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1. Introduction

This project report is an output of an APEC-funded project of Agricultural Technical Cooperation Working Group (ATCWG) from Session 1 of 2020, "ATC 01 2020 - APEC Workshop on the R&D and Promotion of Smart Agriculture". It is co-sponsored by Malaysia and New Zealand.

Climate change, aging population, labour shortages, and global competition nowadays have caused higher costs in producing agricultural products and result in food insufficiency (FAO, 2017). APEC economies are recommended to apply new technologies, such as Artificial Intelligence (AI), Internet of Things (IoTs), agricultural robotics, and Unmanned Aerial Vehicle (UAV) to enhance agricultural efficiency, productivity and innovation to reduce farmers' workload, and improve manpower shortages and global competence. With state-of-the-art smart agricultural systems, farmers are likely to gain better control over crop cultivation and the animal-raising process, enhancing the production efficiency and quantity. Through these practices, smallholder farming has the potential to improve livelihoods and accelerate self-reliance (MDPI, 2020). The APEC region could gain convenience on yield production as well as being on the right track to fulfill the aims of food security.

To better promote smart agriculture 4.0 and safeguard food security, Chinese Taipei had conducted an APEC workshop titled "APEC Workshop on the R&D and Promotion of Smart Agriculture". This hybrid workshop was held from November 23 to 24, 2020 at the Evergreen International Convention Center in Taipei and broadcasted live through the platform of Cisco Webex. This workshop aimed to serve as a platform for both the public and private sectors of APEC economies. Prior to the workshop, a pre-meeting survey, which covered the topics discussed in the workshop was conducted to learn about the application of smart agriculture among APEC member economies. An evaluation survey was also distributed to participants after the workshop.

Apart from the Opening Session, Individual Economy Reports and a Recommendation and Closing Session, this 2-day program was consisted of 5 main sessions, which included "Trends of Prospects of Smart Agricultural R&D and Application", "AI for the R&D and Application of Intelligent Image Recognition", "Development and Application of Assistive Devices and UAV in Agriculture", "Best Practice of Smart Agricultural Application and Promotion Methods" and "How Women Groups Will Benefit from Smart Agriculture". The agenda of the workshop can be referred to Annex 1.

There were a total of 96 participants from 15 member economies taking part in the workshop. Members were from Australia; Chile; Indonesia; Japan; Korea; Malaysia; Mexico; New Zealand; Peru; The Philippines; Russia; Singapore; Chinese Taipei; Thailand; and United

States. Out of 96 participants, 42 were female, which accounts for 44% of the participation rate.

