



**Asia-Pacific
Economic Cooperation**

Advancing Free Trade
for Asia-Pacific **Prosperity**

APEC Workshop on Practices and Promotion of Circular Agriculture

APEC Agricultural Technical Cooperation Working Group

July 2022



**Asia-Pacific
Economic Cooperation**

APEC Workshop on Practices and Promotion of Circular Agriculture

Project Report

Virtual Format | Chinese Taipei | 23-24 November 2021

APEC Agricultural Technical Cooperation Working Group

July 2022

APEC Project: ATC 02 2020A

Produced by

Ms Lily Ting-Hsuan Chu

Associate Research Fellow, Agricultural Policy Research Center, Agricultural Technology Research Institute

Website: <https://www.atri.org.tw/establishment>

Tel: +886-2-2381-2991 Ext: 2266

E-mail: lilychu@mail.coa.gov.tw

Dr Su-San Chang

Adviser, Agricultural Policy Research Center, Agricultural Technology Research Institute

Website: <https://www.atri.org.tw/establishment>

Tel: +886-2-2368-1718

E-mail: susanchang4004@gmail.com

Mr Vincent Lin

Director General, Department of International Affairs, Council of Agriculture

Website: <https://eng.coa.gov.tw/>

Tel: +886-2-2312-4677

E-mail: vincent@mail.coa.gov.tw

For

Asia-Pacific Economic Cooperation Secretariat

35 Heng Mui Keng Terrace

Singapore 119616

Tel: (65) 68919 600

Fax: (65) 68919 690

Email: info@apec.org

Website: www.apec.org

© 2022 APEC Secretariat

APEC#222-AT-04.1

Contents

Acknowledgements	i
1. Introduction	1
1.1. Circular Agriculture in APEC Region	3
1.2. Gender Inclusion in Circular Agriculture.....	4
2. Summaries of the Workshop	5
2.1. Opening Session.....	5
2.2. Keynote Speech	6
2.3. Trends, Prospects, and Innovation of Circular Agriculture.....	7
2.4. Circular Agriculture Practice and Application – Agriculture and Animal Husbandry.....	8
2.5. Circular Agriculture Practice and Application – Aquaculture	10
2.6. Circular Economic System for Sustainable Agriculture	11
2.7. How Circular Agriculture Contribute to Net Zero Carbon Emission Strategies.....	12
2.8. Next Step & Closing Session	15
Annex 1: Results of Surveys	17
Pre-meeting Survey	17
Post-meeting Survey.....	19
Annex 2: Agenda.....	21

Acknowledgements

On behalf of the Project Overseer, we would like to convey our deepest appreciation to all the experts who have provided us with support and encouragement to complete this project.

We are immensely grateful to the APEC Secretariat and the APEC member economies for their active participation and recommendations for this project. It is the joint efforts of the APEC community that has made this project complete.

1. Introduction

This project report is an output of an APEC-funded project of Agricultural Technical Cooperation Working Group (ATCWG) from Session 2 of 2020, “ATC 02 2020A - APEC Workshop on Practices and Promotion of Circular Agriculture.” It is co-sponsored by Australia; Chile; New Zealand; Singapore; Thailand; and Viet Nam.

With a significant rise in the world population, accelerating urban changes, increased competition for natural resources, advancement of technologies, global warming and climate change, and numerous challenges produced by environmental changes, the issue of sustainability is gaining urgency for APEC member economies. In addition, the APEC region is most heavily affected by natural disasters as well as climate change. Solutions to adapt to climate change and mitigate its impact are key issues to the development of the region as a whole as well as in the individual APEC economies.

In this regard, the APEC leaders, in the 2017 declaration, underscored that APEC can play a key role in ensuring food security and sustainable agriculture, aquaculture and fishery of the APEC region and beyond, particularly in the context of climate change and rural-urban development. Also, during the 2017 High Level Policy Dialogue on Food Security and Sustainable Agriculture in Response to Climate Change, economies expressed their concerns of the region's natural resources were under stress from overconsumption, land and marine habitat degradation, fresh water scarcity and loss of biodiversity, and recognized that greater concerted efforts to foster the sustainable use and management of land, forests, water and marine resources were required and essential to food security, environmental protection, and sustainable development in the APEC region.

Circular agriculture can be a perfect vehicle to carry out the goal to close the loop for agriculture. Through the precision use of resources, as well as the recycle and reuse of agricultural residues and byproducts could reduce greenhouse gas (GHG) emission, thus ultimately making a contribution to the mitigation of climate change. Circular agriculture is a particular way of agriculture production with inputs from recycling or renewable sources, applied with the highest precision, efficient use of resources, and without negative external impact. It could not only reduce production costs, food loss, and waste, but also improve the sustainable use of limited natural resources, bringing added value to agricultural production, and ensure the consolidation of a sustainable food system and long-term food security.

To better promote circular agriculture and safeguard regional food security in response to the impact of climate change, Chinese Taipei conducted an APEC Workshop on Practices and Promotion of Circular Agriculture to utilize the latest technical innovation to promote sustainability in renewable energy, waste management, and circular economy strategies.

The workshop was held virtually via Microsoft Teams from November 23 to 24, 2021. The workshop served as a hub to bring experts from member economies together. Prior to the event, a pre-meeting survey, which covered the topics discussed at the workshop was conducted to learn about the application of circular agriculture among APEC member economies. An evaluation survey was also distributed to participants after the workshop.

Apart from the Opening Session, Keynote Speech on Circular Economy Technologies Developed by the United States Department of Agriculture (USDA) in Animal Waste Area, Next Step and Closing Remarks Session, this 2-day program consisted of 5 main sessions, including “Trends, Prospects, and Innovations of Circular Agriculture”, “Circular Agriculture Practice and Application – Agriculture and Animal Husbandry”, “Circular Agriculture Practice and Application – Aquaculture”, “Circular Economic System for Sustainable Agriculture” and “How Circular Agriculture Contribute to Net Zero Carbon Emission Strategies”. The agenda of the workshop can be referenced to Annex 2.

There were a total of 97 participants, including 18 speakers and experts from 11 member economies taking part in this workshop. Members were from Indonesia; Japan; Korea; Mexico; New Zealand; Peru; Singapore; Chinese Taipei; Thailand; and the United States. Out of 97 participants, 55 were female, which accounted for 57 percent of the total participation rate. The ratio of male to female speakers and experts invited was 1:1.



