

FOOD AND THE CITY: OVERCOMING CHALLENGES FOR FOOD SECURITY

Food and the City: Overcoming Challenges for Food Security chronicles Singapore's journey towards achieving food security through sound policies and governance reforms. Given crucial national needs to develop industries and housing in our post-independence era, the government consolidated agricultural land, approved new food sources and devised a comprehensive food safety system. Today, Singapore imports about 90% of its food and thus is exposed to global food supply volatility and price changes. Therefore, an integrated long-term vision to transform the local agricultural sector to supplement food imports is now in place, presenting opportunities for Singapore to emerge as a front runner in sustainable urban food solutions.

"Unlike larger countries, Singapore is not endowed with ample farmlands to produce food. Over the last six decades, the limited farmlands have decreased drastically and Singapore shifted towards a food import strategy. Today, we are recognised as one of the most food secure countries in the world. Food and The City: Overcoming Challenges for Food Security documents how Singapore continues to ensure safe, affordable and adequate food for our people. It not only describes the various programmes to ensure food resilience but also provides insights into the implementation of the programmes as well as policy considerations through in-depth interviews and archival research.

As one who has been intimately involved in food supply to Singapore in the last five decades, I congratulate the Centre for Liveable Cities for capturing the essence of how Singapore has provided and continues to provide safe, affordable and adequate supply of food to our people. I highly recommend this publication to anyone interested in food production and supply of affordable and safe food."

Dr Ngiam Tong Tau, former Chief Executive Officer,
Agri-food & Veterinary Authority of Singapore

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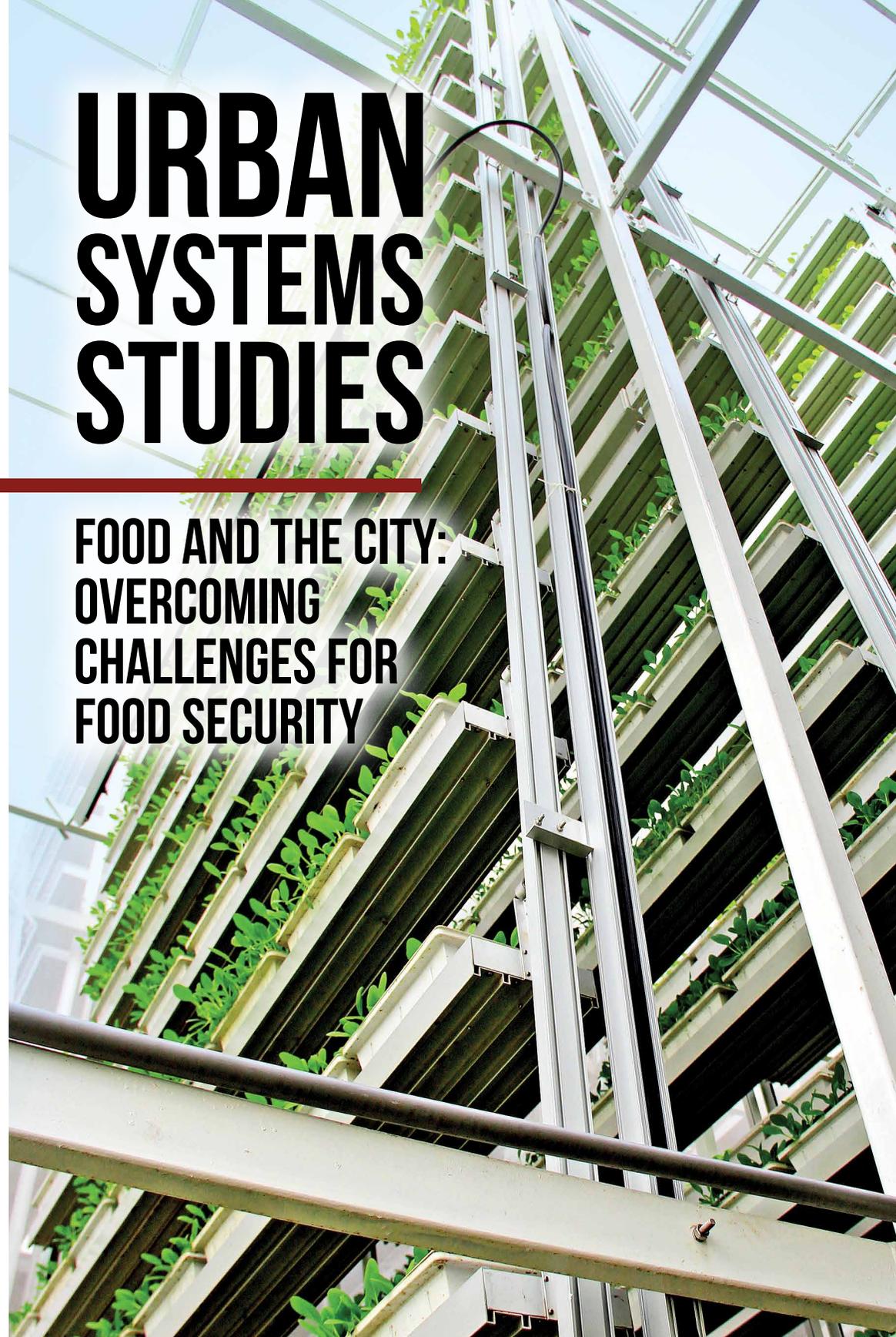
URBAN SYSTEMS STUDIES

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URBAN SYSTEMS STUDIES

FOOD AND THE CITY: OVERCOMING CHALLENGES FOR FOOD SECURITY

CENTRE for
LiveableCities
SINGAPORE

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Set up in 2008 by the Ministry of National Development and the Ministry of the Environment and Water Resources, the Centre for Liveable Cities (CLC) has as its mission “to distil, create and share knowledge on liveable and sustainable cities”. The CLC’s work spans four main areas—Research, Capability Development, Knowledge Platforms, and Advisory. Through these activities, the CLC hopes to provide urban leaders and practitioners with the knowledge and support needed to make our cities better. For more information, please visit www.clc.gov.sg.

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Cover photo:
Similar to skyscrapers, Sky Greens’ patented vertical farming system intensifies land use.
Photo courtesy of Sky Greens.

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FOREWORD

As a small city state, Singapore has always been concerned about food security. Today, we are seen as a food secure country, but this did not happen by chance. Over the years, we actively evolved our strategies and policies to overcome the constraints we face. With limited land, we knew we could not grow all the food that we needed. Thus, we moved away from growing most of our food in the early days, towards relying more on imports. Diversification of our import sources became a key strategy to build up Singapore’s food resilience. In tandem, we developed a robust food safety framework to ensure that our imported food is safe for consumption. To further buttress our food supply against disruptions to our import sources, we developed our local agricultural sector, focusing on the food items we most commonly consume, like fish, vegetables and eggs.

But we did not stay static. Today, we live in an age of disruption. Industries will need to respond to globalisation and the changes being brought about by demography and technology shifts. The agricultural sector is no exception. To guide the long-term future of the sector, we developed the Farm Transformation Map together with the industry. We enhanced schemes like the Agriculture Productivity Fund to spur technology adoption and raise farm productivity. We also launched new farmland on 20-year leases to provide greater certainty to farms and enable them to invest in highly productive technologies.

With a growing and thriving farming sector, Singapore has potential to be a centre for urban food production. We already have high standards for food safety and quality, strong capabilities in R&D, engineering, and biotech, and strong adjacent industries like food manufacturing and urban logistics. We can build on these strengths and use emerging technologies to transform our food industry. We are looking into how to bring the various players together. One possibility is to consider co-locating different players along the food value chain to create synergies and spinoffs. Developing “clusters” of food related activities could be part of re-positioning the food industry as a new growth sector. It would also further enhance our food security. Embracing change and innovation are key to the future of the agriculture sector in Singapore.

Food and the City: Overcoming Challenges for Food Security elaborates on some of our history, which serves as lessons for city leaders and planners—highlighting the ways our government has planned for the long term, while building in enough flexibility with food policies. As needs change over time, strategies will have to evolve ahead of the times to ensure that Singapore is well-placed for the future.

Sun Xueling
Senior Parliamentary Secretary
Ministry of Home Affairs
Ministry of National Development

PREFACE

The Centre for Liveable Cities' (CLC) research in urban systems tries to unpack the systematic components that make up the city of Singapore, capturing knowledge not only within each of these systems, but also the threads that link these systems and how they make sense as a whole. The studies are scoped to venture deep into the key domain areas the CLC has identified under the CLC Liveability Framework, attempting to answer two key questions: how Singapore has transformed itself into a highly liveable city within the last five decades, and how Singapore can build on our urban development experience to create knowledge and urban solutions for current and future challenges relevant to Singapore and other cities, through applied research. Food and The City: Overcoming Challenges For Food Security is the latest publication from the Urban Systems Studies (USS) series.

The research process involves close and rigorous engagement of the CLC with our stakeholder agencies and oral history interviews with Singapore's urban pioneers and leaders to gain insights into development processes and distil tacit knowledge gleaned from planning and implementation, as well as governance of Singapore. As a body of knowledge, the Urban System Studies, which cover aspects such as water, transport, housing, industrial infrastructure and sustainable environment, reveal not only the visible outcomes of Singapore's development, but the complex support structures of our urban achievements.

The CLC would like to thank the Agri-Food and Veterinary Authority of Singapore and all those who have contributed their knowledge, expertise and time to make this publication possible. I wish you an enjoyable read.

Khoo Teng Chye
Executive Director
Centre for Liveable Cities

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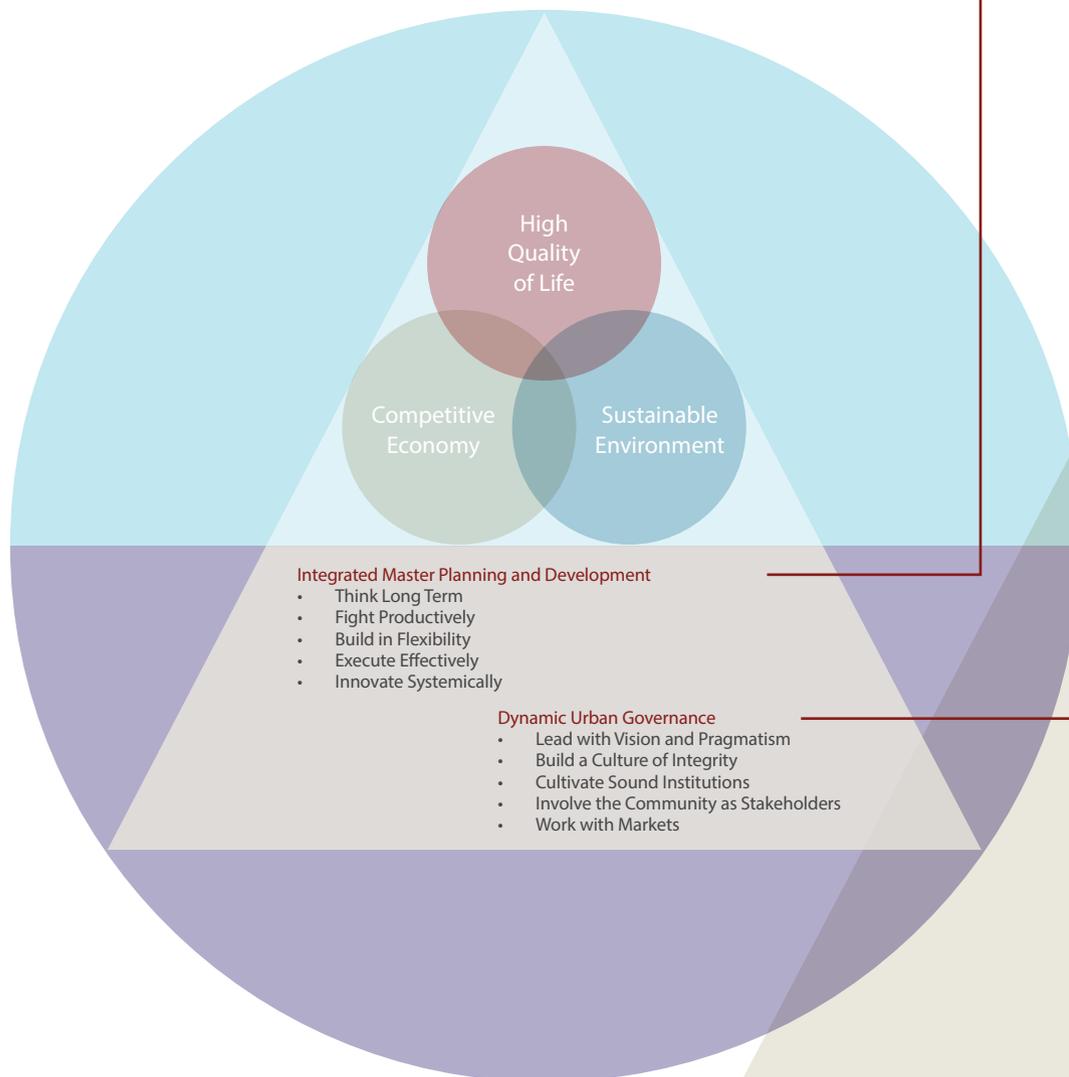
The writers, Elyssa Ludher and Thinesh Kumar S/O Paramasilvam, would like to extend their sincere gratitude to Dr Ngiam Tong Tau and Tan Poh Hong for all their research guidance and support with the production of this Urban Systems Study. The writers also wish to thank their clustermates and colleagues from the Centre, many of whom have provided inputs, sound advice and the support needed to complete this publication. The writers also wish to thank Mr Koh Swee Lai, Chairman of Seng Choon Farm, for sharing his experience and enriching the contents of this publications with his insights. The writers wish to extend special thanks to Sophianne Araib and Lim Wei Da for providing inputs on the earlier drafts of the manuscript. Finally, this publication would not have been possible without the help of Alex Ho, Beverly Fok, Choo Min, Gladys Ng, Kee Jing Yee and Victoria Ong, all of whom have provided research assistance.

As matters of food security and resilience become key concerns globally, the writers hope this publication would serve as their humble contribution towards existing discussions on food futures. They hope it will provide all readers with some food for thought on the way forward to enhance food resiliency.

THE SINGAPORE LIVEABILITY FRAMEWORK

The Singapore Liveability Framework is derived from Singapore's urban development experience and is a useful guide for developing sustainable and liveable cities.

The general principles under **Integrated Master Planning and Development** and **Dynamic Urban Governance** are reflected in the themes found in Food and The City: Overcoming Challenges For Food Security.



Integrated Master Planning and Development

Fight Productively

The scarcity of land and natural resources necessitated the need for efficient planning and use of land resources. Often, this results in various agencies competing for land use, thus resulting in trade-offs. For example, the Singapore government was split on the decision to continue pig farming in Singapore. Although these farms formed an important local source for pork meat, the farms were highly polluting and affected scarce water resources. The decision was eventually made to relocate the pig farms away from the water catchments, thereby ending the "Water and Food Conundrum".

(see "Water First, Before Pigs": The Water and Food Conundrum" p. 29)

Build in Flexibility

By the mid-2000s, the Agri-Food & Veterinary Authority of Singapore (AVA) recognised that more could be done to diversify Singapore's key food items. Existing bans on food imports from certain countries, and the lack of accreditation of new sources limited Singapore's sources of food. This was of concern to authorities since it could potentially lead to a food disaster. Hence, diversification of food imports was devised as one of AVA's core strategies for food security. This allows to build some flexibility into the system, by enabling Singapore to quickly tap on other food sources when key sources are affected or prices spike.

(See "Diversification of Overseas Food Imports" p. 65)

Dynamic Urban Governance

Involve the Community as Stakeholders

Overcoming food security challenges would also include the involvement of the community as stakeholders. From the early days, the Primary Production Department (PPD) and the AVA have involved the community through multiple outreach efforts. For example, in the early days, authorities reached out to consumers via public campaigns to encourage the consumption of frozen meat, which included proper handling techniques to ensure safety of frozen meat. More recently, authorities are seen encouraging households to better manage their food waste. Such efforts ensure a more holistic approach towards ensuring Singapore's food resilience.

(see "Reducing Food Waste" p. 86)

Work with Markets

The private sector plays an important role in ensuring Singapore's food security. Hence, the government works closely with the private sector to ensure that food sources are accredited to meet Singapore's food safety requirements, and to encourage local production. For example, the AVA's Agriculture Productivity Fund helps local farms to invest in farming technology to maximise output and productivity. Such measures ensure the continued close relations between the AVA and local farmers.

(see "Local Food Production" p. 73)

OVERVIEW

SINGAPORE: A FOOD PARADISE

“ We must not rest on our laurels and take for granted the access to affordable and nutritious food that we have now. Singapore is part of a global community and is therefore susceptible to many of the global food security challenges.”

Tan Poh Hong, former Chief Executive Officer, Agri-food and Veterinary Authority of Singapore¹

The need to ensure access to affordable and safe food has emerged as a key policy agenda for many nations, as climatic, socio-economic, demographic and political conditions shift over time. Singapore, too, is no different, and it has recognised the importance of strengthening its food security. A liveable city must be, after all, also a food-secure city.

A city-state of only 719 square kilometres, much of the agricultural land, which once comprised over 25% of the total land area, is now used for housing, industry, infrastructure, services and other important needs. Despite this shift, Singapore has managed to maintain high levels of food security. The Global Food Security Index formulated by the Economist Intelligence Unit ranks Singapore as the 4th most food secure country in 2017.² This is a testament to the efficacy of the sound policies, tools and governance structures that have securitised food resources, over the years.

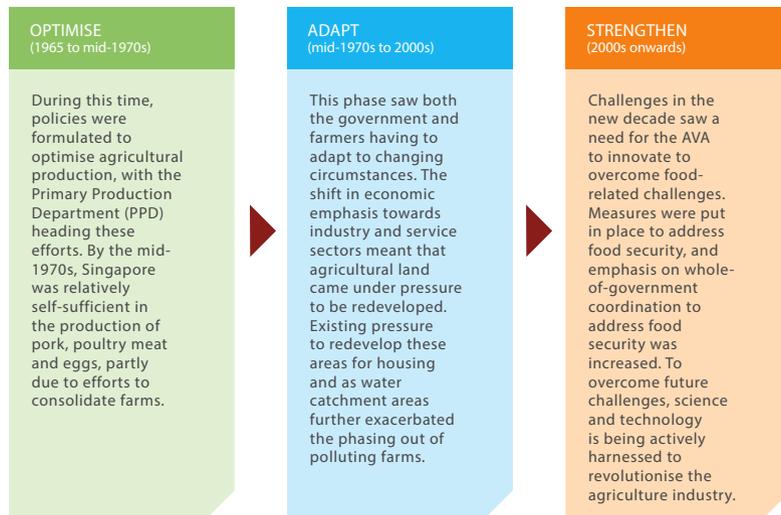
In Singapore, food security can be broadly defined as “access to safe and nutritious food, for all Singapore citizens and residents, at affordable prices, in the short and long run,”³ and it encompasses four key elements.

Exhibit 1:
The Key Elements of Singapore’s Food Security



This Urban Systems Study describes Singapore’s experience with overcoming various constraints, including scarcity of land and competing economic needs, and the consequent trade-offs made to continue to deliver a safe, affordable and uninterrupted supply of food. This was achieved through well thought-out policies and effective governance, which ensured that Singapore became the food paradise that it is today.

Exhibit 2:
Evolution of Singapore’s Agricultural Landscape



The publication will outline the evolution of agriculture and food security policies in Singapore, illustrating the challenges that the government and stakeholders, such as farmers and consumers, faced in the early days. Contributing to existing literature, this publication provides some food for thought on existing discussions, and thereby presents potential food futures for Singapore.

FEEDING SINGAPORE THROUGH THE YEARS

In the early years of Singapore’s development, agriculture was an important sector, providing both livelihood and food to the people. In 1970, 9% of the total population (about 175,400 people) were actively engaged in agricultural activities or were indirectly dependent on farming and fishing for a living.⁴ To improve socio-economic conditions in the rural farming areas, in 1959, the Primary Production Department (PPD), under the Ministry of National Development (MND), was established. The department, though resource-strapped, pioneered numerous actions to optimise the efficiency of the farming sector. Land policies were reviewed to increase productivity, and partnerships were established to facilitate learning. These measures were successful and by the 1980s, the local farming sector managed to achieve self-sufficiency in hen eggs, poultry meat and pork, through local production.



In the early days, the agriculture sector in Singapore was dominated by traditional, family run, land-based farming. Nevertheless, it was an important sector, contributing towards food security and livelihoods. Photo courtesy of the Primary Production Department Collection, National Archives of Singapore.

Singapore's population, which has nearly tripled from under 2 million in the 1960s to more than 5 million today, has required the intensification of all land use, including farmland. Of the 15,000 hectares of farmland that was available in the 1960s, less than 600 hectares remain today.⁵ Land available for farming has been given up to meet other needs, such as housing, industry, roads and other infrastructure requirements. This led to a need for policy changes to address emerging needs, including the resettlement or phasing out of farms, productivity investments, import facilitation and food safety management. During this period, farmland was consolidated into agrotechnology parks.