Figure 1.1 Workshop group photo taken onsite

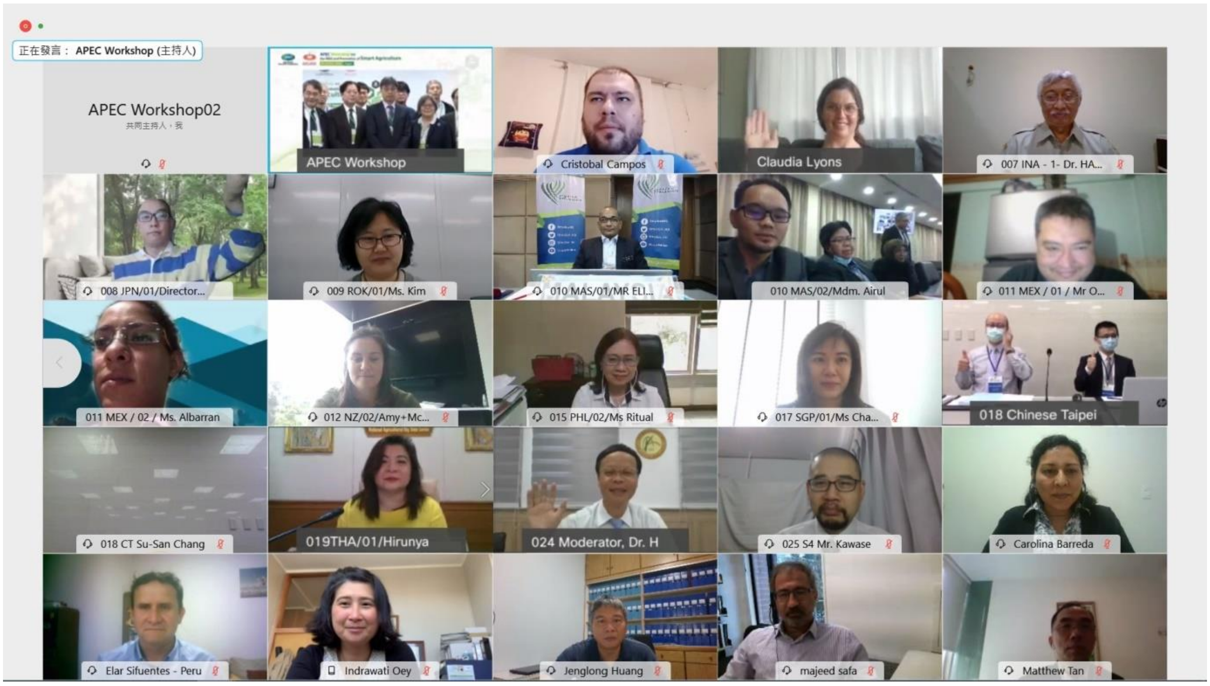

Figure 1.2 Workshop group photo captured through Cisco Webex platform

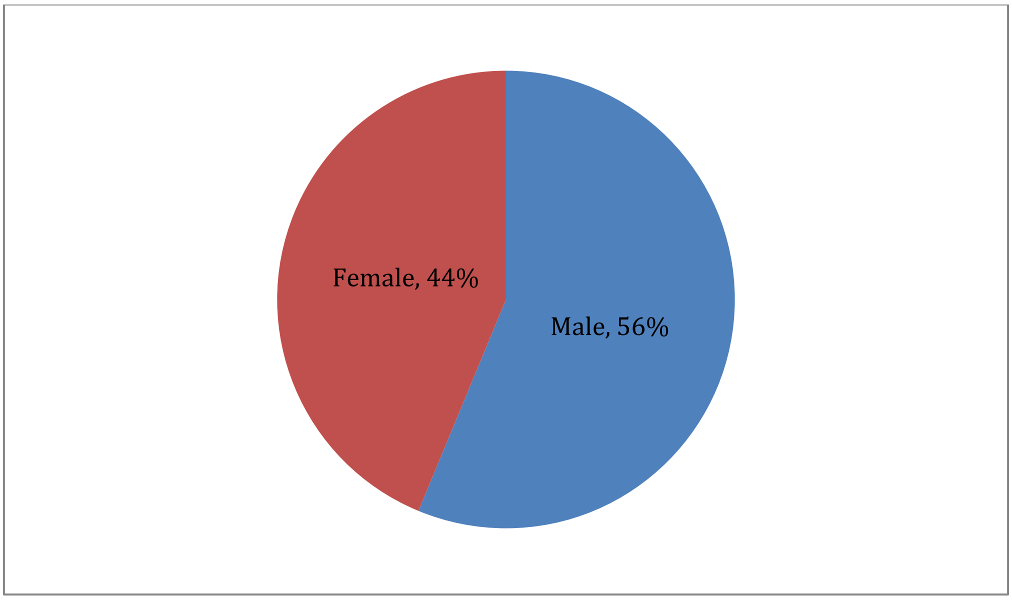

Figure 1.3 Participants' percentages in genders

1.1. Smart Agriculture in APEC Region

Facing increasing challenges of rapid population growth, accelerating urbanization, and decreasing farmland acreage per capita, APEC has recognized that building integrated smart and sustainable food systems are crucial to enhance food security in the Asia-Pacific region. Adopting Information and Communication Technologies (ICTs) to optimize agricultural production is also an effective means of adapting food systems to global warming, which caused frequent and drastic changes in rainfall and temperature patterns and could further increase the vulnerability of farmers.

Advancing the use of technology to increase the quantity and quality of agricultural production with less input and resources is imperative to APEC economies, which account for 38% of the world's population, 54% of global cereal production, and almost 70% of fish production. According to FAO, by 2050, global food production will have to be 70% higher than that of 2005/2007 to meet the growing population's increasing demand (FAO, 2009). Such pressure and challenges are further exacerbated in the APEC region, given that small agricultural holdings constitute a vast majority of farms and are limited in the financial and technological resources.

1.2. Gender Inclusion in Smart Agriculture

To echo the "La Serena Roadmap for Women and Inclusive Growth (2019-2030)" and to best reach the goal of gender inclusion in smart agriculture, one of the main focuses of this project is on sharing best practices in enabling women to gain equal access to affordable inputs and improved techniques and technologies of smart agriculture. Smart agriculture heavily relies on new technology, and in order to ensure women would be in a good position to take advantage of those relevant new technologies, the idea of innovation was examined. The project addresses women's economic empowerment by sharing information and best practices of innovation to ensure women are able to engage in smart agriculture. Therefore, female farmers were invited to the workshop to share their experiences in the scope of smart agriculture.

The implementation of this project was aligned and strived to fulfill the following action areas of the "La Serena Roadmap for Women and Inclusive Growth (2019-2030)" (APEC, 2019):

1. Empowering women through access to capital and markets;
2. Strengthening women's labor force participation;
3. Improving access of women to leadership positions in all levels of decision making;
4. Support women's education, training and skills development and access in a changing world of work.

2. Summaries of the Workshop

2.1. Opening Session

The opening speeches were given by 3 delegates, Dr Junne-Jih Chen, Deputy Minister of the Council of Agriculture, Dr. Su-San Chang, Lead Shepherd of ATCWG, and Mr Vincent Chia-Rong Lin, Project Overseer.

Dr Junne-Jih Chen greeted participants of the meeting. He highlighted two key concepts of smart production and digital service. He shared the experience of Chinese Taipei and stressed that technologies such as AI, IoT, and UAV have been introduced into the agriculture sector to enhance farming efficiency and reduce farm workload, and that with these cutting edge technologies, farmers in Chinese Taipei have gained better control over their crops and farm animals, and have been allowed to maximize profit and minimize potential risks.

Dr Su-San Chang stated that 96 participants from 15 member economies attended the workshop virtually and physically. She pointed out that the APEC region is encountering great challenges in boosting agricultural production to meet the increasing demand for food brought by the growing population, particularly under limited land and water resources, farming manpower shortage, climate change threats, and risks such as the COVID-19 pandemic. Hence, ATCWG has an important mission to promote the benefit of smart agriculture, help build members' capacity to utilize technologies such as AI, IoTs, agricultural robotics, and UAV to enhance the potential of agricultural efficiency, reduce farmers' workload, and improve manpower shortages. She also emphasized the importance of addressing the aging farming society and women workforce in the agriculture sector, how they should also be given equal access to affordable smart agriculture technologies in order to boost production as a whole.

Mr Vincent Chia-Rong Lin introduced the overall agenda of the workshop over the next two days and took the opportunity to briefly report on the workshop's pre-meeting survey results: We gathered 96 participants at the workshop, and received 52 responses. Over 84% of respondents believe that the promotion of smart agriculture can increase agricultural competitiveness, among which; 85% believe it is a challenging task for their respective economies. In general, the results of the survey stressed the significance of the workshop.

2.2. Trends and Prospects of Smart Agricultural R&D and Application

This keynote speech session was led by Dr Chih-Kai Yang. He began the speech by telling participants why smart agriculture matters. The definition of smart agriculture is to use innovative and advanced technologies within the agri-food system to promote sustainable productivity by allowing farmers and other stakeholders to make appropriate decisions.

Global crises have great impacts on agriculture, including global warming and climate change, arable land scarcity, and water shortage. It is important for many member economies to solve such problems using smart technologies to improve food security.

The history of smart agriculture can be traced back to the 1980s, going through the invention of commercial Geographic Information System (GIS), satellite, cloud computing, and now we have come into the age of IoT, Information and Communication Technology (ICT) sensors, big data and AI in promoting development in the sector. Smart agriculture is not only more environmentally friendly; it also saves labor, time, and energy. It draws more participation from the younger generation and brings forth precision production, quality agriculture, resource sustainability, and agri-food safety.

Dr Yang also introduced the trends of smart agriculture in the US, Germany, and Japan. The US aims to strengthen data sharing and integration through the "2018 e-Connectivity Leading Project", which hopes to drive the present and future region economy to promote business development and to connect the public facilities in rural areas. Germany has moved from the "pre agro II" launched in 2004 to the "iGreen" in 2009. Currently, Germany is engaging with the Agricultural Industry Electronics Foundation in promotion of ISOBUS verification. Japan began promoting smart agriculture since 2016. The export amount of Japan's agricultural products exceeded JPY 1 trillion in 2020. Japan also aims to let all of their farmers utilize agricultural data wisely in their agricultural activities by 2025.

Dr Yang pointed out that the value of the global smart agriculture market was USD1.67 billion in 2019, with North America accounting for 52% of the value, due to the fact that the US is the pioneer in precision farming. In comparison, the Asia-Pacific region accounted for 14%, yet with an expected compound growth rate of 18.8%. He referred to a few R&D application cases worldwide, such as the US; Australia; Japan; Chinese Taipei, and India.

In conclusion, Dr Yang believed that the agri-food supply chain can be strengthened by adopting new digital tools and innovative technologies. The development of smart agriculture will enrich the information from the field to table. He also stated that smart agriculture will bring about new digital services. Cross-sectoral cooperation of smart agriculture industrial chain will form an ecosystem in itself, and that by leveraging IoT, big data and cloud computing, cross-border research and replication of successful application models will be an increasing trend.

