EVENT REPORT

Arup Explores Urban Agriculture

Singapore
November 7th 2019

ARUP

ABOUT

Arup Foresight

Arup Foresight helps organisations understand trends, explore new ideas, and radically rethink the future of their businesses. We examine the many forces shaping the future of the built environment. We developed the concept of ‘foresight by design’, which uses innovative design tools and techniques in order to bring new ideas to life, and to engage all stakeholders in meaningful conversations about change.

For more information, please email:
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Front cover image: Funan Mall Urban Farm, Singapore © Arup

ARUP EXPLORES

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Foreword

DR ANNE KOVACHEVICH

Australasia Foresight and Innovation Lead

It is predicted that food production across the world will need to increase by around 25% by 2050. Coupled with growing urbanisation, restrictions in available agricultural land and climate change impacts, this leaves a large challenge to address.

Singapore announced in 2019 that they have a "30 by 30" goal to increase food production from around 10% to 30% of its nutritional needs locally by 2030. In a country where 98% of the fresh produce is currently imported, this ambitious goal makes Singapore the ideal location to start our exploration into the future of Urban Agriculture.

Focusing on four themes – increasing urban food production, rethinking the supply chain, moving towards sustainable consumption and managing/eliminating food waste – the programme included a learning journey, a workshop and a series of fascinating speakers who explored different areas of the topic.

The event provided a unique opportunity for industry and academia to explore this highly complex subject from all angles, and become more informed before drawing any conclusions.

It is our hope that this is the beginning of an endeavour that will help build and strengthen a network of interested parties in Singapore and across the region, perhaps leading to new opportunities for research and collaboration.

Arup will continue to explore the topic of the Future of Urban Agriculture further in 2020 including expanding considerations to a wider Asian context. For more information on what's coming up in 2020 please do not hesitate to contact me.

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About

Arup Explores

Arup Explores is a series of global events, engagements and learning journeys focusing on disruptive themes and their implications on the built environment and society at large.

Arup Explores events aim to get an early understanding of what factors are driving change and what this change means for Arup and our clients. Past events have looked into themes such as Digital Fabrication, Biomimicry, Machine Learning and Prototyping. By bringing together Arup professionals and industry experts from a wide range of disciplines, these events have led to new partnerships and client engagements, supported our culture of innovation, and provided early guidance on our priorities for research, strategic investments and capability development.

Urban agriculture

This event took place in Singapore on the 7th of November 2019. Four key themes framed this event: increasing urban food production, rethinking the supply chain, moving towards sustainable consumption and managing food waste. Formed of three parts, the event was aimed at understanding the complex ecosystem of growing, distributing, consuming and recycling food in the urban environment as well as the ways in which Arup, alongside a wide range of industry stakeholders, can contribute towards a unified, collaborative approach of making this ecosystem as inclusive, secure, efficient and resilient as possible for Singaporeans.

The event brought together a wide range of participants from Arup's Australasia Region offices and experts from the industry. The day started with a learning journey comprising of three visits; **School of Chemical and Biomedical Engineering of Nanyang Technological University (NTU)**, **Oasis Living Lab** - an urban farm in north-west Singapore - and **Funan Mall**, a recently completed mixed use development in the centre of Singapore with an urban farm on its rooftop.

The second part of the day included a workshop, facilitated by Arup Foresight. The participants built upon the learning journey experience and tried to come up with an action plan focused on urban agriculture in order to achieve a hypothetical scenario for the year 2050. The third and last part of the day was a series of burst presentations and a panel discussion with industry experts who closed the day with personal and collective contributions and reflections on the current situation, future opportunities, challenges and risks of the urban agriculture ecosystem in Singapore.

ARUP EXPLORES

Research

According to the Food and Agriculture Organisation of the United Nations, urban (and peri-urban) agriculture can be defined as the growing of plants and the raising of animals within and around cities.

Urban and peri-urban agriculture provides food products from different types of crops (grains, vegetables, fruits), animals (poultry, cattle, pigs, fish, etc.) as well as non-food products (e.g. aromatic and medicinal herbs, ornamental plants, tree products)[1].

Rapid urbanisation and population growth, lifestyle changes, resource scarcity, the climate emergency and technological advancements are contributing to a radical rethinking of the food cycle in cities.

Recent studies project potential urban agriculture food production of 100-180 million tones annually[2]. Urban farms employ people, regenerate neighbourhoods and give city residents access to fresh produce on their doorsteps.

In 2019, Singapore announced their ‘30 by 30’ goal to produce 30% of its nutritional needs locally by 2030. In a country where 98% of the fresh produce is currently imported, this ambitious goal and its implications for city systems, resource constraints, climate resilience, new agri-technology, and food security make Singapore a test bed for innovation and disruption.

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RESEARCH

Increasing urban food production

Feeding a growing society

By 2050 we will need to feed 1.3 billion more people than in 2019. Across the world, highly industrialised farming practices are already in place to try and meet the growing demand for food. At Vulgamore farms in Kansas, up to 25 acres of wheat is harvested an hour. At Granja Mantiqueira in Brazil, 8 million hens lay 5.4 million eggs a day.