Aquaculture farms developed from the late 1980s onwards ensured that Singapore had a continuous local supply of fish.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

These developments also required governance changes—the PPD was restructured into a statutory board, the Agri-food and Veterinary Authority of Singapore (AVA) in 2000. The AVA had greater autonomy and flexibility and thus, was better equipped to overcome future challenges facing Singapore's food and agriculture industries. Other agencies, such as the Ministry of Environment, Ministry of Trade and Industry (MTI), International Enterprise Singapore (IE Singapore), SPRING Singapore (SPRING), the Economic Development Board (EDB), the National Environment Agency (NEA) and the Singapore Land Authority (SLA) have played various roles during this transition.

Moving forward, innovative policies and actions are still needed to address the many challenges that emerge from Singapore's unique circumstances. To this end, the AVA is constantly exploring means to further strengthen Singapore's food security. The 2008 food crisis highlighted Singapore's vulnerability in being import-dependent. Shortages led to a 7.8% increase in prices of imported food between December 2007 and December 2008.⁶ The AVA made concentrated efforts to strengthen the nation's food resilience by strategically diversifying food sources, and supporting investments to enhance local productivity. Coming full circle, more recent efforts have placed emphasis on improving local production through the use of agriculture technology, with concurrent efforts to diversify food sources.



Vertical farming of leafy vegetables at the Sky Greens farm. To overcome land constraints, farming technologies have evolved to allow more intensive production in smaller land plots.

Photo courtesy of Sky Greens.



Indoor farming is increasingly commercialised with recent developments in agri-technologies.

Photo courtesy of Panasonic Factory Solutions Asia Pacific.

This Urban System Study outlines Singapore's ongoing efforts to overcome challenges and achieve food security, with the government working with relevant stakeholders to optimise, adapt and strengthen their approach, as circumstances evolve. The need to reorient urban space—making it work more efficiently while contributing towards achieving food security—remains paramount. Embracing change and innovation are key to the future of the agriculture sector⁷ in Singapore, while local production provides buffers in the face of food supply disruptions and remains key to Singapore's food resilience. Together, these factors contribute to Singapore's vision to become a food paradise.

OPTIMISE: SELF-SUFFICIENCY FOR A NEWLY- INDEPENDENT NATION

“ In the 1960s,⁸ the rural areas were very hostile and neglected under the British Colony Administration. Then, farming was primitive. Whatever [the farmers] did, once a disease came along, it wiped out everything. Farmers were very scared of going large-scale.”

Dr Cheng Tong Fatt, former Director, Primary Production Department⁹

THE EARLY YEARS: INCREASING PRODUCTIVITY OF LOCAL FARMS

In the years prior to independence, Singapore's farm produce was insufficient to meet local demand, and food needs were met by imports from neighbouring countries. Local production was hampered by disease and poor market connections. To address this economically-and politically-important sector, in June 1959, the newly self-governing state of Singapore established the Primary Production Department (PPD), under the Ministry of National Development (MND), by combining the Agriculture, Co-operative Development, Fisheries, and Rural Development and Veterinary divisions that had been operating under various agencies of the British colonial government. The PPD's priority was to assess the state of primary production, identify the needs of farmers and rural communities and build extension services to address those needs.¹⁰ In short, it was to provide for the socio-economic development of rural communities.

One of the PPD's first steps was to develop a range of programmes to address farming productivity. By 1970, 10 Agricultural and Veterinary Extension Centres¹¹ were set up in Jurong, Tuas, Sembawang, Bukit Panjang, Lim Chu Kang, Changi, Tampines, Thomson, Yio Chu Kang and Punggol.¹² With these, farmers no longer had to travel the long distances to government offices in the city to get advice, information or veterinary care. The veterinary offices were simple set-ups—they were equipped with a desk and a telephone and often employed only a single veterinary assistant, assisted by unskilled primary production workers. When the need arose, the few available qualified veterinarians and agriculturists would be called in to treat sick animals, control insect pests and to give advice on feed formulation.¹³



A PPD extension officer building capacity in farmers in relevant technical and scientific advancements in farming. The PPD's earlier initiatives were aimed at improving farming productivity.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Poultry and pig vaccination and breeding programmes were established. Horticulture programmes were set up to optimise vegetable and fruit yield. The PPD also produced bulletins, pamphlets and rural broadcasts in English and Chinese¹⁴ to provide useful technical information for farmers. A farm school was set up at the Sembawang Station to train youth in animal husbandry, horticulture/vegetable gardening and freshwater fisheries. The PPD also produced 57 sound films on farming and fishing, as well as more than 10,000 photos.¹⁵ These augmented the rural talks and study tours offered by extension officers.



Yak Seng pig farm at Punggol Farmway. Vaccination and breeding programmes were established to help poultry and pig farms to reduce disease and mortality, thereby increasing production.

Photo courtesy of National Archives of Singapore.



PPD's extension services were in horticulture and veterinary science to improve productivity.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

A Fisheries Department coordinated usage of the fishing grounds and oversaw the industry's growth. Local fishermen fished in the South China Sea and Indian Ocean. In the mid-1960s, about 60% of fisherfolk engaged in inshore fishing, using wooden offshore platforms called 'kelongs,' fixed traps, drift nets, push nets, lines and beach seines. Such inshore areas were limited in size due to fishing ground restrictions, water pollution from industrial waste and increasing land reclamation projects.¹⁶ Offshore fishing was less prevalent, but accounted for 80% of the catch. Carp and Tilapia were also reared in freshwater ponds. Fish were auctioned in two Ministry of Health-owned (Markets and Hawkers Department) and three privately owned wholesale markets across the island, with the main market being the Jurong Fishing Port and Market. A Fishing Training Institute was established with the assistance of the United Nations Development Programme in 1968, to retrain fishermen (local and regional) to switch from inshore to offshore fishing and train the next generation of fishermen.¹⁷ In 1969, the Marine Fisheries Research Department of the Southeast Asian Fisheries Development Centre was set up at Changi Point; Japan assisted in its establishment by donating a 390-ton vessel. The purpose of the Department was to undertake regional partnership projects with Burma, Cambodia, Indonesia, Japan, Malaysia, the Philippines, Thailand and Vietnam, on oceanography, fishery resources and new fishing grounds.



The Fisheries Department was set up in the late 1960s to oversee the growth of the sector.

Photo courtesy of Primary Production Department Collection, National Archives of Singapore.

DEVELOPING LOCAL EXPERTISE TO ADDRESS URGENT NEEDS

At the time of Singapore's independence, few qualified experts were available in the fields of veterinary science, horticulture, disease control or food science. To build up local capacity, committed young people were provided scholarships, through the Commonwealth and Colombo Plan scholarships.

Beyond this, on-the-job training was also necessary. The PPD reached out to the United Nations Development Programme (UNDP) to build up its primary sector. UNDP agriculture experts from various parts of the world came to Singapore, where they were linked up with local qualified staff, not only to ensure comprehensive knowledge transfer, but also to contextualise solutions to local needs. Dr Ngiam Tong Tau, the Director of the PPD in the 1980s and 1990s, was then a junior staff member. He was paired with a UNDP veterinarian, Dr Mita Ercegen. He recalls Dr Cheng Tong Fatt describing it as being a time of "the blind leading the blind"¹⁸—neither Dr Ngiam nor Dr Ercegen were familiar with the local disease context as yet.

Dr Ngiam and Dr Ercegen worked together at the Pig and Poultry Research and Training Institute (PPRTI) and the Central Veterinary Laboratory at Kampong Java to develop strategies for management and disease control in pig farming. Together with their colleagues, Dr Ng Fook Kheong, and Dr Illeri from the UNDP, they successfully created vaccines for local strains of Swine Fever and Newcastle Disease, both of which can cause 90% mortality rates for pigs and poultry respectively. The vaccines were successfully adopted throughout the region, and swine and poultry production expanded, not only in Singapore, but in neighbouring countries as well. The teams also developed nutritional feed formulas for pig and poultry (Chou Khai Chih and Z. N. Muller), methods of livestock waste management (Dr Lee Boon Yang, Dr Ngiam Tong Tau and Dr Paul Taiganides), and redesigned poultry farms to maximise productivity and reduce disease (Dr Chew Poo Chin and Abraham Weingarten). The PPD also collaborated with Japanese, Thai, Malaysian and Indonesian authorities to improve fish, livestock and vegetable production, and safe food management.

FOSTERING COMMUNITY AND SECTOR PROSPERITY APACE

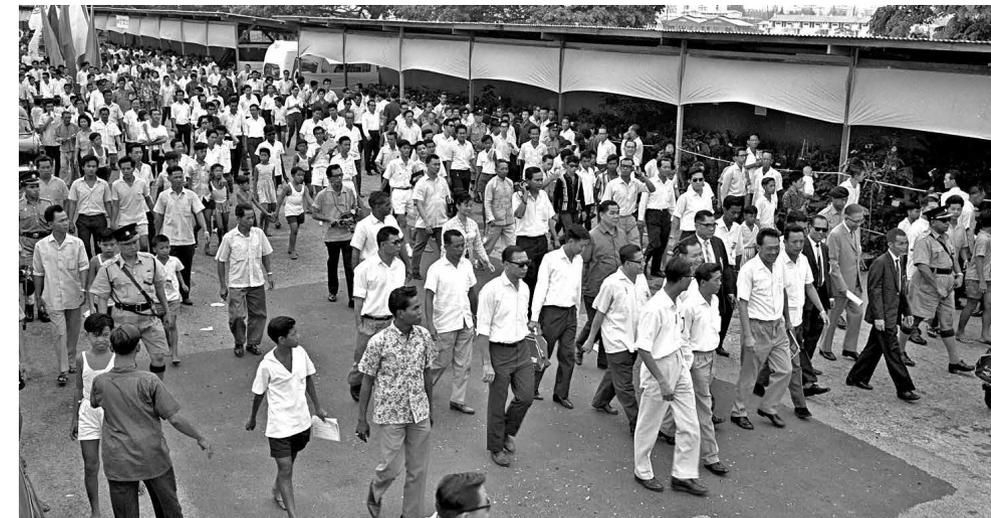
Rural communities' socio-economic needs were not overlooked. The PPD facilitated and oversaw the establishment of cooperatives and societies that provided vital grassroots services, including loans, employee credit, input purchase, marketing and other



PPD's few vehicles would navigate unpaved roads to deliver the heavy loads, including fertiliser, pesticides, feed and the like, to experiment and assist in farming productivity.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Singapore Feedmillers Association. 250,000 people, local and foreign, attended the week-long show at Kallang Park (Old Kallang Airport). The show highlighted Singapore farmers' capacity to produce a variety of vegetables, fruit, livestock, eggs and others. Farmers and traders took part in competitions under numerous categories, delineated by food type. The show was indisputably a success, making a profit of S\$40,000—a considerable sum at that time—from ticket sales.^{20,21}



Then-Prime Minister Lee Kuan Yew arriving at the inaugural Agricultural Show at Kallang.

Photos courtesy of Ministry of Information and the Arts Collection, National Archives of Singapore.

assistance.

Aided by these efforts, by the mid-1960s, Singapore was self-sufficient in eggs, pork and poultry production,¹⁹ even as the population steadily grew. This success led Singapore to organise its first ever Agriculture Show in 1965, in a joint effort by the PPD, Singapore Livestock Association and the

Following this, in 1968, farm licencing was introduced. The cost of a licence was only a dollar, to ensure it was within the means of all farmers.²² Squatter farmers on State lands were formalised through the issuance of Temporary Occupancy Licenses (TOLs), providing some security for them to continue to farm.



Conducting the first ever Agricultural Census required walking through the grounds to establish real data. It was only after then that PPD had a full picture of the extent of farming in Singapore.

Photos Courtesy of Agri-Food and Veterinary Authority of Singapore.

In the early 1970s, the MND's Primary Production Department's Research and Statistics Unit (RSU) and the National Statistical Commission, in collaboration with various agencies, developed a census of Singapore's agriculture sector. Two hundred officers and surveyors, with the help of students serving as census enumerators, carried out this monumental task. Loy Wei Sun, who led the census team, comments:²³

It was a very exciting exercise. It was only after conducting the census that we knew better the distribution of farms in Singapore, the demography of the farming households and the extent of the various existing farming activities. To enable us to conduct the census, we had to first carry out field survey to identify the exact location of all existing farms and mark them on topographical maps to facilitate subsequent visits during census taking. At the same time, we had to determine the types of information required for better understanding of the farming sector and are useful for policy formulation. The information that we planned to collect included, among others, demographics of the farming households, details of farming activities and land area used for different farming activities. We also formulated nearly 180 predetermined tabulations for the census.

The agriculture census established baseline data on farm occupants, which was much needed to further formalise the sector.

WINNING HEARTS AND MINDS: POLITICS, FARMING AND RURAL DEVELOPMENT

In the early years of self-governance, the rural farming communities were political battlegrounds. Communist influence was strong, and the Barisan Socialis (National Front) was also popular. However, the People's Action Party (PAP) governed by a slim majority.

Reeling from the dismantling of the City Council and Rural Board in 1959, the civil service was unsteady. Politics complicated matters further, as Dr Cheng Tong Fatt, the then Assistant Director of the PPD, explains:²⁴

During that time, the political activity was quite high. Ong Eng Guan,²⁵ then-Minister for National Development (1959-1960), brought in a big team of rural organisers. These rural organisers were actually Barisan people. Some of the rural organisers would put on a white coat with a stethoscope and go around as if they were part of the department (PPD) advising farmers, on things which they themselves don't know about. But the main plan was to make friends, write letters or complaints for the farmers, to gain political influence.

The PPD's free extension services—breeding services, vaccination, disease management advice, etc.—resonated well with the rural community. This contributed towards the improvement of the farming landscape and towards building confidence of PPD amongst the farming community.

The political dividends grew further when Malaysia, in competition with Singapore's agricultural success, imposed taxes on eggs, pork and poultry imported from Singapore.²⁶ Singapore responded by banning fish and vegetables from Malaysia, and Malaysian fish and vegetable traders dumped their produce into the Johor Straits at the Causeway as they were highly perishable. Dr Cheng recalls the importance of this move, as farming communities were made aware of the importance of the farming sector in newly independent Singapore.²⁷ The PPD had to work closely with the rural farming communities in the early days to win their hearts and minds while navigating political battlegrounds as it aimed to improve conditions in the farming landscape.²⁸

BUILD A PORT, GAIN A FLEET!

Like all government agencies in the 1960s, the PPD was asked to build up industries, which generated employment. One such sector was the fisheries industry. At that time, fish was trucked daily from Kelantan and Terengganu in Malaysia, to Singapore, in part due to the dearth of infrastructural facilities onshore.^{29,30} Dr Cheng Tong Fatt, then Director of the PPD and later the Permanent Secretary of the Ministry of National Development, believed that building a fishing port in Jurong would not only facilitate fish imports from diversified sources, but it would also create new jobs.³¹

JY Pillay, the Deputy Secretary of the Economic Planning Unit in the Ministry of Finance, supported the effort. The decision to build the fishing port, however, was met with some resistance. Fishing merchants, who financed the fishermen's nets and motors in return for their catches, vehemently opposed the new port, citing higher prices from imports. The local MPs, influenced by the merchants, raised concerns about the impact of the proposed fishing port on the livelihood of merchants. Dr Cheng and JY Pillay were summoned by Dr Goh Keng Swee to justify his plans for building the Jurong Fishing Port.



Jurong Fishing port continues to function as a key marketplace until today.
Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Later, [I was] called up by Dr Goh [and given] a dressing down! 'No political sense!' [he said.]

I reported back to Eddie Barker, who was [my] Minister: 'Looks like we have to abandon the project.' Eddie Barker said, 'No, go ahead!' He supported me and we went ahead, and we completed [building] the fishing port.

Cheng Tong Fatt³²

The Jurong Fishing Port³³ opened in 1969 and was a success. Besides the well-equipped jetty, it also featured a central fish market, ice plants and other supporting facilities.³⁴ Overnight, Singapore "gained" a fishing fleet. Foreign boats began to use the port. Many vessels, including Russian trawlers, would stop by Singapore on the way to fishing off Australia. The Fishing Merchants' proclamations of higher prices was proven unfounded; in fact, the price of fish went down.

Dr Goh...he realised that it was a good move, so he asked me, 'Hey, how did you do it?' I said, 'Competition! as the fishing port provided facilities to diversify sources of fish, which lowered fish prices.'

Cheng Tong Fatt³⁵

DEVELOPING SYSTEMIC RESILIENCE AND AFFORDABILITY OF FOOD

Poor harvests in 1972 and 1973 due to regional monsoon variations,³⁶ coinciding with the 1973 oil crisis, led to concerns over Singapore's rice access and affordability. In the words of Ambassador Chandra Das, then head of the Export Promotion Centre at Intraco:³⁷

This started when there was a shortage. The rice merchants went to the Finance Minister one day, and told him 'Sorry, we cannot import rice as there isn't any for sale—there is a worldwide shortage of rice. We only have two weeks' supply.'

Eventually, the government addressed the issue of rice shortage and looked into systemic changes to address food shortages and affordability. This episode, along with others, triggered a focus on food resilience and affordability issues.

NOT ALL RICE IS EQUAL

At the time of the rice shortage, rice was (and still is) mainly imported from Thailand, due to Singaporeans' preference for Thai rice. The urgency of the situation resulted in then-foreign Minister, S. Rajaratnam, flying to Bangkok to negotiate for 10,000 tonnes of rice on a G2G (government to government) basis. However, the government was concerned that this was insufficient - it was not clear how long the rice shortage would last. Intraco, the government bulk buying entity, was requested to source rice from other countries.

I went with a group of colleagues to Pakistan. We bought 40,000 tonnes of rice. However, Singaporeans don't eat Pakistani rice. Rice is sold by grades, 100%, 5% broken, 10% broken. Pakistani rice was about 25% broken, not the best grade. Good for making chok (rice congee), but not good for eating steamed.

Ambassador Chandra Das³⁸

A few days after the Thailand trip, the 10,000 tonnes of Thai rice arrived, and the pressure subsided. By the time the Pakistani consignment of rice arrived, however, prices had normalised. So as not to waste the rice, it was sent to the prisons; unfortunately, even the prisoners rejected the rice.

I asked an Ah Mah (matron), 'Why are you buying expensive rice, when you can buy 10% broken? It's much cheaper.' Her answer was very important. For her, rice is the most important thing. She will forgo a vegetable or meat but she will not forgo good quality rice.

Ambassador Chandra Das³⁹

This experience was repeated when Singapore took the precautionary measure of banning infant formula from certain countries in Europe, after the 1986 Chernobyl disaster spread a cloud of radioactivity across the continent. Traders switched to infant formula from Australia. The PPD, however, was not prepared for the deluge of complaints from mothers, whose infants were unwilling to switch infant formulas due to their developed taste for European milk formulas. Thus, the PPD learnt, some items were more taste-sensitive than others.



Stages of rice milling.
Photo courtesy of homebodyhubby,
<https://flic.kr/p/3mJzTZ>

At around the same time, the Committee for Profiteering from Inflation, chaired by the Ministry of Trade and Industry, was formed. The committee was set up to address predatory business practices. The PPD participated in the committee and later set up a system to monitor feed and grain prices.

Rice supply resilience was addressed through stockpiling. The Ministry of Trade and Industry introduced rice importer licensing, under the Price Control Act.⁴⁰ A condition of the licence was that all traders were required to stockpile 2 months' supply of rice⁴¹, at designated government warehouses.⁴² The rice was initially stored in a government warehouse—the Singapore Storage Warehouse—but later, larger importers like FairPrice were allowed to stockpile rice in their own warehouses.

A second instrument introduced to address continued access and affordability of food items was the establishment of FairPrice by the National Trade Union Congress (NTUC). NTUC had already successfully established two businesses: Income—an insurance company and Comfort—a taxi company. The first two NTUC businesses were formed in the early 1970s; NTUC FairPrice was set up in 1973.

Ambassador Chandra Das, who was then a Member of the NTUC FairPrice Board, detailed the objectives of FairPrice as being to benchmark prices, to ensure quality of goods was maintained and to avoid profiteering, which would artificially inflate prices.⁴³

FairPrice has a social objective...my motto was simple: to stretch the dollar earned by the worker as much as I can. So, that means the prices must be competitive...especially for essentials. If somebody tells me the price of rice is higher in FairPrice than in another major supermarket, then I would be worried, because then FairPrice is not fulfilling its objective of being the benchmark.

SOFT INFRASTRUCTURE TO ENSURE A ROBUST SYSTEM

Singapore's capability development in farming started early. A Farm School was established in 1965⁴⁴ at the Sembawang Field Experimental Station to provide formal training in animal husbandry, horticulture, and freshwater fisheries to youth. The school offered a one-year residential course, with practical attachment to various sections of the Station, private farms and nurseries, for on-the-job training. Graduates successfully introduced these new technologies and practices into local farms, thereby improving overall productivity.



Parliamentary Secretary Ho Cheng Choon at the opening of the Sembawang Farm School.

Photo courtesy of Primary Production Department Collection, National Archives of Singapore.

Apart from education, advancement came through technology transfer. The Pig and Poultry Research and Training Institute (PPRTI), established in 1970, contributed to enhancing scientific capabilities in livestock management, disease management, vaccine production, horticulture, value addition and quality control. With the assistance of the UNDP, a Meat Technology Unit⁴⁵ was set up within the PPRTI, to train technical staff to analyse meat and meat products in accordance with international procedures. The PPD's research findings in horticulture, animal husbandry, veterinary science and related subjects were published in the Singapore Journal of Primary Industries, which was publicly available from 1973. The Meat Technology Unit/Laboratory also used new technologies to develop value-added meat products, such as sausages, bacon, hamburgers and others. Though initially not very popular with the consumers, processed meat gained acceptance over time, particularly after the opening of McDonald's in 1979.