2.3. AI for the R&D and Application of Intelligent Image Recognition

Application of Smart Aquaculture, Mr Matthew Tan, Singapore

Mr Tan addressed the issue of shrimp and fish casualty in the aquaculture industry under the impact of the COVID-19 pandemic, which has resulted in the potential risks on the availability of food and agriculture produce, and also attributed to the decrease of purchasing power and capacity to produce food. He gave an overview on how the aquaculture has enjoyed a good harvest over the past few decades, however in the past 15 years, a rapid decline can be seen due to two main reasons: massive disease outbreak and massive algal bloom; also, the COVID-19 has taken a significant toll on production and exposed the massive gap in the supply chain. He took the shrimp industry as a classic example, how disease outbreaks have greatly impacted it with losses amounting to USD 1 billion annually and production falling around 40% in the Asia-Pacific region. The algal bloom has also impacted the floating cage aquaculture in the South East Asia region that is valued at over half a billion US dollars and has suffered severe casualty over the past period. Mr Tan stressed the importance of smart aquaculture applications and creating a smart urban farming system to respond to the current situation where a lack of manpower overseeing the aquaculture operations is happening due to the COVID-19 lockdowns. The smart urban farming system must be urban and small foot-printed, adopt climate climate-smart farming technology, adopt bio secure farming technology, be energy efficient, use clean energy, and be antibiotic and chemical-free. Automated harvesting and minimal manpower are the key features of such technologies. Mr Tan pointed out that public and private sector partnership is necessary to ensure food security and aquaculture farmer survival. For example, he took the grant call for 30x30 Express to ramp up local food production in Singapore, which calls for investment in local production as a key strategy to ensure food security and awards companies with promising technologies. He emphasized that, for farmers to survive, new technology is no longer a choice but a necessity.

An Intelligent Imaging and Sensor System Based pm IoT for Automated Insect Pest Monitoring, Dr Ta-Te Lin, Chinese Taipei

Dr Lin stressed the severity caused by plant pests and diseases, pointing out the importance of monitoring as the prerequisite for all measures applied in the integrated pest management process. He stressed that monitoring allows for the forecast and early warning to farm managers in their evaluation and decision-making process, and conventionally, manual observation has been practiced in the monitoring of sticky paper for pest control and monitoring process, which is time consuming and laborious. To solve such problems, Dr Lin proposed developing an imaging and environmental sensor module, composing an embedded system integrated with off-the-shelf component sensors such as light intensity sensor, temperature and humidity sensors, and cameras. As such, sticky paper images can be readily acquired and sent to the servers for analysis. The deep learning approached is adopted for the pest detection analysis, with the first stage being pest detection, the second stage being the pest recognition stage. The pests are detected then recognized, and then the images are delivered directly to users via the website or mobile apps. Information including temperature, humidity and light intensity can also be displayed. The sensors are currently installed in ten agriculture farms across Chinese Taipei, with six more planning to be installed. The integrated sensor network includes both real-time monitoring and long-term monitoring capabilities; together with the rapid delivery of information, farm managers are provided with a better opportunity to take control measures before a pest, insect, or disease outbreak occurs. Dr. Lin believes that with this new approach, real-time and precise information may be accessed, and with such information, farmers can readily take action in the field and efficiently reduce crop loss.

Wild Bird Detection in Poultry Farm Based on Deep Learning and Integrated with Laser Mechanism for Automatic Wild Bird Repellent System, Dr. Yao-Chuan Tsai, Chinese Taipei

Dr Tsai explained the need to repel wild birds from poultry farms due to the fact that many wild birds bring about avian flu viruses and also consume too much poultry feed. He introduced two automatic wild bird detection and laser repellent systems, through which successful detection of wild birds through the first method of traditional image process and the second method of deep learning process were made. Both systems were sufficient in repelling wild birds with success rates of 89% and 57%, respectively. More attention will be paid in the future to collecting more images to enhance detection ability and to provide more energy through the use of batteries aimed to enhance power supply.

Measuring the Length and Identifying the Species of Dewatered Fish and Measuring the Length of Shrimps in Vivo Using Intelligent Machine Vision, Dr Yan-Fu Kuo, Chinese Taipei

Dr Kuo stressed that conservation and production of marine resources are necessary. It is also why the Electronic Monitoring System (EMS) was established onto fishing vessels to monitor processes of fish harvesting and identify fish species, and also the reason that the underwater imagery system Vivo was developed to detect shrimp and measure shrimp’s body length. For fish identification, the goal is to automatically identify fish through EMS images without human interpretation. With the input of fish images into the convolutional neural network (CNN), the output would be the fish species. Through resizing and image augmentation processes, an accuracy of 95% for the identification of 14 fish species has been achieved, and the estimation error of fish body length is at approximately 6%. The model applied to segment fish bodies from the background is called YOLACT. For the second part of the presentation, Dr. Kuo talked about the estimation of shrimp body length through an underwater imagery system to define shrimp activity levels, and measure the amount of feed needed to provide to the shrimps without wasting feed. The YOLOv3 is used in the shrimp detection process; the performance is approximately 85.08% in mean average precision, and the error rate of shrimp body length estimation is approximately 5.76%.

2.4 Development and Application of Assistive Devices and UAV in Agriculture

Development and Application of Drone/UAV in Agriculture, Mr Mohd Amiruddin bin Ramli, Malaysia

Mr Amiruddin bin Ramli's objective in his presentation is to share the potential use of drone/UAV in agriculture, explain the challenges currently faced, and propose a way forward. He first explained why the use of Unmanned Aerial Vehicles (UAVs) are needed in addressing problems such as enhancing monitoring efficiency and making up for manpower shortage for pesticide spraying. Then he elaborated on the current application in Malaysia for UAVs in the agriculture sector, for example, in the use of agriculture activities, disaster monitoring, paddy monitoring, etc. Mr Amiruddin bin Ramli explained the current rules and regulations, where approval from five competent authorities must be acquired, and at least a three-person team consisting of a commander, pilot, and engineer must be formed in order to conduct drone operations. He then described the challenges met with UAV adoption, such as sensor resolutions, imagery, and optimal settings. He suggested the APEC Agricultural Technical Cooperation Working Group (ATCWG) to establish a service provider framework, methodology or SOP, tools/devices affordable and friendly to farmers, and invite specialists' collaboration to form best practices for drone operation, and also create more job opportunities for the young and jobless.

Development and Application of Assistive Devices in Orchard Farming, Dr Wei-Chih Lin, Chinese Taipei

Dr Lin explained the serious labor shortage in the agriculture sector, particularly in the case of Chinese Taipei, where the major farming population is between age 50-64, with many showing physical discomfort. The goal of developing and applying assistive devices is to lightened farmers' workload. In this project, the research team achieved the development and evaluation of three different types of wearable assistive devices, namely the joint-types of powered braces, battery-powered assistive exoskeleton, and non-powered assistive muscle suit. The team applied and tested the developed muscle suits in several fruit orchards and greenhouses, receiving electromyography (EMG) measured data showing the muscle suits saving up over 50% muscle stress consumption and providing stronger weight support. Also developed in the project were semi-autonomous spray vehicles, which could be applied to fertilizer spraying and other farming activities. Dr. Lin hopes for the developed products to be soon commercialized at an affordable price and available on the market to all farmers.