Demand for meat has tripled in the developing world in the last four decades, while egg consumption has increased sevenfold, driving a huge expansion of large-scale animal operations. A team of scientists from the University of Minnesota have identified five steps that must be taken for the world to feed its population in 2050: freeze agriculture's footprint, grow more from the land we already use, use resources more efficiently, shift diets and reduce waste[3].

Hydroponics and vertical farming

While industrial methods have resulted in a greater supply of food, they have also resulted in increased waste, and greater strain on natural resources and our environment. With 80% of all food expected to be consumed in cities by 2050, these future cities will be key players in the production and consumption of food[4]. One key response to these issues is the rise of vertical farming driven by hydroponic crop production. The hydroponics industry is estimated to be worth $3 billion by 2024. Globally, a third of all food produced is wasted, which is approximately 1.3 billion tonnes - a loss of $1 trillion annually.

This is primarily due to poor crop management leading to disease and pest invasion as well as lacking finances[5]. Hydroponic farming occurs under controlled conditions with reduced water requirements, allowing crops to withstand unfavourable weather and produce high yields[6].

2x

more production will be needed to feed the expected population

1/3

of all food produced is wasted which is approximately 1.3 billion tonnes.

© Miguel Sousa.

© Thomas Le

RESEARCH

Rethinking the supply chain

Transparency

Global sales for products produced with sustainable methods have been rapidly increasing with a growth of 7.2% from 2016-17. This good food movement is being driven by a growth in consumer awareness around the benefits of eating nutrient-rich food that has minimal negative impacts on the environment[7]. It was found that income is not a prohibitive barrier to purchasing ethically. 68% of consumers who earn less than US$20,000 per year compared to 63% of consumers who earn over US$50,000 are willing to pay more for products from companies committed to positive social and environmental change. What is good for the earth is good for companies.

Those committed to sustainability grew 4% globally compared to less than 1% of growth for those not committed.[8] In the UK, there is an £81.3 billion market for ethical products and services. This sector has grown by more than £40 billion from 2008 to 2017. Young consumers are driving these changes. In 2017, the proportion of 18 to 24 year olds turning to vegetarianism for environmental or welfare reasons increased from 9% to 19%[9].

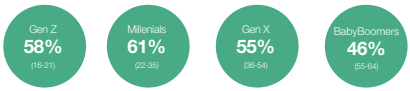
The circular economy

The world is aiming to shift towards a circular economy, increasing economic gain, whilst reducing our environmental and carbon footprint. A 5% improvement in the effective use of materials across the Australian economy could benefit GDP by as much as $24 billion. In order to capitalise on the economic opportunities presented by a circular economy, a strategic and collaborative perspective must be taken with our approach to waste as a resource. We must establish new frames for problem-solving across the entire food system that pivot from the current linear mode of operation[10].

CSIRO is working to transform food waste streams into new food and beverage products for human and animal consumption. CSIRO are also exploring cost-effective, scalable and environmentally sustainable separation technologies. These involve AI decision-making tools, food loss and location mapping and better informed food processing. Additionally, new sensor technologies are enabling rapid analysis of the quality of raw material for edible use[11].

%

of people per generation who agree that they would pay more for eco-friendly products[12]



RESEARCH

Moving towards sustainable consumption

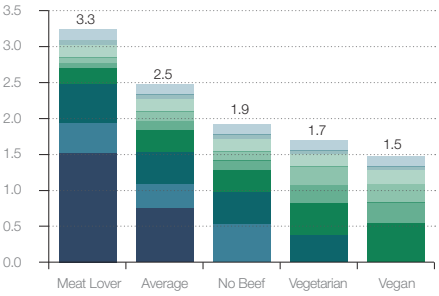
Changing diets

Every year, a quarter of all greenhouse gas emissions globally (5 billion tonnes of CO_2) is a result of crop and livestock production. At the same time, our demand for soy is the driving force behind deforestation across the globe.

However, 70% of soy production is being fed to livestock. Beef production using soybeans as feed produces 105kg of CO2 per 100g, while producing tofu with soy only produces 3.5kg of CO2 per 100g[13]. Changing a person's diet from meat lover (see figure below) or average to vegetarian or vegan can reduce their carbon footprint by over 50%[14].

The growth in adopting vegan and vegetarian diets is on the rise in developed nations. In Australia, between 2014 and 2016, the number of food products carrying a vegan claim rose by 92%. Australia is also the third fastest growing vegan market in the world[15]. However, globally, the consumption of meat is projected to grow by 73% and dairy by 58% by 2050[16].

Foodprints by diet Type: tCO_2 e/person[20]



Food as a service

Over time, cooking and eating meals at home has become a rarer occasion. It is predicted that meal and ingredient delivery will become the new standard for households in developed nations. In the USA, almost 10% of all homes purchased a meal kit in 2018 and 65% of these customers are making repeat purchases[17].

A growing focus on the delivery of great customer service, the increasing virtualisation of the restaurant experience and data driven marketing are driving the rise in meal delivery services[18].

Almost 90% of Americans either hate or feel hesitant towards cooking. Despite how relatively new some of the aggregated delivery business models are, online meal delivery has hit US$120 billion in gross food sales globally. It is estimated that by 2030, about 2.8 billion people will be able to afford and access home meal delivery globally. This will be a 150% increase from the 1.8 billion who can do so today[19].