Figure 1.1 Opening remarks delivered by the Project Overseer, ATCWG Lead Shepherd, and Program Director of the ATCWG



Figure 1.2 Workshop group photo captured through Microsoft Teams platform

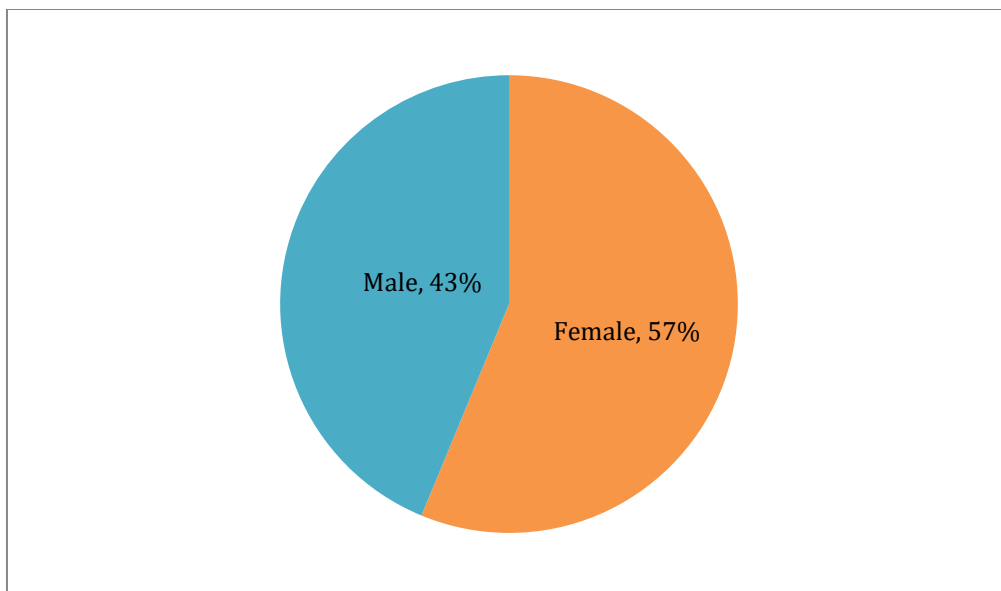


Figure 1.3 Participants' percentages in genders

1.1. Circular Agriculture in APEC Region

The goal for APEC to implement circular economy could date back to 2014, when APEC leaders supported the efforts to explore new and promising economic growth areas such as the Green Economy, the Blue Economy, and the Internet Economy, and promote green, circular, low-carbon and energy-efficient development at the 2014 Leaders' Declaration.¹

¹ https://www.apec.org/Meeting-Papers/Leaders-Declarations/2014/2014_aelm

The APEC region accounts for approximately 60 percent of the world GDP², therefore, APEC has the potential to play a vital role in driving the global economy towards a circular one. Moreover, it is well recognized that the APEC region is densely populated with a huge and increasing demand on food, however, relatively deficient in the sustainable use of natural resources. It is believed that circular agriculture could provide an opportunity for APEC economies to reduce natural resource loss, close nutrient loops, valorize agri-food wastes, fight negative climate change and contribute to sustainable agricultural development and the net-zero goal.

In this light, this project supports the APEC's goals of capacity building, including attaining sustainable growth and equitable development in the Asia-Pacific region; improving the economic and social well-being of the people, and deepening the spirit of community in the Asia Pacific. Furthermore, this project follows the APEC's operational principles for capacity building by 1) contributing to APEC goals and needs of enhancing food security and sustainable agriculture as well as building a shared and inclusive community; 2) disseminating knowledges and skills among APEC economies and beyond, and; 3) exchanging views and expertise among officials and regional exports in a consistent, transparent and inclusive manner.

1.2. Gender Inclusion in Circular Agriculture

To echo the “La Serena Roadmap for Women and Inclusive Growth (2019-2030)” and to best reach the goal of gender inclusion in circular agriculture, member economies were encouraged to raise female delegate participation. To our delight, economies strongly supported the goal, and the female participants' rate surpassed the original goal of 40 percent, reaching 57 percent. This project also strived to invite an equal number of male and female speakers and experts.

Regarding the 5 pillars of the Gender Criteria stated in the Guidebook on APEC projects, the project particularly addressed the pillar of Skills, Capacity Building and Innovation and Technology through the implementation of its outputs. Also, 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): Support women's education, training and skills development and access in a changing world of work.

² <https://www.apec.org/about-us/about-apec/achievements-and-benefits>

2. Summaries of the Workshop

2.1. Opening Session

The opening speeches were given by 3 delegates, Mr Vincent Lin, Project Overseer and Director General of the Department of International Affairs, Council of Agriculture, Dr Su-San Chang, Lead Shepherd of ATCWG, and Mr Teddy Pavon, ATCWG Program Director of the APEC Secretariat.

Mr Vincent Lin pointed out that with a significant rise in the world population accelerating urban changes, increased competition for natural resources, advancement of technology, fluctuations in various agri-products markets, global warming and climate change, and numerous challenges produced by environmental change, the issue of sustainability is increasing its urgency for APEC member economies. In circular agriculture, all steps of the food system from growing, harvesting, packing, processing, transporting, marketing, consuming and disposing food are designed to promote sustainable development. With the goal of sustainable agriculture development, Mr Lin expressed that Chinese Taipei has been encouraging practices of innovative technologies to promote circular agriculture and has actively implemented the programs of net-zero emissions in animal husbandry.

Dr Su-San Chang stated that the APEC region is densely populated with a huge and increasing demand on food, however, relatively deficient in sustainable use of natural resources. Therefore, the importance of reaching food security and fostering a sustainable agriculture system are addressed within the ATCWG Strategic Plan for 2021-2025 as well as the ATCWG 2021 Work Plan. Dr Chang indicated that circular agriculture could be one of the best solutions to minimize using raw materials and could greatly improve food security and to achieve a sustainable food system. It proposes a feasible model to minimize the “take-make-waste” linear approach by reducing external inputs for agricultural production, closing nutrient loops and lowering negative impacts to the environment by recycling and reusing agricultural residues and byproducts and eliminating discharges.

Mr Teddy Pavon mentioned the importance of food security and safety within the APEC region, especially with the huge impact caused by the COVID-19. The Food Security Roadmap Towards 2030 was developed to ensure sufficient and affordable access to food in a sustainable way, so the main focus is to reduce food loss and waste and maximize the use of limited resources. Mr Pavon also pointed out that to achieve the agenda, member economies are encouraged to inclusively cultivate talents.

Lastly, Mr Vincent Lin briefed to all participants upon the sessions in the two-day event exploring various topics. He also disclosed the result of the pre-meeting survey. Among all the respondents, 80 percent believe that circular agriculture will be the future trend; 80

percent consider it challenging to promote and necessary for heavy investment. 90 percent think that circular agriculture can increase the competitiveness in the agriculture sector. The result showed that this workshop is meaningful and of great help to the APEC region.

2.2. Keynote Speech

Circular Economy Technologies Developed by USDA in Animal Waste Area, Dr Matias Vanotti, the United States

This keynote speech session was led by Dr Matias Vanotti. He explained technologies developed by the USDA aiming to improve manure management for circular economy, such as solid separation, wastewater purification, recovery of proteins and amino acids, and the Environmentally Superior Technology (EST) system. He then moved on to the world trends in livestock production development, where the pressing concern has been agglomeration throughout both the United States and the globe. Due to increasingly high-density production, manure management issues, along with surplus nitrogen and phosphorus and ammonia emissions, were planned on the agenda. 70 percent of phosphorus in the manure exceeded what could be used on the farm, so there was a need to develop phosphorus recovery technologies to reach a closed loop in agriculture. Research indicated that one third of phosphorus demands could be met through increased recycling and extraction from human excreta, manure or food waste. Dr Vanotti also indicated that circular agriculture makes the most efficient use of resources and creates value chain with solutions. With circular agriculture in place, reuse and recycling could bring added value and new income, while resources would be used to the largest extent in order to achieve a sustainable food system.