Drones Application in Farming Management in Chinese Taipei, Mr Horng-Yuh Guo, Chinese Taipei

Mr Guo talked about the development of drone application in Chinese Taipei's agriculture sector, where drones are used mainly for field scouting by smallholders conducting precision agriculture. It is used as field robots for pesticides, fertilizers, and seeds spraying. Also, it helps crop damage assessment for agriculture insurance, 3D image application, and autonomous flight development. He noted, for crop monitoring, that in small-area agricultural disaster damage areas, UAV survey can reduce time and manpower of post-disaster damage assessments; for drone spraying pesticides, benefits are time and labor-saving, less harm to human health, less pesticide consumption, less pesticide residue in crop and achieves higher food safety standards; and for crop damage assessment, UAVs provides the exact location of plant health problems in the crop, and the precise location of the disease/pest outbreak helps decide the best crop management solutions, such as applying pesticides or disposition of diseased plants. He further described future drone developments being focused on increasing farmland monitoring and management accuracy, increasing pesticide spray and fertilization accuracy, improving regional management efficiency, assisting field trials, cultivating acreage surveys, surveying crop damage, and estimating insurance compensation, and applying them as production tools.

2.5 Best Practice of Smart Agricultural Application and Promotion Methods

Data-Driven Pasture Management via Satellite Technology, Ms Rebecca Dalrymple, New Zealand

Ms Dalrymple talked about how important it is for farmers to measure the feed and know how much they have in storage ready for their animals. Through collaboration between Livestock Improvement Corporation (LIC), Syngenta and Planet, Satellite Pasture and Cover Evaluation (SPACE) was able to deliver to farmers, through reports conducted by satellite imaging technology, a clear picture of the landscapes. She also talked about how farms in New Zealand are digitalized. She emphasized that the current SPACE team is predominantly females in the age of 20-35, enabling young women participation in the agriculture sector with the latest technologies. She also talked about the potentials of the technology having a quicker response time to adverse changes and enables the minimization of impacts, and that high-quality information allows for better decision-making. She stressed that for the future, they would continue to refine New Zealand's based offerings, explore overseas expansion opportunities, and develop new ways to provide farmers with greater insight.

The Application and Promotion of Smart Agriculture in the Corn Industry in Chinese Taipei, Ms Ya-Ping Hsiung, Chinese Taipei

Being a successful female farm entrepreneur, Ms Hsiung introduced her company, the Great Agricultural Technology, sharing with participants its main corn products and its marketing channels and destinations. She talked about her bottoms-up and fair farming strategies, engaging with farmers, and holding both domestic and international exhibitions. Ms Hsiung elaborated on the application of smart agriculture in the corn industry and its prospects. She is especially proud of her company's cold chain system that ensures fresh product quality, which is a unique system that makes her company stand out from her competitors. In terms of smart technology applications, Ms Hsiung has asked farm leaders to assist in taking pictures of their fields, has established sensors in the fields, and also has cooperated with UAV teams to collect imaging for research projects as well. She hopes to create benefits not only for her company but more importantly, for farmers and consumers. Under her leadership, the company allows farmers to enjoy more rights and ensure food safety for all of its consumers.

Application of Infrared Thermal Imaging Camera for Early Warning and Detection of Dairy Cow Diseases, Mr Kuo-Hua Lee, Chinese Taipei

Mr Lee talked about the challenges faced in the dairy industry recently, most importantly being how diseases in dairy cows go unnoticed until too late, and so it is essential for farmers to be able to detect diseases early on. He spoke on the application of infrared thermal imaging techniques in taking dairy cows' temperature from their eye sockets and udders without having to take the cows' rectal temperature. The goal is to gain early warning and detect possible cow diseases, which could significantly reduce losses, and hopefully also improve the feeding efficiency of dairy farms in the future.

Smart Agriculture in NARO, Mr Yoshiyuki Kawase, Japan

Mr Kawase from the National Agriculture and Food Research Organization (NARO) in Japan gave a brief introduction of NARO. Established in 1893, it is the core research institute for agricultural and food sciences in Japan. He also introduced Society 5.0, which is a new concept for society. Society 5.0 provides products and services to the people, regardless of their age, gender, region, or language. It achieves both economic growth and resolves social problems, including environmental conservation. Mr Kawase then processed on the smart food value chain. The process in food value chain is made "smart" by utilizing AI and the Agricultural Data Collaboration Platform called WAGRI. The Cross-ministerial Strategic Innovation Promotion Program (SIP) was also mentioned. SIP is a cross-ministerial project in which the Minister of State for Science and Technology Policy and the Prime Minister take leadership. In this project, by using two robot tractors, labor efficiency is 160%. By combining robot tractors, robotic transplanter, robot combine harvester and automatic and remote water management system, farmers' income have increased by 45%. Finally, Mr Kawase talked about the automated agri-machinery test. In Japan, various automated agri-machines have been put on the market and are being introduced into agricultural fields gradually. Smart agriculture technology combined with automated agri-machinery greatly enhances farm productivity and growth. Explicit examples on how the application of smart technologies increased the profit and growth in individual farmer cases were given.

Delivering the Digital Future of Agriculture, Mr Justin Webb, Australia

Mr Webb introduced his company AgriWebb in Australia, he pointed out that the company focuses on digitising ranch management and redefining global protein production. For digitizing ranch management, Agriwebb views farming as a business, where one has to understand the cost per kilogram/pound of meat produced, and how to improve that output. Through technology, AgriWebb is a platform that makes it flexible for farmers to operate seamlessly on their mobile devices anytime and anywhere, with all data flowing onto one single platform. As for redefining global protein production, Mr Webb emphasized that the carbon emission generated from protein production, which accounts for 9% of total global carbon emissions, can be sequestered by the regeneration of grass that is greater than the methane emission of the animals that feed on it. Fundamentally, protein production can have a net negative carbon impact. AgriWebb proposes an interconnected smart farm ecosystem by gathering on-farm data, focusing on the digitalization of information, and ultimately creates a comprehensive ecosystem that will bring about a huge transition for the industry.