© Jonathan Borba

Managing and eliminating food waste

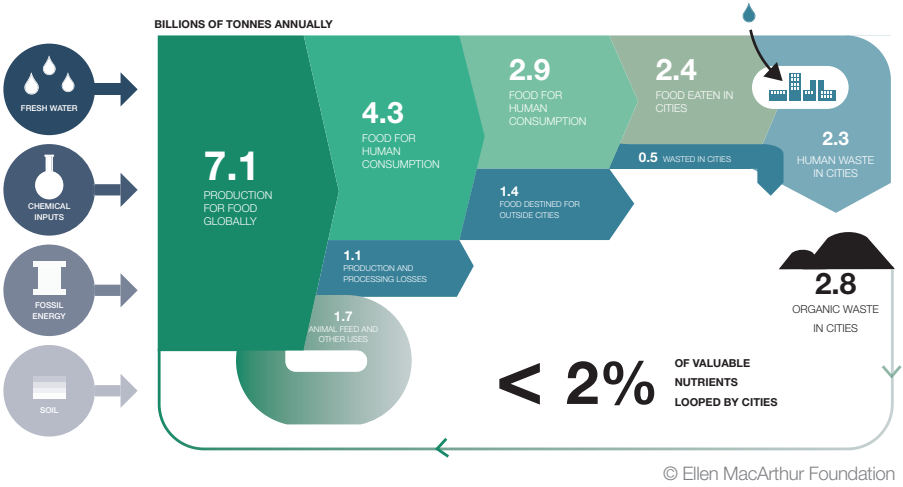
Reducing Food Waste Impacts

With our increasing consumption, comes an increase in food waste. This includes waste of food itself as well as its supporting products and materials such as packaging. For every dollar spent on food, society pays two dollars in additional health, environmental and economic costs associated with food production and waste. Approximately half of these additional costs (USD 5.7 trillion per year) are a result of the impacts from the waste we generate in this sector. The current linear approach to food production is what drives these added costs. The agriculture industry is responsible for the production of almost 25% of all greenhouse gasses emitted annually. Globally, an equivalent of six garbage trucks of edible food is lost or wasted every second. Cities are where most of this waste occurs, and with 80% of all food to be consumed within cities by 2050, cities will continue to influence the way food is grown, consumed and disposed of. The circular economy offers a food system that can reduce or remove the additional costs associated with food waste. Beyond the current 'take, make dispose' food system, a circular approach aims to design out waste and pollution, keep products and materials in use and regenerate the natural systems that facilitate food growth.

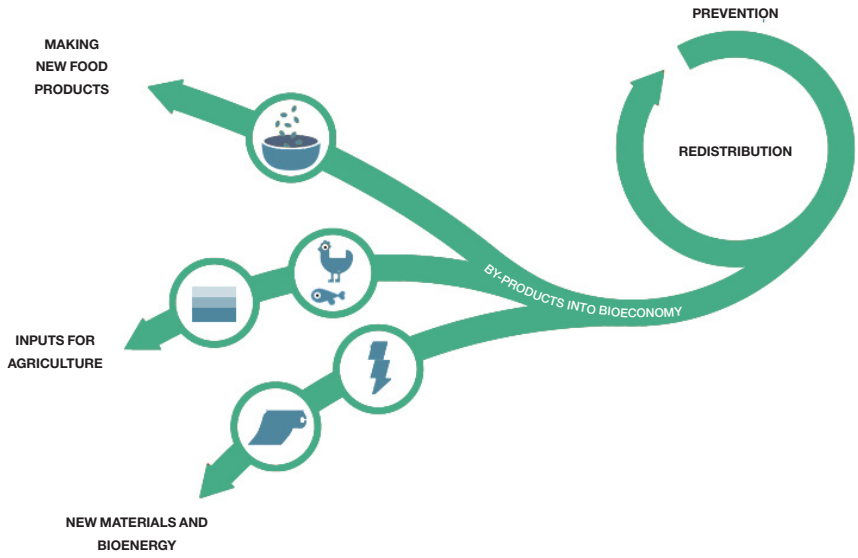
Making the Most from Food Systems

Cities have a key role to play in fundamentally shifting the ways we think about disposing of food waste as well as other by-products. The release of nutrients caused by food waste creates significant consequences for the natural environment. Supply chain management that better matches food supply with fluctuating demand, as well as initiatives to utilise produce before it expires such as using overripe produce for in-store food outlets or discounting soon-to-expire or "ugly" produce, can help people save money while also making better use of food resources. Even if all edible food is used to its greatest capacity, there are non-edible by-products such as human and green waste that will continue to be produced by cities. These organic materials contain valuable nutrients that can be repurposed in other products. Less than 2% of the nutrients from human waste and food-by-products is repurposed with the majority being disposed to landfill. Global organic waste is expected to double from 2016 levels by 2025, with 70% of this increase expected to occur in developing nations. By recognising the benefits of collecting organic materials in the short term, future infrastructure in emerging economies can be designed to make more optimised use of organic waste and food by-products. Keeping organic matter and other by-product waste streams in their purest form will be essential for ensuring materials can be extracted at their highest value. Food and packaging design have an important role to play in making sure materials, ingredients and processes that are used do not inhibit the ability to reliably separate materials for processing and capture of nutrients and other resources.