Another important application of the circular economy concept was greenhouse gas emissions from livestock. To apply this, a value chain with solutions is necessary to turn waste into resources. Dr Vanotti introduced both the dry system and liquid system. For the former, it involved solid separation which could produce vermicompost on plant growth media, as for the latter, reusing phosphorus and ammonia could generate clean water. It depended on each economy to choose the best combination out of a large number of possibilities. What was noticeable was that there were two ways for greenhouse gas reduction, methane generation and destruction, and methane avoidance which could reduce 97 percent of emissions through an aerobic system.

Dr Vanotti also worked on the recovery of ammonia because ammonia fertilizers could consume 20 percent of energy in agriculture. They used gas-permeable membranes and managed to remove 97 percent of ammonia from digested wastewater, while some were turned into liquid fertilizers. Another approach was to reuse air from poultry houses to clean the overall environment, therefore reducing bird mortality rate by 47 percent. By the end,

he mentioned a case example of the application of the EST system in a pig farm, which showed that a cleaner environment could improve air qualities in the barns as well as enhance animal productivity and health.

2.3. Trends, Prospects, and Innovation of Circular Agriculture

Development and Practice of Circular Agriculture, Dr Jeng-Feng Huang, Chinese Taipei

Dr Jeng-Fang Huang revealed two dynamic impact factors of our environment: high population to reach 9 billion people by 2050 and limited resources with land to be depleted by 2025 if no further action is taken. He stressed the importance of supporting the circular economy to get to net-zero agriculture by 2050 by enhancing energy efficiency and circular agriculture. In order to process a larger amount of agricultural waste in a value-added way, Chinese Taipei has initiated an integral cycle across different sectors. For example, on one hand, agricultural waste, namely rice husk and straw, could be used to replace plastic or turned into biochar for farm use. On the other hand, wood and bamboo waste from forestry could go to family and farm use or livestock house bedding, and the cycle proceeded with the livestock management. With the concept, the project that Chinese Taipei has implemented included a few phases where technology integration and industrialization were more focused in 2019, subsequent to circular agriculture and demonstration in 2020. Apparently, the project has given rise to several benefits, including mature technologies developed, industrial investment, demonstration sites and environmental benefits such as reducing 20,800 metric tons of CO₂.

Dr Huang illustrated the technologies for circular agriculture. For fertilizer, they have invented a system to utilize granulated raw chicken manure and avoid transportation as it might spread diseases. For energy, they made use of residue derived fuel or biochar from wood or bamboo to enhance soil quality and decrease carbon. For materials, farmers had the option for biodegradable films to substitute for plastic ones, and they could also make the best of oyster shells to produce heating bags to heat food. He then gave participants a glance at 10 organic circular farms, such as Toucheng Leisure Farm, Taikang Organic Farm, and Donghaifong Farm, which put together diverse technologies and models so that consumers would have an overview of how circular agriculture worked. Improving mature and integrated technologies to add value to novel circular products are crucial for further implementing circular economy.

2.4. Circular Agriculture Practice and Application – Agriculture and Animal Husbandry

Conservation, Sustainable Use and Development of Animal Genetic Resources by Participatory Action Research with Farmers and Communities, Dr Kalaya Boonyanuwat, Thailand

Dr Kalaya Boonyanuwat gave details about conservation and management of animal genetic resources, which constitute one of the important parts of agrobiodiversity. She presented reasons for conservation, such as opportunities to meet future market demands or socio-economic value, present socio-economic value, opportunities for research, and ecological value. They all fell into the criteria of the Biology Economy, Circular Economy, Green Economy (BCG) Model that Thailand is implementing. She continued to introduce the importance and representation of Participatory Action Research (PAR) which identified problems and empowered community members to build solutions. To demonstrate the significance, she showcased a wide selection of PAR applications in Thailand. She began by mentioning compost fertilizer produced from manure to raise native cattle, along with the combination of paddy rice. The conservation of native species could be done through PAR collaboration with farmers, communities, schools, universities, government agencies, such as the Department of Livestock Development. Their efforts were put to transform manure into fertilizer and further decrease the use of pesticide. Another example also showed the transformation of biogas from swine farms, and local people could even power their motorcycles with biogas. She stated that an integrated crop-livestock farming system was established and helped reduce greenhouse gas emissions from feed transportation and the use of chemical fertilizer. Next, Dr Boonyanuwat unveiled a chicken value chain where all kinds of network farms, such as conservation and breeding, community, or retail, have been interconnected to produce local products. To realize a circular economy, PAR was critical in terms of conservation, sustainability, identification of problems and needs.

Practice of Agriculture Circular Economy at Fwusow Industry, Mr Yau-Kuen Hung, Chinese Taipei

Mr Yau-Kuen Hung focused on Fwusow's agri-food circular economy and the four circular loops that have been devised to facilitate effective use of resources. First, a pet food circular loop was performed by using locally grown corn to produce pet food. Second, the company grew local sesame and peanuts to manufacture organic fertilizer to complete the cooking oil circular loop. Third, Fwusow established an eco-farm in 2011, which provided pasture raised cage free eggs, pork, and chicken products for consumers as part of the livestock and poultry circular loop. Mr Hung added that they were the first to introduce European engineering automatic poultry processing equipment to greatly reduce the risk of cross contamination and turn by-products into feed using the chilling process. Fourth, the organic

fertilizer circular loop targeted chicken manure, mushroom compost, and oil meal for animal and plant-based compost that was used as feed or to grow tea trees ultimately. Mr Hung elaborated on the measures to be applied as they promoted friendly farming, held a greenhouse gas inventory certificate, and carried out digital transformation with AI applied for smart operation. Going forward, Mr Hung has been committed to developing more biotech products, better manage energy and carbon footprint as a sustainable green business.

Practice of Circular Economy in Swine Industry, Ms Pei-Chen Chou, Chinese Taipei

Ms Pei-Chen Chou shared Taisugar's practice of circular economy which consisted of a biological cycle (phase 1) and an industrial cycle (phase 2). In phase 1, manure from a pig house would be turned into energy by microorganism in a biogas center. Digestate was also produced in the process to be used as fertilizer for crop and feed for pigs. Phase 2 happened in a slaughterhouse, where the collected blood, bones, and organs could go to a biorefinery for digestate as well, so the cycles were connected and closed. Her talk was mainly developed upon Donghaifong (DHF) Circular Agriculture Park to demonstrate the practice. Starting from 2017, through a feedstock survey, the waste output, like fruit peels, from nearby farms could be organized and delivered to the biogas center, followed by a lab test to analyze the composition of the biogas resources. Then she introduced applications of using digestate to nourish grassland, green soybean, and corn. She also compared the difference of traditional and modern approaches where the latter created a better environment for pigs and employees. It can also provide environmental education to allow the public to have a better understanding.

