for Grain Quality and Nutrition Resources". Dr. Duan Xiaoliang, Professor, Academy of NAFRA, China: The presenter delivered a comprehensive overview, which was segmented into four distinct sections: the establishment of a cereal quality and nutritional resource database, the architecture of the platform, an exposition and application of the platform's modules, and a concluding synthesis with future perspectives. The sophisticated database platform for the quality and nutritional resources of staple and minor crops in China has been meticulously developed. This platform facilitates detailed information retrieval and analytical processes parameterized by cultivation year, geographical region, crop variety, and performance metrics, thereby providing a comprehensive assessment of China's cereal production resources and a detailed quality profile.

The platform's architecture comprises a sampling mini-program, a webpage, a sample data entry management system, and a backend data management system. The webpage includes several sections: homepage, search, quality evaluation, good grain recommendation, premium product recommendation, and quality report. Based on the samples and database, some rapid and non-destructive testing instruments and technology have been developed, including NIR and image-based technology for variety identification. Dr. Duan concluded that it is important to construct a data service platform that caters to the needs of breeders, seed corporations, storage and processing entities, research institutions, instrument manufacturers, and food processing firms, thereby amplifying the socio-economic value derived from the database.

"Bold Innovation for Practice-New Technologies Application in Grain Storage under Carbon Emission Reduction and Energy Saving". Mr. LI Xingang, Chief Engineer, FAMSUN CO., LTD., China: The speaker introduced the challenges in grain storage industry, including high operational costs, a disconnect between intelligence and engineering equipment, dust emissions from multiple sources, poor environmental and working conditions, and issues with grain quality, loss, and storage volume management. To address these challenges, we need to focus on improving equipment, advancing technical processes, and integrating intelligence. Improvements in storage equipment include reducing breakage rates through optimized bucket elevator design, achieving lower return rates, and increasing capacity. Whole enclosed conveyors minimize dust emissions, enhancing environmental standards. Energy-efficient, large-capacity belt conveyors and "3 highs & 3 lows" drying technology reduce costs and pollution. High-efficiency cleaning equipment, such as the Combined Sifter (300T/H), streamlines the process, promoting a sustainable storage industry.

Intelligent storage systems integrate sensors for real-time monitoring, improving efficiency and cutting costs. They feature automatic ventilation and moisture management based on environmental factors and use 3D radar for precise grain volume tracking. Sustainable practices are emphasized with renewable resources, and a digital twin provides a virtual model for real-time system oversight.

The grain storage sector is transforming with intelligent initiatives, such as CP Group's Equipment Management in Indonesia, Muyuan's precise Silo Capacity Management in Henan province, China, and an integrated storage-logistics project in Hubei province, China. These innovations feature "one-button" service tracking, grain condition monitoring, and eco-friendly, new energy solutions to minimize breakage and enhance uniformity.

"Practice and Innovation of Intelligent Equipment for Grain Storage under New Quality Productivity". Dr. MA Zhenzhou, Deputy general manager, Aisino Corporation, China: Aisino's development goals and research directions focus on smart supervision, intelligent detection, unmanned loading and unloading, and smart warehousing, aiming to become a leader in intelligent grain

storage equipment and services, serving the high-quality development of the grain industry.

Dr. Ma shared some innovative cases in his presentation. Mobile quick-install nitrogen filling equipment for atmosphere conditioning storage is functioned by real-time wireless monitoring and collection device in the warehouse, increased efficiency and reduced energy consumption. Unmanned grain transport vehicle and dispatching system for grain depot are capable of fine-grained configuration of each node in the custom task to improve docking accuracy and customized linkage control logic for multiple grain machines to achieve full-process control. Intelligent video analysis series integrate numbers of edge computing devices, special algorithms and cloud platforms..

Looking ahead, future granaries will place greater emphasis on the freshness and nutritional value of grain, reducing food loss and waste, while utilizing solar energy, wind energy, and other environmental protections to lower operational costs and environmental impacts, promoting the development of ecological granaries.

"Data-driven Transformation of the Grain Milling Process". Dr. CUI Chenhao, Data scientist, Buhler Group, Switzerland: The presentation began with a few images that set the stage for understanding the modernization of the industry. Modern mills are a testament to technological advancement, capable of producing 600 pounds of flour a day with a mere 12 employees. The paradigm has shifted; operators no longer directly interact with machines but instead engage with data, which is generated at a staggering rate of 15,000 data points per second during the milling process. The vision of a Smart Mill, or a self-optimized mill, is to revolutionize the industry by achieving the maximum possible yield from any given raw material, realizing over a 10% reduction in energy consumption, ensuring no deviation from target quality, and guaranteeing maximum availability for complex mill designs. Three Pillars of a Data-Driven Flour Mill are listed below:

Intelligent Single Machine Sensors: Sensors are the eyes and ears of the modern mill, providing 24/7 real-time monitoring. They ensure that production parameters and product quality at every stage are accessible online, enabling intelligent equipment to automatically adjust production parameters based on sensor data

and production targets, thereby optimizing production efficiency and product quality.

Data & Algorithms: The backbone of a data-driven mill is its structured dataset, which links raw material quality, production parameters, intermediate product indicators, and final product characteristics. Large amounts of data from various sensors are collected and analyzed using machine learning algorithms. These algorithms are crucial for in-depth data analysis and prediction, such as identifying grain quality and optimizing production parameters, ultimately improving production efficiency and product quality.

Automation & Digitalization: Full automation in production, transportation, packaging, and loading/unloading processes is achieved to minimize human intervention and operational errors. Comprehensive digitalization through the integration of systems like ERP and MES ensures that all production processes and management decisions are based on real-time data, fostering transparency and efficiency.