The linear flows of materials in the food system [21]



Food system byproducts that can be transformed into valuable resources [22]



ARUP EXPLORES

Learning journey

The learning journey aimed at showcasing urban agriculture innovations and practical applications happening in Singapore.

From lab breakthroughs in reusing food waste, to leveraging IoT solutions with the aim to monitor the growing of plants in an urban farm, to tasting herbs and vegetables grown on the roof terrace of a mall in the centre of the city and consumed at one of its farm-to-table restaurants, the learning journey set the scene for what followed during the rest of the day.

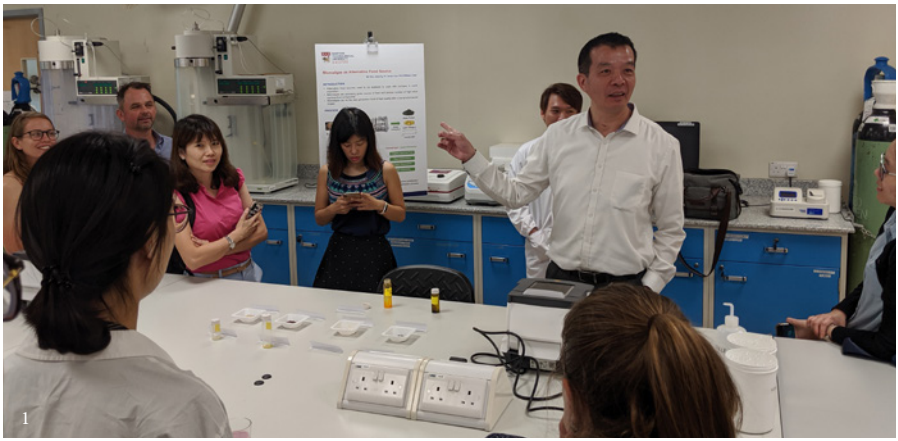
LEARNING JOURNEY

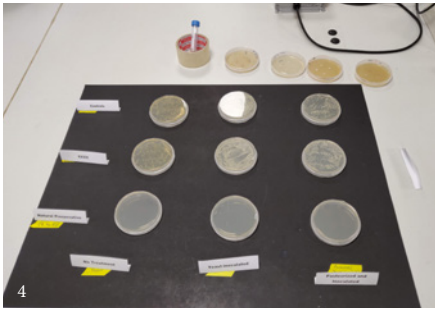
Nanyang Technological University

The journey began at Nanyang Technological University (NTU). The particiapants, staff from Arup's Australasia region and Arup clients with a keen interest in the topic of urban agriculture, were welcomed by Professor William Chen, director of the Food Science and Technology programme in the School of Chemical and Biomedical Engineering and his team.

Participants were shown current projects which focused on ways of upscaling food by-products to improve the quality and pace of nutrient recovery, as well as reusing soybean waste and durian husk to produce biodegradable materials for everyday use like cellulose film.

The NTU team also showcased alternative food sources that could have a lower environmental impact -like microalgae -, new types of natural preservatives and opporunities to re-purpose food waste - like the durian husk - into nutrient sources like produce probiotic powder.





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NTU FOOD SCIENCE AND TECHNOLOGY LAB

50 Nanyang Ave, Singapore

1. Professor Chen showcasing the lab's latest projects.
2. Professor Chen showcasing the lab's latest projects.
3. Biodegradable cellulose film prodcued by durian husk
4. Natural preservatives

OASIS LIVING LAB

21 Neo Tiew Lane 1, Blue Aqua Breeding Center,
Singapore 718788

1. A panoramic view of the facility with its main greenhouse on the left and some of its multi-purpose containers on the right.
2. The greenhouses of Oasis Living

LEARNING JOURNEY

Oasis Living Lab

The second stop of the learning journey included a visit at Oasis Living Lab, an urban farm in the north of Singapore operated by Netatech, an organization which designs integrated solutions for rain, sun and crop harvesting. David Tan, CEO of Netatech, welcomed the explorers and guided them through the farm and its facilities.

The farm features greenhouses, an indoor plant lab, a smart technology research lab, a lab used for plant physiology and light spectrum training as well as its own stormwater management system and rain garden. The container-based, modular layout of the facilities allows for spatial flexibility and adaptability.

At the same time, the farm utilizes a cloud computing platform combined with IoT devices which allow total control of the farm remotely. All Oasis Living Lab systems are designed and built in-house, simulating technological solutions and leveraging know-how from overseas collaborations with private organisations and academic institutions.

LEARNING JOURNEY

Funan Mall

The last stop was Funan Mall where participants experienced a rooftop garden built by Netatech and operated and maintained by Edible Garden City, a company that designs, builds and maintains food gardens in urban Singapore.

In addition to its outdoor garden terraces, Funan urban farm features three edible walls, a microgreens growing room for edible plants (coriander, amaranth, pea tendrils, etc.), a mushroom fruiting chamber, an aquaculture tank and an outdoor Research & Development bed where Edible Garden City's farmers experiment with growing innovative types of edible produce and the soil they grow in, testing new growing methods or ingredients, such as new types of organic fertilizer, worm castings, or different watering cycles.

The journey concluded with lunch at Noka, a farm-to-table restaurant serving food from the roof garden.

