

PUNGGOL: FROM FARMLAND TO SMART ECO-TOWN

Over the last three decades, Punggol has transformed from farmland with highly pollutive industries to an attractive waterside smart eco-town beloved by residents. This successful outcome was achieved only through focused and deliberate actions that addressed recessions, complex pollution problems and the challenges of building a highly dense community from the ground up.

Punggol Town's development journey is a result of innovations in housing, water infrastructure, urban design, transport, smart technologies, and greening. The outcome is now a sustainable, vibrant, smart and ecologically sensitive township of nearly 200,000 people.

This Urban System Study captures the decisions, policies and actions in Punggol's development journey.

"Experience gained in the planning process, together with rigorous testing in large-scale, real world settings, make Punggol a replicable model for master-planned communities, both nationally and globally."

Urban Land Institute

Citation for Punggol Town winning the 2021 Asia Pacific Awards for Excellence

CENTRE for
LiveableCities
SINGAPORE



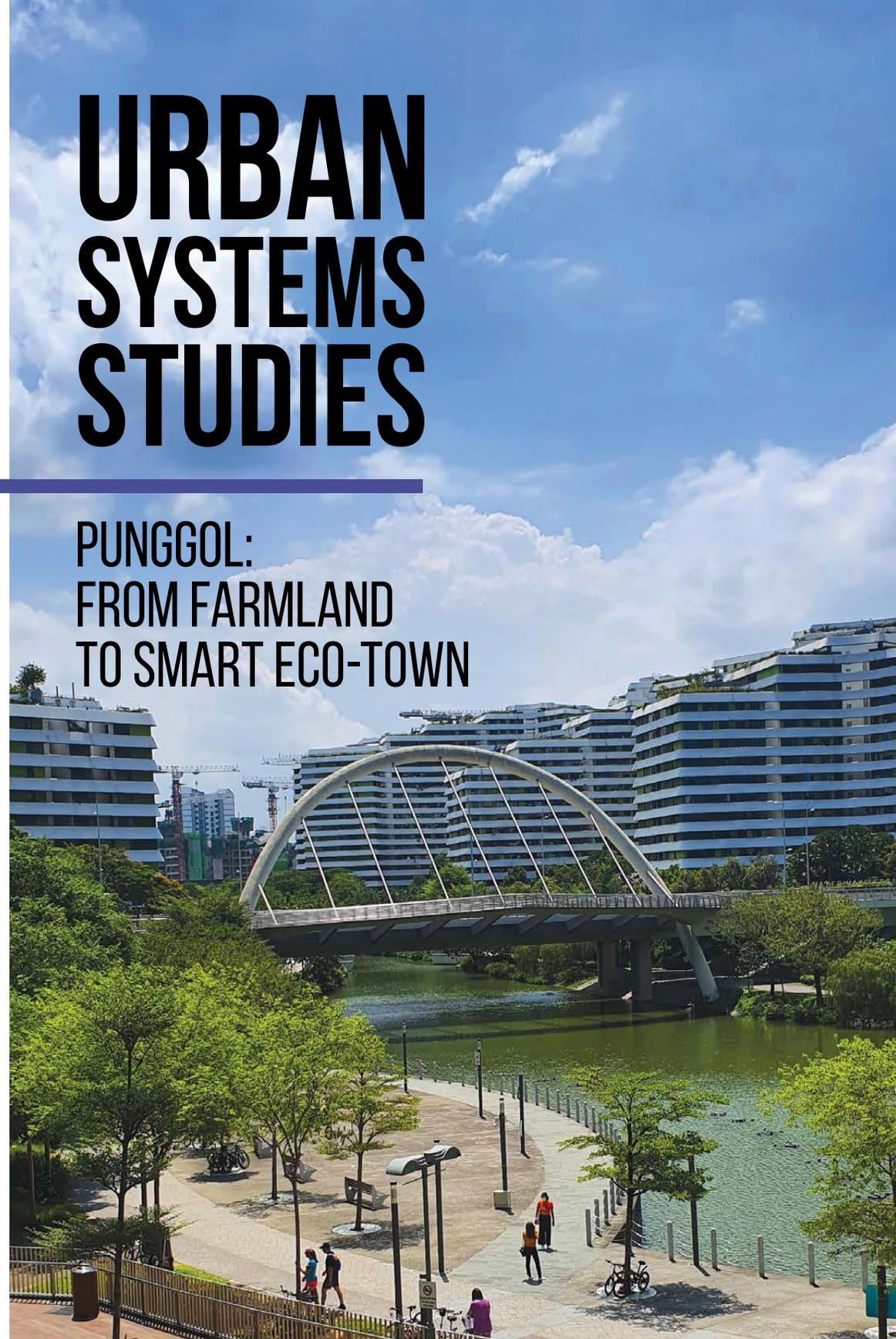
URBAN SYSTEMS STUDIES

PUNGGOL: FROM FARMLAND TO SMART ECO-TOWN

CENTRE for
LiveableCities
SINGAPORE

URBAN SYSTEMS STUDIES

PUNGGOL: FROM FARMLAND TO SMART ECO-TOWN



**PUNGGOL:
FROM FARMLAND
TO SMART ECO-TOWN**

Urban Systems Studies Books

Water: From Scarce Resource to National Asset
Transport: Overcoming Constraints, Sustaining Mobility
Industrial Infrastructure: Growing in Tandem with the Economy
Sustainable Environment: Balancing Growth with the Environment
Housing: Turning Squatters into Stakeholders
Biodiversity: Nature Conservation in the Greening of Singapore
Financing a City: Developing Foundations for Sustainable Growth
Land Acquisition and Resettlement: Securing Resources for Development
Built by Singapore: From Slums to a Sustainable Built Environment
Planning for Tourism: Creating a Vibrant Singapore
Cleaning a Nation: Cultivating a Healthy Living Environment
Urban Redevelopment: From Urban Squalor to Global City
Port and the City: Balancing Growth and Liveability
The Active, Beautiful, Clean Waters Programme: Water as an Environmental Asset