In 1969, the Marine Fisheries Research Department of the Southeast Asian Fisheries Development Centre was set up at Changi Point. It undertook investigations into oceanography, fisheries resources and the search for new fishing grounds. In 1971, a joint Singapore–UNDP project was set up to provide theoretical and practical training in marine engineering and navigation/fishing gear technology to trainees from all over the region. Unfortunately, this effort was less successful, as many of the graduates went on to join merchant navies, which offered better pay as compared to the fishing industry. However, the Centre was successful in training local manufacturers on creating value-added fish products, such as fish balls and fish jelly, by bringing in experts from Japan.

In 1974, an Economics Unit was set up in the PPD, to build market intelligence on production, prices and marketing of certain foodstuffs and feedstuffs in both the local and global markets.⁴⁶ The PPD paid particular attention to pig farming, as it was increasingly capital intensive and the land available for agriculture was declining. The quality standards were high. Singapore achieved a milestone that year when it was able to meet the very high Japanese health authority requirements for meat exported to Japan.⁴⁷ This was a direct result of the stringent regulations introduced by the PPD on meat processing premises. These measures, and more, combined to ensure that Singapore's food systems became more robust.



The PPD researched for food species that could be localised. For example, the PPD introduced the Chinese cabbage successfully to local farmers.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

By the mid-1970s—less than two decades since the push for socio-economic development in the rural areas—the productivity programmes were bearing fruit, and Singapore's farm productivity was amongst the highest in the region. Singapore established itself as a key player in the region in establishing agricultural protocols, capacity and safety standards for livestock development. The quality of life and environment, and socio-economic standards for rural and city residents were gradually improving. Regionally, experts looked to Singapore for productivity know-how. By the late 1970s, however, Singapore's economic restructuring and transformation placed pressures on land, and required Singapore's food policies to adapt to the prospect of a decline in local food production.

ADAPT: SHIFTING CIRCUMSTANCES

“ The primary goal of our agriculture policy is to ensure a stable and adequate supply of safe, wholesome and good-quality meat, fish and vegetables. Our strategies are threefold. First, maximise productivity of our limited farmland. Second, diversify sources of supply to complement what we can produce locally. Third, constantly maintain a high standard of food hygiene and safety.”

Lee Boon Yang, former Minister of State for National Development⁴⁸

CANNOT MAKE AN OMELETTE WITHOUT BREAKING EGGS

With the development of larger commercial farms and the adoption of more intensive methods of production, agricultural production soared in the 1970s. In 1970, 9% of the population, some 175,400 people,⁴⁹ were engaged in agricultural activities or were indirectly dependent on farming and fishing for their livelihoods. By 1974, 50% of Singapore's vegetables and 30% of fish was sourced locally.⁵⁰ By 1977, intensive farming had ensured self-sufficiency in fresh pigs and poultry, which formed a major component of local diets,⁵¹ and the production of pork, chicken, and hen eggs had reached 104%, 80% and 100% respectively.



By the late 1970s, Singapore was about 50% self-sufficient in the production of leafy vegetables and was 100% self-sufficient in the production of pork.

Photos courtesy of Agri-Food and Veterinary Authority of Singapore.

However, the number of farmers and fisherfolk was in decline. The 1970s and 1980s saw a consolidation of farms. The government's economic development efforts meant more non-farm jobs were available; its long-term planning efforts also reorganised scarce land for housing, schools, roads, infrastructure and other purposes to achieve high quality of life, a sustainable environment and a competitive economy for its residents. Rural lands, particularly those closer to the central core, slowly gave way to new public housing estates and vital infrastructure.

By the late 1970s, industrialisation, urbanisation and the development of water catchment areas competed for the limited land available. In those days, farm waste flowed directly to the rivers, including the Kranji Reservoir, which became heavily polluted by pig waste. Singapore could import food from diverse sources, but it was not economical to import water from anywhere other than its current source, Malaysia. As the need for clean waterways to ensure water security superseded the need for farms that contributed to food security, it was decided that the farms should be relocated and, subsequently, phased out to prevent the pollution of pristine water catchments. Eventually, these vacant lands were developed into housing estates.

Moreover, there was an active push to consolidate smaller farms into large-scale commercial farms. For example, parts of Punggol and Jalan Kayu were redeveloped into three intensive pig farming estates. Between 1969 and 1979, farmlands shrunk by 40% and the farm population dropped from 175,500 to 109,600. However, the value of agricultural production more than doubled, from \$249 million to \$561 million.⁵²

In 1980, the Ministry of National Development adopted an agriculture policy where farmland was required to reach fully commercial footing.⁵³ Farmland rental was placed at 2% to 6% of the market value of land.⁵⁴ Farms were also required to meet production targets, to maintain their leases. Subsistence farmers gave way to larger farms, which used more intensive methods of farming. To maximise land productivity, the PPD began developing farmlands into agrotechnology parks, with the introduction of automation, mechanisation of traditional farming systems and the concurrent development of high-technology modern farms.⁵⁵

Agricultural land reduced from about 14,000 hectares in the 1960s to about 8400 hectares in the 1970s and, finally, to about 1,500 hectares by 1980s.⁵⁶ Between 1975 to 1984, approximately 8,000 farms were phased out, leaving around 7,900 farms.⁵⁷ Up till the 80s, the agriculture sector was focused predominately on food production. This changed with the development of agrotechnology parks, where a majority of farms were non-food farms. The value of production, which had steadily increased in the 1970s and 1980s—contributing up to \$605 million to the Singapore economy in 1980—eventually declined as well, halving to \$312 million by 1989.^{58,59}

NOT JUST AN INCOME SOURCE: FARMING AS IDENTITY

To the multi-generational Singaporean farmer, farming was more than an occupation, it was linked to the “natural process of life” and was seen as a productive lifestyle in harmony with the ecological system. Most importantly, it was seen as family tradition.⁶⁰ During the Japanese Occupation in the 1940s, farming contributed to people’s survival; post war, it was linked to national pride, resilience and security in the event of another war, particularly as the heightened threat of communist insurgencies and Singapore’s sometimes troubled relationship with Malaysia and Indonesia cast their shadows through the 1980s. These sentiments were best encapsulated by Ang Ah Bee, a pig farmer.⁶¹

We can plant the basic necessities in our own land here and help others in need. If this were not the case, we would all have died during the Japanese occupation. We helped each other survive. So you tell me, what is going to happen when we face another dangerous situation? During the war, we provided the soldiers with vegetables. What is going to happen now? We are going to die!

Amongst many, farming was indelibly linked to religion and worship. Farmers prayed to bounteous deities for prosperous harvests, erected altars to oversee fields, and protected and nurtured ancestral trees. Family farms were treasured as heirlooms passed from one generation to the next. It defined kinship ties and provided a deep sense of belonging. Marriage alliances were forged based on strengthening farming networks. As Lim, a chicken and vegetable farmer in Choa Chu Kang, said:⁶²

Naturally, I have sentiments towards the land. No words can express how I feel. Do you know how much this land means to me? My father had nothing except this piece of land to make a living. Who doesn't treasure his father's heritage?

The eventual dispossession of farmers greatly impacted farming communities. Beyond an occupation, lifestyles, identities and kinship ties were altered. Farming families were large; they often included three generations of aunts, uncles, cousins and the like. These families were often divided when they moved to new flats by the Housing and Development Board (HDB) which, despite having clean running water and electricity, were unfamiliar surroundings and made for a considerable change from living life off the land. One pig farming family, Tan Chye Huat, eventually turned to setting up a supermarket chain, Prime Supermarkets, to keep the four-generation, 59-member family united.⁶³

“WATER FIRST, BEFORE PIGS”: THE WATER AND FOOD CONUNDRUM ⁶⁴

“Every other policy had to bend at the knees for our water survival.”

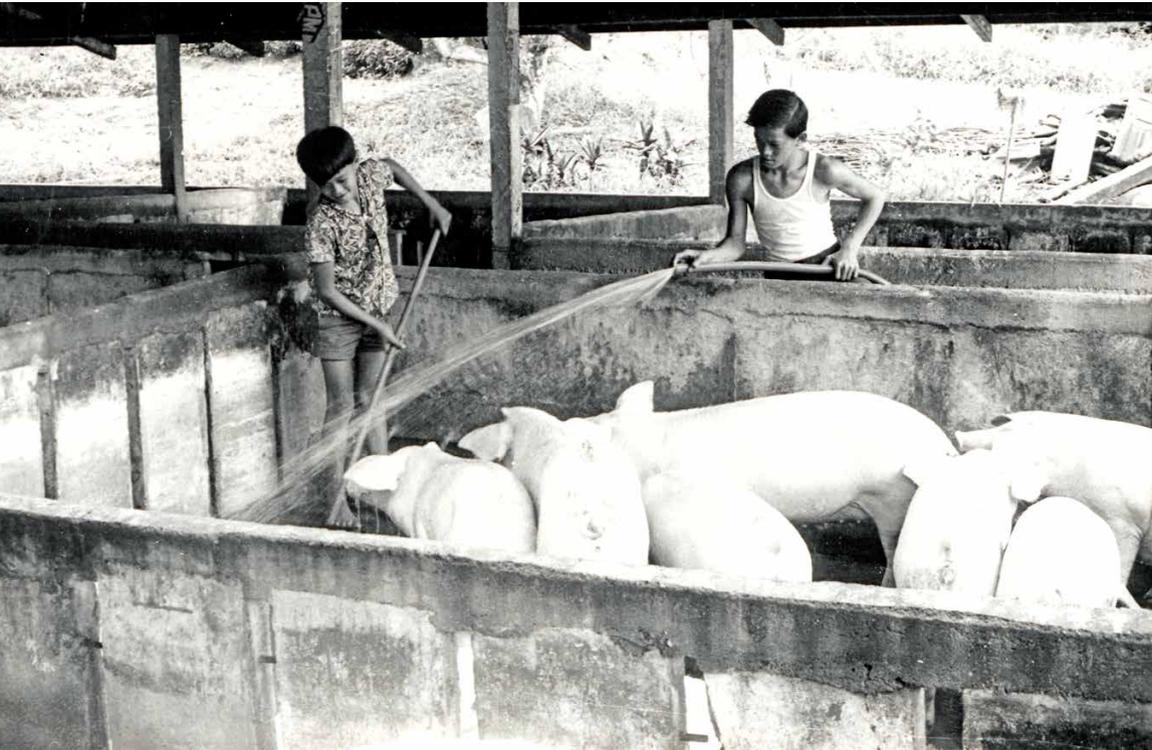
Former Prime Minister Lee Kuan Yew ⁶⁵

The decision to resettle farms away from water catchment areas emerged in the mid-1970s. Then, more than half of Singapore's water supply was imported from Malaysia and, due to increasingly unstable relations between the two countries, Singapore moved to ensure its water security by capturing rainfall in water catchments.⁶⁶ Between 1965 and the mid-1970s, farms that were deemed polluting, including pig farms, were required to be resettled in non-catchment areas such as Kranji.

Plans to develop Singapore's first unprotected water catchment in Kranji were finalised in 1971.^{67,68} Although unprotected water catchments allowed for developments within the catchment areas—unlike the protected water catchments of MacRitchie, Peirce and Seletar⁶⁹—polluting industries, such as pig farms, had to be resettled to ensure that only clean rainwater run-off was collected in these reservoirs. Tan Gee Paw, former Chairman of the PUB, described the challenge as follows:⁷⁰

One pig is equivalent to six human beings defecating into the water courses! We had something like a quarter million pigs in the unprotected water catchments, threatening to defecate into reservoirs that were yet to be built. There was a mad rush to clear away all the pig farms in these unprotected water catchments, even as the reservoirs were being built.

With the completion of the Kranji Dam construction in May 1975, Kranji river was converted into a reservoir. However, pollution run-off from the existing farms had already resulted in the eutrophication of the reservoir. In hindsight, the resettlement should have been completed prior to the construction of the Kranji reservoir, rather than carried out contemporaneously. This incident illustrates the issues and challenges faced by the public sector in the early days, including challenges in ensuring inter-agency coordination.



An early-day pig farm in Kranji. Attaining self-sufficiency in the production of pork came at a high price as pig farms were highly polluting.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

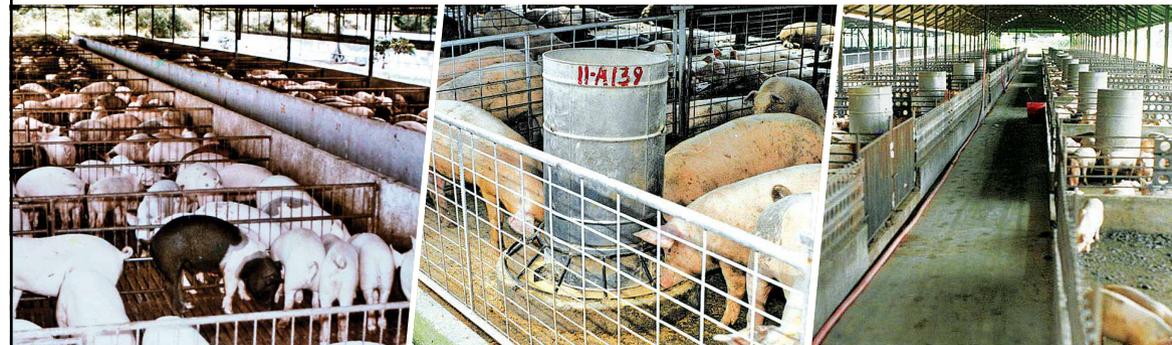
Pig farming was eventually prohibited in the Kranji catchment area on 1st October 1977, with farmers being warned that “pigs found within the gazetted area after that date would be liable to be impounded and physically removed”.⁷¹ By the end of the resettlement exercise in 1977, 248 farms, including nine commercial farms had been resettled in Punggol.⁷²

The resettlement of the pig farms to Punggol provided an opportunity to restructure, optimise and modernise smaller, subsistence farms. The new farms could rear up to 600 pigs per hectare. The PPD’s additional investment of S\$2 million to set up the intensive pig farm areas also opened up more land for farms in Punggol.⁷³ Singapore remained self-sufficient in pork production till the early 1980s,⁷⁴ with an output of nearly a million pigs by 1983.⁷⁵

While the new farms were designed to deter free-flow of pig effluent into drains, these intensive farms also generated greater amounts of waste. Smaller farms typically used pig waste as fertiliser, which was relatively sustainable. However, as farms consolidated to intensive, single-purpose farms, this method of waste management became impractical. The PPD had initially experimented with relocating the traditional pig farms from Kranji to high-rise (stacked) intensive pig farm units at Punggol, as a means to maximise farm space.⁷⁶ However, the idea was shelved due to the high construction costs,⁷⁷ the high load factor and the complexity of waste management in high-rise structures,⁷⁸ given that there was no existing commercially-feasible waste collection system. Eventually, pig farms were tasked to manage their waste responsibly through individual treatment plants; however, flooding and overflow often led to pig waste continuing to pollute water resources.

THE PIG FARM PHASE-OUT

Through 1975 and beyond, there were many debates in parliament, on the impact of pig farms on the environment.^{79,80} Increasingly, an economic argument was presented against continuing pig farms in Singapore, given competing resource needs. At the same time, the former Senior Minister of State (National Development), Dr Tan Eng Liang, assured farmers that the resettled pig farms in Punggol would remain there for another 15 years.⁸¹



The Punggol pig farms featured automated feeding machinery and then best practice waste management systems.

Photos courtesy of Agri-Food and Veterinary Authority of Singapore.

Hence, the years that followed the resettlement exercise were clouded by an unclear vision of the future of the pig-farming sector. This was possibly indicative of the lack of a long-term vision for this industry.⁸² The government could not confirm the permanency of the Punggol intensive pig-farming area, and only 15-year leases were granted. Furthermore, parliamentary debates as early as 1975 highlighted the possibility of the land being allocated for other uses.⁸³

In 1979, two years after the pig farms were resettled in Punggol, it was announced that Lim Chu Kang would be developed as a large-scale pig-farming area with pollution control facilities, and that pig farms in other areas of Singapore would be phased out. The confinement of pig farms to Lim Chu Kang was deemed as a solution to contain pollution in an area away from residential locations, and to free up large tracts of land that could be used for other purposes.⁸⁴ This announcement raised anxiety amongst the pig farmers, who were already uncertain about the sustenance of their farms and their livelihoods. Moreover, the third phase of the development of the Punggol pig-farming estate was still underway, pending land acquisition and the resettlement of squatters.

Despite this announcement, the years that followed saw the PPD investing in enhancing facilities and capabilities to increase productivity in the pig-farming sector. For example, in 1981, the PPD launched career training in pig farming for Advanced-level students. The first batch, which graduated in 1982, saw 25 students being trained as farm supervisors. A PPD spokesperson's words on the training course: "Pig farming in Singapore is no longer a way of life. It has to become a business."⁸⁵ This signalled the PPD's continued efforts to modernise the pig-farming sector, with reports highlighting the efficiency and productivity of the intensive pig-farming centre in Punggol.⁸⁶ Such developments, despite the 1979 announcement to phase out farms in Punggol, continued to cause uncertainty regarding the future of the pig-farming industry in Singapore.



Minister and Member of Parliament for Bukit Merah Lim Chee Onn visiting a pig farm at Buangkok South Farmway 1 during his walkabout of Punggol Constituency.

Photo courtesy of Ministry of Information and the Arts Collection, National Archives of Singapore.

In 1984, it was announced in parliament by then-Deputy Prime Minister Dr Goh Keng Swee, that all pig farms would be phased out.⁸⁷ Continuing to farm pigs in Singapore was not economically viable, given the scarcity of land and water resources, coupled with the exorbitant cost of treating pig waste.⁸⁸ Even after treatment, the run-off was still very polluted by the Ministry of Environment standards of that time, of approximately Biological Oxygen Demand (BOD) level of 250 mg/l. Overall, it was hard to continue justifying the subsidised treatment of pig waste by the PPD and the government as there were other cheaper options available.

Does it make sense to spend some \$80 million on waste treatment plants [only] to achieve poor environmental standards? If pig farms have eventually to go, why prolong the agony? Are we assured of reliable sources of live pigs from imports? Can we persuade the Singapore consumer to buy frozen imported pork at lower cost?

Dr Goh Keng Swee, former Deputy Prime Minister⁸⁹

The relocated Punggol pig farms created tremendous environmental problems. If you had friends living along Yio Chu Kang, the minute you opened your car door, you could smell the pig waste. Naturally, all the residents there were all up in arms. In fact, I had a friend who stayed there, and I went to visit him one evening. As soon as I stepped out from my car, I could smell it. So strong! I went to his house and said, 'Do you get the smell? It's so strong. How can you live here?' And he asked me, 'What smell?' Because he [had] lived there so long, he was used to the smell of the pig waste!

Tan Gee Paw, former Chairman, PUB, Singapore's National Water Agency⁹⁰

The decision to phase out all pig farming came as a surprise to most of the staff at the PPD,⁹¹ as the PPD had just completed the third phase of land acquisition in Punggol, to be used for pig farms.⁹²

While the directive was to phase out pig farms, it took several years for farmers to divest their stock. As a result, there were concerns over the phase-out.

The phasing out of pig-farming mean[s] the pig farmers [have] lost their last frontier in Singapore. It was only a few years ago that these pig farmers [had moved] from places such as Nee Soon and Choa Chu Kang, [and] were encouraged by [the] Primary Production Department to pool their capital and resources together to invest in pig farms in Punggol. And they are now asked to cease their operations.... I hope the Government will be sympathetic in deciding on the terms of compensation because the Government is to be blamed for leading or misleading them to this dead end.

Koh Lip Lin, former Member of Parliament⁹³

In retrospect, Dr Cheng noted that the 15-year term committed to by Dr Tan would have ended in 1991.⁹⁴ The last pig was phased out in 1989, just two years' shy of the end of the term. With proper planning, the pig farms could have been phased out in a smoother manner by putting a quota on each farm to gradually reduce headcount, and pig farmers could have progressively cashed out.⁹⁵

Although disappointed by the phasing out of the pig farms, Dr Ngiam, on hindsight, believed that the phase-out was the right decision,⁹⁶ as it completely curtailed a key source of pollution of Singapore's waterways, and was a vital policy decision to fulfil Singapore's water security needs. This episode in Singapore's agricultural history illustrates the complexities involved in any policy decision—with policymakers often divided on the best way forward. The episode also illustrates how changing circumstances can impact the continuity of any policy.

SAFEGUARDING LAND FOR FOOD PRODUCTION THROUGH AGROTECHNOLOGY PARKS

Singapore's Ministry of Trade and Industry (MTI) was conducting an economic review addressing Singapore's recession. Dr Tony Tan, then-Minister for Trade and Industry, appointed a committee in 1985 to review the progress of the Singapore economy. The report identified particular sectors to propel the economy. Agrotechnology was identified as a key area for Singapore to develop through the development of agrotechnology parks.⁹⁷

Hence, it was decided that some agriculture could be consolidated in newly-designated agrotechnology parks.

The objective... is to develop Singapore into an agrotechnology service centre in this part of the world and also for other tropical areas. This includes providing consultancy services for farm design, construction and management, turnkey farming projects, farming machinery and equipment and veterinary drugs and biologics. To achieve this objective, the Primary Production Department has been working closely with the EDB to attract investments in hi-tech demonstration farms, which can also carry out some R&D in agrotechnology. The incentive scheme that is being worked out would include pioneer status, investment allowance incentives, double deductions of R&D expenses and industrial building allowances to such companies.