Practice of Circular Economy in the New Zealand Horticulture Industry, Mr James Kuperus, New Zealand

Mr James Kuperus brought his insights from three levels in New Zealand, government, industry, and company levels. The government of New Zealand set up policies and directions for the industry, then the industry leaders followed and interpreted for individual farming companies. Finally, the growers transferred the way they grow plants and animals in New Zealand. In New Zealand, universities, research institutes, and private researchers worked on circular economy science challenges across sectors. A main focus was on regenerative agriculture. It could replace the end-of-life concept with restoration with usage of renewable energy and elimination of toxic chemicals. There are partnerships between farmers and the government to fight on climate change. From the industry level, there has been concern about soil health, biodiversity, less harmful agrichemicals, more added-value waste utilization and carbon reduction. Currently, robotic weeders could replace herbicide

for a better environment as well. Mr Kuperus then shared two best practices. The first example was to feed chicken on the corn leftover and debris after corn harvest, and grow other vegetables with the manure from the chicken left on the soil. The second example was to collect rainwater from the roof for tomato planting, in addition to using natural gas to heat the greenhouse for producing tomatoes more efficiently.

2.5. Circular Agriculture Practice and Application – Aquaculture

Recovery and Valorization of Value-Added Products from Seafood By-Products – An Opportunity for a Circular Economy Approach, Dr Chang-Wei Hsieh, Chinese Taipei

Dr Chang-Wei Hsieh provided information about his research and innovation of seafood by-products based on the global circular economy trend of reuse and regeneration. There was around 35-50 percent of fish and seafood loss, the majority of which came from processing, amounting to US\$50 billion a year. In terms of strategic research and innovation, one focal point was to reduce waste and add value to the re-production. For instance, collagen from fish skin could be easily applied in cosmetics goods or bio-packaging, such as MarinaTex, which could biodegrade on its own in four to six weeks. Fish head, liver and guts contained high content of omega-3 and EPA/DHA which were good for health. Fish bone, rich in calcium and phosphorus, was used as a food supplement. With regards to fish scale, often discarded, it was composed of collagen, hydroxyapatite, and others, facilitating cell migration that speedily helped repair bone tissue. Dr Hsieh also presented proprietary processing technologies. One was an electric field generator built in the refrigerator to keep the food fresh. To sum up, manufacturers should keep an eye on responsible sources, make the most of food and waste, and promote sustainability.

From Waste to Resource – Efficient Utilization of Seafood By-Products, Dr Chyuan-Yuan Shiau, Chinese Taipei

Dr Chyuan-Yuan Shiau started with different types of seafood waste, namely all fish parts, trimmed meat, shell, and so on. He probed into the nutritional and bioactive compounds in fish by-products where protein accounted for more than 50 percent, not to mention collagen, peptide, chitin, or chondroitin which could contribute to a high market value. Hence, recovery and efficient utilization of seafood waste was a crucial issue. Examples included fish skin treated as a cold dish and other waste turned into fish meal for feed or pet food. Dr Shiau then listed other useful waste elements for recycling and reuse: collagen as well as chitin isolated from crab and shrimp shells to become chitosan that could be applied in cosmetics, health food, and textile industry; chondroitin extracted from shark bone was beneficial for joint diseases; bioactive peptide is antimicrobial, antihypertensive, and

antioxidant. The fishery industry even found out high value-added oyster shells that could improve aquaculture water quality and be used as biofertilizer because it contained probiotics. He concluded that the long-term goal was zero waste processing to reach a circular fishery as well as a sustainable way of waste reduction and efficient utilization of marine resources.

2.6. Circular Economic System for Sustainable Agriculture

New Agricultural Innovation with Green Energy and a Circular (GC) Economic System, Dr Chia-Lin Chang, Chinese Taipei

Dr Chia-Lin Chang started from the perspectives of the APEC region in terms of renewable energy (RE), circular agriculture, and greenhouse gas emission. The APEC economies have had a specific goal for renewable energy development, which was to double the share of RE by 2030 and 2035, with New Zealand achieving the soonest for now. When it comes to global waste composition, statistics from the World Bank showed that food and green wastes are among the highest, consisting of 44 percent. She also pointed out that N₂O has had a more substantial impact on global warming than CO₂ and CH₄. Moreover, carbon emissions have increased, while emission intensity has decreased, which suggested that APEC's effort into agricultural carbon reduction was effective.

She moved on to reveal the result of two Willingness-to-Pay (WTP) surveys conducted in Chinese Taipei in 2020. The purpose of both surveys was to understand the public's awareness and willingness to support renewable energy development and the increase in the coverage of solar photovoltaic (PV) facilities on farm ponds. The result for the first survey showed that 35 percent of more than 1,000 respondents preferred premium Feed-In Tariff (FIT). They were willing to pay US\$0.44 to 1.26 cents /kWh extra for renewables. The economic value reached US\$ 1,247 to 1,356 million in 2019. For the second survey, out of 1,067 respondents, 46.8 percent preferred 40 percent coverage of solar photovoltaic facilities on farm ponds rather than 60 to 70 percent. Overall, male who think clean energy is beneficial to natural ecosystem are prone to increase the coverage of floating solar photovoltaic (PV).

In conclusion, it was suggested to build a sharing platform for exchange of knowledge and expertise of circular agriculture. The consensus was that consumers were the main driving force.

2.7. How Circular Agriculture Contribute to Net-Zero Carbon Emission Strategies

Circularity within Pastoral Livestock Systems in New Zealand, Dr Warren Parker, New Zealand

Dr Warren Parker illustrated examples of circularity in a pastoral farming system to indicate where the development was occurring. In the pastoral economy, waste minimization is of top priority. Product stewardship was supported to recycle waste from farming into other purposes. Levies were collected and allocated to, in one instance, Agrecovery, a non-profit program. He continued to share a case of great integration of milk plants and wetlands where about 500,000 liters of water required from the plants were put through wetlands. Dr Parker considered the major area in pastoral farming to be the use of effluents, especially in dairy farms. Effluents were collected and put in a large pond, sprayed back on the pasture through irrigation, and therefore reduced the requirements for farm and fertilizer input. Mr Parker also talked about the integration of forestry and pastoral farming. The forests stored carbon on farms, providing shelters for livestock and source materials for future bioproducts, which complemented pastoral farming operation. The Climate Change Commission of New Zealand announced its carbon budgets, land use changes, and breeding lower methane producing livestock as the major pathway to net-zero emissions by 2050.