2.6 How Women Groups Will Benefit from Smart Agriculture

The Human Approach to Technology: Methods to Increase Adoption of Smart Technology by Women in Agriculture across New Zealand, Ms Claudia Lyons, New Zealand

Ms Lyons demonstrated how technology nowadays empowers women by easy access to information. Technology allows the transfer of information from one person's mind to being accessible by the public. This is how females are being brought to the floor for decision-making, which New Zealand has a comparatively high level of gender equality in agricultural business decision-making. New Zealand also has established courses and training to bring technology to women in the agriculture sector. This support system is also crucial in enabling long-term behavioral change and adoption of new ideas. She shared with the workshop three case studies in which technology is regarded as a tool, a system, and a program to assist women in agriculture decision-making. The first case is a "Cloud Farmer" app created by a female New Zealander. It is a one-stop platform that offers information and data farmers need and can be easily utilized on cellphones. The second case is about how the number of females in leadership agricultural roles is still limited, especially if they also have a home committee at the same time. However, with technology's assistance, barriers can be removed. Females can strike a balance between work and home. Ms Lyons mentioned two especially helpful websites, namely "FARMIQ", a platform that can improve farm productivity, and "Farm(x)", an all-in-one platform to manage irrigation, fertilization, and yield. Finally, Ms Lyons mentioned that the "Agri-Women's Development Trust" has well-known courses and development programs specifically to empower and educate women in agriculture. It helps with strengthening their networks.

Trickle-Down and Bottom-up Effects of Women's Representation in Adoption and Diffusion of Smart Agricultural Application, Dr Yu-Hua Chen, Chinese Taipei

Dr Chen first gave a brief overview on the current gender gap in the agriculture sector, how Chinese Taipei's agriculture sector is male-dominated and suffers from labour shortages. Dr. Chen also pointed out that there has been a discussion whether men and women benefit equally from technology. In general, it is harder for women to have equal access to agricultural resources such as land, farm inputs, and loans in rural settings systematically. Women also do not have enough representation in decision-making bodies such as rural organizations and farmers' cooperatives and associations. On participation to the agricultural organization, since agriculture is male-dominated, there are limited extension services available for women. However, women's inequality situation is getting more attention by international organizations like APEC. The "2016 Declaration of the 24th APEC Economic Leaders Meeting" urged members to facilitate women's and girls' access to technology, engineering, and math education. In 2019, APEC encouraged women to participate in smart technology in agriculture, which can reduce the burden of labour on female farmers. With the application of smart technologies, women in Chinese Taipei's agriculture sector could be given a comparative advantage to boost overall agriculture production, and trickle-down and bottom-up effects can be seen.

Involvement of Women Groups in Agrofood Industry: Malaysia Perspective, Dr Florence C. Ginibun, Malaysia

Dr Florence talked about women's group involvement in the Malaysia agrofood industry. She shared the general information of the current population, registered farmers in the Department of Agriculture, and the women's groups under the Ministry of Agriculture and Food Industries. She shared a specific case with the Parit Kemang's Women Group and spoke of its annual sales values, achievements, projects, and activities. She also pointed out the main challenges are financial constraint, aging factor, and promotion and product marketing. She stressed that new technology and smart agriculture adoptions along the food supply chain will benefit the woman's group and contribute to the development of the economy.

2.7 Individual Economy Reports

Among all the APEC economies that attended the workshop, 9 of them shared their latest progress and future plans of smart agriculture with participants as below.

Indonesia

Indonesia pointed out that the implementations of smart agriculture in Indonesia bring forth an increase of production and productivity and expand their agriculture land use. Currently, Indonesia is launching a series of smart systems in climate monitoring, irrigation, greenhouses, land preparation, breeding, planting, protection, harvesting, and marketing.

Japan

Japan introduced its advanced agricultural technologies, including drones for rice seeding and automated cultivating tractors. They believe that these technologies are suitable for the majority of small-scale farmers in the APEC region. Japan also mentioned their agricultural data collaboration platform called WAGRI. WAGRI collects agricultural data, including soil conditions, weather information, and market conditions.

Korea

Korea is facing an aging issue in the agricultural sector. Therefore, Korea is establishing a youth business incubation program, leasing smart farm facilities, and establishing smart farm test sites. A smart farm innovation valley was also created to nurture talents, provide technological innovation and inclusive growth of upstream and downstream industries. Korea is currently expanding outdoor smart farms, advancing agricultural machineries and strengthening the R&D of vertical farms.

Malaysia

Smart agriculture creates high-value careers for Malaysia. Agricultural challenges could be mitigated. Also, farmers' income and productivity can increase. Malaysia is implementing agricultural drones, remote sensing and GIS, digital marketing and precision farming. Malaysia is launching the National Agrofood Policy 2.0 (2021-2030) and the 12th Malaysia Plan 2021-2025. There will be grants for suitable agriculture machinery innovation and technologies. Malaysia is also looking at increasing adoption technology and automation as well as training and education in smart agriculture sector.

New Zealand

New Zealand is launching Sustainable Food and Fibre Futures (SFF Futures) funds to create more value and improve sustainability for the food and fibre industries. Also, New Zealand utilizes software tool that combines on farm management, topography, soil, and climate to determine nutrient losses and greenhouse gas emissions to support on-farm decision-making to maximize land use. To combat greenhouse gas emission, New Zealand has a long-term Agritech Industry Transformation Plan and it also established a research centre to work in the agricultural greenhouse gas area and the Pastoral Greenhouse Gas Research Consortium (PGgRc).

Peru

Peru displayed its efforts on developing projects and initiatives aligning with smart agriculture objectives in scopes of sustainable productivity, adaptation and mitigation. Peru also conduct smart tools such as crop inventory, planning and monitoring agriculture, agro-climatic monitoring and digital marketing. In the future, Peru is going to further encourage innovation and application of digital tools and sustainable crop production.

The Philippines

The Philippines showcased a video on how they implement smart agriculture. The economy is digitalizing its agricultural and fisheries sectors by centralizing big data, applying precision farming, updating Farmers and Fisherfolk Registry System. The Philippines' Roadmap on the Digitalization of Agriculture includes 4 phases. It begins with big data centralization, and follows with improvement of cost effective digital systems and strengthening linkages between inter-agencies and stakeholders. Then follow by integrating online import and export certifications, national single window and ASEAN single window and enhance training on data science, AI and machine learning. Finally, continue to upgrade system and infrastructure to ensure security, reliability and integrity.

Chinese Taipei

Chinese Taipei gave a brief introduction of the timeline of smart agriculture implementation within the economy. Since 2017, the initiative of Smart Agriculture 4.0 has drawn attention to the academic. At least 6 universities have established relevant offices and research centres. Demo farms and the Crop Disaster Early Warning and Notification System were set up to guide local farmers to a more efficient way of crops planting, and to mitigate from disasters and disaster-related economic losses.

Thailand

Thailand has been implementing intelligent agriculture for 4 years with technologies such as, sensors, embedded systems, Global Navigation Satellite System (GNSS) and IoTs. The technologies are easy to develop and navigate by small scale farmers. The cost of the sensors for smart rain tank and timer for irrigation system is fairly affordable as well.

2.8 Recommendations and Closing Session

Dr Ta-Te Lin was invited to summarize and provide constructive recommendations to all the member economies in this session.

