

HIGHLIGHTS OF 'GROWING MORE WITH LESS' EXHIBITION

i) **Cultivating a more food resilient future**

New technologies are enabling farmers to intensify production vertically and move farms indoors. Modern high technology farms are growing large volumes of produce all year round with significantly less resources. Find out how Singapore can enhance her food resilience if more of such farms were to sprout up on our island.

Leafy vegetables

Giant vertical outdoor farms

Vertical vegetable farming can be intensified by developing new growth systems comprising more growth layers while ensuring optimal plant growth. Sky Urban, the local company behind Sky Greens, has developed a 9m vertical growth system. Sky Urban plans to scale up to 2,000 towers on 3.65 ha, producing about 3,000 tonnes of leafy vegetables a year.

Highly automated indoor farms

Advancements in artificial intelligence and robotics can significantly reduce manpower for farming. SPREAD, a Japanese company, is developing its next-generation vertical farm, *Techno Farm™* in Kyoto.

Set to operate from 2018, its aim is to develop a system where humans and machines would work together. Robotic arms, conveyor belts and stacker cranes facilitate the vegetable cultivation process – raising the seedling, transplanting, growing and harvesting. Multiple sensors and a cloud based system will also monitor and control environmental parameters remotely. This automation will reduce contamination risks and improve consistency in quality.

SPREAD targets to produce about 1,000 tonnes of lettuce annually on its 3,950 square-metre farm.

Large indoor farm factories

Growing leafy vegetables vertically indoors is possible with new lighting technology, cheaper and more accurate sensors, and the Internet of Things. Modern Controlled Environment Agriculture (CEA) farms enable farmers to control all aspects of the environment to optimise crop growth, independent of weather and pests. All types of crops requiring different conditions can be produced within the same indoor location all year round.

Local farm Sustenir defies farming conventions. Located in an industrial building, it grows temperate produce such as tuscan kale, arugula, cherry tomatoes and strawberries within tightly controlled and customised environments to ensure optimal plant health. Thus, the time taken for plant growth is half that of traditional outdoor farms and vegetables can be grown all year round. With its CEA techniques, very little to no water is wasted; water usage is reduced by approximately 95 percent compared to traditional farming. Furthermore, no harmful pesticides are used as insects are unable to enter the growing room. Hence, products are healthier and there is no pollution to the environment.

Sustenir can also constantly monitor and track plant growth along with material consumptions using a centrally controlled system. The staff are alerted on their smart phones of any disruptions to a product's growth cycle and can resolve them remotely to prevent failures. Sustenir's system allows it to be agile and expand rapidly in indoor urban areas to farm food and enhance food resilience for communities.

Fish

Multi-level fish farms

Fish farms are creatively using space by growing fish indoors and scaling upwards. Apollo Aquaculture Group has piloted a three-tier vertical recirculating aquaculture system with six 135 square-metre tanks growing grouper, coral trout and prawns on 0.1 ha of land. The current farming capacity of Apollo Aquaculture Group's fish farm is around 114 tonnes a year. Apollo Aquaculture Group plans to scale up to 15 eight-tier buildings to grow multiple varieties of fish, and targets to produce 5,000 tonnes of fish annually on 3.5 ha of land.

Productive open sea farms

90 percent of fish production in Singapore is carried out in the sea and mainly in traditional 'kelong' fish farms. Barramundi Asia's open sea fish farm sets itself apart by leveraging technology to improve efficiency and reduce dependency on manual labour.

With its unbroken cold chain, fresh fish are supplied locally and exported to Australia and America. Barramundi plans to expand its operations to 19.5 ha with a target production volume of 6,000 tonnes a year by 2020.

Offshore aquaculture hub

In exploring other strategies to enhance farming efficiency and productivity, fish farmers can leverage expertise from other industries to redesign fish farms and streamline processes.

Keppel Offshore and Marine is exploring the adaptation of offshore technology by transforming oil rigs into modern offshore aquaculture hubs that are automated and remotely controlled. Its Aquaculture Hub concept originates from the semi-submersible – a raised platform connected to a floating ring pontoon by columns.