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FUNAN MALL

107 North Bridge Rd, Singapore

1. The microgreens growing room of the Funan mall rooftop farm.
2. The microgreens growing room of the Funan mall rooftop farm.
3. The explorers had the opportunity to taste the farm-to table menu of Noka.
4. Noka staff taking the explorers on a short tour before lunch.

ARUP EXPLORES

Workshop

Following the learning journey, a facilitated workshop took place in Arup's Singapore office. The workshop focused on our four key themes, wherein participants were asked to focus on one of the four topics:

1. Increasing urban food production
2. Rethinking the supply chain
3. Moving towards sustainable consumption
4. Eliminating/managing food waste

Considering their topics, the participants reflected on what they learned during the learning journey, assessed the current state of Singapore food production, identified the key challenges cities might face in the future as well as the technologies and initiatives necessary to address these challenges. In groups, they were encouraged to paint a picture of what urban agriculture looks like for Singapore in 2050, focusing on their respective topic and the implications it might have on the way people live.

Once visions were decided upon, participants were asked to create a roadmap of key actions that could turn their vision into reality. They identified key steps, events and actions and placed them on a timeline, starting from 2050 and, through backcasting, finishing with the present day.


Arup EXPLORES
The Future of
Urban Agriculture
Workshop 7 November 2019

© Arup

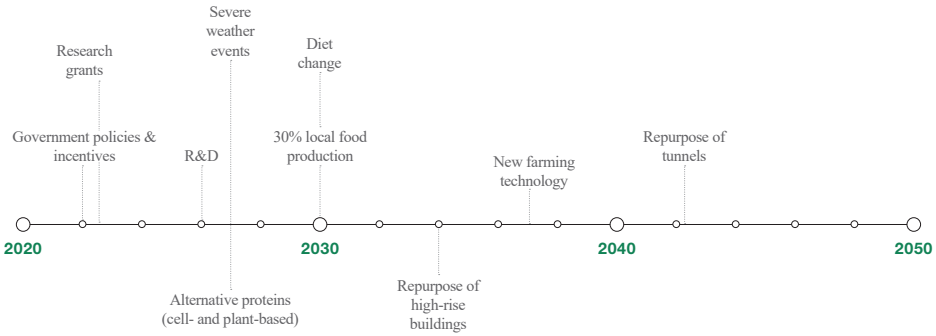
WORKSHOP

Findings

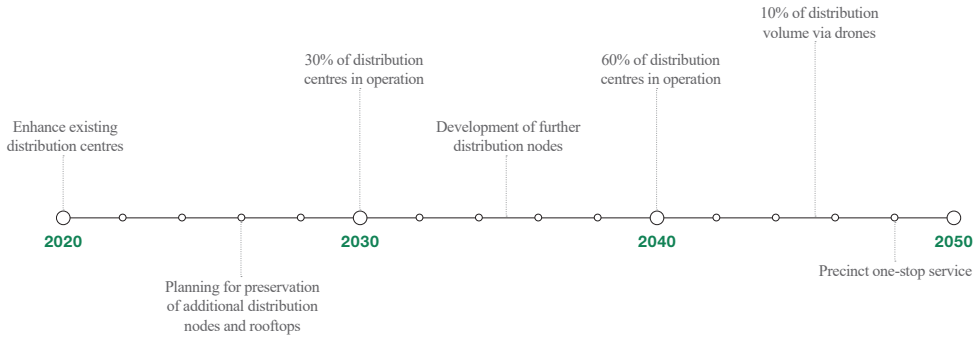
The workshop focused on our four key themes, and aimed to develop roadmaps to 2050 for each of them. The results highlighted a need for a more coordinated approach if we are to achieve the desired, and any desired, future urban agriculture scenario.

All teams made clear in their roadmaps that policy, technology and societal awareness will be basic pillars for a secure, efficient and resilient future. Two of the teams thought that the way to a desirable future is through a severe weather event and a population shock; events that could potentially be major drivers for a future behavioural change.

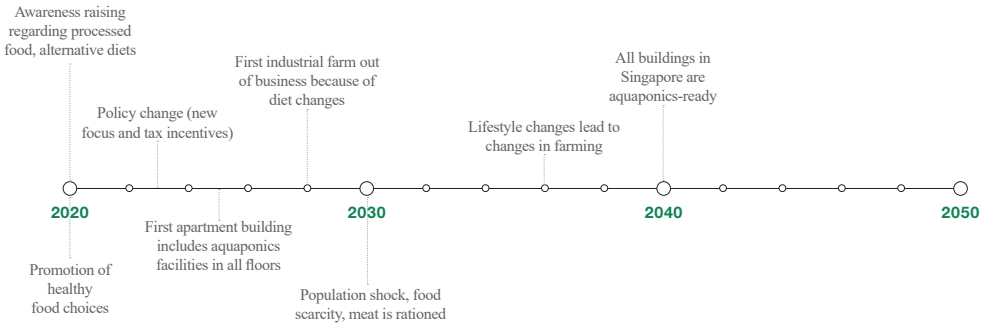
Increasing urban food production



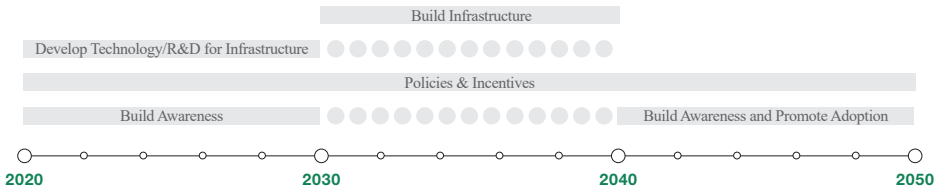
Rethinking the supply chain



Moving towards sustainable consumption



Managing and eliminating food waste



ARUP EXPLORES

Speaker presentations

For the third and last session of the day, a group of experts delivered a set of 5-minute burst presentations and engaged in a panel discussion followed by Q&A with the audience.