Firstly, smart agriculture is considered a new wave for modern agricultural development. It is capital-intensive involving with fast technological diffusion into agricultural practices. Farmers, business managers and stakeholders devote themselves in innovating technologies and applying them on various occasions such as fisheries, dairy industry, and plant crops. However, when it comes to the development of smart agriculture, both driving factors and barriers shown in the table below need to be carefully considered and examined.

Table 2.1. Driving factors and barriers for smart agriculture development

Driving Factors	Barriers
• Labor shortage in agricultural operations • Increasing demand for food worldwide • Technology diffusion in agriculture • Rising need of monitoring health of livestock • Environmental friendly practices and perception • Government policy to adopt modern agricultural technologies	• Low awareness of technological innovations • Slow acceptance by the agricultural sector • High cost and/or low return on investment • Smart agriculture installations are fragmented • Low consumer demands • Difficult to reach and train farmers • Regulatory and policy issues

Secondly, to develop smart agriculture, it relies heavily on collaboration among APEC member economies and especially the following groups of people:

- Farmers
- Equipment suppliers
- Technology providers
- Agricultural enterprises
- Governments
- Non-governmental organizations (NGOs)
- Academic researchers

Lastly, it is firmly believed that female farmers create important roles in contributing to smart agriculture sector. In accordance with the "La Serena Roadmap for Women and Inclusive Growth", this project we are implementing serves as a tribute to female farmers. Lin also urged all the APEC member economies to integrate forces and work jointly to make smart agriculture beneficial to farmers and the whole planet.

3. Results of Surveys

To better understand the current trends and implementation of smart agriculture among APEC member economies, there were two surveys conducted within the project period. They are the "Pre-meeting Survey" and a post-meeting survey titled "APEC Project Evaluation Survey". The "Pre-meeting Survey" was designed and implemented prior to the "APEC Workshop on the R&D and Promotion of Smart Agriculture" to collect data and information that would improve the quality of the workshop. Then, after the 2-day workshop, a post-meeting survey was distributed to the workshop participants to gather information and opinion on whether they are satisfied with the project and how should it be improved.

Since it was not mandatory for respondents to put down their names when filling the surveys, some of the responses we received remain anonymous. We are not certain if respondents for both surveys are the same. The accuracy of the results would have been highly improved if we could make sure to have the same batch of respondents to cover both surveys.

3.1. Pre-meeting Survey

We received a total number of 52 feedbacks prior to the workshop. Figure 3.1 reveals that 60% of the feedbacks are somewhat or very familiar with smart agriculture.

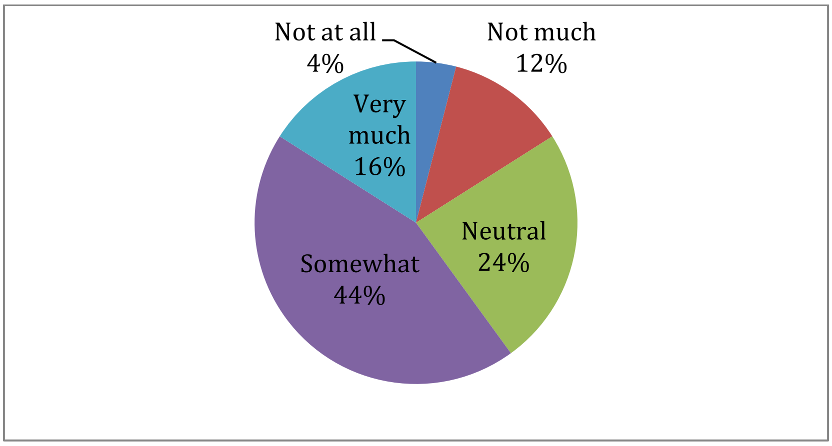

Figure 3.1. The understanding of smart agriculture prior to the workshop

In this survey, as reveal in Figure 3.2, 77% of the respondents indicated that their economies are somewhat or actively developing smart agriculture and they are willing to share such new technologies with other economies, while 42% showed that they personally have little or no experience in developing smart agriculture as shown in Figure 3.3. 88% of the respondents agreed that smart agriculture is the future trend of agricultural development and is one of the focuses that their economies are planning to implement. 84% of the respondents also believe that the promotion of smart agriculture can increase agricultural competiveness.

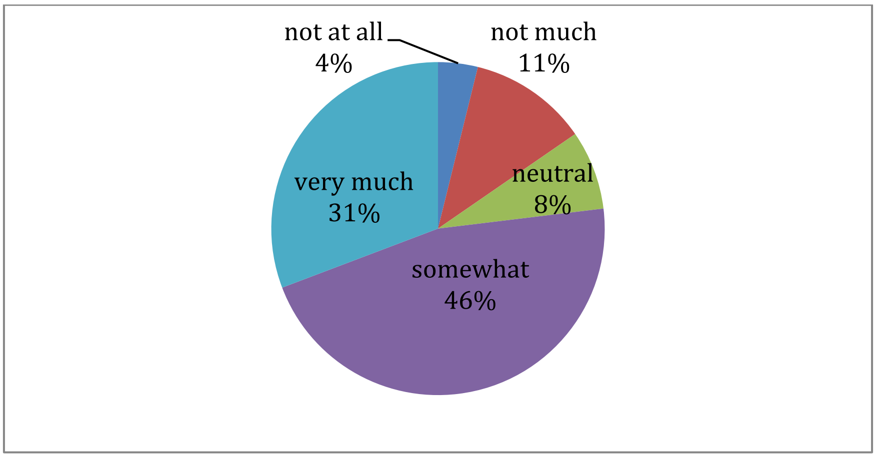

Figure 3.2. The activeness to develop smart agriculture among member economies

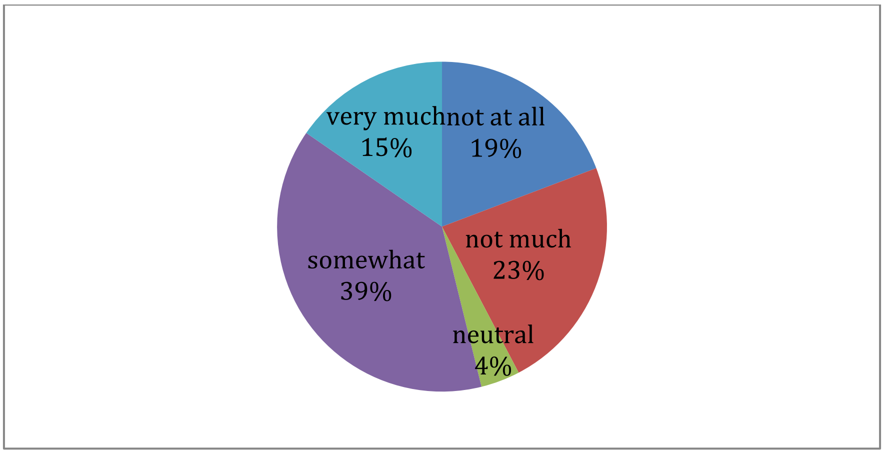

Figure 3.3. Personal experience in developing smart agriculture

Also, 73% of the respondents indicated that it is somewhat costly or very costly to promote smart agriculture. Hence, it is important to elaborate this topic within the APEC economies to multually develop affordable and reliable technologies that can be easily introduce to small scale and big scale farmers.