Working with Markets: Harnessing Market Forces and Private Sector for Development
A City of Culture: Planning for the Arts
Sino-Singapore Guangzhou Knowledge City: A New Paradigm in Collaboration
Land Framework of Singapore: Building a Sound Land Administration and Management System
Integrating Land Use & Mobility: Supporting Sustainable Growth
Engaging Well, Forging Bonds: The Community as Stakeholders in Urban Development
Food and The City: Overcoming Challenges for Food Security
Technology and the City: Foundation for a Smart Nation
Energising Singapore: Balancing Liveability and Growth
one-north: Fostering Research, Innovation and Entrepreneurship
Planning for a Secure City
The Rule of Law and Urban Development
Past, Present and Future: Conserving the Nation's Built Heritage
Integrating the Planning of Airports and the City: The Singapore Story
Resettling Communities: Creating Space for Nation-Building
Water: From Scarce Resource to National Asset (2nd edition)
Religious Harmony in Singapore: Spaces, Practices and Communities
Enhancing Liveability, Fostering Communities: Estate Management for Singapore's Public Housing
Towards Ageing Well: Planning a Future-Ready Singapore
Preparing for a Climate Resilient Singapore
Transport: Overcoming Constraints, Sustaining Mobility (2nd edition)
The Government Land Sales Programme: Turning Plans into Reality



PUNGGOL: FROM FARMLAND TO SMART ECO-TOWN

For product information, visit



**URBAN SYSTEMS
STUDIES SERIES**
[www.clc.gov.sg/research-
publications/publications/
urban-systems-studies](https://www.clc.gov.sg/research-publications/publications/urban-systems-studies)



CLC PUBLICATIONS
[https://www.clc.gov.sg/
research-publications/
publications/books](https://www.clc.gov.sg/research-publications/publications/books)

CENTRE for
LiveableCities
SINGAPORE

Singapore, 2021

Editorial Team

| | |
|------------------------|---------------------------|
| Writer: | Elyssa Ludher |
| Research Supervisors: | Dr Limin Hee, Michael Koh |
| Editor: | Brooklyn-media Pte Ltd |
| Production Supervisor: | Gregory Lee |
| Design and Production: | Epigram |

© 2021 Centre for Liveable Cities, Singapore. All rights reserved.