Lee Boon Yang, former Minister of State for National Development⁹⁸

The PPD, Urban Redevelopment Authority (URA) and other agencies worked together to identify lands that would be suitable for intensive farming. To further gain support, the PPD arranged for Richard Hu, then Minister of Finance, to undertake a field trip to Lim Chu Kang, to better understand the viability and importance of the agrotechnology parks.⁹⁹ He supported the initiative, granting \$200 million for its development, a princely sum in the lean times following Singapore's economic recession in the mid-1980s.¹⁰⁰ In 1986, the URA set aside 3,555 ha for agrotechnology parks in 6 locations—Lim Chu Kang, Murai, Sungai Tengah, Nee Soon, Loyang and Ah Ma Keng.¹⁰¹

With land, political and administrative support and a budget in place, the PPD proactively sought to modernise farming, to ensure cost efficiencies.

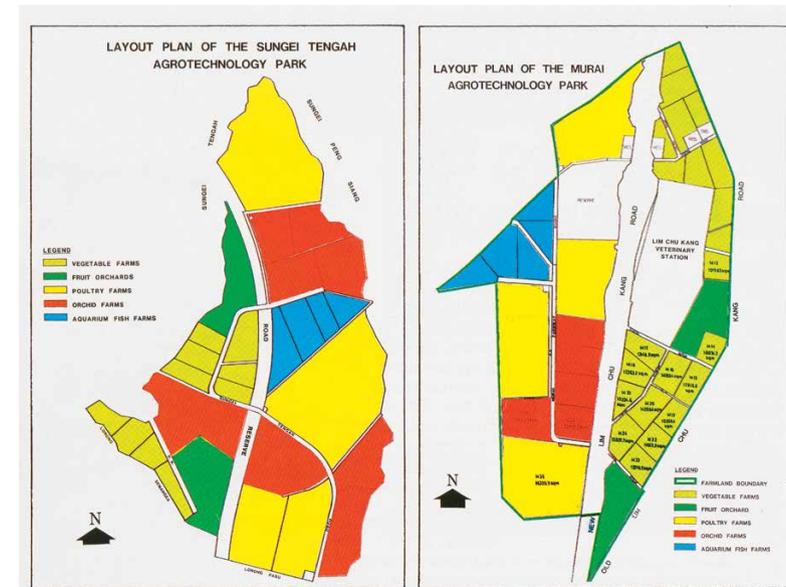
My colleagues and I went to countries such as Holland, France, Norway, USA, Argentina, Brazil and Israel which had more advanced farming systems, to acquaint ourselves with modern farming technology. We brought the technology back and introduced them to our farmers; we also offered land on 20-year leases. We developed the land, provided roads, electricity, water supply and designed lots which are ecologically compatible. This means that we do not situate a vegetable farm next to a fish farm, because vegetables farms use pesticides, and if the pesticides get into the fish farm, all the fish would die.

Dr Ngiam Tong Tau, then Director, Primary Production Department¹⁰²

However, not all were convinced that move to agrotech parks were the best way ahead, such as Member of Parliament Tang See Chim.¹⁰³

We have very high-sounding names like agrotechnological parks. Why can't we call a farm, a farm? We were adequate in our supply of some farm produce, but we resettled the farmers. And now, we are trying to replace the farms...there is really no point having very grandiose-sounding policies when what we need are actual down-to-earth policies.

Tang See Chim



Agrotechnology Parks were planned to maximise productivity and reduce conflicts. For example, livestock farms were spaced out to avoid cross contamination.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Eventually, each agrotech park had specific uses to accommodate required farm layout specifications and disease control needs. Mandai was designed for orchid farming, Loyang for fisheries, Lim Chu Kang for horticulture, poultry, fish, ornamental fish and others. Farmers were granted twenty-year leases and regulations were set to ensure that at least 70% of the land had to be used for farming purposes, with the remainder for infrastructure (roads, septic tanks, etc.) and buildings.¹⁰⁴

I think it's the assurance of the land—when we give a lease of 20 years to a farmer, the farmers actually can be more confident and assured to invest in better technology and to automate their systems, because there is this long-term use for the land.

Yap Boon Chark¹⁰⁵

USING ORIGINALITY AND PRAGMATISM TO SOLVE THE PORK CONUNDRUM

Few today understand how important pork was to the Singaporean Chinese household. Meat on the table was a sign of household well-being. Pork supply, however, was a complex challenge. Households demanded fresh pork, which required live pigs—frozen pork was not readily accepted by consumers, and cold chain technology for chilled pork was underdeveloped.

In the 1980s, Dr Goh commissioned several studies to consider options for local pork production. One of these was high-rise pork farms; however, the idea was dismissed as the infrastructure needed was not cost-competitive. Another option considered was pig farming on decommissioned freighters on the sea. This too was dismissed, as it was noticed that pigs that were imported by sea were often seasick, which impacted the quality of the resulting meat.

A third experiment considered whether pigs could solve another sustainability issue—sewage waste water. The PPD conducted a 3-year experiment on sows and their offspring to see if they could survive on sewage water from the Ulu Pandan Treatment Plant. The experiment showed that the pigs did not show signs of heavy metal poisoning or other ill-effects, with the exception of a few lesions on their stomach linings. The PPD, however, recommended against regularising the practice, due to the potential health risks it carried. Dr Goh, however, was satisfied that in times of emergency, pigs could survive even on sewage water.

With few feasible alternatives, the decision to phase out pig farms was eventually reached. This decision was not taken without planning for contingencies. Measures in this regard included sending a senior team from the PPD to Thailand, to work out the feasibility of importing healthy, high-standard pigs. When Dr Ngiam, then a Senior Primary Production Officer in the PPD, arrived in Thailand, the Director-General of the Thai Department of Livestock Tim Banasari told him that Dr Goh had, in fact, visited earlier.



The PPD's "Frozen Pork is Just as Good" campaign.
Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

'Two weeks earlier, Dr Goh had already gone to check out the availability of pigs in Thailand, then he sent us there to look at the technical details.'

Clearly, Dr Goh had not taken the decision to phase out pig farms without plans in place to ensure the continued supply of pork.

USING ORIGINALITY AND PRAGMATISM TO SOLVE THE PORK CONUNDRUM

Continued ...

Plans were also made to ensure some domestic supply of pork, though without inconvenience to the residential population. The Primary Industries Enterprise (PIE), the commercial arm of PPD, was tasked with this enterprise. In partnership with the Salim Group,¹⁰⁶ the PIE set up a pig farm on nearby Pulau Bulan (Bulan Island), putting into action all technology developed by the PPRTI on housing, feed and breeding. Not only was the island close enough to deliver live pigs by barge directly to the PIE Abattoir at Jurong,¹⁰⁷ but it also allowed for better disease control and biosecurity.

In 1985, the PPD launched a 5-week long “Eat Frozen Pork” education campaign to encourage consumers to buy and consume frozen pork. A key component of the campaign was aimed at dispelling common norms about frozen pork — especially since the public felt that frozen pork was an inferior alternative as compared to fresh pork. The campaign’s key messages were as follows:

- “Frozen pork is just as good.”
- “The freshness is frozen for you.”
- “Frozen pork, the better buy.”¹⁰⁸

This was strategically an important move for the PPD. The phase-out of pig farms and the heavy reliance on imported pork meant that there was a need to look into diversifying sources (fresh, chilled and frozen) to satisfy local demand for pork.

This provided the impetus for industry to invest more in cold chain technology as more frozen meat had to be imported.

THE COMPLEXITY OF JUST COMPENSATION

Through the 1970s and 1980s, many farms, both on private and state lands were consolidated and redeveloped for other uses, in line with Singapore’s master plan. Private land was acquired through the Land Acquisition Act. Where farmers were leasing land from the State or did not have formal land titles, compensation was provided for assets owned by them. Because the PPD was closely involved in individual farm development, in most cases it had detailed records of how much each farmer had spent on their respective farms. Tenant farmers’ compensation was pro-rated, based on depreciation of assets.

When it came to the pig farm phase-out, which turned out to be contrary to previously-announced policy to relocate and intensify pig farms, the PPD believed further compensation should be applied beyond the established resettlement schedule, and championed the cause on behalf of the pig farmers. Dr Ngiam Tong Tau, Director of the PPD, submitted a paper to Dr Goh, to request approval for further funds.¹⁰⁹

Dr Goh called me up, to discuss why I wanted to give more compensation to the commercial pig farmers in Ponggol Pig Farming Estate Phase 3. I replied that it was only fair because they had invested heavily in the buildings and in the breeding stock, and since the government terminated the lease unexpectedly, we should pay the compensation to at least cover the residual value of the farm structures.

And then Dr Goh, in his usual manner, he just closed his eyes. I thought he had fallen asleep. Then he opened his eyes and he said ‘Dr Ngiam, are you working for the Social Welfare Department?’

I thought he will definitely not approve this paper. The next day, it came back—he had approved it!

Dr Ngiam Tong Tau, former Director, Primary Production Department

In August 1985, an increase in compensation of up to 30% was announced for resettled pig farmers, to help them cope with the financial cost of shutting down their farms.¹¹⁰ Rehousing rules were also relaxed to enable the extended families to continue living together.¹¹¹ Thus, over decades of farmland phase-out, most farmers were compensated in a fair manner by the government.

FARMING THROUGH THE YEARS: INTERVIEW WITH KOH SWEE LAI, SENG CHOON EGG FARM—PART 1¹¹²

My family was in the feed transportation business. When I was 18 years old, I drove a truck and transported goods at Clarke Quay. The importers would use bum boats to unload corn at Clarke Quay from larger vessels, which could not enter the Singapore River harbour. It was here I witnessed how commodity prices increase with each passing through a middle-man, sometimes, as many as three in the process. We started a feed-mill to grind the corns as the value-added service resulted in higher prices. Then, we forward integrated into pig farming as the returns were even better when we go further down the chain. When pig farming was phased out in the early 80s, I decided to switch to poultry farming. Prior to switching I went to Japan, England, Denmark and Netherlands to observe their poultry farming—quite challenging as my English is limited—and then brought in high-tech poultry farms to Singapore.

Seng Choon Farm was established at Sungei Tengah Agrotechnology Park, in 1987. The government provided an empty plot of land. The EDB was pushing for industrialisation and provided us with a lower-than-market fixed-interest loan. We also benefitted from an investment and building allowance, which funded part of our building works. In 1999, we decided to upgrade from two-tier farming to closed-housed farming. This involved a fair bit of risk as we would need to actively ventilate the coops instead of relying on natural wind. At that time, no other farm

in the South East Asia region did that. If we succeeded, we could triple the quantity of birds. SPRING had a funding scheme and decided to fund the conversion of one house as an R&D project to try out modern farming methods. The PPD (now AVA) had linked us up with the EDB and SPRING.

In 2001, the government wanted to phase out some farming.¹¹³ Three out of the four egg farms accepted the offered ex-gratia payment and shut down their farms, but we insisted on keeping the farm and stayed on. We had a hard time, because there were complaints from residents over at Choa Chu Kang about our farm's smell. The HDB flats across the road (KJE) were built 10 years earlier than expected, and the patch of forest in between the farms and the residential area was cleared to make a golf course. Hence, when residents looked out of their windows, they could see the farms, and pointed out that the smell came from the farms. The Ministry of Environment kept putting pressure on us to address this.



Seng Choon Egg Farm was first built at the Sungei Tengah Agrotechnology Park with the support of the government. The introduction of agromachineries and automation improved production levels.

Photos courtesy of Agri-Food and Veterinary Authority of Singapore.

FARMING THROUGH THE YEARS: INTERVIEW WITH KOH SWEE LAI, SENG CHOON EGG FARM—PART 1¹¹²

Continued ...

We tried to control the smell as best as we could, but there were diminishing returns on the investment we made in technology and the amount of smell that was reduced. It is easy to control 90% of the smell, but to go from 90% to 99% required heavy investment in not-yet-mature technology. There was also a lack of clear guidelines on smell, because it is often subjective. Finally, in 2006, we were able to secure an alternative site in Lim Chu Kang. Building works only started two years later as soaring prices in construction materials made setting up a new farm prohibitive. We salvaged whatever we could from the old farm, including wooden and steel structures dismantled from old houses. The new site was uneven, swampy and covered with trees and undergrowth. We needed to build an electricity substation, because our needs were beyond the existing substation's capacity. We also built our own septic tank and sewage treatment facility, for our household waste. For chicken waste, we treated it by composting, and the composted matter was sold to Malaysian vegetable farms as fertilizer. This was banned in 1995, and we [then] looked into making biogas out of chicken manure. The farm was able to generate electricity from the biogas. We aimed to sell 50% of the total electricity generated back to the grid. However, setting up the whole system was quite challenging.



Seng Choon Egg Farm.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Making decisions on investing in equipment was also challenging. The short tenure allowed for agricultural purposes made farmers reluctant to invest large amounts of money in the farms. We were worried that we might have to source for a new piece of land once the current lease expired. Furthermore, renewal of our lease could only be done in the last few years of the lease, and that added to the degree of uncertainty when planning for the future.

Our government has begun to realise the importance of having some local farms and has started to provide us with funding, to allow us to increase our productivity through R&D. This is important as, in future, countries such as China and India may shift from being net exporters of grain to being net importers. As a result, the price of chicken feed, and therefore, production could rise. We farmers are still subject to market forces, and we do not have control over egg prices. It is a delicate process to balance the incurred costs and our revenues.

ADAPTING TO FOOD DEPENDENCY: DEVELOPING A WORLD-CLASS FOOD SAFETY SYSTEM

By the 1980s, local food production had declined and reliance on imports increased. The PPD was charged with creating systems to ensure that imported food was of acceptable safety. Food safety was (and still is) a key part of social security; consequently, this was an issue that was of interest at the highest levels of government. Despite the strong interest in food safety, setting up a food safety programme and system was an uphill task, as Dr Chua Sin Bin, then a junior officer in PPD, shared:¹¹⁴

In those days, there was a lot of cheating. There were illegal slaughters and adulterations. Butchers would pump water into the pig and then sell you meat and water. Did you think that the British just left us with a good system, a silver spoon on a platter? No. There were a lot of issues, and we had to tackle all of them. We had to look at what is the responsibility of the government. The government must ensure food safety and we must develop a proper food safety system, based on science.

To formulate the food safety system, the PPD needed technical experts. Such experts, however, were expensive, and it was difficult to procure finances for their engagement. The PPD staff, therefore, had to get creative. The PPD thus leveraged on the UNDP funding to set up the first Veterinary Public Health Laboratory in 1979:

At that time, Singapore was poor. It was very hard to get money from the Ministry of Finance... and we hung onto the UNDP Programme, because Singapore was a developing country. It was important for us to leverage on that, to get as much assistance out from an international body as possible. We put up a project on Veterinary Public Health, using their terminology with sound justifications so that the WHO (World Health Organisation) would accept it. Veterinary Public Health encompasses food safety. It's basically dealing with the diseases transmissible from animals to humans, and also how to ensure food safety.

[The] UNDP helped us a lot to develop a comprehensive food testing laboratory, not just a basic facility.

Dr Chua Sin Bin, former Chief Executive Officer, Agri-Food and Veterinary Authority¹¹⁵

With the establishment of the Veterinary Public Health Laboratory in 2000, Singapore's food safety capabilities improved. This complemented Singapore's other testing and R&D facilities, namely the Animal and Plant Health Laboratory, the Horticulture Centre, the Post-Harvest Technology Lab and the Marine Aquaculture Centre. Together, these provided the crucial facilities for testing and R&D to maintain competitiveness. The facilities were staffed by well-trained and committed experts, many of whom had worked in the field for decades and were therefore able to constantly develop each lab's capabilities.

Singapore also sought to build food safety in the region as a whole. Under the aegis of the Association of Southeast Asian Nations (ASEAN) and with funding from the Australian International Development Assistance Programme, the PPD set up a regional training programme for veterinary public health and food safety, called the ASEAN Meat Laboratory. Training was extensive, consisting of five runs of 10-week courses conducted by trainers from the Hawkesbury Agriculture College (now incorporated into the Western Sydney University) in Australia, which specialised in various food safety and quality issues.

Trainees returned to their home countries and, in turn, trained their own colleagues, who eventually moved to senior positions in their government agencies. The bonds formed in these trainings, however, remained, ensuring good relationships between food safety agencies in the region for decades to come. This paid off, as more and more food was imported from within the region.

GAINING ROBUSTNESS IN FOOD SAFETY AS A RESULT OF REAL-WORLD SHOCKS

The first test to Singapore's food safety system came in the mid-1980s. Nearly 90% of the vegetables imported into Singapore came from Malaysia, and nearly 60% of those vegetables were found to have pesticide residue levels higher than the permitted range.¹¹⁶ While not immediately fatal when consumed,¹¹⁷ prolonged consumption of pesticide could lead to serious health issues. The PPD set up a system to systemically eliminate contamination in the whole food chain (see box story). Eventually, it was able to reduce the amount of vegetables that exceeded the maximum pesticide residue levels to an acceptable level.¹¹⁸

ADDRESSING CONTAMINATION BY WORKING WITH STAKEHOLDERS

In the mid-1980s, high levels of pesticide residue were found on imported vegetables, often above safe limits. The Ministry of Environment's Food Control Department sought to address it; however, the problem was so endemic, it appeared nearly impossible.

In 1986, the PPD was requested to deal with the issue.

It was then the nightmare started. We knew how bad the situation was. How to bring it down? We told our government that we will bring it down within five years to safe levels because if you couldn't do it overnight, otherwise there would be nothing to eat.

Dr Chua Sin Bin¹⁹



Pasir Panjang Wholesale Market. Monitoring pesticide levels for imported vegetables remains a complicated task involving various stakeholders.

Photo courtesy of Ministry of Information and the Arts Collection, National Archives of Singapore.

To address the situation, the PPD set up a vegetable inspection unit, with qualified horticulturalists who understood farming practices, including why and when pesticides were applied. Monitoring, however, was insufficient, as a whole-of-food-chain approach; one that involved farms, middle men, traders, distributors and policymakers was needed to address the serious health issue.

We talked to the Malaysian farmers, their associations, worked with them to reduce pesticide [use] and helped them to solve their pest problems. They could use pesticide, but it had to be used judiciously. The chemical-sellers had added micro-nutrients into the pesticides; if the farmers didn't apply the pesticide, the plants looked sick, not just from weevils and other pests, but also due to the lack of micro-nutrients for growth. So, we requested the chemicals-sellers to separate the components, and the farmers were asked to apply twice, once as pesticide, once for the micro-nutrients. If the chemicals were mixed, it would have been easier for the farmers, but then we would have a pesticide residue problem!

We also took the carrot and stick approach. We narrowed down the problem to 21 types of vegetables prone to pesticide contamination. We also made lists of good farmers and lousy farmers, almost like accreditation, but not exactly. We renewed the list every week, and it was posted at Pasir Panjang Wholesale Centre—these are the good guys, these are bad suppliers. We took samples to test, but we knew the good suppliers were less likely to fail. For the second group, we did not release the consignments until we finished testing (within 24 hours); that way, they naturally lost the market.

Dr Chua Sin Bin

ADDRESSING CONTAMINATION BY WORKING WITH STAKEHOLDERS

Continued...

Eventually, the farms and suppliers adapted, and the proportion of vegetables exceeding the maximum pesticide residue levels was reduced from 70% to 2%-3%. This was done without significant disruption to the availability of vegetables in Singapore.

You must offer a way. We worked with their association to teach them, and with a few progressive farmers. Get them on your side and they will be the change agent for you. They'll demonstrate to the rest that it can be done.

Dr Chua Sin Bin



Another important case was the detection of beta-agonist drugs in meat. Beta-agonists are illegal feed additives which are widely-used to enhance lean muscle gain, increase growth rate and increase feed efficiency.¹²⁰ Beta-agonists add lean muscle in pigs, but they may cause fatalities for some people with heart conditions. While diagnostics for this is costly, the AVA maintains a strict monitoring programme to keep it out of the food supply.

An important third test and learning experience on zoonotics was the Nipah virus incursion, from Malaysia. Initially, the PPD believed Singapore was safe, as accredited farms had not been affected. However, some farms were able to manipulate the system: non-accredited farms sold their pigs to the accredited farms, thereby the virus still slipped through to Singapore. When the anomaly was discovered in 1999, pork imports were immediately suspended.¹²¹ Overnight, supermarket shelves were empty of pork. It caused turmoil for local consumers; however, the suspension helped to avert an epidemic. An important lesson was learnt: no matter how well the accreditation system was, it could still be circumvented. Consequently, vigilance was, and still remains, crucial.

Over time, a science-based, integrated food safety programme—the Enforcement and Elimination Regime—was established to regulate and manage risks from the ever-increasing volume and variety of imported food. It included a comprehensive accreditation system from “farm to fork”, with various levels of intervention inherent in the design.

Apart from the PPD/AVA's involvement in the regulation of food supply, Singapore Customs plays a major role as a gatekeeper, and the National Environment Agency (NEA) plays a crucial role in ensuring the safety of cooked food.