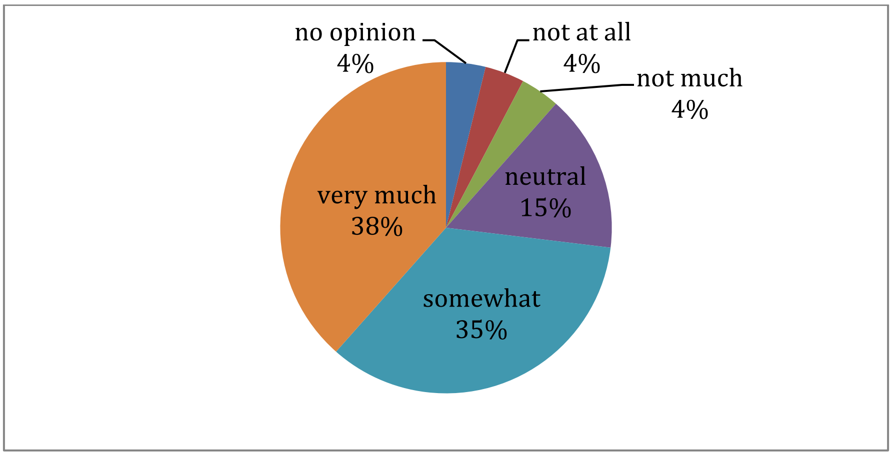

Figure 3.4. Whether promoting smart agriculture requires heavy investment

3.2. Post-meeting Survey

After the workshop, we distributed the "APEC Participant Evaluation Form" to participants and received 62 responses. It is shown that with the implementation of this project, participants received better understanding of various R&D achievements and their applications such as, ICT technologies, big data, UAV, monitoring sensors, and assisted devices. They reported that they acquired knowledge of improving food supply chain as well as different female training programs in smart agriculture. We also learned that operating international workshops via videoconferencing systems can let more representatives of member economies be benefitted. Most importantly, we see a 17% increase of knowledge toward smart agriculture after attending the workshop. 87% of the respondents show that they have either high or very high understanding of smart agriculture.

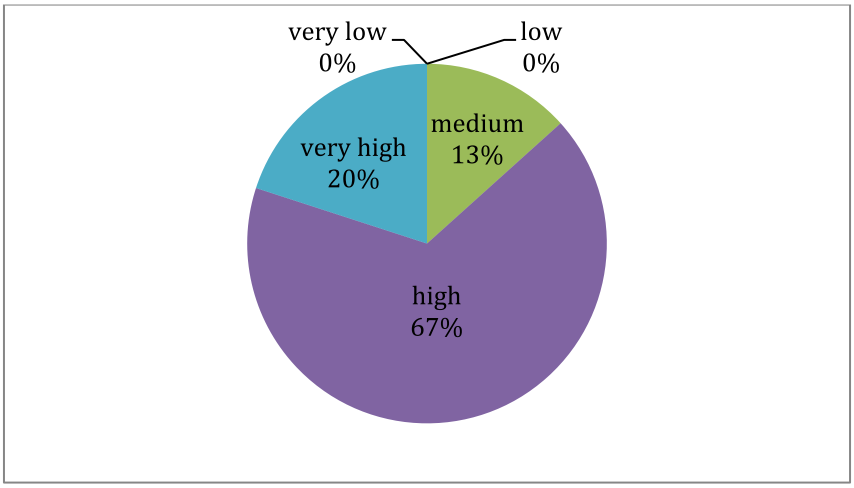

Figure 3.5. The understanding of smart agriculture after the workshop

When asking if this workshop achieved its intended objectives, there is no objection to it.

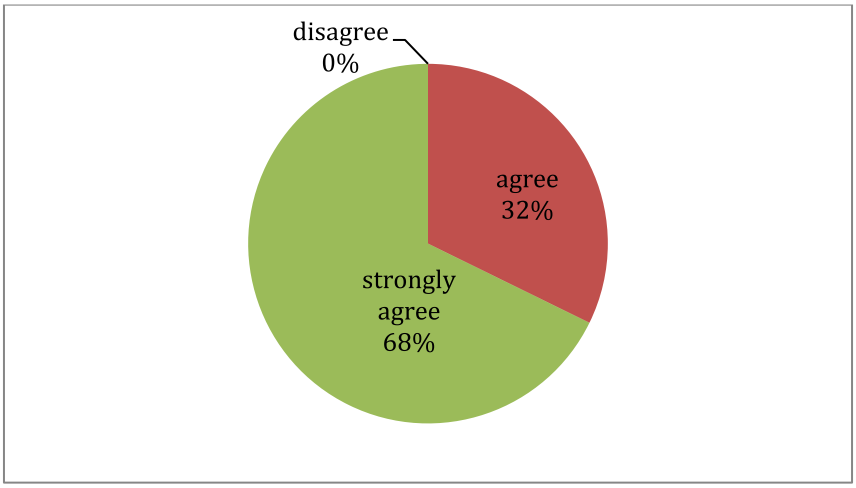

Figure 3.6. The result on whether the project achieved its intended objectives

All the respondents agreed that the content of the workshop is well organized and easy to follow.

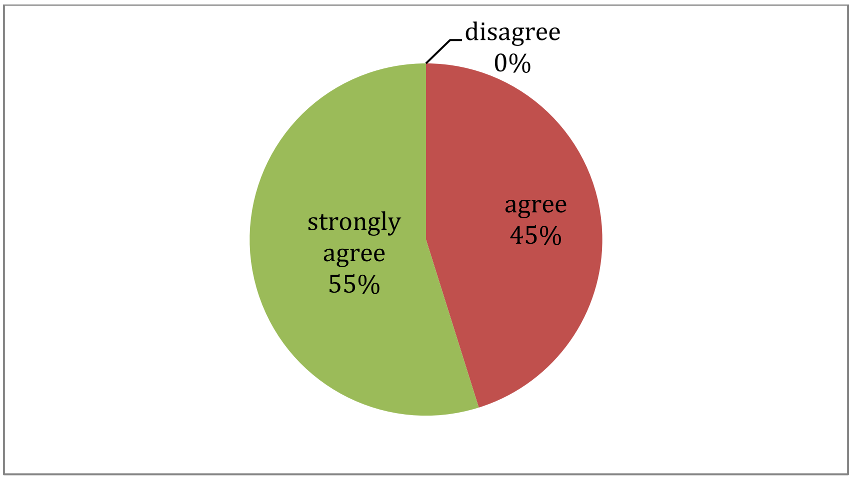

Figure 3.7. The result on if this workshop is well organized and easy to follow

Regarding whether gender issues were sufficiently addressed during the implementation, above 78% of the respondents agreed that it is adequately addressed.