CENTRE for
LiveableCities
SINGAPORE

CLC is a division of  MND
SINGAPORE

Set up in 2008 by the Ministry of National Development and the then 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. CLC's work spans four main areas—Research, Capability Development, Knowledge Platforms, and Advisory. Through these activities, 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.

Research Advisors for CLC's Urban Systems Studies are experts who have generously provided their guidance and advice. However, they are not responsible for any remaining errors or omissions, which remain the responsibility of the author(s) and CLC.

Printed on Enviro Wove, a paper made from 100% post-consumer recycled pulp.

For queries, please contact:

CLC Publications
45 Maxwell Road #07-01
The URA Centre
Singapore 069118
T: +65 6645 9560
E: mnd_clc_publications@mnd.gov.sg

ISBN 978-981-18-1908-7 (print)
ISBN 978-981-18-1909-4 (e-version)

All rights reserved. No part of this publication may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior written permission of the publisher.

Every effort has been made to trace all sources and copyright holders of news articles, figures and information in this book before publication. If any have been inadvertently overlooked, CLC will ensure that full credit is given at the earliest opportunity.

Cover photo:
A sunny day in Punggol New Town.
Image courtesy of Elyssa Ludher.

CONTENTS

| | |
|--|------|
| List of Illustrations and Exhibits | vii |
| Foreword | xi |
| Preface | xiii |
| Acknowledgements | xv |
| The Singapore Liveability Framework | xvi |
| OVERVIEW | 1 |
| CHAPTER 1 | 7 |
| PUNGGOL THE FARMING HINTERLAND | |
| • <i>Farms Need Planning Too! Phasing in of Pig Farms</i> | 10 |
| CHAPTER 2 | 13 |
| REHABILITATING PUNGGOL | |
| • Shifting Out Pollutive Industries and Activities | 14 |
| • Making the Tough Decisions: Phasing Out Pig Farms | 16 |
| • <i>No Place for Pigs</i> | 17 |
| • From Foul to Potable Water: Cleaning up Serangoon and Punggol Rivers | 18 |
| • <i>Establishing Data for a Systems-based Approach to Water</i> | 21 |
| • <i>Innovating Systematically: Urban Catchments</i> | 22 |
| • Shifting Away From Dumping: Moving Towards Incineration | 24 |
| • From Dumping Ground to Biodiverse Wetland: Remediation of Lorong Halus | 24 |
| CHAPTER 3 | 29 |
| LAYING THE FOUNDATIONS FOR A RESIDENTIAL TOWNSHIP | |
| • North-Eastern Reclamation Scheme | 30 |
| • Integrating Transport With Land Planning | 31 |
| • Public Transport Network | 32 |
| • Planning With Regional Concerns in Mind | 37 |
| CHAPTER 4 | 39 |
| A NEW TYPOLOGY: A HOUSING ESTATE FOR THE 21ST CENTURY | |
| • A New First for the HDB: A Waterfront Town | 40 |
| • Planning for the 21st Century and the Needs of a Future Demography | 42 |
| • Planning for Viable Commercial Centres and Retail | 44 |