© Arup

Harvest more with less: smart water and farm

DAVID TAN

CEO | Netatech

David Tan is the founder and CEO of Netatech Pte Ltd, a leader in providing end-to-end solutions for urban water challenges. With over 25 years' experience in IT and control engineering, David's knowledge and expertise has enabled the company to innovate and implement on-line monitoring and control of environmental conditions and processes. Today, David is taking it a step further to tackle the challenge of food sustainability, realising his vision of smart agriculture. He has collaborated with top global academics, tapping on their domain expertise to research and solve water and food challenges faced by our urban cities.

> "Young people in Singapore don't drive, they 'Grab'. In the future, this could leave us with a lot of empty car parking space on top of buildings. Why don't we turn these spaces into farms?"

Building on his experience in designing and building urban farms across Asia, David spoke about the importance of integrating smart farms into smart cities by using technology that allows farms to be decentralised, automated and their crops to be adaptable to local climatic conditions. David touched upon social and community benefits of urban farming and his team's efforts to establish a strong network of small farmers across Asia who, through a digital platform called CrowdFarmX, are now able to access necessary resources, knowledge and equipment to set up and operate an urban farm.

Some key insights from David's presentation were:

- Intensifying local production, exploring new spaces to grow food in the city, using renewable energy and recycling farm waste form the backbone of a successful roadmap.
- We have to step away from centralised farming and focus on decentralised urban farming models.
- Blockchain, IoT and cloud computing are key ingredients in building and operating an urban farm. They allow real-time monitoring and can solve pest and disease problems through climate control and biosecurity while enabling urban farms to operate sustainably.

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SMARTS FARM FOR SMART CITIES

Singapore

David spoke about the experience of building a farm on the rooftop of a shopping mall in the centre of Singapore and how technology (IoT) was a vital ingredient in designing, operating and monitoring the functions of the farm.

Only connect: localising food production

EIKE SINDLINGER

Associate, Arup Integrated City Planning

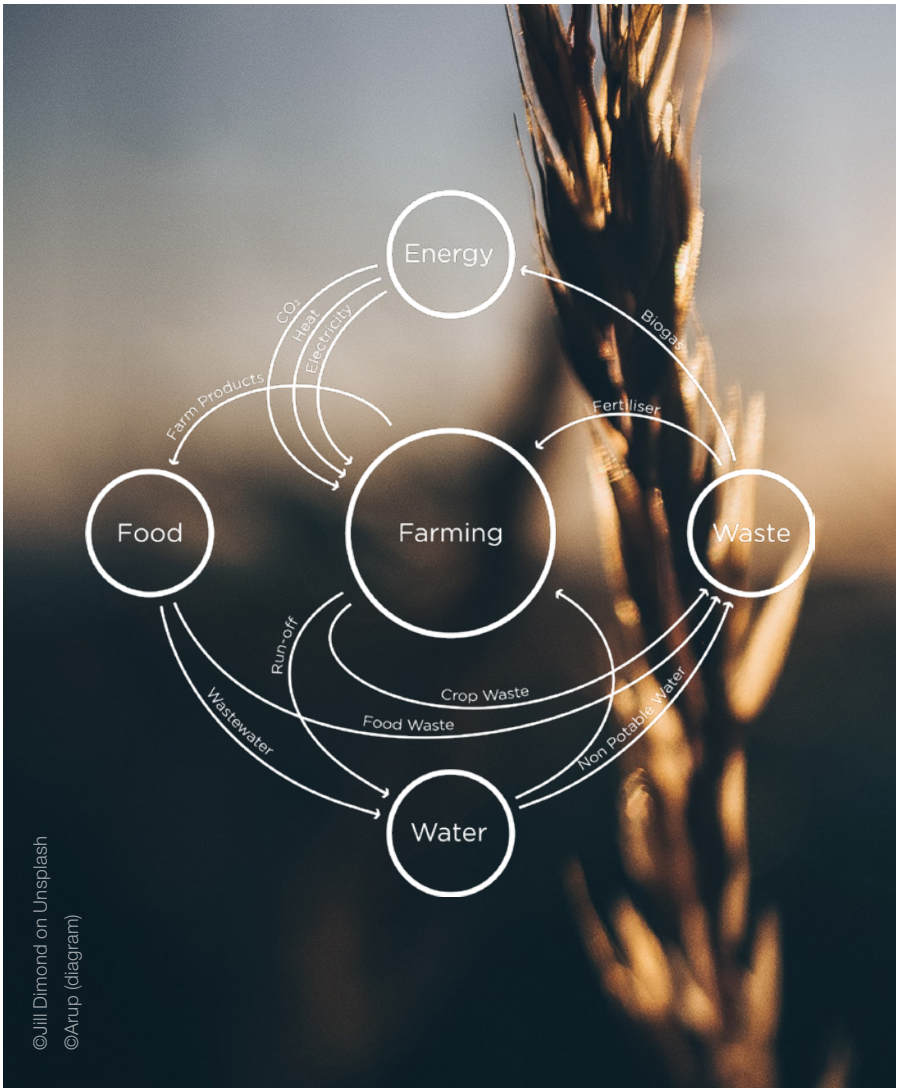
Eike is an Associate at Arup. He works in Integrated City Planning as an urban designer, leading high-profile projects in the UK and internationally. He is one of Arup's specialists in exploring the link between food, cities and development. Working closely with a government agency, he led the masterplan for a national food security programme in the Middle East. As an urban designer, Eike believes passionately that the food system should be treated as integral part of our urban infrastructure.