VIGILANCE AND LEADERSHIP CRUCIAL TO ADDRESSING FOOD SAFETY ISSUES

In 1998, a disease was found to be affecting pigs in Malaysia. At first, it was misdiagnosed as Aujeszky's disease, which does not affect humans. Later, it was thought to be Japanese Encephalitis and was managed through mosquito control. However, when pig farmers started to fall fatally ill, a concerned Malaysian medical microbiologist brought the virus he isolated to the United States' Centre for Disease Control (CDC), which diagnosed the disease as caused by a new, fatal, zoonotic virus from bats, spread through pigs. Given the initial misdiagnosis, mosquito control measures to curb the entry of the virus into Singapore were not appropriate, and the virus came into Singapore. However, even prior to the CDC's diagnosis, officials in Singapore had already decided to take action.

One evening, a lady called me and said, 'Dr. Chua, my brother is in Changi Hospital.' The brother, who was a butcher, had signs similar to those being shown by Malaysian farmers. So, I called up Professor Chew Suok Kai from the Ministry of Health—he was the Director of Epidemiology and Disease Control. I asked him to look at all our hospitals to see how many cases there were of apparent meningitis in patients who worked in the abattoirs. Did we have an isolated case or did we have an outbreak?

The next morning, he called back to say there were 11 cases. They were scattered all over the country. Different hospitals. Nobody in the hospitals would have seen any significance, because one or two cases of meningitis is normal. It's quite

common...but when we realised we had an aggregate of 11 cases, and all of these could be traced back to abattoirs, we knew we had an outbreak.

Dr Chua Sin Bin, former Chief Executive Officer, Agri-Food and Veterinary Authority¹²²

Armed with that information, the PPD faced a difficult decision: whether or not to bypass protocol, and directly reach out to a Minister and share their findings. Dr Chua and Dr Ngiam decided that direct action was necessary.

We contacted the Minister (for National Development, Lim Hng Kiang) and said, 'Sir, we have this situation.' Within half an hour, he said, 'You do what you think is necessary professionally, I will take the political flak.' He was the best minister we could have had in such a crisis situation.

Dr Chua Sin Bin

The PPD went on to call a meeting with the pork butchers, to advise them of the decision to ban all pig imports from Malaysia. Dr Chua recalls he was warned—'You will be slaughtered alive! You will not come out of that meeting!'—because of the imminent loss of business. On the contrary, they thanked him.

It saved their life! None of them had dared to stop imports because their competitor would have taken over their share of the market. The Chinese have a saying—they're riding on the tiger and they can't get off [骑虎难下]. The ban allowed equal misery. It's very important, equal misery, nobody has an advantage over the other.

Dr Chua Sin Bin

The Ministry of Health, working with the PPD, swiftly contained the situation. Unfortunately, there was one fatality. However, the disease did not spread further in Singapore, though it killed 105 people and resulted in the culling of more than 1 million pigs in neighbouring Malaysia.¹²³



The Pasir Panjang Wholesale Centre was built and opened in phases between 1983 and 1984. The centre served as a main distribution point for fruits and vegetables, ensuring quality control and affordability.

Photos courtesy of Ministry of Information and the Arts Collection, National Archives of Singapore.

BUILDING SOFT AND HARD INFRASTRUCTURE TO MAINTAIN AFFORDABILITY AND QUALITY

As food systems became dependent on global trade, new challenges emerged. To address these, soft and hard infrastructure had to be built over time. For example, new infrastructure for fruit and vegetable trading had to be built to maintain quality and affordability. In the 1950s and 1960s, locally and regionally sourced fruit and vegetables were traded at Rochor Market, Beach Road, Hong Kong Street, Merchant Road, Lao Pa Sat, Merchant Court, New Bridge Road, Queen Street, Toa Payoh Lorong 8 and Mohamed Sultan Road.¹²⁴ The HDB constructed the Pasir Panjang Wholesale Centre to serve as the main distribution point and thereby reduce obstruction caused by hawkers on the streets. The market accommodated importers and wholesalers of fruits, vegetables and dried food affected by clearance in the city areas such as the Beach Road Market (also known as Clyde Terrace market then).

To streamline trade documentation, in 1989, Singapore Customs introduced TradeNet, which is the national single window for trade declarations. Through this, Singapore Customs, AVA, NEA and others are able to monitor the movement of food products to enforce health, safety and other regulatory requirements.

The need to ensure the continued affordability of pork, then the most important consumed meat in Singapore, led to the development of the Hog Auction Market, a physical auction market combined with an electronic system. This was introduced in 1990. The system was adapted from Taiwan's successful Livestock Auction System. It ensured that at least 20% of all imported live pigs were priced based on real demand, through an auction system. The system, which is still in use, has kept pork prices relatively stable over the last 20 years, even as 100% of all pork is now imported.

REGULATING THE PRICE OF PORK TO ENSURE CONTINUED FOOD AFFORDABILITY

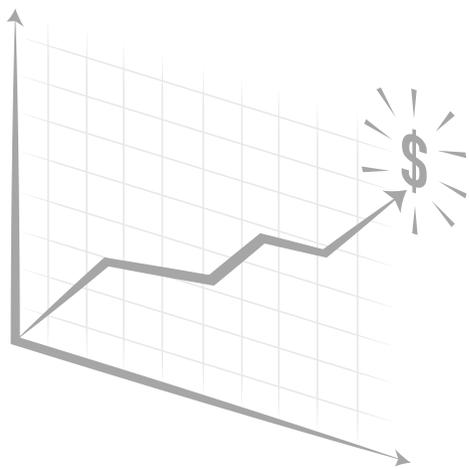
Prior to 1990, nearly all live pig trade was through a group of approximately 20 pig traders.¹²⁵ The 20 would meet in a coffee shop in Punggol every Monday, under the general consultation of a representative of the Pig and Poultry Research and Training Institute to set the price of pigs for the week. The Ministry of Trade and Industry also monitored the weekly Consumer Price Index, which included pork prices. If prices were too high, the MTI would send a request to the pig farmers to reduce prices. This system was, however, imperfect. The agreed price did not always reflect the market price and so was potentially subject to manipulation. Furthermore, farmers exported their pigs on consignment, without a price commitment. Consequently, incomes were volatile.

To address this, the PPD researched international models that it could possibly emulate and finally settled for Taiwan's Livestock Auction Market model as a prototype. Taiwan had converted its livestock markets to electronic trading systems as early as 1979, and its system had matured over the years. The Primary Industries

Enterprise (PIE), the commercial arm of PPD, hired Taiwanese experts to recreate the system in Singapore. The system featured an electronic Auction Processing System with a back end Management Information System,¹²⁶ a highly sophisticated mechanism at the time.

The introduction of the system, however, did not go smoothly: pig traders protested, concerned over the potential loss of livelihood. Under the new system, farmers could sell to the Hog Auction Market and receive their dues within 24 hours, whereas under previous norms, pigs were sold on consignment, and traders sometimes took 3 months to repay farmers. The reception was so hostile that the PPD staff even received death threats.¹²⁷

The PPD, however, persisted. Then-Minister for Trade and Industry, Lee Hsien Loong, agreed to expand the Price Control Act to include pork. The Act required that 20% of all live pigs sold from each importer or farmer had to go through the Hog Auction Markets.¹²⁸ Within a short time, the Hog Auction Market successfully achieved its purpose: to set price benchmarks, thereby keeping pork relatively affordable. Additionally, this more equitable and transparent system ensured that farmers, all of whom were by then based overseas, felt at ease about selling to Singapore. Eventually, 100% of the pigs were sent to the Hog Auction Market. The middlemen began to purchase their pigs through the Auction as well.¹²⁹



EVOLUTION OF GOVERNANCE MECHANISMS

Prior to the 2000s, food safety was monitored by two agencies. Meat and fish were managed by the PPD, and all other foods were monitored by the Ministry of Environment's Food Control Department. The monitoring of vegetables was eventually moved over to the PPD in 1986, after the vegetable pesticide residue contamination issue.

On 1 April 2000, the PPD was restructured as a statutory board—the Agri-Food and Veterinary Authority of Singapore (AVA). This change provided a more autonomous framework, allowing greater responsiveness and flexibility to meet the challenges under the organisation's mandate.¹³⁰

The AVA's mission then was to ensure a resilient supply of safe food, safeguard the health of animals and plants and facilitate agri-trade for Singapore and its objectives were to: 1) Ensure a stable and adequate supply of safe, wholesome and quality meat, fish and vegetables; 2) safeguard the health of animals, fish and plants; 3) be a centre of excellence for tropical agrotechnology services; and 4) support trade in primary produce.¹³¹ In 2003, the Food Control Department was also moved to the AVA, from the Ministry of Environment, so that the scientific monitoring of all food could be housed within one agency. The National Environment Agency, which oversees the safety of cooked food, hawker centres, waste and others, works closely with the AVA on food safety issues to ensure that food is safe from farm to fork.

Singapore's economic, social and environmental imperatives required its agencies and its industry to adapt to changes in the food landscape. Difficult decisions were made, often with lasting impact. On the whole, however, Singapore's food supply was not significantly or adversely interrupted or threatened at any time. This was a direct result of the ability of the agencies and the industry to collaborate to solve issues and evolve together to address Singapore's food needs. Changes in world food production, trade, safety and supply, however, continued to provide challenges to Singapore's food security. Innovation was therefore needed to address these emerging concerns.

CHAPTER 3

STRENGTHEN: ENSURING CONTINUED FOOD SECURITY

“ Many Singaporeans asked, and in fact, Members (of Parliament) asked, whether local farming has a future in Singapore. This is a fundamental question. And the answer is an unequivocal ‘YES!’ Farming will be a part of Singapore’s future. But it will have to be a different-looking farming sector from what it is today, in order for the sector to fulfil its important role of strengthening Singapore’s food supply resilience and our food security.”

Koh Poh Koon, Senior Minister of State for National Development¹³²

By the mid-2000s, rapid economic growth in emerging countries such as China, India and Brazil accelerated the growth of global demand for food. Due to economic uncertainties, global prices for staple foods, in particular, started to soar. In many developing countries, prices of rice, corn, wheat and soybean increased at an unprecedented rate.¹³³ Coupled with shortages and reduced access to food, especially in developing countries, these price increases gave rise to the global food crisis of 2008. For example, the price of corn increased by about 70%, while the price of rice doubled during this period.¹³⁴

At that time, 90% of Singapore’s food was imported.¹³⁵ As a price taker, Singapore was directly affected by global food trends. This led to a 7.8% increase in prices of imported food between December 2007 and December 2008.¹³⁶ The effect, however, was not as dire in Singapore as it was in many other countries, as a smaller proportion of household income was spent on food.¹³⁷ Moreover, the stockpiling of rice helped to keep the price of rice steady.¹³⁸

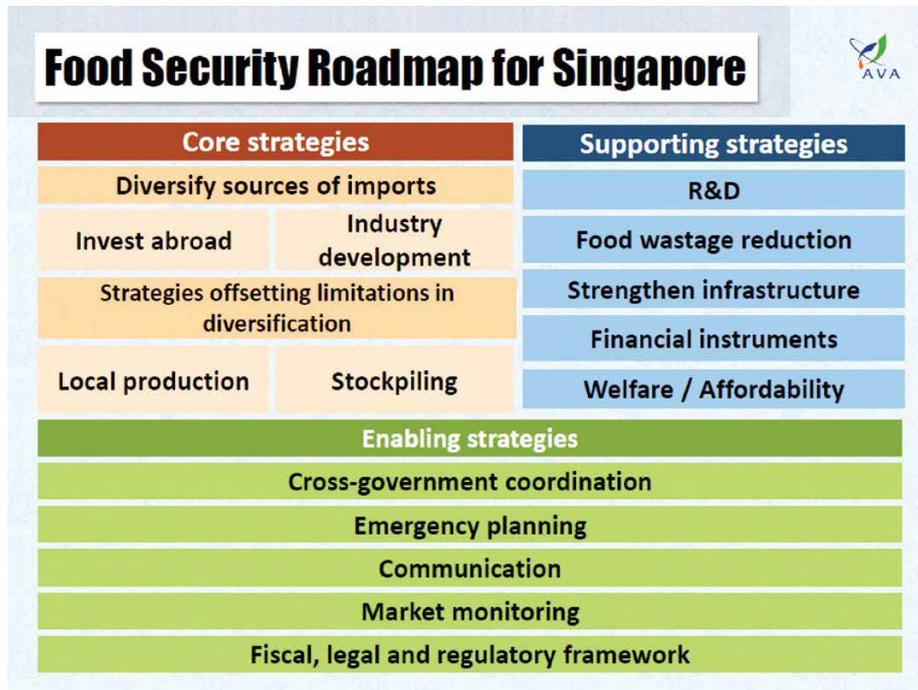
However, given Singapore’s strategic choice to rely on global food supplies to meet the needs of its people, it would remain susceptible to global volatility and consequent price challenges. Singapore shifted from local agriculture to supplying food from the global market for the reasons that: (i) the free market structure allows for food to be sourced at competitive prices from around the world; and (ii) it does not put additional strain on our limited land resources unlike stockpiling or local food production.

These events illustrated that Singapore, even as a high-income nation, was susceptible to fluctuations in global food trade¹³⁹ due to its unique position as a price-taker for imported food,¹⁴⁰ and prompted a rethink of Singapore’s approach to food resilience.¹⁴¹

TAKING THE BULL BY THE HORNS: THE FOOD SECURITY ROADMAP

Concerned about the volatile global food security situation and how it impacted Singapore, Ministry of National Development (MND) and Ministry of Trade and Industry (MTI) co-chaired an Inter-Agency Committee (food supply resilience) to map out the medium to long-term strategies needed to strengthen Singapore’s food resilience. The committee studied the gaps and challenges affecting Singapore’s food resilience and reinforced the importance of diversifying our food sources. More importantly, it also identified that food imports had to be supplemented by secondary measures, such as stockpiling and local production. These strategies would later form the foundations of the Food Security Roadmap.

In its review, the IAC (FSR) report highlighted a list of six food types of strategic importance to Singapore (key food items) – pork, chicken, fish, eggs, vegetables and rice. These items were identified based on their importance to an average consumer in Singapore, supply and price pressures, as well as qualitative considerations (e.g. ethnic group preferences, vulnerable groups).



Implemented in 2013, the Food Security Roadmap highlights core, supporting and enabling strategies to improve food security. Image courtesy of Agri-Food and Veterinary Authority of Singapore.

In 2012, Agri-Food and Veterinary Authority of Singapore (AVA), in consultation with stakeholders, including producers, processors, retailers, importers, logistic companies and government agencies, developed the Food Security Roadmap.¹⁴²

[As] we look back [at the] food crisis in 2008, we find that even if you have money sometimes you cannot buy food. Nobody wants to sell to you because there are many instruments and levers that countries can use, to not sell to you. We needed a larger framework than just buying from all over the world, so that's when we started looking into what we call Food Security. So, we formulated a Food Security Roadmap.

Tan Poh Hong¹⁴³

The Roadmap highlights core, supporting and enabling strategies to improve food security:

- Core Strategies
 - Food source diversification to mitigate supply disruption.
 - Local production optimisation to provide buffer for key food items in times of disruption.
 - Stockpiling for price stabilisation and supply stability, in times of short-term shortage.
- Supporting Strategies
 - Research and development to boost productivity and improve cold-chain, infrastructure, packaging and post-harvest management facilities to prolong shelf life.
 - Reduction of food waste along the whole food supply-chain.
 - Enabling Strategies.
- Multi-agency coordination for policy formulation and implementation of food security measures.
 - Emergency planning and scenario planning for food security risk management.
 - Communication on issues related to food safety or risks.
 - Monitoring of global markets for commodity price and supply changes.



The Food Security Roadmap was launched at AVA's inaugural Food Industry Convention by the Minister for National Development Khaw Boon Wan.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

As a result of the Food Security Roadmap [process], we also realised that it requires a whole-of-government effort. Many ministries and agencies have to come in.

Tan Poh Hong¹⁴⁴

To enhance whole-of-government coordination on food security, in 2012, the MND formed an Inter-Ministry Committee on Food Security that comprised the MND, AVA, EDB, IE Singapore, ISD, MFA, MHA, MOH, NEA, NSCS, A*STAR, SPRING and SPF. The committee was chaired by the Deputy Secretary (Planning), MND, and its terms of reference were to identify the risks and vulnerabilities in Singapore's food security, and formulate plans and build Singapore's capabilities to mitigate food security risks and manage food security-related incidents.

The Inter-Ministry Committee currently has five workgroups looking into the areas of industry development, reducing food wastage, food defence, research and development and overseas agri-investments.

DIVERSIFICATION OF OVERSEAS FOOD IMPORTS

Diversification remains Singapore's primary strategy for food resilience for two main reasons: first, the free market system allows for food to be sourced at competitive prices from all over the world and second, it does not put additional strain on our limited land resources, unlike stockpiling or local farming.

By the mid-2000s, Singapore was relatively resilient to global price fluctuations, since the sources of most key food items had been diversified. Pork, chicken, fish, vegetable and fruit were all imported from more than one key source, and less than 50% of food needs were imported from any one country.¹⁴⁵ This was despite the fact that Singapore was importing a bulk of its food needs, about 93,260 tonnes of pork, 165,287 tonnes of chicken, 82,645 tonnes of fish, 394,162 tonnes of vegetables and 288,555 tonnes of rice in 2008.¹⁴⁶ Hen eggs, however, continued to be predominately imported from Malaysia (approximately 77%), supplemented with locally-produced eggs.¹⁴⁷ At the same time, the AVA was aware that more could be done to diversify food sources. Existing bans on food imports from certain countries, and the lack of accreditation of new sources, limited Singapore's sources of food. This was of concern to authorities since it could, potentially, lead to a food disaster.

Promoting diversification, however, can be a challenge, as Dr Chua Sin Bin explains.¹⁴⁸

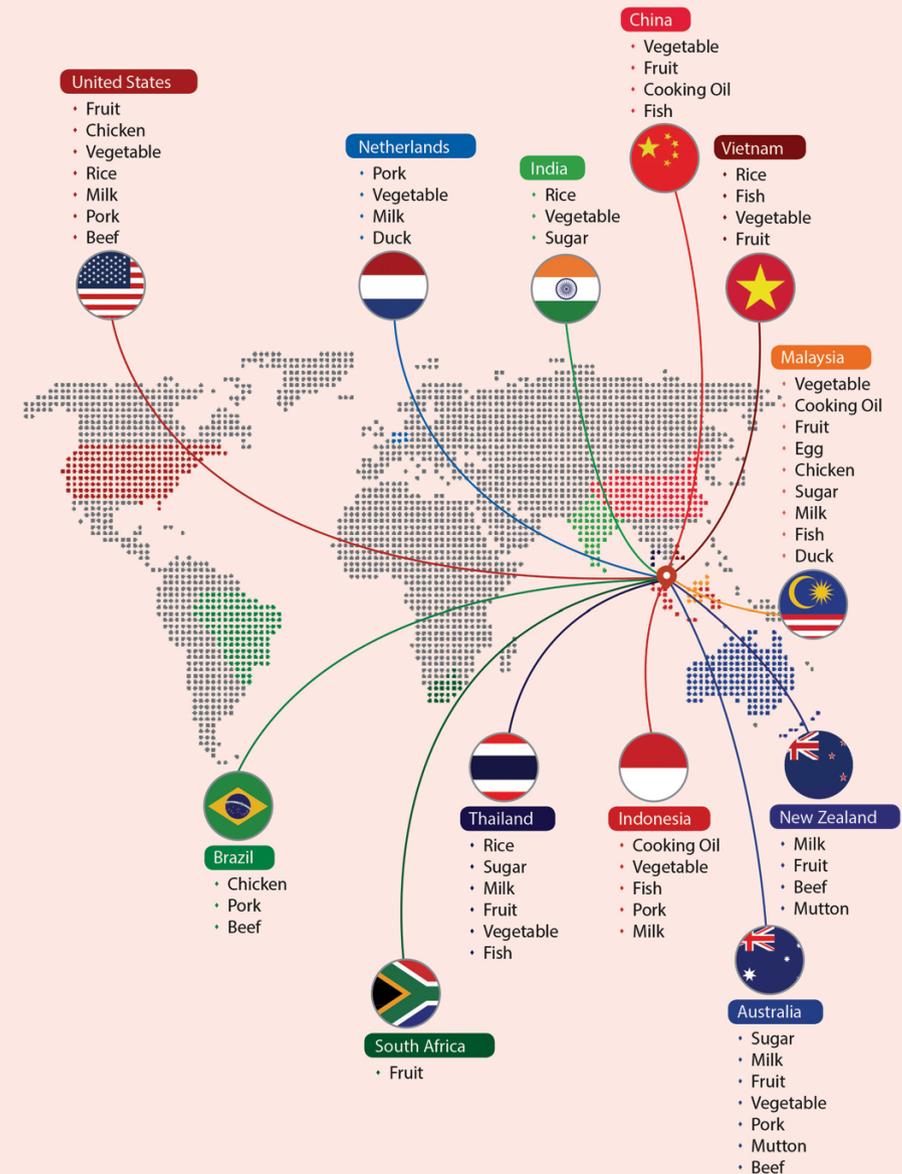
In Singapore, we must bear in mind that the cheapest supplier will dominate the market, to the detriment of diversification. It will kill off the competition, and there will be always this dominant supplier, and you can say that they distort the market, not because they are the most productive, but by logistics, they are most competitive.