| | |
|---|-----|
| • A Town Planned to Enhance “ <i>Kampung Spirit</i> ” Through Recreation and Greenery | 45 |
| • Excitement and Interest, Thwarted by the 1997 Asian Financial Crisis | 47 |
| CHAPTER 5 | 49 |
| REJUVENATING PUNGGOL: BREATHING NEW LIFE | |
| • Building Momentum for Better Things to Come | 50 |
| • The Trickle That Led to a River: The Launch of Punggol 21+ | 53 |
| • Master Planning and Urban Design: Keys to a Great Town | 54 |
| • <i>Building Institutional Capacity to Respond to New Needs</i> | 58 |
| • Leveraging Talents: Involving the Private Sector | 60 |
| • Developing a Town of Unique Identities | 61 |
| • Providing Community Facilities and Amenities | 63 |
| • A Living Laboratory to Pursue Sustainable Green Living | 67 |
| • Infusing Warmth Into the Town, and a Sense of Ownership | 70 |
| • <i>Punggol as an Inclusive Community</i> | 72 |
| • Building on <i>Kampung Spirit</i> With Civil Organisations | 74 |
| • <i>Punggol: Uniting Hearts Beyond Its Borders Through Otters</i> | 76 |
| CHAPTER 6 | 79 |
| PUNGGOL: BEARING FRUIT AS A SMART AND SUSTAINABLE TOWN | |
| • Layering on Frameworks for a More Liveable and Sustainable Punggol | 80 |
| • Ensuring Greater Access and Connectivity | 85 |
| • From a Commuter Town to Self-Contained Town: Punggol Digital District | 85 |
| • Putting People on Top: A Car-Lite Punggol Digital District | 89 |
| • Establishing a Smart and Sustainable Town Infrastructure From the Ground Up | 91 |
| • Beyond Ones and Zeros: Smart Technology Delivering Real Value in Smart Towns | 93 |
| • Punggol: Paving the Way for the Future of Singapore’s Towns | 94 |
| • <i>A Resident’s Voice: Foo Ling Fang, Punggolian of 20 Years</i> | 96 |
| • The Fruits of Punggol | 97 |
| Post-script | 100 |
| Timeline | 102 |
| Endnotes | 106 |
| Bibliography | 113 |
| Image Credits | 117 |

LIST OF ILLUSTRATIONS AND EXHIBITS

Illustrations

- Punggol was home to many *kampungs* till the 1980s.
- Changes in and around Punggol as captured by Landsat satellite imagery.
- Changes and refinements made on the master plan over the years.
- My Waterway@Punggol spurred a new master planning process that brought greenery and recreation facilities closer to residents.
- The introduction of the waterway resulted in a new master planning process, as shown by this artist’s impression of Punggol.
- Punggol remained designated as “rural” under the 1971 Concept Plan, even though the Koenigsberger’s Ring City Plan of 1963 had proposed it to have 100,000 residents.
- Chicken and pig farms in Punggol during the 1970s and early 1980s.
- Location of pig farming areas and the phases in which they were settled.
- The Lorong Halus Dumping Ground was commissioned in 1970 and was one of only two sanitary landfills in Singapore at that time.
- Punggol and Serangoon Reservoirs are the 16th and 17th reservoirs in Singapore.
- An 18-m deep cut-off wall was buried to prevent leachate from the Lorong Halus Dumping Ground from entering Serangoon Reservoir.
- The Lorong Halus Wetland is an ABC Waters project that uses bio-remediation efforts to clean the leachate from the former dumping ground.
- A bio-remediation pond in the Lorong Halus Wetland.
- A total of 2.77 km² of land was reclaimed in the 1980s to build up land stock for future housing needs.
- Punggol’s shoreline changed over the years as a result of reclamation and conversion of Punggol and Serangoon Rivers into reservoirs.
- The Constellation Plan and new corridors, including the one towards Punggol.
- Punggol’s MRT and road networks were planned as part of the 1991 Concept Plan and modified over time.
- The “butterfly wings” of the LRT network was planned so that most residents live within 200 to 400 m of an LRT station.
- Singapore’s connectivity expanded as more townships and commercial centres emerged, including in and to Punggol.
- Punggol 21 features three rivers—Punggol River, Serangoon River, and a third river being formed by Coney Island and the mainland.
- Punggol was planned to feature a continuous waterfront promenade that would meet with the new Punggol Marina.
- Punggol MRT station was to be integrated with the Town Centre and commercial facilities, making it more convenient for residents.
- Punggol introduced Common Greens, which are gathering and meeting places, into estates. Coney Island was to be the Town’s regional park.
- The plan included six to eight recreation clubs to be run by SAFRA or the NTUC. Residents could become members to enjoy the facilities.
- The Punggol North Taskforce was a platform for agencies and grassroots leaders to work together to address the needs of Punggol residents.