Recycling Practice and Net Zero Strategy in the Livestock Industry, Dr Meiping Cheng, Chinese Taipei

Dr Meiping Cheng brought the insight of livestock Industry in Chinese Taipei, showing that it was methane from the manure which contributed to the highest greenhouse gas emission of the agriculture sector, and thus, this specific area was the primary target for mitigation. Chinese Taipei has been determined to set a net-zero pathway task force. The Food and Agriculture Organization of the United Nations (FAO) has proposed five practical actions, two of which were particularly discussed in her speech. For boosting efficiency of livestock production and resource use, she found out from the milk production that the production of raw materials generated the majority of carbon footprint. That was why production efficiency needed to be boosted. As for intensifying recycling efforts and minimizing losses for a circular bioeconomy, she worked with a sweet potato farm and used ugly sweet potatoes as cow feed, and they were able to produce a new product of milk. This showed the importance of recycling and reuse. Afterwards, Dr Cheng shared two case examples. One was carbon offset in a swine farm where biogas was utilized to prevent methane emissions and 24,000 tons of carbon was offset per year by recycling manure. The other one was the adoption of carbon-neutral eggs which generated only 1.3kg of carbon emissions, compared to 4.0kg of general eggs. Circular feed, made of 95 percent leftover, was the key

factor here as it produced 50 percent less carbon footprint. All in all, she stressed that the livestock industry cannot close the loop by itself, so inter-sector cooperation and education for farmers were needed.

Case Study on Benefit Analysis of Carbon Reduction of Circular Agriculture, Dr Chiling Chen, Chinese Taipei

Dr Chiling Chen explained the greenhouse gas inventory report of Chinese Taipei, where the emissions did not increase after 2006, but non-fuel combustion in the agriculture sector accounted for 47 percent, almost half coming from fertilizer, so it was essential to make it more efficient. She then demonstrated one case study of applying livestock manure on farmlands. Though carbon emissions did drop after the application, there was only 7 percent of application rate. If all manure could be applied, the economy could reduce 4 percent of greenhouse gas emissions from agriculture. Dr Chen continued her points by bringing up the 4 per 1000 initiative launched by France, which urged economies to increase carbon sequestration on the soil surface and adapt agriculture to climate change. She discovered that biochar had the highest potential for soil carbon sequestration, among organic farming, green manure, and others. With different combinations of materials and facilities for biochar, she conducted another case study to apply biochar to farmlands. The result showed that applying 2 percent biochar in acid soil could increase 5 to 23 percent of Pak Choy yield. However, applying biochar in alkaline soil, the yield will then decrease. If Chinese Taipei could apply biochar to 2 percent of 300,000-hectare acid land in total, it was possible to reduce 12 percent of greenhouse gas emissions from the agriculture sector. Thus, she considered this as an important strategy to move toward the net-zero goal.

How the Circular Livestock Contributes to a Low-Carbon Society in Korea, Dr Youngah Lim, Korea

Dr Youngah Lim supported the government policies to reach carbon neutrality by 2050 through a circular economy as climate change has become a main threat for sustainability. She provided data of Korea's practice in agriculture nowadays. For instance, the number of livestock farms declined, while scale-up and corporatization have taken place instead. Some principles of circular economy included decrease and reuse of waste as well as the maximization of resource productivity. She emphasized the importance of linking crop farms and livestock farms together. This kind of circular crop-livestock farming could be achieved by using by-product supplements to quantify the effect of reducing methane, allocating high-quality feed crops to improve ruminants' digestion system and decrease import of raw materials, and replacing synthetic fertilizer which contained excess nutrients with liquid pig manure. The Korean government has put forth a pilot project to encourage the use of customized liquid fertilizer, which is conventional and synthetic blended for precision

farming. As for policy challenges, apart from targeting cost-effective activities and positioning farmers as a resource manager to act more sustainably, tailoring to appropriate boundaries in circular farming and utilizing biomass were also critical.

Assessment of Carbon Sequestration Capacity by Shell Calcification of Bivalves through their Culture, Dr Yew-Hu Chien, Chinese Taipei

Dr Yew-Hu Chien identified some adverse effects of global warming, such as severe climate or ocean acidification caused by CO₂. He expressed the need for technologic deployment. He then compared the difference of carbon capture and storage. Growing trees could capture carbon temporarily and is considered a temporary carbon sink. Dr Chien saw the potential of carbon sequestration through calcification, so he went on with an experiment about four bivalves. The result demonstrated that freshwater clams had the highest capacity to capture and store carbon, followed by marine clams, oysters, and mussels. A further comparison experiment found that coral reefs even had three times more capacity than forests and freshwater clams. Then Dr Chien focused on returning carbon to where it belongs to through calcification as mineralization. Forest might wither and be decomposed, but bivalves could store carbon within forever. What's more, the merits of carbon storage in shells featured low cost, eco-friendly, and the carbon credit, fringe benefit of bivalve cultures, constituted 7.81 percent of the production value of three bivalves. This approach also worked to solve the conflict between the industrial sector and aqua farmers and eventually implement a sustainable partnership.

Using Different Strategies to Approach Carbon Neutrality, Dr Chin-Chang Hung, Chinese Taipei

The CO₂ emission of Chinese Taipei is around 270-290 million tons per year. Dr Chin-Chang Hung talked about 3 major carbon pools, namely atmosphere, ocean, and soil and forest. Atmosphere contains 2 percent of active carbon pool, soil and forest 5 percent, and the ocean, on the other hand, played an important role as the most active carbon pool with 93 percent of capacity, though it was hard to quantify its performance. Seaweed aquaculture was found relatively effective as opposed to the biological pumping process from phytoplankton and zooplankton. He suggested that in addition to planting more trees or promoting public transportation, the economies survey the capacity of deep oceans around western Pacific area, excellent carbon-storage locations and applied micro- and macro-algae to capture more carbon and store them in deep oceans which offered longer residence time.

2.8. Next Step & Closing Session

Dr Jeng-Fang Huang, was invited to summarize and provide constructive recommendations to all the member economies in this session. Since circular agriculture could play a vital role for the APEC region, he offered recommendations as follows:

1. To reach a common goal of net-zero emissions, member economies should consider improving mature and integrated technology to add value to novel circular products, such as biobased and upcycled products, and reduce the production cost of recycling products.
2. Animal genetic resources (AnGRs) are an important factor to agrobiodiversity. The practice of circular agriculture methods can help in the success of AnGR conservation.
3. To boost livestock production and utilize resources efficiently, the livestock sector needs to join force with agricultural and industrial sectors. It is also necessary to educate both farmers and consumers.
4. It is recommended to use natural practices such as solar power or biogas to offset carbon emissions.
5. For managing integrated production systems such as a crop-livestock farm, it is recommended to conduct a survey of raw materials, and develop a complete operational plan.
6. Composting would provide help to recycle farm waste for other purposes.
7. Forests store carbon, provide perfect shelters for livestock and natural resources for future bioproducts, which complement pastoral farming operations.
8. Applying biochar in the soil could not only improve the acid soil properties but also have significant benefits on crop production and it would be a key practice to enhance soil carbon.
9. For practices of circular agriculture in aquaculture, recovery and efficient utilization of seafood waste is a crucial issue. The nutritional and bioactive compounds in fish by-products where protein accounted for more than 50 percent, not to mention collagen, peptides, chitin, or chondroitin which could contribute to a high market value. The long-term goal should be set for zero-waste processing to reach a circular fishery as well as a sustainable way of waste reduction and efficient utilization of marine resources.
10. The bivalve aquaculture for carbon sequestration has biological superiority. It is low cost and eco-friendly. This approach also worked to solve the conflict between the industrial sector and aqua farmers and eventually implement a sustainable partnership.
11. Member economies are encouraged to focus research on carbon storage.
12. Climate change and natural resources limitations are two serious challenges that will negatively affect the sustainable development of businesses. Therefore, we urge APEC member economies to take the initiative to reuse resources and reduce waste, and proactively expand our agri-food circular economy model. Through the digital transformation, businesses integrating with smart manufacture and operation will lead

to a sustainable green business to ensure that the businesses provide safe and healthy food products to the consumers.