This was the case with pork supply when the Nipah Virus pandemic broke out in 1999, necessitating the suspension of live pig imports from affected Malaysian farms, which then controlled 95% of the market. Malaysian pigs provided a competitive cost advantage, as they could be transported over land. Importers had to quickly turn to alternate supply sources from Australia. These supplies, however, came at a higher price, though some reprieve was offered by the PPD's experiments with cold chain technology that had begun about two years before the outbreak.¹⁴⁹ As a result of these technological developments, chilled pork meat, which met the PPD's food safety guidelines, could be imported from Australia.¹⁵⁰

The chilling technology was able to ensure that the quality of meat [which] arrived here was good enough. [The PPD] had been doing trial runs with them, for over about two years before the Nipah virus broke out, and had a body of data to show that [chilled pork] could be safely imported.

Dr Chua Sin Bin¹⁵¹

As the need to import frozen meat increased, capabilities of cold chain systems had to be further developed in tandem. This includes development in corresponding logistics, transportation and cold store infrastructure amongst others. These developments ensured that there were no breaks in the cold chain system, and played an important role to safeguard Singapore's food safety systems while facilitating Singapore's move to further diversify food imports.



A map of Singapore's major food sources. Diversification is one of the core strategies in the Food Security Roadmap.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Diversifying food sources, is complex; it goes beyond how many countries Singapore imports from. Upstream diversification is also a concern.

...say that I am buying vegetables from [many farms in the same region] then if I look backwards...you may find they all have the same source, say for the seeds. So that increases our vulnerability.

Tan Poh Hong¹⁵²

To mitigate the challenges of upstream diversification, food must come from different climatic conditions; from the northern and southern hemisphere, as well as from within the region and from further afield. This way, if one link in the value chain is disrupted, other sources can fill the gap. Industry development is necessary to ensure that small, medium and large importers all recognise this need and have the capacity to break into these new markets.

The facilitation of industry growth to meet strategic needs goes beyond the AVA to include other economic agencies: SPRING, IE Singapore, the EDB and MTI. To achieve such growth, agencies actively engage with industry stakeholders through business cluster meetings, to discuss potential new sources of food and food-related technology. Agencies also organise overseas sourcing and accreditation missions, to which industry stakeholders are invited to the former. Between 2012 and 2015, trips were organised to Myanmar, South Africa, Poland, Philippines, Denmark and Indonesia. These trips have been successful; for example, a trip to Indonesia in 2013 secured new import contracts of 30 metric tonnes of fish,¹⁵³ and another mission to South Africa in 2015 saw the satisfactory negotiation of imports of three containers each of persimmons and pomegranates.¹⁵⁴

Singapore has also taken steps to secure supplies of food items at their source. This allows for greater control of product quality, as well as first-right-of-purchase in times of supply crunch. The first initiative of this kind was a private sector-led, government-supported partnership with China on the Singapore—Jilin Food Zone, in 2012. The idea for the zone was mooted in 2008, after a bilateral meeting between Prime Minister Lee Hsien Loong and Chinese Premier Wen Jiabao, to continue diversifying food sources for Singapore, as well as to improve safety standards for Chinese consumers.¹⁵⁵ The Food Zone, which is twice the size of Singapore, produces pork, rice and other food items. The Zone has established an "Integrated Food Safety System", which has strict benchmarks for safety and quality, based on AVA's high standards. It is also certified as a Hand, Foot and Mouth Disease-free zone by both the Singapore and Chinese authorities. Its first product to the Singapore market, Fragrance 43°N Japonica rice, which is uniquely grown in temperate climates, was successfully imported in 2015.

Efforts were also made to raise awareness on food alternatives, for example, using liquid or powdered eggs instead of shell eggs. These are already used extensively in bakeries and commercial kitchens; however, they are not popular in homes. Powdered eggs can be stored for longer periods of time and thereby contribute to food resilience.

In all, as Singapore depends predominantly on food imports, diversification will remain a key policy to ensure food resilience.

“DON'T PUT ALL YOUR EGGS IN ONE BASKET”: LESSONS FROM THE AVIAN INFLUENZA OUTBREAK

Singapore experienced first-hand the importance of food source diversification, stringent emergency responses and food safety protocols when the supply of fresh hen eggs was disrupted, following the emergence of the Avian Influenza H5N1 virus on a poultry farm in Kelantan, Malaysia. A ban was imposed on all poultry products from Malaysia by the AVA, on 18 August 2004.¹⁵⁶

At that point, Malaysia supplied two-thirds of the eggs and half of the poultry consumed in Singapore. Consequently, the import suspension impacted Singapore's supply of fresh poultry meat and eggs, less so the former as there was an adequate supply of frozen poultry to overcome the shortage. Furthermore, importers increased their orders of frozen meat from the USA, Brazil and the Netherlands, when the ban was imposed.¹⁵⁷ These measures also helped to stabilise the prices of poultry meat in supermarkets, despite the ban.



Seng Choon egg farm today.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Singapore's dependence on Malaysia for hen eggs, however, meant that the ban resulted in a temporary shortage of eggs. Although there were other sources for import, these were more expensive, and would cause the price of eggs to rise sharply. This, in turn, would have a direct impact on consumers, many of whom relied on eggs for their daily protein intake. Local eateries that used eggs as part of their cuisine also suffered, with many being forced to change their menus to adapt to the shortage.¹⁵⁸ Local eggs, which used to cost between 13 and 19 cents before the ban, saw the price increase by 5 cents, twice. Australian eggs, which were brought in to address the shortage, were more expensive at 40 cents each.¹⁵⁹ At one point, egg prices spiked up to 70 cents per egg—triple the price that was prevalent before the ban.¹⁶⁰

Prices eventually stabilised some weeks later, as the AVA took measures to remedy the situation. It reviewed farms listed under the accreditation scheme and analysed Malaysia's response and management of the disease to identify areas unaffected by the disease. AVA resumed the imports of poultry and eggs from Malacca and Johor on 17 September 2004. Thanks to these measures, Singapore continued to be free of Avian Influenza.

The episode highlighted the need for food source diversification and the importance of stringent safety measures and emergency contingency plans. Since then, more attention has been paid to increasing the number of sources of hen eggs. The import of hen eggs has always been associated with high costs and strict accreditation processes, which limit potential source countries to a select few. However, in 2017, the AVA allowed for the import of hen eggs from Thailand, for the first time. Following satisfactory documentary evaluation, site inspections by the AVA, and laboratory results submitted by Thailand's Department of Livestock Development, two-layer farms were approved and accredited for export of table eggs to Singapore.¹⁶¹ The first shipment of 325,000 hen eggs from Thailand arrived in Singapore in April 2017. At the same time, measures were also put in place to increase local production of hen eggs, through use of the Agricultural Productivity Fund.

“DON'T PUT ALL YOUR EGGS IN ONE BASKET”: LESSONS FROM THE AVIAN INFLUENZA OUTBREAK

Continued...

In addition, the AVA also worked on improving its disaster management strategy, to reduce the impact of further disease outbreaks. For example, in 2005, the AVA and Malaysian counterparts established an agreement to establish Disease-Free Zones to facilitate the export of live poultry (chickens and ducks), poultry products and table eggs from Malaysia in the event of an outbreak.¹⁶² This meant that poultry could still be imported from unaffected areas if cases of Avian Influenza were detected in affected areas. The disease-free zones in Malaysia include Johor, Malacca, Negri Sembilan, Selangor and 2 zones [Zone A: Tg. Tualang, Kampar, Cenderiang and Zone B: Sg. Tinggi, Trong) in Perak.¹⁶³ Moving beyond blanket country bans and instead compartmentalising products by regions or zones meant that poultry could still be imported, even if isolated cases of Avian Influenza were detected in other areas.

As a result, during subsequent Avian Influenza breakouts, disruption in the supply of hen eggs to Singapore was minimal.

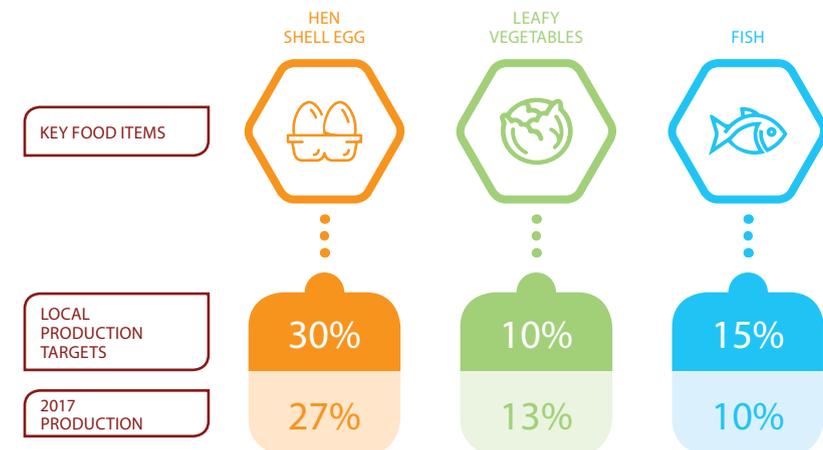
LOCAL FOOD PRODUCTION

Due to the many competing needs for land, Singapore was not able to devote large tracts of land for agricultural production. Even so, Singapore recognises the importance of local production of strategic food items to mitigate vulnerabilities and provide a crucial buffer in times of supply disruptions.

After the 2008 Global Food Crisis, the government reviewed Singapore's food vulnerabilities. The AVA identified three food items that Singapore could not easily diversify import sources of, and set local production targets for each. These were: leafy vegetables, food fish, and hen shell eggs, all of which have short shelf lives and therefore are more vulnerable to supply disruptions. As land remained limited, production increase was planned for through productivity enhancements.

Exhibit 3

Singapore Local Production Targets and Production Figures



FUNDING SCHEMES TO BOOST PRODUCTIVITY AND REDUCE LABOUR RELIANCE

In 2009, the AVA launched the Food Fund, to improve production capacities of local food farms by co-funding R&D in local food farming technology.¹⁶⁴ S\$31 million was committed over 3 phases, and the Food Fund supported 310 projects, 221 of which were related to farm capability upgrades.¹⁶⁵

In 2014, the Food Fund was replaced with the Agriculture Productivity Fund (APF), which farmers could apply for to undertake innovation or technological improvements. To date (May 2018), approximately S\$12.8 million has been committed under this scheme.¹⁶⁶ Funds from the APF have supported 115 projects. The APF continued to fund investments in farming technology, but on a reimbursement basis. To encourage more farms to take up APF Funding, the scheme was revised in April 2017, such that the AVA would disburse up to 30% of the approved funding quantum upfront, to facilitate the adoption of technology, which complements concurrent changes in land tenure to 20-year leases.¹⁶⁷ In 2018, further enhancements to the APF were made, increasing the co-funding quantum to \$2 million from \$700,000 for strategic food farms, and allowing farms to tap on the APF for test-bedding projects. These shifts in policies were intended to encourage farms to invest in new farming technology, making them more productive, which, in turn, would go towards the aim of reaching local production targets.

As the scheme gains traction in the years to come, it is expected that there will be notable take-up and disbursement of funds to farms. So far, the projects receiving the highest APF funding have been those that involve the purchase of advanced automated production systems. The size of grants depends on the nature and scale of the project. Generally, farms can receive up to 50% co-funding for basic capability upgrading, and up to 70% co-funding for productivity enhancements and R&D projects, depending on the different farm types.¹⁶⁸ Thus, the APF is a mechanism used by the AVA to encourage local farms to innovate and transform through investments in farming technology, with an aim to increase productivity and outputs.



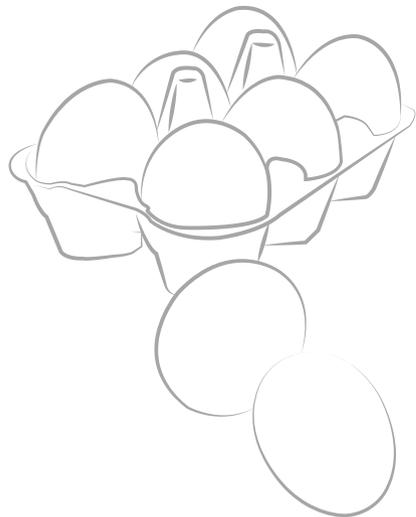
Senior Minister of State, Dr Koh Poh Koon engaging local farmers.
Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

One of the issues addressed under the funding scheme is that of shortage of labour. As fewer young Singaporeans are interested in traditional farming, securing an adequate labour supply has been a challenge, leading to farms' dependence on foreign workers. The use of technology and automation would be necessary to help farms reduce labour requirements. For example, a local layer farm secured funds under the APF to purchase robot cleaners. This technology brought down the layer house cleaning time by 25%-33%, and manpower requirements by up to 80%, reducing 5 jobs in the farm.¹⁶⁹ Another vegetable producer received support through the APF to purchase machinery and upgrade the farm's growing houses. This farm was then able to enjoy a 60% reduction in manpower for one of its processes and increase annual yield by 20%.¹⁷⁰

CHEAP BUT CHALLENGING: INTERVIEW WITH KOH SWEE LAI, SENG CHOON EGG FARM—PART 2

Most people are surprised when they realise that the cost of egg production has remained at approximately slightly over 10 cents per egg [毛多钱] for the last 40 years (excluding costs of packaging, transportation and retailers' mark-ups). But egg farming is very competitive. We face stiff competition from importers, who are sometimes able to sell eggs below cost because of surplus in supplies. Furthermore, strict regulations imposed by the government increases our costs—local farms are subject to higher standards than most of our overseas competitors. In addition, if our hens were to fail AVA's inspection, we would have to cull the hens at our own cost, without any form of compensation from the government.

To address this, we looked at multiple ways of keeping our costs competitive and adding value to our product. This includes selling eggs farm fresh, directly to retailers and food industries instead of going through the wholesalers. As I used to work in a feedmill, I know the importance of a good quality feed and its impact on the egg quality. Our feed is made in-house with premium ingredients. We have also increased productivity by increasing the number of automated processes within the farm, ensuring eggs are sent out as fresh as possible. Now conveyor belts bring feed to the hens and carry eggs and waste away from them. We also have robots to clean the coops. Of course, we still require a certain amount of manpower to operate.



So, if the price gap is small, we are still confident that we can compete based on the higher quality of our eggs. Our stringent quality checks ensure that the eggs leaving the farm are minimal of dirt, cracks and any form of defect. We have strict hygiene measures within the farm, because we believe that the chickens must be well-fed and kept healthy to produce good eggs. However, if the price gaps widen, we may no longer be able to compete.

Koh Swee Lai¹⁷¹



The robot pelletiser transfers egg cartons on to the pallet after eggs are packed (left) and Seng Choon's auto-egg grader runs at a packing speed of 126,000 eggs per hour (right).

Photos courtesy of Seng Choon Egg Farm.

GROUNDING FISH FARMS: LAND-BASED AQUACULTURE

In 2015, algal blooms in coastal waters resulted in the loss of approximately 500 tonnes of fish stocks in 77 fish farms across Singapore.¹⁷² With the advent of climate change and the consequent changes in ocean currents and temperatures, and the increasing frequency of severe weather events, coastal fish supply will become less reliable.

For more resilient fish supply, companies have now moved towards controlled environments, land-based aquaculture, and recirculation systems. These innovations have been shown to not only reduce the risk posed by algal blooms and climate-related disruptions, but are also proven to reduce water consumption.

One early adopter of land-based aquaculture, Apollo Aquaculture, maintains the aquarium environments at optimal conditions for fish growth year-round, and has reduced water consumption by up to 90%. In February 2017, Apollo Aquaculture opened a 12-hectare high-tech vertical fish farm in Brunei, in collaboration with His Excellency Pangiran Haji Kamarulzaman. The new farm features a multi-storey raceway system and packing facilities, and has a projected yield of 5,000 tonnes of grouper per year.¹⁷³

Forward planning by private companies such as Apollo, supported by government initiatives, facilitate quicker adoption of new technologies. This way, Singapore is able to achieve, and even exceed, its self-sufficiency targets of 15% of all fish consumed being produced locally, without requiring considerably more land.

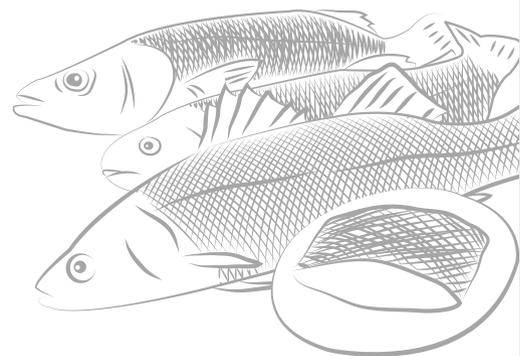


Opening of the Marine Aquaculture Centre in 2003. Located at St John's island, the centre was set up to facilitate the development and expansion of large-scale hatchery and fish farming in Singapore. It also included deep sea cages to rear fishes.

Photos courtesy of Agri-Food and Veterinary Authority of Singapore.

The AVA has also worked with industry stakeholders to develop closed containment aquaculture systems for coastal fish farms that mitigate risks from adverse environmental conditions.¹⁷⁴ Closed containment systems differ from conventional open net-cage farming through the use of water treatment technologies to improve the quality of incoming seawater before the seawater reaches the culture tanks that isolate fish from the external environment. AVA also set up the Marine Aquaculture Centre (MAC) located on St John's Island to develop large-scale hatchery technologies and build capabilities in the production of quality fish fingerlings for grow-out farms. In addition, the AVA, in collaboration with the Temasek Life Sciences Laboratory, worked together to develop genomic tools that identify Asian seabass carrying the right genetic variants for faster growth and lower susceptibility to diseases.¹⁷⁵ This form of selective breeding, which does not involve genetic modifications, can significantly improve farming yields.

These initiatives by the AVA ensured that local farms were transformed to function more efficiently, harnessing technology to maximise utilisation of limited farm land. Moreover, this also signalled that local production remained important.



REACH FOR THE SKIES: INNOVATION IN LOCAL FARMS

Research and technology has brought about considerable innovation in vegetable farming, particularly leafy vegetables, through greenhouse and indoor farming methods.

To intensify production on limited land, the AVA, in 2010, signed a Research Collaboration Agreement with local entrepreneurial farm Sky Greens, to develop a vertical farming prototype for leafy vegetables that is suited to the tropics. The efforts resulted in the development of the “A-Go-Gro”—a rotating vertical A-frame structure supporting trays of vegetables, based on a low-energy water pulley system, in 2011. The design maximised the benefits of climatic conditions in Singapore while offering yields of up to 10 times that of traditional land-based farming and generating up to 800 tonnes of fresh leafy vegetables per hectare, per year.¹⁷⁶ The innovation eventually earned Sky Greens the merit award in Singapore’s Urban Sustainability R&D Congress in 2011 and, more significantly, the coveted international INDEX: Design award in 2015.

In 2011, the company successfully applied for and received seed funding from SPRING Singapore, to scale up and commercialise “A-Go-Gro.” Later, it also successfully secured a grant from IE Singapore under IE’s Global Company Partnership Scheme, which allows concessions for intellectual property protection in certain countries. This aided in the internationalisation of Sky Greens.¹⁷⁷ Sky Greens’ system has also attracted the interest of global companies and is now being used in China and Thailand.

This, and other public-private collaborations, have bolstered innovations to find sustainable methods of improving yield and contributing to Singapore’s food security.



Sky Greens’ patented technology enables farming using methods suited to Singapore’s climate, while maximising limited land space.
Photos courtesy of Sky Greens.

MANAGING AGRICULTURAL LAND

In the early 2000s, land used for farming came under further review. It was decided that, given the fact that Singapore could rely on imports for food, there was little imperative to maintain lands for farming, in perpetuity.¹⁷⁸

At the same time, the large number of arrears in farm tenancies and leases resulted in the SLA changing its lease policy from payment of rental fees annually to upfront payment at the beginning of the lease. This resulted in the set-up cost of farm leases and tenancies going out-of-reach of all but the most prosperous farmers, discouraging new farming entrepreneurs.¹⁷⁹ These changes, and the lack of availability of long-term leases, led to difficulty in raising productivity of existing farms. Farmers were reluctant to invest in infrastructure improvements, due to the high risk of their leases not being renewed prior to full recovery of investment, coupled with difficulties in raising capital from financial institutions, due to lack of guarantees. As a result, the number of farmers and farms dwindled over time, further shrinking farmland area in the country.

In recognition of such challenges that farmers faced, and the need to encourage greater productivity for Singapore's long-term food security, in 2017, the SLA and the AVA worked together to establish 20-year leases for select new farm sites. This shift occurred in tandem with the recognition that local farming was important in supplementing food imports. To ensure all farmlands were not misused, the policy of farmland management was revisited. Productivity targets were tied to each new lease, to ensure that these farms contributed to Singapore's food security targets. This was a positive turn to better manage agricultural land.

Overtime, some agricultural land was rezoned and changed to other uses. Although some farms had to relocate as a result of land use changes, the AVA continued to work closely with affected farms and businesses by providing necessary assistance. For example, when the leases on 62 farms in Lim Chu Kang expired, they were not renewed. Instead, farms that wished to continue were given the option of bidding for alternate sites. Due to extensive land preparation works involved at these alternative sites and to make the transition to new farms smoother, AVA extended all 62 affected farms' leases temporarily. This provided them with sufficient time to bid for new land and to transit their operations.¹⁸⁰

The longer, 20-year lease tenure will provide more certainty to farms and enable them to invest in intensive, highly-productive technologies that operate on minimal manpower.