> "Bringing food production back to the cities, connecting it to urban infrastructure and adopting a systems thinking approach are all key steps towards achieving sustainable food production and improving food security."

Eike opened the session by highlighting the importance of linking the food lifecycle in cities with infrastructure. By localising food production in urban environments and treating food as a system (and a system of systems), cities will be able to achieve their food production targets at a time when global population growth shows no signs of slowing down, arable land is decreasing and food production emissions keep spiking.

Some key insights from Eike's presentation were:

- The global population is expected to reach 9.5bn people by 2050.
- By 2070, we have to produce the same amount of food that mankind has produced during 10,000 years of historical food production.
- Localising food production and leveraging the phosphate that can be found in urban environments could address the negative agricultural productivity projections anticipated by 2080.
- Localising food production will not be possible without linking food production to city infrastructure.



©Jill Dimond on Unsplash
©Arup (diagram)

APPLYING SYSTEMS THINKING

In the context of the food cycle

This diagram represents the systems thinking that could be applied to the food cycle and the relationships between its various resources.

GROWing the AgriFood ecosystem in Singapore

VANDANA DHAUL

Head of Accelerator Operations, GROW

Vandana Dhaul is the Head of Accelerator Operations at GROW - Singapore's first global agri-food tech accelerator. She works with startups, corporates, researchers, and investors to accelerate the development of cutting edge agri-food technologies, products, and business models. She speaks from her experience and knowledge as a successful entrepreneur and thrives on guiding and mentoring startup founders to implement innovative, practical and outcome-driven strategies. Her work at GROW also involves building capabilities to support growth in the Singapore and ASEAN agri-food ecosystem.

> "Establishing a solid framework of understanding between key stakeholders and enabling an environment where startups can innovate and thrive will facilitate and strengthen this effort."

Vandana described how, through her work with agri-tech and food-tech startups, she explores new food frontiers. She highlighted the importance of understanding all aspects of the complex ecosystems of urban agriculture and urban food production. From alternative proteins, personalised nutrition and functional foods to precision agriculture, digital value chains, traceability and waste reduction, Vandana's work focuses on building an ecosystem where capabilities, innovation and networks are at the forefront of the process.

Some key insights from Vandana's presentation were:

- Singapore startups focus on 4 key areas: alternative protein, urban agriculture, aquaculture, digital supply chains.
- Knowledge sharing both locally in Singapore and regionally is critical to the success of the agri-food ecosystem.
- Collaboration is key (between startups, government agencies and legislators, investors, etc.).
- Stakeholder engagement, through a common language of communication, is necessary if we seek better outcomes.

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ECOSYSTEM BUILDER

Key focus areas

GROW and Singapore startups focus on these key areas with the aim to accelerate the local and regional agri-food ecosystem. According to Vandana, these are the key characteristics of a successful agri-food startup ecosystem.

Urban farming can influence food consumption

CHRISTOPHER LEOW

Business Development Manager, Edible Garden City

Having worked from 'Farm to Table' as an urban farmer and a chef, Chris has gained a deep understanding of the food supply chain from growing to distribution, preparation, and food waste in countries such as Australia, Japan and Singapore. Chris seeks to establish new frontiers in food production and uplift the current food system through his work in Edible Garden City, which uses urban farming to create social and environmental impact in land-scarce Singapore.

> "Urban farming is a great way to start meaningful conversations about the food we eat, where it comes from, where it ends up, about the impact of urban gardens and farms and about the importance of bringing people together using nature and green spaces."

Chris, reflecting on his own transformational journey from being an aerospace engineer, to becoming a chef and then a farmer, talked about the notion of social ecology and the role urban farming can play in enabling social change and creative a cohesive social fabric.

Some key insights from Chris' presentation were:

- Urban farming is now considered a Landscape Replacement Area (LRA) by Singapore's Urban Redevelopment Authority (URA); this means that the greenery lost by land taken up by buildings can now be replaced vertically through rooftop and vertical farms.

- Urban farms can be used as touchpoints for sustainability and environmental messaging.

- Urban farms can be used to educate the younger generations about the importance of responsible and ethical consumption by connecting them to nature and the food that feeds them.

- They can also be used to reconnect the elderly with their communities, enhance their sense of belonging, employ them and help them find meaning and purpose.