13. When formulating policies, governments should allow both industries and companies to be able to implement and carry out outcomes jointly. All the participants should implement circular agriculture principles that maximize resource use efficiency, reduce waste, maintain soil health, reduce carbon emissions, and foster ecological regeneration.

Annex 1: Results of Surveys

To enhance the understanding of the current trends and implementation of circular 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 Practices and Promotion of Circular 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 it should be improved. We are grateful for everyone who took time to complete the surveys.

Pre-meeting Survey

A total of 85 feedbacks were received prior to the workshop. 40 percent of the respondents were male, and 60 percent female. Figure 1 reveals that about half of the respondents were somewhat or very familiar with circular agriculture. This shows that there is still space for circular agriculture to grow, and that it is necessary for the APEC region to put more efforts into the promotion of it.

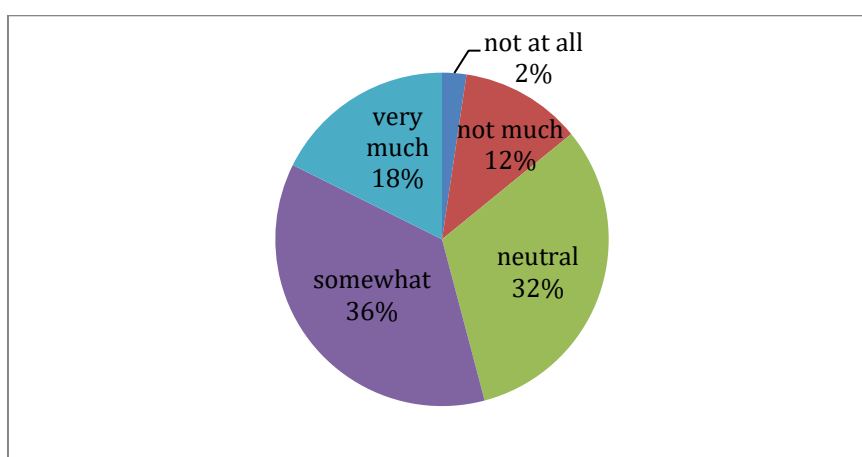


Figure 1. The understanding of circular agriculture prior to the workshop

In this survey, as revealed in Figure 2, 84 percent of the respondents agreed that circular agriculture is the future trend. Moreover, 80 percent of the respondents as shown in Figure 3. responded that their economies are interested in investing in circular agriculture. Not to mention, 89 percent of the respondents thought this method would increase competitiveness of his/her own economy as shown in Figure 4.

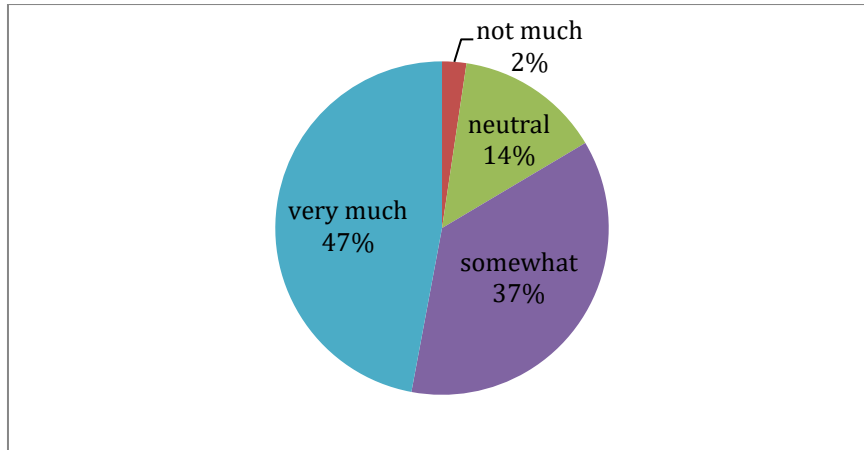


Figure 2. Circular agriculture is the future trend of agricultural development

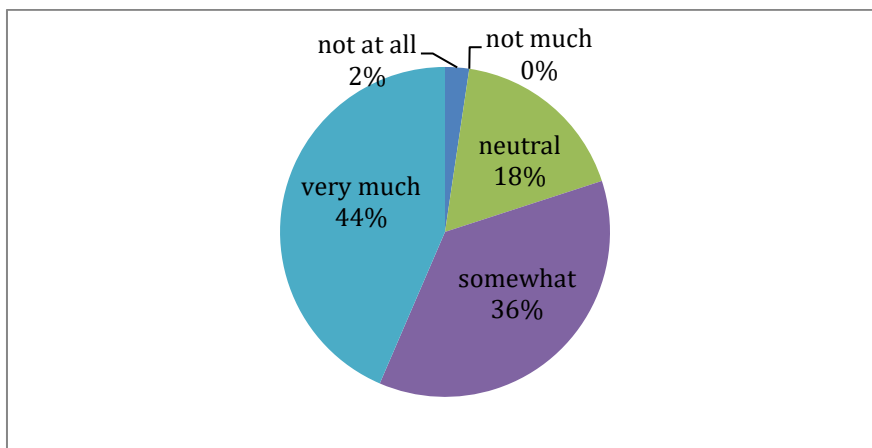


Figure 3. Circular agriculture serves as one of the directions that your economy would like to invest in

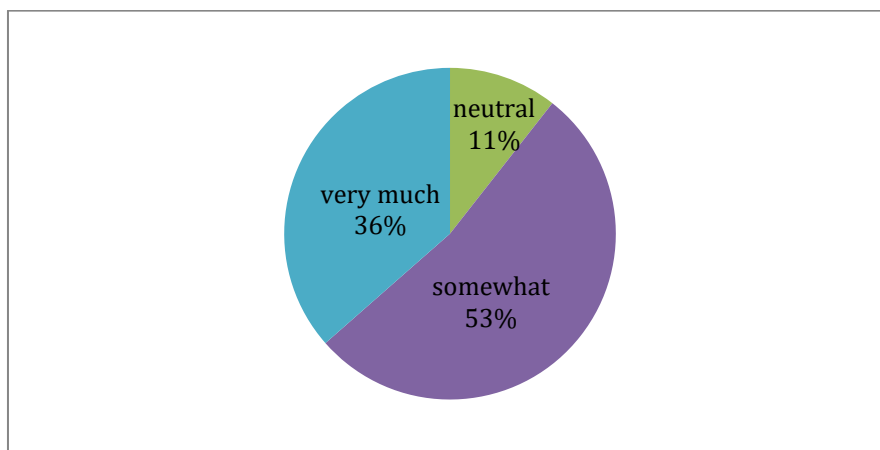


Figure 4. Circular agriculture can increase agricultural competitiveness of your economy

Regardless of all the benefits, such as closing loops and minimizing loss of wastes, 78 percent of respondents conveyed that it is somewhat or very challenging to promote circular agriculture within his/her economy as shown in Figure 5. One of the factors was that

it requires heavy investment. It is also noticeable that not all the economies are developing circular agriculture at the current stage.