Tan Poh Hong¹⁸¹

TENDER OF NEW AGRICULTURAL LAND

In August 2014, the AVA and NParks announced new agriculture and landscape nursery policies. The new agricultural policies involved the use of at least 90% of land for production, and set minimum production level requirements.

In June 2016, following feedback and consultations with farmers on the lease tenure, the AVA reviewed its policy and announced that new agricultural land would be tendered out as 20-year leases, instead of in 10-year blocks. The 20-year tenure provided more time and certainty to farmers, enabling them to be commercially viable, given the AVA's push for farms to invest in intensive, highly-productive farming technologies.

In May 2017, the AVA announced that 36 plots of farmland in Lim Chu Kang and Sungei Tengah, totalling about 60 ha, would be tendered out in tranches from August 2017 onwards. These new plots provided farms with expired leases, or those that were affected by Government's redevelopment plans, the option to bid for alternative sites to continue farming on. In a departure from past tender practices, where agricultural plots were awarded to bidders with the

highest bid, these plots would be tendered under "fixed price" and "concept & price" tender mechanisms. The new land tender mechanisms and evaluation criteria signalled the importance of high productivity, and tenders were awarded to the best concepts, rather than on bids alone. The proposals would be assessed by an evaluation committee comprising agencies and external experts based on the following evaluation criteria:

- Production capability—Ability to achieve high production levels
- Innovation and sustainability—Ability to use innovation to improve and sustain production, and maintain business viability
- Production track record—Ability to achieve projected production levels based on past performance
- Relevant experience and qualification—Ability to deliver results

The AVA has since launched tranche 1 (vegetables) and tranche 2 (food fish) of the agricultural land sales schedule. The results for tranche 1 and tranche 2 were released in February 2018 and April 2018 respectively, and 10 vegetable land parcels were awarded to 8 companies, while 3 food fish land parcels were awarded to 2 companies. These companies had submitted proposals that incorporated productive and innovative farming systems, including greenhouses with automation and smart controls, multi-tier hydroponic systems using LED lights and data analytics to optimise growing conditions, multi-storey farms that use automated soilless cultivation system and robotics for vegetable farming, as well as Recirculation Aquaculture System technology with bio-filtration, and multi-storey facilities with automated fish pumps and advanced water treatment processes for food fish farming.

REDUCING FOOD WASTE

Another key component in ensuring Singapore's food security is the need to tackle food waste. In 2016, Singapore generated approximately 791,000 tonnes of food waste, equivalent to approximately 130 kg of food waste per capita. Of this, 14% was recycled.¹⁸² Food waste has increased by 48% since 2005 and is expected to continue to grow, due to population increase and greater affluence. Educating the public to better manage food waste is one of the supporting policies in the Food Security Roadmap. This ensures a more holistic approach to food resources, with little waste. To address food waste, the NEA, AVA, and SPRING have developed guidelines for food manufacturers and retailers to identify areas of waste in the supply chain. The NEA facilitates innovations to reduce food waste through its 3R (Reduce, Reuse, Recycle) Fund, which takes a four-pronged approach to food waste management.¹⁸³

- Strategy 1: Prevent and Reduce Food Wastage at Source
- Strategy 2: Redistribute Unsold/Excess Food
- Strategy 3: Recycle/Treat Food Waste
- Strategy 4: Recover Energy

The AVA also collaborates with tertiary organisations in its Post-Harvest Technology Centre (PHTC), on projects to reduce food wastage, such as:¹⁸⁴

- Improving packaging and thereby extending shelf life all along the food chain through:
 - Nano-composites packaging materials to reduce food spoilage due to oxygen, moisture and UV.
 - Modified Atmosphere Packaging for specific foods, such as threadfin fish.
 - Non-invasive, cost effective stick-on sensors for fruit ripeness to better control food distribution based on fruit quality.
- Food preservation techniques, such as light-emitting diode (LED) treatment for vegetables, or advanced cold chain technologies.

The PHTC has also worked on the conversion of homogenous waste from the manufacture of food items to other edible or productive purposes. Examples of this include, the conversion of soy bean waste to Okara floss for human consumption and the use of fish trimmings for fish food.

A holistic means of achieving food resilience also involves the need to manage food waste at a household and individual level. This includes reducing the amount of waste produced, through public education, mainly under the purview of the NEA. One such initiative undertaken by the NEA was a campaign to encourage the adoption of smart food purchase, storage and preparation habits, which could help consumers save money while reducing food wastage, at source. Another programme was the Love Your Food Recipe Contest in 2016, that encouraged the public to submit creative recipes that made use of common types of leftover food. To target the youth, the NEA launched the Love Your Food @ Schools project, which introduced a closed-loop food waste management system at 10 participating schools.¹⁸⁵

The NEA also complements these measures by encouraging both organisations and individuals to sell their unsold/excess food to food distribution organisations. Unsold and/or excess food can be delivered to two not-for-profits, Food Bank Singapore or Food from the Heart, where it is packed and distributed to needy households. These initiatives have been successful: Food from the Heart's Bread Programme regularly collects about 28,000 kilograms of bread every month, which is then redistributed to beneficiaries from welfare homes, senior citizen activity centres, self-collection centres and to needy families island-wide, daily.¹⁸⁶ Under the inter-Ministry Committee on Food Security, a Food Wastage Reduction working group co-chaired by the NEA, the AVA and representatives from agencies like the EDB and MEWR,¹⁸⁷ worked with stakeholders such as food manufacturers, hawkers, hotel operators, retailers and non-governmental organisations to better understand the factors contributing to food wastage.

DELIVERING AFFORDABLE, HYGIENIC COOKED FOOD AND FOOD ASSISTANCE

Achieving food security involves the provision of both affordable and hygienic cooked food. One of Singapore's unique features is the availability of affordable cooked food through its hawker centres. Before independence, more than 40,000 hawkers sold cooked street food along the banks of the Singapore river and at other gathering spots. Being on the street, food was often prepared in unsanitary conditions, causing health and environmental concerns. Moreover, the improper disposal of food waste exacerbated hygiene problems in already unsanitary living conditions. A licensing scheme was introduced in 1966, and again in 1973, to better control the sector.

During the 1970s and 1980s, hawkers were gradually relocated to purpose-built hawker centres situated in the central business district and new housing towns. Hawker centre stalls, which were equipped with clean piped water, electricity, and tables and chairs, ensured that street hawkers could continue to make a living and provide a variety of affordable food to the general public. Stall owners were educated on sanitary and hygienic practices.

The hawker centres fall under the purview of the Environmental Public Health Act and are managed by the Hawker Centres Division, in the NEA. As of 2017, there were 107 public hawker centres and markets all over Singapore.¹⁸⁸ In addition, privately-owned hawker centres, such as NTUC's FoodFare, which owns 24 hawker centres throughout the country, are also prevalent.¹⁸⁹

As Singaporeans eat regularly at hawker centres, with an average of 37% of their food budget spent on hawker food, these centres are an important aspect of Singapore's food security. This is particularly so for the lower-income quintile group, which spends approximately 44% of total food expenditure on food from hawker centres.¹⁹⁰ Prices are kept affordable by increasing the supply of government hawker centre stalls by building new centres, ensuring that stalls are personally-operated, without the practice of subletting and, finally, by abolishing the concept of reserve rent. Reserve rent tends to result in the rejection of bids of less than 85%

of the assessed market rent. Doing away with the practice of reserve rent keeps stall rentals down and, as a result, prices at these stalls affordable.¹⁹¹ A full meal at a hawker centre stall typically costs between S\$3 to S\$6. NTUC FoodFare keeps prices affordable by incorporating a price cap on basic dishes.¹⁹²

The continued popularity of hawker centres has made them a Singaporean cultural icon, loved by residents and tourists alike.

Hawker centres are a great social leveller in Singapore, a place where people of different races, religions and cultures can mingle, and rich and poor equally queue up for their favourite dishes. They are emblems of our country, spaces we remember when we are away. Hawker centres also provide a unique experience for visitors to Singapore, increasingly recognized as a food destination.

Simon Tay, Former Chairperson of the National Environment Agency¹⁹³

In addition, Singapore maintains food security by providing assistance to lower-income families, for example, through the distribution of NTUC FairPrice vouchers. In 2012, NTUC FairPrice foundation handed out approximately \$1 million worth of food vouchers to 20,000 low income families and individuals.¹⁹⁴ This initiative was in view of the fact that in a volatile food market, food prices can spike in times of shortage. Such volatility would affect lower-income individuals and households disproportionately, as these groups tend to spend a larger proportion of their income on food.¹⁹⁵

PLANNING FOR CONTINGENCIES

Food security planning extends to ensuring that food is secure, even in times of contingencies. To this end, Singapore regularly conducts exercises to simulate crisis conditions, to better prepare agencies for unexpected disruptions. As a result, the 2003 SARS outbreak did not cause any major disruption in food supply, due to the AVA's swift disaster management.

REDUCING FOOD DISRUPTIONS IN UNEXPECTED TIMES: THE CASE OF SARS



Severe Acute Respiratory Syndrome, or SARS, entered Singapore in February 2003.¹⁹⁶ The Ministry of Health invoked the Infectious Diseases Act in March, to quarantine persons who had contact with SARS patients.

One of these patients was a vegetable salesperson who worked in Pasir Panjang Wholesale Market, Singapore's main vegetable and fruit wholesale market. He infected three others. The Ministry of Health, working with the National Environment Agency (NEA), ordered the shutdown of the market and the quarantine of all 240 stall holders and direct employees for 10 days. In total, the market was closed for 15 days.

This meant the disruption of fruit and vegetables supplies across the country. However, through coordination amongst agencies and stakeholders, this disruption was overcome. As Tay Thiam Back, Chair of the Fruits and Vegetable Importers and Exporters Association, recalls:¹⁹⁷

It was a Saturday night around 9pm, and a lot of vegetable imports were coming into the market. I negotiated with the health authorities to allow those trucks, which had not yet unloaded their vegetables to leave the market. That

night, I stayed back until 2.30am to discuss the arrangements with the various shop owners and authorities, and the health authorities and AVA initially informed us that it would take 3 days for them to disinfect the whole market, which was stocked full at that time. It has a huge effort – I had to communicate with the traders, with the AVA and MOH; many of the shop owners were so stressed they didn't even lock their shops. The manager of the wholesale centre, Mr Teng, couldn't go home at all and stayed at the centre during the entire close-down period.

During this (eventually 15-day) period, I acted as liaison person between our AVA contact and the stall owners. My phone rang from morning till night: there was so much coordination to do that it was challenging to even find time to eat meals! The vegetable sellers had to find people who were not under quarantine to enter the market, clean up their rotting goods, pick up important documents, and even feed their pets! Of course, those people would also be placed under quarantine once they left the market.

The closure affected businesses, impacting incomes. Some customers changed suppliers and started importing directly from farms. Fortunately, assistance was provided to manage the losses, for example, through discounts on electricity bills. The Port of Singapore Authority (PSA) allowed the storage of produce containers at the port for free, when imports were not allowed into the market. This helped to mitigate the adverse impact on the fruit and vegetable traders.

ADOPTING AN INTEGRATED FOOD SAFETY APPROACH

In this era of greater globalised trade and technology, Singapore's food safety system has kept up with global standards. Singapore enjoys one of the lowest incidences of food-borne disease outbreaks, compared to the rest of the world. This is despite the fact that more than 90% of all food consumed here is imported. Singapore's stringent food safety regulations play a crucial role to ensure that only approved food items are allowed through Singapore's land, sea and air ports, which are managed by the Singapore Port Authority, Changi Airport Services and Singapore Customs.

For example, following the Fukushima nuclear disaster in 2011, which was believed to cause radioactive contamination of food, AVA allowed food imports from all Japanese prefectures except Fukushima and its surroundings. AVA implemented a series of import control measures and surveillance testing on these imports. In addition, all foods had to be accompanied by pre-export testing certificates and Certificates of Origin (COO). After conducting tests on radioactivity of food samples over the next 3 years, Singapore further lifted restrictions in 2014 to allow approved food items from Fukushima, with the exception of food from the vicinity of the nuclear power plant.¹⁹⁸

Further, shipments are randomly tested at port and on shelves to monitor food safety standards. Samples are tested at AVA's Veterinary Public Health Laboratory (VPHL), which offers state-of-the-art food safety hazards and risks testing facilities, including:¹⁹⁹

- The use of nuclear techniques to trace foods to its origins. This includes Isotope Ratio Mass Spectrometry, Inductively-coupled Plasma Mass Spectrometry, and Inductively-coupled Plasma Atomic Emission Spectrometry. This capability can be used as a verification tool to determine food supply-chain integrity and food traceability systems.
- Non-targeted analytical tests and molecular characterisation, to identify rare or unanticipated compounds in foodstuffs that may be hazardous to health.
- Nano-material testing, to ascertain the safety of the more complex and technologically-advanced foods.

These food testing capabilities are complemented by a robust monitoring system. Authorities look out for potential food concerns through regular monitoring of international news and by participating in international agencies and set-ups, such as the United Nations Food and Agriculture Organisation (FAO), ASEAN Integrated Food Security Framework (AIFS) and the Strategic Plan of Action on Food Security (SPA-FS).



Live poultry and meat imported into Singapore are subject to food safety checks, ensuring that only approved food items are allowed through Singapore's land, sea and air ports.

Photos courtesy of Agri-Food and Veterinary Authority of Singapore.

In addition, the AVA also facilitates trade through the provision of export health certification services to the food industry. For example, the Food Safety Award, which recognises food businesses, that have consistently maintained high standards of food safety. This way, food safety practices were not only rewarded, but also shared with others in the sector.

One of the benefits of having a good reputation in food safety is the resultant branding. Food manufacturers from Singapore, who satisfy AVA's high food standards, often face less scrutiny at destination ports, contributing to their competitive advantage. This situation did not come about easily, as it took a long time to get local food manufacturers on board with the idea of food safety standards and accreditations.



Food Safety Exhibition 2007. AVA's food safety mascot, Oscar, is part of a range of community outreach programmes to educate the public on the importance of food safety habits.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

Initially, it was very difficult. Every year, I had to face MTI, the [National] Productivity Board, SISIR (Singapore Institute of Standards and Industrial Research) and others because of complaints that we [PPD] were very tough, that we were not pro-export, [that we were] creating a lot of obstacles. But the good ones [manufacturers] saw the advantage of having a high food safety standard. Our certificate is highly valued by the importing countries; you can't buy it with a packet of cigarettes.

Dr Chua Sin Bin²⁰⁰

FINDING NEW OPPORTUNITIES: THE TASKFORCE ON URBAN FARMING

As Singapore develops further, more mechanisms are put in place to ensure that Singapore is able to tide over global fluctuations in food supply and prices. Despite the scarcity of land, technological innovations, particularly in hydroponics, lighting, climate control and seed improvement, have enabled the formation of urban farms, driving a return towards local produce as a means to supplement imports. A Taskforce on Urban Farming (aptly called "TURF"), chaired by the MND's Infrastructure Division and consisting of representatives from the AVA, EDB, HDB, NParks, PA, SLA and URA²⁰¹ was set up to study the space and technology potential, and the regulatory approach to facilitate more urban farming.

In 2013, MND's Infrastructure Division led an inter-agency delegation to visit New York City and a few cities in Japan to survey their models of urban farming and chart out the next steps in reorienting idle urban spaces such as rooftops in Singapore for farming, with a focus on increased community outreach and the use of technology to maximise outputs.

The TURF identified key challenges, including the need to improve the urban farming value chains, reduce regulatory barriers that impede community farming, and establish support structures to enhance community farming. While individual and community models of urban farming were not likely to raise Singapore's overall food supply, they would add resilience in times of food supply disruption. The TURF encouraged agencies to think creatively about how to allow unutilised spaces in housing estates (e.g. rooftop spaces) and parks to promote community farming. For vacant State land and buildings, there is also potential to allow shorter leases for commercial farming with portable systems which could be redeployed when the land is required for future development.



An inter-agency study visit was organised to New York City in 2013 to survey their models of urban farming.

Photos courtesy of Ministry of National Development.

As planners, as policymakers, we look forward: what are the opportunities, what are the needs? We could be more creative in the use of space, more efficiently use space. There's always this concern about food security, just like your water supply—the Four Taps. With food, we could have something like that.

Lim Chee Hwee, Senior Director, Ministry of National Development²⁰²

The Taskforce worked to identify and execute pilot projects showcasing the benefits of urban farms, providing a platform for agencies to discuss possibilities and ideas, including more flexible application of commercial farming regulations for the community farms.

The Citizen Farm at Jalan Penjara was a successful pilot project that stemmed from the efforts of the Taskforce. This sustainable model of urban farming was piloted on an unused plot of land in the housing estate of Queenstown, and was the result of a lot of coordination amongst the agencies involved, including the SLA, for leasing the land, and the AVA, for regulating the agriculture produce.

A NEW ERA OF FOOD PRODUCTION IN SINGAPORE: AGRICULTURE SECTOR TRANSFORMATION

Moving forward, it is clear that Singapore's farms have to explore innovations in food production, such as in indoor, multi-tier farming automation and precision agriculture via sensors and the internet of things, in order to raise local production in a resource-restricted environment.

In the Committee of Supply (COS) debate in April 2016, Senior Minister of State, Dr Koh Poh Koon announced plans to transform Singapore's agriculture sector to raise local production.²⁰³ The agriculture sector is envisioned to consolidate and intensify their operations, ensuring more productivity and maximisation of manpower resources. Space remains a concern for the agriculture sector and thus, there is a need to maximise the use of technology to produce food with less space. More so, agrotechnology could be marketed as a Singapore—brand solution to other cities facing similar issues.

Singapore can carve a niche in urban solutions by becoming a living lab for food production technologies, just like what we've done for water recycling and desalination—turning a disadvantage into something we can be proud of.

Dr Koh Poh Koon, Senior Minister of State, Ministry of Trade and Industry and National Development²⁰⁴

To spur farm sector transformation and chart out the future of the agriculture sector in Singapore, in March 2017, the Farm Transformation Map (FTM) was unveiled. The FTM comprises 4 key thrusts: 'Space' thrust focuses on ways to create and make more efficient use of space. This ties in with 'Innovation' thrust, which covers R&D on ways to grow more with less and to translate research into commercially viable farming solutions and to help farmers to adopt technologies. 'People' thrust defines strategies to build a future core workforce. These include working with Institutes of Higher Learning to increase the awareness of farming among students and job seekers through Earn and Learn Programmes and internships. 'Eco-system' thrust defines the strategies to create an enabling environment for the agriculture sector to thrive, and to produce for both the local and international market.

To better assist the farms in their transformation, the Account Manager Approach was introduced. Each farm is assigned an account manager who provides advice on business development, technology adoption and financial assistance as well as to facilitate farmers' interaction with AVA and other agencies.

The government also works closely with the industry through the Singapore Agro-Food Enterprises Federation (SAFEF), an industry-led, not-for-profit organisation representing agro-food enterprises in Singapore. SAFEF, as the pinnacle body for the food farming sector, harnesses the collective effort of industry players to address common challenges related to policies, infrastructure and agri-trade matters.

The transformation of the agriculture sector is one way to enhance Singapore's food security in the longer term. Efforts to intensify local agriculture will help to supplement food imports, as the AVA continues to diversify food sources and find new ones. These measures will ensure that Singapore remains a food paradise in the years to come.



Intensive and indoor farming technologies are being actively developed internationally; Senior Minister of State Dr Koh Poh Koon visited one such farm during a study trip to Japan.

Photo courtesy of Agri-Food and Veterinary Authority of Singapore.

A MODEL OF FARMING: THE CITIZEN FARM

Set up under the Edible Garden City group, a sustainable urban farming model—the Citizen farm—was piloted in the housing estate of Queenstown, in 2016. With the help of the Urban Farming Taskforce and the SLA, a dilapidated, abandoned former prison along Jalan Penjara, with an 8,000 square meter plot of land, was sourced. Aptly named the Citizen Farm, the model was designed to be a closed-loop urban farming system that integrated natural systems with modern technology.²⁰⁵ Beyond its use of technology and innovation, the farm had in its foundations a social enterprise model, with an aim of connecting communities through farm spaces. Smaller start-up technologies and innovations were encouraged in the farms. These included indoor microgreen harvesting, mushroom farming, insect farming and an indoor fish farm, amongst others. In this way, the dilapidated, abandoned former prison was transformed into a thriving urban farming model.²⁰⁶

The development of the Citizen Farm not only showcased the viability of small-scale urban farming set-ups in Singapore, but also highlighted the potential to convert underused, marginal land for interim purposes. Moreover, these farming models are designed to be moveable and therefore, can be easily adapted to various spaces. Such set-ups could help to supplement local food production. In addition, these set-ups also provide much-needed spaces for start-ups to explore innovations in agrotechnologies. Sometimes, creativity and flexibility goes a long way in maximising the potential of underused spaces.



Set up under the Edible Garden City group in 2016, the Citizen Farm piloted closed-loop urban farming systems.

Photo courtesy of Edible Garden City.

**CONCLUSION:
THE WAY FORWARD —
FEEDING SINGAPORE IN
THE YEARS TO COME**

“ We have a mission to achieve that is as crucial as water—and that is to strengthen our food security in an era of global food uncertainty.”