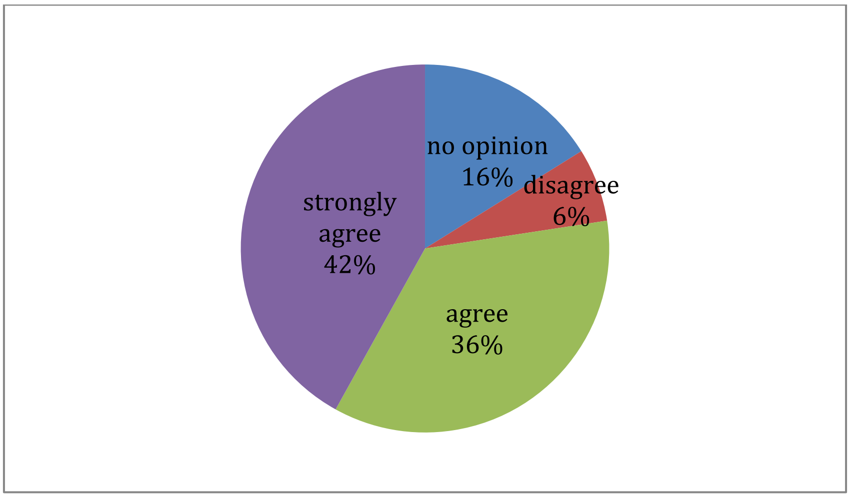

Figure 3.8. Gender issues were being sufficiently addressed during the implementation

Overall, respondents are satisfied with the implementation of this project. This project sets a good beginning to promote smart agriculture. Respondents recommended further elaborating the topic of smart agriculture by organizing site visits, training courses and inviting speakers from various agricultural sectors to exchange ideas and collaborate. It is also suggested that in the future, this topic could be examined in three categories: crops, fisheries, and livestock.

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Annex 1: Agenda

Agenda
APEC Workshop on the R&D and Promotion of Smart Agriculture
Mon. & Tue. 9:00 am-12:15 pm, Malaysian Standard Time, UTC+8
23-24November 2020, Virtual Meeting
Livestream in Taipei / via Webex

	Topic	Speaker	Moderator
23 November			
08:30-09:00	Participants Registration and the Media Stream Connection Confirmation		
09:00-09:20	**Opening Session** ● Welcome Remark (1) Dr Junne-Jih Chen, Chinese Taipei (5 mins) (2) Dr Su-San Chang, Chinese Taipei (5 mins) ● Introduction of Workshop (4 mins) Mr Vincent Chia-Rong Lin, Chinese Taipei ● Introduction of Delegations (2 mins) ● Workshop Group Photo (Screenshot) (4 min)		
09:20-09:45	**Session 1: (Keynote Speech) Trends and Prospects of Smart Agricultural R&D and Application**		
09:20-09:40	● Trends and Prospects of Smart Agricultural R&D and Application	Dr Chih-Kai Yang, Chinese Taipei	Dr Hsueh-Shih Lin, Chinese Taipei
09:40-09:45	Q&A		
09:45-11:00	**Session 2: AI for the R&D and Application of Intelligent Image Recognition**		
09:45-10:00	● Application of Smart Aquaculture	Mr Matthew Tan, Singapore	Dr Shyh-Shyan Wang, Chinese Taipei
10:00-10:15	● An Intelligent Imaging and Sensor System Based on Internet of Things for Automated Insect Pest Monitoring.	Dr Ta-Te Lin, Chinese Taipei	
10:15-10:30	● Wild Bird Detection in Poultry Farm Based on Deep Learning and Integrated with Laser Mechanism for Automatic Wild Bird Repellent System	Dr Yao-Chuan Tsai, Chinese Taipei	
10:30-10:45	● Measuring the Length and Identifying the Species of Dewatered Fish and Measuring the Length of Shrimps in Vivo Using Intelligent Machine Vision.	Dr Yan-Fu Kuo, Chinese Taipei	
10:45-11:00	Q&A		
11:00-11:10	{Break}		
11:10-12:10	**Session 3: Development and Application of Assistive Devices and UAV in Agriculture**		
11:10-11:25	● Development and Application of Drone/UAV in Agriculture	Mr Mohd Amiruddin bin Ramli, Malaysia	Dr Joe-Air Jiang, Chinese Taipei
11:25-11:40	● Development and Application of Assistive Devices in Orchard Farming.	Dr Wei-Chih Lin, Chinese Taipei	
11:40-11:55	● Drones Application in Farming	Mr Horng-Yuh Guo,	

	Topic	Speaker	Moderator
	Management in Chinese Taipei	Chinese Taipei	
11:55-12:10	Q&A		
24 November			
08:30-09:00	Participants Registration and the Media Stream Connection Confirmation		
09:00-09:05	Recap from the first day	Dr Po-Chung Chen, Chinese Taipei	
09:05-10:35	**Session 4: Best Practice of Smart Agricultural Application and Promotion Methods**		
09:05-09:20	● Data-Driven Pasture Management via Satellite Technology	Ms Rebecca Dalrymple, New Zealand	Dr Yi-Chich Chiu, Chinese Taipei
09:20-09:35	● The Application and Promotion of Smart Agriculture in the Corn Industry in Chinese Taipei	Ms Ya- Ping Hsiung, Chinese Taipei	
09:35-09:50	● Application of Infrared Thermal Imaging Camera for Early Warning and Detection of Dairy Cow Diseases	Mr Kuo-Hua Lee, Chinese Taipei	
09:50-10:05	● Smart Agriculture in NARO, Japan	Mr Yoshiyuki Kawase, Japan	
10:05-10:20	● Delivering the Digital Future of Agriculture	Mr Justin Webb, Australia	
10:20-10:35	Q&A		
10:35-11:15	**Session 5: (Panel Discussion) How Women Groups Will Benefit from Smart Agriculture**		
	● The Human Approach to Technology: Methods to Increase Adoption of Smart Technology by Women in Agriculture Across New Zealand	Ms Claudia Lyons, New Zealand	Dr Ching-Cheng Chang, Chinese Taipei
	● Trickle-Down and Bottom-Up Effects of Women's Representation in Adoption and Diffusion of Smart Agricultural Application.	Dr Yu-Hua Chen, Chinese Taipei	
	● Involvement of Women Groups in Agrofood Industry : Malaysia Perspective	Dr Florence C. Ginibun, Malaysia	
	Q&A		
11:15-11:25	{Break}		
11:25-12:05	**Individual Economy Reports (3 mins each)**	Economies	Dr Su-San Chang, Chinese Taipei
12:05-12:15	**Recommendations and Closing Session**	Dr Ta-Te Lin, Chinese Taipei (8 mins)	Mr Vincent Chia-Rong Lin, Chinese Taipei (2 mins)