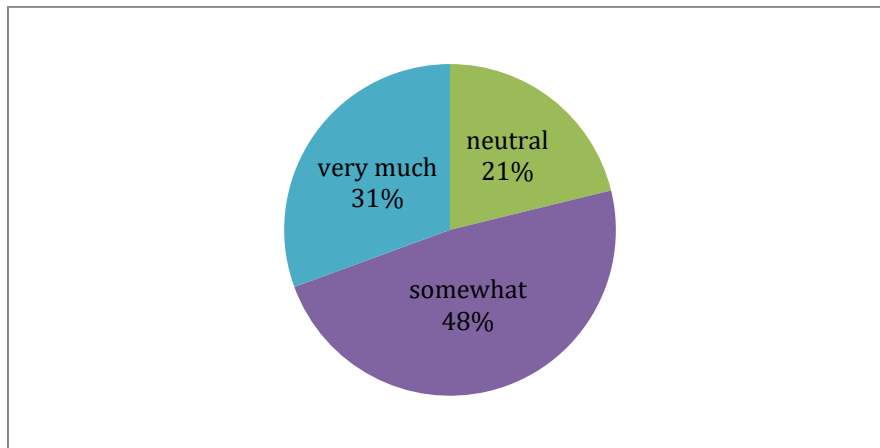


Figure 5. It is challenging to promote circular agriculture

Post-meeting Survey

After the conduction of the workshop, we distributed the “APEC Participant Evaluation Form” to participants and received 50 responses. Respondents showed that the workshop was easy to follow and clearly defined. It is shown that with the implementation of this project, participants received a better understanding of various circular agriculture techniques and their applications. Respondents replied that they have gained knowledge on development of agrarian production systems, regulations for farm recycling, latest trends of animal waste management, calcification of bivalves, seafood by-products, and so on. We learned that after attending the workshop, up to 92 percent of respondents indicated that this project is related to his/her economy. Most importantly, we see a 18% increase of knowledge toward circular agriculture after attending the workshop. 72% of the respondents show that they have either high or very high understanding of circular agriculture.

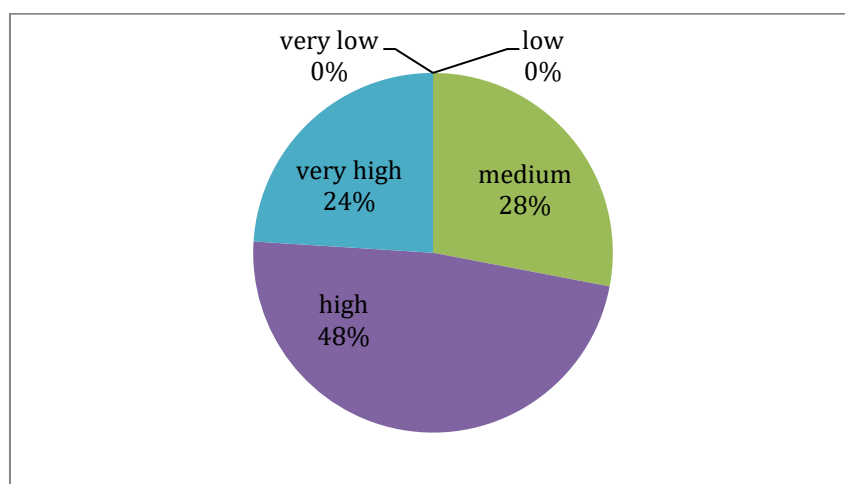


Figure 6. The understanding of circular agriculture after the workshop

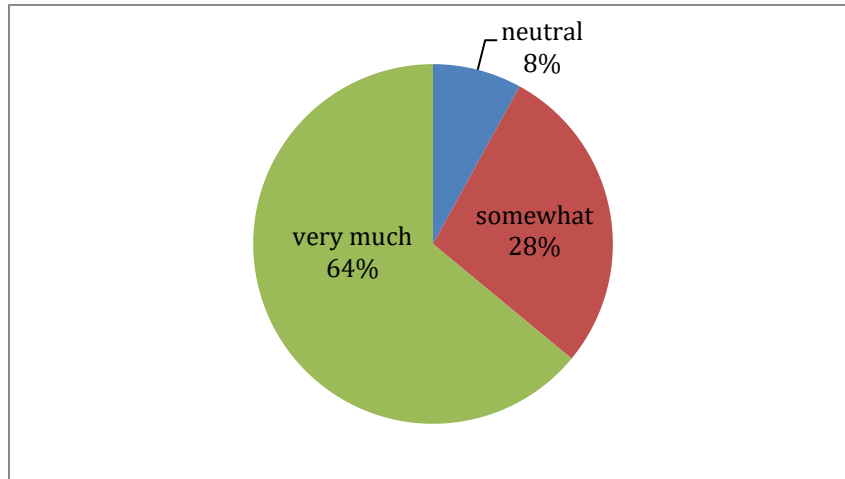


Figure 7. The relevancy of this project to your economy

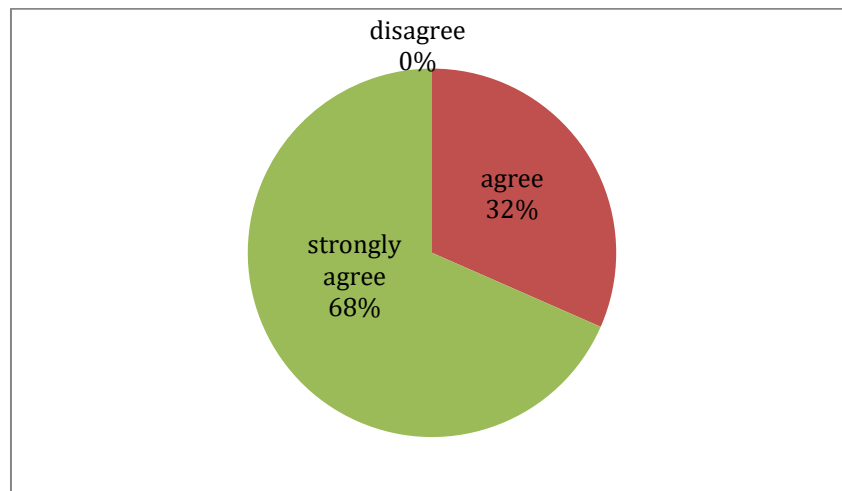


Figure 8. The content of the workshop was well organized and easy to follow

Overall, respondents are satisfied with the implementation of this project. This project paves the way for the implementation of circular agriculture. It is recommended to set up a circular agriculture knowledge sharing platform among APEC member economies to let members learn from each other, so that we could be reaching the net-zero emissions goal.