III. Discussion, Recommendations and Conclusions

1. Outcomes of Panel Discussion

Topic 1. The current practice, planning for the application, issue and suggestion of digitalization and innovation in food supply chain

Current situation and challenges

- Most economies have policy frameworks concerning digitalization and innovation in food supply chain, but implementation is an issue for many.
    - Many economies have digital platforms but lack inter-operationality and connectivity. Inconsistent digital standards impeded data convergence.
    - Digitalization level varies in different sectors. For example, the level in crops is lower than that in fisheries. Even in crops, it varies in different stages, which causes incomplete digital chains in various stages.

- Skepticism about new technologies and incorrect mindset of the old generation farmers, exist in many economies.
- The high cost of digital technology limits its promotion and application.
- Lack of infrastructure, skilled workforce, investment mechanism, capital sources, information sources, incentives for private sectors involvement, training.

Suggestions

- Share information on the current policy frameworks and implementing practices of economies concerning digitalization and innovation in food supply chain.
- Monitor the process of digitalization and innovation. Strengthen data security, consolidation of database, and data protection.
- Climate change needs to be taken into account.
- Facilitate public-private partnerships.
- Disseminate digitalization from advanced sectors to less advanced sectors.
- Strengthen education for the younger generation.
- Strengthen agricultural facilities, block chain systems, AI empowering the certification system and develop block chain systems to food supply chains.
- Increase affordability of technology by development of easy-to-use and low-cost applications, sharing information and strengthening training for SMEs, especially for small farmers.
- Look into every link of the food supply chain from upstream to downstream and keep the smoothness of the logistics.
- Communicate on the harmonization of international, domestic and business standards.

Topic 2. How female participation is promoted with digital and innovative technologies.

- Digital technology has narrowed the gender gap and brought more opportunities.
- With the widespread application of digital technology, there are more and more female practitioners and researchers in the grain supply chain, promoting gender equality.
- Women can improve their personal abilities by actively participating in digital technology training and learning.
- Raising women's awareness of food loss and waste is important since they can play the key role in FLW reduction.

Topic 3. The related issue of the Research Center for Food-loss reduction technologies.

- It is necessary to establish a research center for food-loss reduction technology, to facilitate communication and cooperation between economies, sharing policies and advanced technologies.
- Food loss should be defined. Meanwhile, identify technologies in need, partners, pool experts, commodities to be included ect.
- Consideration of technologies including cold chain, block chain, available digital tools, as well as regulatory frameworks and partnership of APEC members.
- The center should be a non-profile organization, and should focus on technology promotion and pay attention to data security.
- Quantifying economic, social and environmental benefits should be taken into account.
- The potential of biomass, packaging technologies and genetic technologies to extend shelf life should be considered.

Topic 4. Discuss on the survey of digitalization and innovation of food supply chain, and the knowledge acquisition from the seminar.

Survey

- Allow for submitting the survey without answering the whole questions.
- Better research into private sector.
- Conduct survey on unmanned facilities, including grain depot, vehicle, processing plant ect.
- Expand survey subjects to other industries for the horizontal comparison.

Knowledge acquisition

- Learn about the latest and practical digital technologies applied in food supply chain.
- Attendants from different economies are looking forward to more in-depth exchanges and cooperation in the future.
- Understand the challenges for FLW reduction, and learn about solutions with policy as well as digital and innovative technologies.
- The workshop has promoted exchanges and cooperation between different economies. It is strongly suggested to continue sharing and cooperation in APEC region.

2. Recommendations and conclusions

Through the presentations, Q&A sessions and panel discussions, the attendants exchange their knowledge and views on the best practices and applications of digitalization and innovation on food supply chain. It has reached a consensus that digital transformation is an effective path to ensure food security, but it still faces numerous challenges. Combined with the research of survey result, recommendations on how to promote the application of digitalization and

innovation to accelerate the digital transformation of food supply chain are proposed and summarized as below:

- Improve digital infrastructure, increase government investment in digital infrastructure, and promote the accelerated application of new-generation information technologies and new digital infrastructure.

- Increase financial, tax and other support for digital technologies, encourage enterprises to strengthen R&D of digital technologies, and introduce tax incentives for digital technology R&D.

- Intensify research on digital technologies, and develop more low-cost and individualized technologies to meet the development needs of different economies and different entities in the supply chain.

- Strengthen the integration between digital technologies and other technologies, encourage the in-depth integration of new-generation digital technologies into the food supply chain.

- Leverage existing platforms like APIP, or set up a case studies section on APEC's official website to strengthen the sharing of typical digitalization cases, and actively hold seminars on the digitalization of the food supply chain to enhance the exchange of information and sharing of experience among economies.

- Intensify digital technology training and talent cultivation, develop courses or training programs that meet the needs of economies, and cultivate more digital technology talents at different levels.

- Promote the establishment of more demonstration and pilot projects for the application of digital technologies.

- Explore the establishment of research centers for food loss reduction technologies, encourage governments, MSMEs, research institutes and other groups in the food supply chain to join in, facilitate the application and promotion of digital technologies in loss reduction throughout the food supply chain,

promote the connectivity of relevant standards among economies, and ensure an efficient and smooth flow of information.

- Increase efforts to train and enhance women's digital skills, and provide guidance and support to build capacity for young women. Actively develop digital products for women, promoting women to enjoy the benefits of the digital economy, and enhancing their ability to participate in the development of the digital economy.

Further thoughts and discussion should be conducted for the herein above concept at the next Seminar to transform it into a document that could be endorsed in APEC region.

IV. E-book of the Seminar

The presentations of the Seminar have been compiled into an e-book, and the link is as follows:

http://ags.ac.cn/englishnew/news/202412/t20241212_11411.html