The Aquaculture Hub will serve as a test bed for developing suitable aquaculture technology for Singapore. It will also support skills acquisition, training and development for the next generation fish farmer. With artificial intelligence advancements, the Aquaculture Hub is envisioned to become autonomous, gently correcting its drift along a plotted course to allow farmed fish to grow naturally.

ii) Farming anywhere and everywhere

With limited land for farming, cities can explore creative ways of integrating farms into different parts of the city. This section explores the various spaces and possible building typologies that can incorporate farming.

Commercial rooftop farming

Commercial rooftop farming in the city has multiple benefits such as fresher produce for consumers, reduced carbon footprint and lower building temperatures. Rooftops are suitable as they are often underutilised and receive a lot of sunlight. Farmers, real estate owners and tenants can partner to farm on the rooftops of commercial buildings.

In Singapore, Edible Garden City has transformed some local commercial building rooftops with edible greenery. Vegetables such as herbs, micro-greens and edible flowers are harvested and supplied to nearby restaurants, hotels and other businesses as part of its “Grow Your Own Food” movement.

Comcrop takes rooftop farming a step further by intensifying vertically. Its farm on the rooftop of *SCAPE in Orchard Road utilises a 12-tier vertical hydroponic system to intensify production. Crops are irrigated by an automatic water pump system. The use of solar panels to power the automatic watering system is also under study.

Pesticide-free crops such as basil, mint, and wasabi greens are harvested and supplied to nearby establishments such as hotels as well as online grocers on the same day. Comcrop plans to set up a second farm on the rooftop of an industrial building in Woodlands.

Farms in underutilised spaces

Farms can be located in previously underutilised spaces. Citizen Farm piloted a modular farm under the West Coast Viaduct for a period of three months in 2017. Its system comprised racks fitted with LED lights in containers cooled by fans. The farm

was powered by a nearby electricity source, with water supplied externally. A variety of vegetables, micro greens and mushrooms produced were supplied to eateries within a one kilometre radius. With this simple system, farms like this can be placed anywhere, from corridors to viaducts and other spaces.

Sustainable fish farms within the urban environment

With Surbana Jurong's "floating ponds" typology, fish farms can be located anywhere within the urban environment. In collaboration with Apollo Aquaculture Group, Surbana Jurong has conceptualised a modular and scalable farm with vertically stacked fish raceways to stretch its production capacity per unit area of space.

The fish farm is also designed to be self-sustainable. It has a closed-loop ecosystem where the exchange and flow of water, nutrients and energy are integrated thus reducing wastage.

Farming on water

Cities can also explore floating farms on water to overcome land constraints. Dutch company, Beladon, is piloting the world's first floating dairy farm in Rotterdam, Netherlands based on its design of a closed-loop modular floating platform. The platform can be scaled by a factor of two to five, and units can be connected and configured to suit specific farming and spatial requirements. The platform can be located on any large water body such as the sea or reservoir. It can be connected to land to transport food produce easily. Currently under construction, the three-storey farm will accommodate 40 cows on the top floor and produce 800 litres of milk daily.

Creating new building typologies

In Linköping, Sweden, Plantagon is constructing a prototype 17-storey mixed-used development that will integrate a greenhouse with an office space named the World Food Building. In the World Food Building, vegetables will be cultivated in a controlled environment and the growing, harvesting and packing process will be automated.

The vegetables are planted in specially designed pods which automatically resize to adapt to the growth of the seedlings. They are also grown in reusable pumice that is cleaner and easier to sterilise than soil. To ensure even distribution of natural light, the vegetables are moved up and down and watered via an automated vertical cultivating track. LED lights are also installed to provide additional lighting when needed.

Plantagon estimates that the World Food Building can produce 500 tonnes of vegetables a year, 10 times more than a traditional flat greenhouse over the same area.

Integrating farms in mixed-use districts

With the emergence of modern architecture that integrate innovative farms systems, cities can take a step further to design dynamic mixed-use agriculture districts to live, work, shop and farm food.

The 100 ha Sunqiao Urban Agriculture District in Shanghai, China, will integrate farms with community, residential, and commercial space. Based on the master plan designed by Sasaki, the district will feature large-scale vertical leafy vegetable farms with a total gross floor area of 70,000 square-metres for production and education. The development of the district is expected to commence in 2018.