Annex 2: Agenda

APEC Workshop on Practices and Promotion of Circular Agriculture

Agenda³

Dates: Nov. 23 – 24, 2021, 09:00am - 12:00pm (CTT / UTC+8)

Location: Microsoft Teams

Organizer: Council of Agriculture

Host economy: Chinese Taipei

Day 1: Nov. 23, 2021 (Tuesday)	
08:30-09:00	Login and system checks <ul style="list-style-type: none">- Delegates to login using the assigned usernames- Check of audio and visual connections- Connection confirmation, Familiarization with 'Chat' function
09:00-09:20	Session 1 – Opening (MC) <p>Welcome and Opening Remarks</p> <ul style="list-style-type: none">- Representative from the Council of Agriculture- Dr Su-San Chang, Lead Shepherd, Agricultural Technical Cooperation Working Group- Mr Teddy Pavon, Program Director, APEC Secretariat- Mr Vincent Lin, Project Overseer, Council of Agriculture Group Photo
09:20-09:50	Session 2 - Keynote Speech <p>“Circular Economy Technologies Developed by USDA in Animal Waste Area”</p> <ul style="list-style-type: none">- Dr Matias Vanotti, USDA-ARS Scientist, ST (SuperGrade) Moderator: Dr Hsu-Sheng Lur, Dean, College of Bioresources and Agriculture, National Taiwan University
09:50-10:00	Rest Break
10:00-10:20	Session 3 -Trends, prospects, and innovation of circular agriculture <p>“Development and Practice of Circular Agriculture”</p> <ul style="list-style-type: none">- Dr Jeng-Fang Huang, Director General of Livestock Research Institute Moderator: Dr Hsu-Sheng Lur, Dean, College of Bioresources and Agriculture, National Taiwan University
10:20-12:20	Session 4-Circular agriculture practice and application-agriculture and animal husbandry <p>“Conservation, Sustainable Use and Development of Animal Genetic Resources by Participatory Action Research with Farmers and Communities”</p> <ul style="list-style-type: none">- Dr Kalaya Boonyanuwat, Chief of Biodiversity Research and Development Section, Thailand Department of Livestock Development <p>“Practice of Agriculture Circular Economy at Fwusow Industry”</p> <ul style="list-style-type: none">- Mr Yau-Kuen Hung, Chairman, Fwusow Industry Co., Ltd. <p>“Practice of Circular Economy in Swine Industry”</p> <ul style="list-style-type: none">- Ms Pei-Chen Chou, Chief, Taiwan Sugar Corporation <p>“Practice of Circular Economy in the New Zealand Horticulture Industry”</p>

³ Disclaimer: The names of public or private institutions referred in this document do not imply the political status of any APEC economy.

	<p>- Mr James Kuperus, CEO, Onions New Zealand</p> <p>Moderator: Dr Chung-Ling Chen, Professor, Institute of Ocean Technology and Marine Affairs, Department of Hydraulic and Ocean Engineering, National Cheng Kung University</p> <p>Session 5-Circular agriculture practice and application- aquaculture</p> <p>“Recovery and Valorizing of Value-Added Products from Seafood By-Products – An Opportunity for a Circular Economy Approach”</p> <p>- Dr Chang-Wei Hsieh, Distinguished Professor, National Chung Hsing University</p> <p>“From Waste to Resource – Efficient Utilization of Seafood By-products”</p> <p>- Dr Chyuan-Yuan Shiau, Emeritus Professor, National Taiwan Ocean University</p> <p>Moderator: Dr Chung-Ling Chen, Professor, Institute of Ocean Technology and Marine Affairs, Department of Hydraulic and Ocean Engineering, National Cheng Kung University</p>
	<p>Closing of Day 1 (MC- What is planned for Day 2)</p>

Day 2: Nov. 24, 2021 (Wednesday)	
08:30-09:00	<p>Login and system checks</p> <ul style="list-style-type: none"> - Delegates to login using the assigned usernames - Check of audio and visual connections - Connection confirmation, Familiarization with ‘Chat’ function
09:00-09:30	<p>Session 6- Circular Economic System for Sustainable Agriculture</p> <p>“New Agricultural Innovation with Green Energy and a Circular (GC) Economic System”</p> <p>- Dr Chia-Lin Chang, Professor, National Chung Hsing University</p> <p>Moderator: Dr Hsu-Sheng Lur, Dean, College of Bioresources and Agriculture, National Taiwan University</p>
09:30-11:30	<p>Session 7 -How circular agriculture contribute to net zero carbon emission strategies</p> <p>“Circularity within Pastoral Livestock Systems in New Zealand”</p> <p>- Dr Warren Parker, Chair of Landcorp Farming Limited (Pāmu)</p> <p>“Recycling Practice and Net Zero Strategy in the Livestock Industry”</p> <p>- Dr Meiping Cheng, Researcher and Chief Secretary, Livestock Research Institute</p> <p>“Case Study on Benefit Analysis of Carbon Reduction of Circular Agriculture”</p> <p>- Dr Chiling Chen, Researcher, Taiwan Agricultural Research Institute</p> <p>“How the Circular Livestock Contributes to a Low-Carbon Society in Korea”</p> <p>- Dr Youngah Lim, Research Fellow, Korea Rural Economic Institute</p> <p>“Assessment of Carbon Sequestration Capacity by Shell Calcification of Bivalves through their Culture”</p> <p>- Dr Yew-Hu Chien, Professor, National Taiwan Ocean University</p> <p>“Using Different Strategies to Approach Carbon Neutrality”</p> <p>-Dr Chin-Chang Hung, Dean, National Sun Yat-sen University</p> <p>Moderator: Dr Churng-faung Lee, Researcher and the Deputy Director General, Livestock Research Institute</p>
11:30-11:40	Rest Break

11:40-12:00	<p>Session 8: Next Step & Closing Remark (MC)</p> <p>“Collated Recommendations”</p> <ul style="list-style-type: none"> - Dr Jeng-Fang Huang, Director General of Livestock Research Institute <p>“Closing Remarks”</p> <ul style="list-style-type: none"> - Dr Su-San Chang, Lead Shepherd, Agricultural Technical Cooperation Working Group - Mr Vincent Lin, Project Overseer, Council of Agriculture
	<p>CLOSE WORKSHOP</p>