26. The old Punggol Road in the 1980s; the road was retained as part of the Punggol Heritage Trail.
27. Punggol 21+ introduced a fourth, man-made waterway created by connecting Punggol and Serangoon Rivers inland.
28. Residents and the wider community were engaged to contribute ideas for the waterway.
29. Residents only need to take a short walk to the waterway to enjoy continuous public pathways and the rest spots along it.
30. The HDB's comprehensive Sustainable Development Framework was drawn up to guide the development of Punggol as an eco-town.
31. Waterway Terraces was the winning entry for the Punggol Waterfront Housing Design Competition for its distinctive terraced concept.
32. Waterway View was designed based on the Undulating and Rustic sub-theme concept.
33. Matilda House before government acquisition and after conservation and integration as a clubhouse of A Treasure Trove condominium.
34. A number of unique bridges are located along the waterway, giving each section of the waterway a distinctive identity—Lorong Halus Bridge, Adventure Bridge, Punggol Jewel Bridge and Punggol Walk Arc Bridge.
35. Oasis Terraces, a new typology of community centres, provides an important space not only for recreation and sport, but also for community activities and events.
36. Punggol's famed seafood restaurants at Punggol Point were also retained and redeveloped to suit the growing crowds.
37. As the population increased, Punggol is now home to many regional facilities.
38. The UEM tool is able to simulate wind flow and irradiance patterns to aid design for maximising thermal comfort for residents; heat-sensitive community facilities are then located in shaded areas.
39. Treelodge@Punggol incorporated many sustainable innovations that were subsequently adopted in newer HDB precincts.
40. Bioswales with natural barriers were designed following the guidelines of the ABC Waters Programme.
41. The floating wetlands and mangroves, located along Punggol Waterway, contribute as natural water cleansers.
42. Punggol is famed for its many community events, such as the Racial and Religious Harmony Street Parade and Family Carnival.
43. The SEED@SIP site was developed into a social entrepreneurship space through the capital that was raised from social investors.
44. SEED runs leadership programmes and provides a platform for social entrepreneurs to set up businesses.
45. Residents are able to contribute to the maintenance of their homes by volunteering with the WWS, which keeps the various waterways of Punggol clean.
46. Otters are popular inhabitants in Punggol, attracted by its clean and green environment.
47. Some of the various "layers" that were applied on Punggol included accessibility, community spaces, distinctive districts, and green and blue recreational spaces.
48. Green corridors are created at the Punggol Northshore development to enhance ecological balance and connectivity with existing green areas.
49. Nature Ways have been established throughout Punggol on rooftops, in parks and along roadways.
50. The Punggol Digital District is one of the key employment and innovation nodes within the Northern Gateway, part of Singapore's long term planning initiatives to strengthen the economy.
51. The Punggol Digital District Master Plan featured greenways, solar roofs and 1 km² of pedestrian-free zone on the ground level.
52. The Collaboration Loop is a physical manifestation of the "interwoven" nature in which the business park companies and SIT students are integrated.
53. Punggol's new economic centre was designed with connectivity, integration and interaction in mind.

54. Seamless integration between the JTC business park and SIT in the Punggol Digital District with a common campus boulevard and sky bridges to foster interaction.
55. The Open Digital Platform allows the various smart technology components to communicate with each other.
56. The Digital Twin mirrors Punggol's live environment in a virtual platform, allowing for easy testbedding of new smart technologies.
57. Encouraging the activation of Punggol's many recreational and public spaces is key to ensuring a vibrant and loveable town.
58. Punggol's development journey was decades in the making but it is now a loveable and smart eco-town.

Exhibits

1. Various HDB design schemes in Punggol.
2. Community facilities and amenities.

FOREWORD

The global rise of cities has been unprecedented. It is estimated that every week, nearly 1.5 million people become urban dwellers. By 2050, the urban population will account for more than two-thirds of the world's population. Such growth puts tremendous pressures on cities and many are unable to keep pace with the accompanying needs and demands. The shortfall and uneven access to infrastructure and, in particular, decent affordable housing have led to rising inequities, especially among the urban poor.

For Singapore, the challenges are even greater, given that we are land and resource constrained. Our city-state strives to not only overcome our limitations, but to continuously push towards an improved quality environment and quality of life, to meet rising aspirations and expectations. Within the larger context of national development is the remarkable story of the public housing programme by the Housing & Development Board (HDB). Over six decades, the HDB has housed almost an entire nation in affordable public housing. Some 80% of the population now live in 26 towns and estates, with the majority owning their own homes.