Dr Koh Poh Koon, Senior Minister of State, Ministry of Trade and Industry and National Development²⁰⁷

Food and The City: Overcoming Challenges for Food Security chronicles the nation's journey towards achieving food security through sound policies and governance reforms. Given crucial national needs to develop industries and housing in the post-independence era, the government had to gradually phase out agricultural land, to free up limited space. These were difficult decisions that affected the livelihoods of many farmers, but were necessary in those circumstances. Nevertheless, these instances serve as lessons to civil servants on the need to balance trade-offs and to communicate government's intent and policy decisions sensitively and in a timely manner. In addition, these early-day challenges highlight the importance of prioritising problems and issues.

Today, less than 1% of Singapore's land is used for agriculture. This means that moving forward, food needs cannot be met locally, and Singapore will have to tap on the global food market. Notwithstanding the vulnerabilities posed by global fluctuations in food supply and prices, the strategies the government have pursued so far have served us well. Singapore's food supply has remained resilient, even during periods of supply disruptions in the region. Singapore also has a vibrant food manufacturing industry that benefits from our strong logistics infrastructure.

As Singapore's population continues to grow,²⁰⁸ the demand for food will grow apace. Apart from quantity, consumers also demand food that is safe and also of a better quality, as well as a wider variety to choose from. Global factors like climate change, increasing demand for food would also add pressure on food supply for Singapore. Singapore will need to continue to innovate and find new ways to mitigate the risks of food supply disruption and price fluctuations. The various ways forward to ensure continued food security is therefore of prime importance.

REAPING OPPORTUNITIES FOR THE FUTURE

Singapore is not generally thought of as an agricultural nation. As a small island, we have never had enough land to accommodate large scale traditional farming... We recognize our vulnerability to factors like climate change and disease outbreaks, which can result in food supply shocks. Fortunately, modern technology is opening up new opportunities for small countries like us. In particular, advances in indoor agrotechnology make it possible to produce significant amounts of food without delegating huge amounts of land and labour.

Dr Koh Poh Koon²⁰⁹

The future of food would be dependent on constant innovation and scientific advancements, amongst other efforts that will help to strengthen local production. More importantly, as Singapore grows, the agriculture sector has to explore ways to maximise the potential of scarce land, while functioning more effectively. With smart governance, policies and innovation, Singapore can retain its high levels of food security, well into the future.

The government will have to continue to work closely with the industry and other stakeholders to harness the opportunities arising from the food and agri-tech industry, as the farming industry evolves to resemble manufacturing (i.e. more efficient, automated and sustainable).

Beyond high-tech agriculture production, there is scope for the government to tap on existing competencies to grow other higher value parts of the value chain such as agriculture inputs, farming systems and logistics.

This clustering strategy – to bring related companies and industry players together is not something new, we have done it before in our history. In the 60s, we developed Jurong Industrial Estate and we became a manufacturing base. Later, we expanded into Jurong Island, and we created Jurong Island, and made Singapore a chemicals hub. We built Biopolis and we developed our biomedical science industry.

Time and again we have done this by creating the infrastructure, bringing in companies, growing our own companies, and building a new industry. In fact, we did this for water too. We all know that we are water scarce, limited in our own supply, and we are dependent on others for water. But by developing the water treatment and management industry, we are now a recognised centre for water in the region, and even in the world.

There is potential for us to do the same for food in Singapore, to bring our farmers together, our stakeholders and food producers together, grow and increase productivity significantly, and leverage on new technologies. By expanding this sector, we not only enhance our food security, but we also develop a new growth industry that can create jobs for Singaporeans.

Lawrence Wong, Minister of National Development²¹⁰

Production of primary food aside, unconventional innovations, such as culturing meat and animal products in laboratories, and the use of insect protein are emerging as options. Such alternative proteins are possible substitutes to traditional forms and can be produced sustainably and efficiently, and would also satisfy consumers' nutritional requirements. As traditional food systems are threatened by climate change and other global pressures, food produced using technologies such as synthetic biology and cellular agriculture may well prove crucial to the 21st century diet. However, public acceptance may prove a challenge, as preference for familiar foods, consumer perception of these future foods and a lack of information about them are likely to impede their adoption.

[Singapore's food security] challenges will always be there, and the question remains: Are we able to shape public perception and garner their acceptance, so that these foods will have a proper future and can be sustainable?

Tan Poh Hong²¹¹

In an ever-changing environment, food security will require cooperation and coordination. The AVA and other government agencies will have to continue to work closely with the industry and consumers, while developing robust, scientifically-backed policies to address food security challenges, at the same time. Future initiatives could also include measures such as increasing the public's resilience to food supply disruptions, either by encouraging stockpiling of food in homes or by shaping consumers' willingness to switch to substitutes, in times of shortage. This would also include the need to consider issues of food waste and devise the right public campaigns to educate the masses on need to reduce food waste.

History has showcased Singapore's ability to adapt to changing circumstances and overcome new challenges. Singapore's agriculture sector has evolved over time through efforts to optimise, adapt and strengthen food security, but potential remains to do more, particularly in coming times. With the rapid progression of food and agriculture technologies, and an increasing global demand for food, this is the opportunity for Singapore to emerge as a forerunner in sustainable urban food solutions, while fully meeting local food needs. An integrated urban systems approach would be necessary to overcome land constraints, while maximising land use. Moreover, it is important that the government continues to work closely with all stakeholders involved as it transforms the agricultural sector. Such measures would ensure that there is no trouble in this food paradise in the years to come.

FOOD AND THE CITY: OVERCOMING CHALLENGES FOR FOOD SECURITY

1959

- ▶ Formation of the Primary Production Department (PPD). Merged the five Divisions:
 - 1) Agriculture
 - 2) Veterinary
 - 3) Co-operative
 - 4) Fisheries
 - 5) Rural

1965

- ▶ Singapore's inaugural Agricultural Show. Showcased Singapore farmers' capacity to produce a variety of vegetables, fruit, livestock, eggs etc. To acquaint the urban population with the activities of the farmers and fishermen.

1968

- ▶ Introduction of farm licensing. Provided essential data on agriculture in Singapore; licences were kept affordable at \$1 to ensure easy availability to all.

1965/66

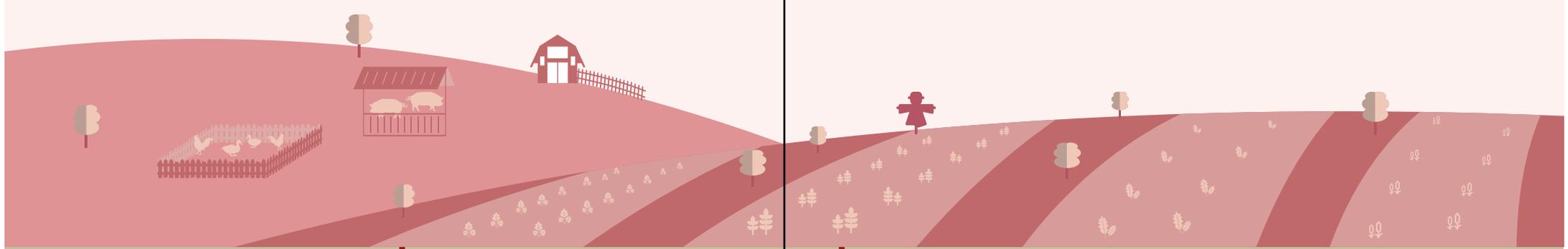
- ▶ Farm school established. Set up at the Sembawang Field Experimental Station to provide formal training in animal husbandry, horticulture, and freshwater fisheries to the next generation of farmers.

1969

- ▶ A Marine Fisheries Research Department was established. Set up to retrain fishermen (local and regional) to switch from inshore to offshore fishing and build the next generation of fishermen. The Department as boosted in 1971 through a joint venture with United Nations Development Programme (UNDP).
- ▶ Opening of the Jurong Fishing Port to facilitate diversified fish imports.

1950s

1960s



1971

- ▶ The administrative building for Pig and Poultry Research and Training Institute was completed. It enhanced scientific capabilities in livestock management, disease management, vaccine production, horticulture, value addition and quality control.

1975

- ▶ Kranji River was converted into a reservoir. Polluting industries such as pig farms had to be resettled elsewhere to reduce contamination.
- ▶ Development of an intensive pig-farming estate in Punggol.

1973

- ▶ Agricultural Census conducted jointly by the Research & Statistics Unit of the Ministry of National Development, National Statistical Commission, and Primary Production Department.

1977

- ▶ The production of pork, chicken, and hen eggs had reached 104%, 80% and 100% respectively, as a result of improved farming techniques.
- ▶ Pig farming was prohibited in the Kranji catchment area.

1974

- ▶ Singapore's food safety regulations met Japanese health requirements for import of meat. This earned the Republic a place in the approved list of countries allowed to export meat products to Japan.
- ▶ Economics Unit set up in PPD. To build up market intelligence on production, prices and marketing of certain foodstuffs and feedstuffs in both the local and world market.

1979

- ▶ Establishment of the Veterinary Public Health Centre (VPHC), with UNDP assistance to develop a comprehensive food testing laboratory.



1983

- ▶ Opening of the first phase of the Pasir Panjang Wholesale Centre. The centre served as a main distribution point for fruits and vegetables, ensuring quality control and affordability.
- ▶ Announcement of pig farm phase out.

1985

- ▶ PPD launched the 5-week long "Eat Frozen Pork" education campaign. To dispel common misconceptions on frozen pork and promote its consumption over fresh pork.

1986

- ▶ Establishment of Agrotechnology Parks.

1989

- ▶ Last pig farm phased out.
- ▶ Singapore Customs introduced TradeNet, the national single window for trade declarations. Singapore Customs, AVA, NEA and others can monitor the movement of food products to enforce health, safety and other regulatory requirements.

1990

- ▶ Establishment of the Hog Auction Market. Integrated an innovative electronic system, was crucial in keeping prices stable and to ensure the continued affordability of pork.

1999

- ▶ Ban on the import of pigs from Malaysia due to Nipah virus.

1970s

1980s

1990s



2000

- ▶ Establishment of the Veterinary Public Health Laboratory and the Animal and Plant Health Laboratory. To strengthen Singapore's ability to deal with emerging threats, and to position the two laboratories to serve as regional reference centres for food safety, and for animal and plant health.
- ▶ Restructuring of the PPD into a statutory board, the Agri-Food and Veterinary Authority (AVA). To respond to: 1) emerging diseases and food-borne hazards, 2) resilient supply of safe food, 3) R&D in agri-biotechnology, 4) gearing up for the future.
- ▶ Establishment of the Marine Aquaculture Centre at St. John's Island (Officially opened in 2003). To boost marine aquaculture development in the region by spearheading technological developments in marine fish breeding and fry production.

2001

- ▶ Successful R&D development in
 1. Deep netcage fish farming
 2. Vacuum dried shrimps
 3. Seed plug transplanting system.

2003

- ▶ Transfer/Integration of the Food Control Division, formerly of the Ministry of Environment, to the AVA. To rationalise food safety functions into one seamless operation.
- ▶ Closure of Pasir Panjang Wholesale Centre due to the detection of SARS in a worker from the Centre. Short term disruption of vegetables available in markets.
- ▶ AVA introduced the Food Safety Partnership scheme. To provide friendly competition and recognise the efforts of food manufacturers, importers, supermarket operators and retailers.

2008

- ▶ 2008 global food crisis. The Consumer Price Index (CPI) for food in Singapore spiked by 7.8% between 2007-08.

2009

- ▶ Launch of the first tranche of the AVA's Food Fund to diversify food sources and raise local production. Replaced with the Agriculture Productivity Fund (APF) in 2014.

2012

- ▶ Opening of commercial vertical farm, Skygreens, a successful collaboration with AVA's R&D. The new system had the potential to increase certain vegetable yields by five times.

2013

- ▶ Launch of the Food Security Roadmap.

2014

- ▶ World Organisation for Animal Health (OIE) endorsement of the Veterinary Public Health Centre (VPHC) as Southeast Asia's first OIE Collaborating Centre for Food Safety, serving the Asia and Oceania region.
- ▶ Changes to tender process for agricultural land. The new agricultural policies involved the use of at least 90% of land for production, and set minimum production level requirements.

2015

- ▶ NEA Campaign "Waste Less, Save More" to reduce food wastage at source. Encouraged the adoption of smart food purchase, storage and preparation habits that can help consumers save money.

2017

- ▶ Singapore ranked the 4th most food secure country in the Global Food Security Index formulated by the Economist Intelligent Unit.
- ▶ Farm Transformation Map was unveiled. To spur farm sector transformation and chart out the future of the agriculture sector in Singapore.

2000s

2010s

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APPENDIX A

Governance Tools for Food and the City: Overcoming Challenges for Food Security

(I) Legal Instruments

Legislation	Description
Agri-Food and Veterinary Authority Act	The Act is to establish the Agri-Food and Veterinary Authority, to provide for its functions and powers, and for matters connected therewith.
Animals and Birds Act	An Act for preventing the introduction into, and the spreading within, Singapore of diseases of animals, birds or fish; for the control of the movement of animals, birds or fish into, within and from Singapore; for the prevention of cruelty to animals, birds or fish; for measures pertaining to the general welfare and improvement of animals, birds or fish in Singapore and for purposes incidental thereto.
Control of Plants Act	An Act to consolidate and amend the law relating to the cultivation, import and export of plants and plant products, the protection of plants and plant products against pests and diseases, the control of the introduction of pests into Singapore, the use of pesticides, the measures pertaining to the development and improvement of the plant industry in Singapore and for purposes connected therewith, and to repeal the Agricultural Pests Act (Chapter 5 of the 1985 Revised Edition), the Controlled Plants Act (Chapter 59 of the 1985 Revised Edition) and the Export of Plants (Control) Act (Chapter 101 of the 1985 Revised Edition).
Fisheries Act	An Act for the protection and conservation of fisheries, and to make provision for the control of fishing, the control of the marketing and distribution of fish and the use and control of fishing ports and harbours, for measures pertaining to the general welfare and improvement of the fishing industry in Singapore and for purposes incidental thereto.
Feeding Stuffs Act	An Act to provide for the control of feeding stuffs for animals and birds.
Price Control Act	The Ministry of Trade and Industry introduced a rice importer licensing under the Price Control Act. A condition of the licence was that all traders were required to stockpile 2 months' supply of rice, at designated government warehouses.
Sale of Food Act	An Act for securing wholesomeness and purity of food and fixing standards for the same; for preventing the sale or other disposition, or the use of articles dangerous or injurious to health; to provide for the regulation of food establishments.
Water Pollution Control and Drainage Act	An Act to make provision for effectual drainage of inland areas and for maintaining or restoring the cleanliness of rivers and watercourses and to regulate and control the collection, treatment and disposal of sewage and for matters connected therewith.
Wholesome Meat and Fish Act	The Wholesome Meat and Fish Act is an Act to regulate the slaughtering of animals and the processing, packing, inspection, import, distribution, sale, transshipment and export of meat products and fish products and for matters connected therewith.

(II) Executive Polices

Tools	Description
Farm licensing	In 1968, farm licencing was introduced. The cost of a licence was only a dollar, to ensure it was within the means of all farmers. Squatter farmers on State lands were formalised through the issuance of Temporary Occupancy Licenses (TOLs), providing some security for them to continue to farm.
Development of Agricultural and Veterinary Extension programmes and services	PPD set up 10 Agricultural and Veterinary Extension to Improve farming productivity in 1970. With these centres, farmers no longer had to travel long distances to government offices in the city to get advice, information or veterinary care.
Prohibition of pig farming in Kranji catchment area	With the completion of the Kranji Dam construction in May 1975, Kranji river was converted into a reservoir and thus, designated as a protected catchment area.
Phasing out of pig farms	In 1984, it was announced that all pig farms will be phased out completely. Continuing to farm pigs in Singapore was not economically viable, given the scarcity of land and water resources, coupled with the exorbitant cost of treating pig waste.
"Eat Frozen Pork" Campaign	In 1985, the PPD launched a 5-week long "Eat Frozen Pork" education campaign to encourage consumers to buy and consume frozen pork. A key component of the campaign was aimed at dispelling common norms about frozen pork especially since the public felt that frozen pork was an inferior alternative as compared to fresh pork.
Formation of the Singapore Economic Review Committee	The Minister for Trade and Industry, appointed a committee in 1985 to review the progress of the Singapore economy. The committee identified particular sectors to propel the economy and agrotechnology was identified as a key area for Singapore.
Inter-Agency Committee on Food Supply Resilience	Inter-Agency Committee to map out the medium to long term strategies needed to strengthen Singapore's food resilience.
AVA Food Fund	Set up in 2009 to strengthen the AVA's strategies to diversify sources and raise local farm production by co-funding research and development (R&D) in local food farming technology, upgrading of the production capability of local farms, and food source diversification.
Agriculture Productivity Fund	Launched in Oct 2014, the APF is set-up to assist farmers to raise farm productivity through investments in farm equipment, farm systems, technology and research. The APF has 3 key components: (a) Basic Capability Upgrading, which provides co-funding for all farm owners to acquire basic equipment; (b) Productivity Enhancement, which provides co-funding for progressive farms to implement advanced and high-tech integrated production systems to make big leaps in productivity; and (c) Research & Development, which works on a grant call basis and funds research in innovative farm production technologies.
Food Security Roadmap	Launched in 2012, the food security roadmap outlines core, supporting and enabling strategies to improve food security. The roadmap highlighted food source diversification and local production as two important strategies that will continue to ensure food security for Singapore.

Inter-Ministry Committee on Food Security	To enhance whole-of-government coordination on food security by identifying the risks and vulnerabilities in Singapore's food security and formulate plans and build Singapore's capabilities to mitigate food security risks and manage food security-related incidents. Formed in 2012 by MND and included AVA, EDB, ISD, MFA, MHA, MOH, NEA, NSCS, A*STAR, ESG and SPF.
"Waste less, Save more" campaign	Launched by NEA in 2015 to encourage the adoption of smart food purchase, storage and preparation habits that can help consumers save money while reducing food wastage at source.
Farm Transformation Map	Announced by the AVA in 2016 to raise local production in a resource tight environment through initiatives to encourage Singapore's local farming sector to harness farming tech innovations.

(III) Institutions

Institution	Description
Primary Production Department (PPD)	PPD was formed in 1959, combining the Agriculture, Co-operative Development, Fisheries, Rural Development and Veterinary divisions that had been operating under various agencies of the British colonial government. The PPD's priority was to assess the state of primary production, identify the needs of farmers and rural communities and build extension services to address those needs.
Agri-Food & Veterinary Authority of Singapore (AVA)	Previously known as the Primary Production Department (2000), it was restructured into the statutory board, AVA, to better manage the challenges of ensuring a safe and resilient food supply. Currently, AVA is responsible for ensuring Singapore's food security and food safety, promoting agrotechnology and Agri-Trade and safeguarding animal and plant health to ensure the resilience of our food supply.
Ministry of National Development (MND)	Parent government ministry of AVA.
Ministry of Trade and Industry (MTI)	Oversees issues related to economic growth and job creation. Responsible for managing trade agreements and monitoring the weekly Consumer Price Index, which includes food prices, to ensure affordability.
Singapore Economic Development Board (EDB)	Government agency under the MTI supporting the shift to industrialization in the 1980s – 1990s. Responsible for attracting investments in hi-tech farms, which can carry out R&D in agrotechnology.

APPENDIX B

Key Initiatives under the Farm Transformation Map

The Farm Transformation Map puts forth four key thrust areas to develop the local agriculture sector:

(I) Space

To rejuvenate the farming sector, the AVA plans and develops new farmlands for sale on open tender, with a focus on production, innovation and intensification. A basket of new agricultural policies was also set in place to support these objectives, e.g., the stipulation that 90% of farmland must be used for production purposes, longer lease terms to allow farmers sufficient time to recoup costs of investing in technologies, tender evaluation criteria that take into account concept and innovation, as opposed to bid values only. To make better use of vacant spaces, the AVA embarked on leasing out vacant state properties for urban farming/test-bedding as an additional option for innovative businesses to consider. While urban farming in alternate spaces does not contribute greatly in terms of production, there are other benefits, such as the opportunity to test-bed new innovations in urban farming technologies and to raise awareness on local production.

(II) Innovation

The AVA recognises the need for R&D in urban food production to optimise the use of limited space and increase production yields. The AVA is identifying specific research areas, seeking funding and partnering with competent research partners. R&D will be in areas such as inputs optimisation (feed & nutrition, improved genetics, water and energy efficiency), automation and systems integration (robotics, sensors & the Internet of Things) and adaptation to climate change.

(III) People

Transforming the sector requires a knowledge-based workforce made up of “agri-specialists” with multi-disciplinary expertise. The AVA follows three human resource development strategies to build a core local workforce:

- (a) Attract, emplace and retain local talent through new courses, structured internships and placement programmes.
- (b) Promote farming as a viable career by working with educational institutions and job banks to increase awareness on farming, thereby attracting fresh graduates/job seekers into the agriculture industry.
- (c) Encourage farm owners to adopt modern management practices to engage a new breed of young locals joining the farming workforce and to groom future industry champions.

(IV) Eco-system

To help farms raise consumer demand, the AVA works on promoting local produce through collaboration with the industry. One key area is on how we can help farmers collectively brand, market and distribute their produce, e.g., through regular farmers’ markets in residential districts.

A holistic transformation of the farming sector requires the creation of a robust eco-system, which includes established ancillary players, e.g., producers of high-yield seeds, nutrients, vaccines, fertilisers, pesticides, bio-pesticides, etc. The AVA is constantly on the lookout to anchor such companies in Singapore.



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