LUSH

Landscaping for Urban Spaces and High-rise Buildings

Singapore's Urban Redevelopment Authority (URA) introduced LUSH in 2009 to encourage pervasive and accessible greenery. The programme, is now in its third version, considers vertical greenery or extensive green roofs as Landscape Replacement Areas (LRAs).

Zero waste processing for enhanced food systems

PROFESSOR WILLIAM CHEN

Director, Nanyang Technological University (NTU FST)
Food & Science Technology Programme

Professor Chen is the Michael Fam Chair Professor. At the NTU FST he integrates Education, Research and Innovation. NTU FST has developed innovative technologies of relevance to Singapore's food industry. These innovations have contributed to Food Circular Economy in Singapore and have attracted significant interest and investment from government agencies, food industry, and local/international media. He is an advisor to government agencies and food industry on matters related to food security and future food technology.

> "We should systematically aim for recovering nutrients from food waste. If this is not possible, then we should turn food waste into something else; like biodegradable packaging material for example."

Professor Chen talked about his research and laboratory work, which some of the attendees witnessed and heard about during the learning journey, and his team's endeavours to reduce food waste. He highlighted the importance of turning food waste into something more usable and the necessity to close the current food system loop between food production and food waste management.

Some key insights from Professor Chen's presentation were:

- Disposing food waste is no longer an option. We should systematically aim for nutrient recovery from food waste.
- Food technology is still something that many people don't relate to. We should change this perception, starting with the younger generations.
- Collaboration between academic institutions and the private sector is crucial for commercialising innovations that minimise food waste.
- Zero-waste food processing technologies are key for circular food systems and could be transferred and applied to other, more complex systems.

▲

ZERO WASTE FOOD PROCESSING

Towards a circular economy

According to Professor Chen, technological innovations for circular economy food processing systems could be transferred to other food waste systems/sidce streams.

ARUP EXPLORES

Conclusion

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Conclusion

What does this all mean?

Population growth, urbanisation, technological advancements, lifestyle changes and the climate emergency present challenges to the way food is produced, supplied, consumed and reused in cities.

At the same time, these trends present an unprecedented opportunity to lead the next wave of innovation in the development of alternative food sources, new food production methods, sustainable supply chains, urban infrastructure optimisation and future-proofing, food security enhancement, and community outreach.

If we get it right, urban agriculture can help Singapore, and other cities achieve these goals. The Arup Explores event has shown how one combination of technology, infrastructure, policy and awareness has the potential to deliver benefits to both Singapore and the ASEAN region while contributing to the fulfillment of the UN Sustainable Development Goals.

What's next?

To move forward and work towards a better urban agricultural system we must consider different types of partners, clients, collaborators and industries; these would include building relationships with farmers, governments, the wider public sphere, academia, small and medium enterprises as well as large corporations. As an industry we should aim to identify and support the implementation of unique and different types of projects and initiatives with high potential.

This Arup Explores event helped identify some key areas of focus and potential success factors that can act as guiding principles in building a secure, inclusive, resilient and sustainable food system through urban agriculture.

KEY AREAS OF FOCUS AND POTENTIAL SUCCESS FACTORS

These key areas of focus, paired with some potential success factors, can act as guiding principles for future endeavours.

Four key areas of focus

POTENTIAL SUCCESS FACTORS

TECHNOLOGY	INFRASTRUCTURE	POLICY	AWARENESS
			NURTURE FARMER MENTALITY AKA 'MAKE FARMING COOL AGAIN': ENABLE SMALL FARMERS TO REACH VOLUME AND MAKE A LIVING IN RURAL AREAS. CONNECT THEM TO THE SUPPLY CHAIN AND EDUCATE YOUNGER GENERATIONS
START SMALL AND EXECUTE WELL WHEN IT COMES TO THE FUTURE OF FOOD, THERE IS NOT ONE SILVER BULLET FOR INFRASTRUCTURE AND TECHNOLOGY		ALIGN POLICY EFFORTS BETWEEN LOCAL, REGIONAL, NATIONAL AND INTERNATIONAL GOVERNING BODIES TO MAXIMISE ADOPTION AND EFFECTIVENESS	
	DON'T GROW EVERYTHING (INFRASTRUCTURE IS NOT CHEAP SO MAINTAIN A BALANCE BETWEEN FOOD THAT IS GROWN LOCALLY AND FOOD THAT IS IMPORTED)		EMBRACE THE CULTURAL CHALLENGE ACROSS DIFFERENT REGIONS
LEVERAGE LATEST TECHNOLOGICAL ADVANCEMENTS (BLOCKCHAIN FOR SUPPLY CHAIN SUSTAINABILITY VIA DIGITAL TRACEABILITY, AGRI-FOOD TECHNOLOGIES TO LEVERAGE UNDERUTILISED CROPS AND REINTRODUCE THEM TO THE FOOD SYSTEM)			HIGHLIGHT THE BENEFITS OF BIOPHILIC DESIGN
		BE CREATIVE WITH PLANNING	TEAM UP WITH CHEFS: THEY CAN INCREASE DEMAND, INFLUENCE CONSUMERS AND CATALYSE 'FARM FOR FLAVOUR'
			UTILISE THE POWER OF GOOD BRANDING

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