This book chronicles the development of Punggol Town—the HDB's first township that reflects its ambition to build a "sustainable" waterfront town, when "sustainability" was then still a relatively new concept to Singapore. The development of Punggol over the past two decades holds many lessons for us.

First, it illustrated the need for a visionary plan with a long-term perspective. We must dare to dream, be innovative and take calculated risks when introducing new ideas. For example, Punggol Waterway was an innovation during its time, marrying functional needs with leisure needs, and it catalysed many new housing typologies that line the waterbody. It became the central iconic image that distinguished Punggol from other HDB towns. The trialling of sustainability initiatives at Treelodge@Punggol as a pilot project enabled the HDB to manage the risks, learn from them and eventually scale up such initiatives to many other towns. Punggol Northshore as the first smart and sustainable district is yet another experimental urban laboratory in the HDB's learning journey.

Second, for large townships that span some two to three decades to complete, disruptions are hardly unusual. At the same time, an extended timeframe often provides opportunities to harness new ideas and technologies as they become available. In the late 1990s, Punggol was affected by an economic downturn that caused the overall demand for housing to fall sharply. This slowed down the development of Punggol considerably, with impact on the building programme and infrastructure,

such as the light rail that was built in anticipation of demand. A decade later, the second phase of Punggol's development plans took on bolder moves with the adoption of new housing typologies, and more sustainable and smart initiatives. Even as we kept our eyes on the longer-term vision, we understood that plans can benefit from constant refinements and therefore should be kept flexible to adapt to circumstances. Our approach to planning was a dynamic one.

Third, aspirations and goals must be clearly defined and cascaded to detail implementation. It is not enough to aim to be “sustainable” in a vague way. The HDB's development of a clear Sustainability Framework helped it to set out the goals and measurable KPIs to be achieved, and to work out detailed strategies and initiatives to hit these goals. These initiatives must also be backed by science, using technology to attain and stretch the sustainability goals. This disciplined approach will ensure that Punggol moves towards being truly a sustainable town.

Fourth, multi-stakeholder collaboration is essential to implement transformation strategies. Punggol's successful implementation can be attributed to the integrated efforts of government agencies, industry stakeholders and the active involvement of the community. The building of townships, not unlike that of cities, is a complex affair. Building and strengthening the matrix of collaborative efforts generate a sense of ownership among all stakeholders, enabling the harnessing of a wider slate of ideas and resources, hence giving such large projects a greater chance of success.

Punggol Town represents a significant milestone project for the HDB and Singapore. Its successful implementation and the lessons learnt will pave the way towards a more sustainable future for Singapore.

Dr Cheong Koon Hean

Chairman, Centre for Liveable Cities and
CEO, Housing & Development Board (2010–20)

PREFACE

The Centre for Liveable Cities' research in urban systems unpacks 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 domains identified under the Singapore Liveability Framework, and attempt to answer two key questions: how Singapore transformed itself into a highly liveable city over 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. *Punggol: From Farmland to Smart Eco-Town* is the latest publication from the Urban Systems Studies (USS) series.

The research process involves close and rigorous engagement of our stakeholder agencies by the Centre's researchers, and oral history interviews with leaders and pioneers from Singapore's urban sector, to gain insights into development processes and distil tacit knowledge that has been gleaned from planning and implementation, as well as the governance of Singapore. As a body of knowledge, the USS series, which covers aspects such as water, transport, housing, industrial infrastructure and sustainable environment, describes not only the visible outcomes of Singapore's development, but reveals the complex support structures of our urban achievements.

In this book, we have sought to share how the actions of multiple agencies have coalesced in the development of Punggol as it evolved from a polluted part of our city to a dynamic and sustainable township, and more recently, to a smart town—a forerunner for future Singapore.

The Centre would like to thank all those who have contributed their knowledge, expertise and time to make this publication possible. I wish you an enjoyable read.

Hugh Lim

Executive Director
Centre for Liveable Cities

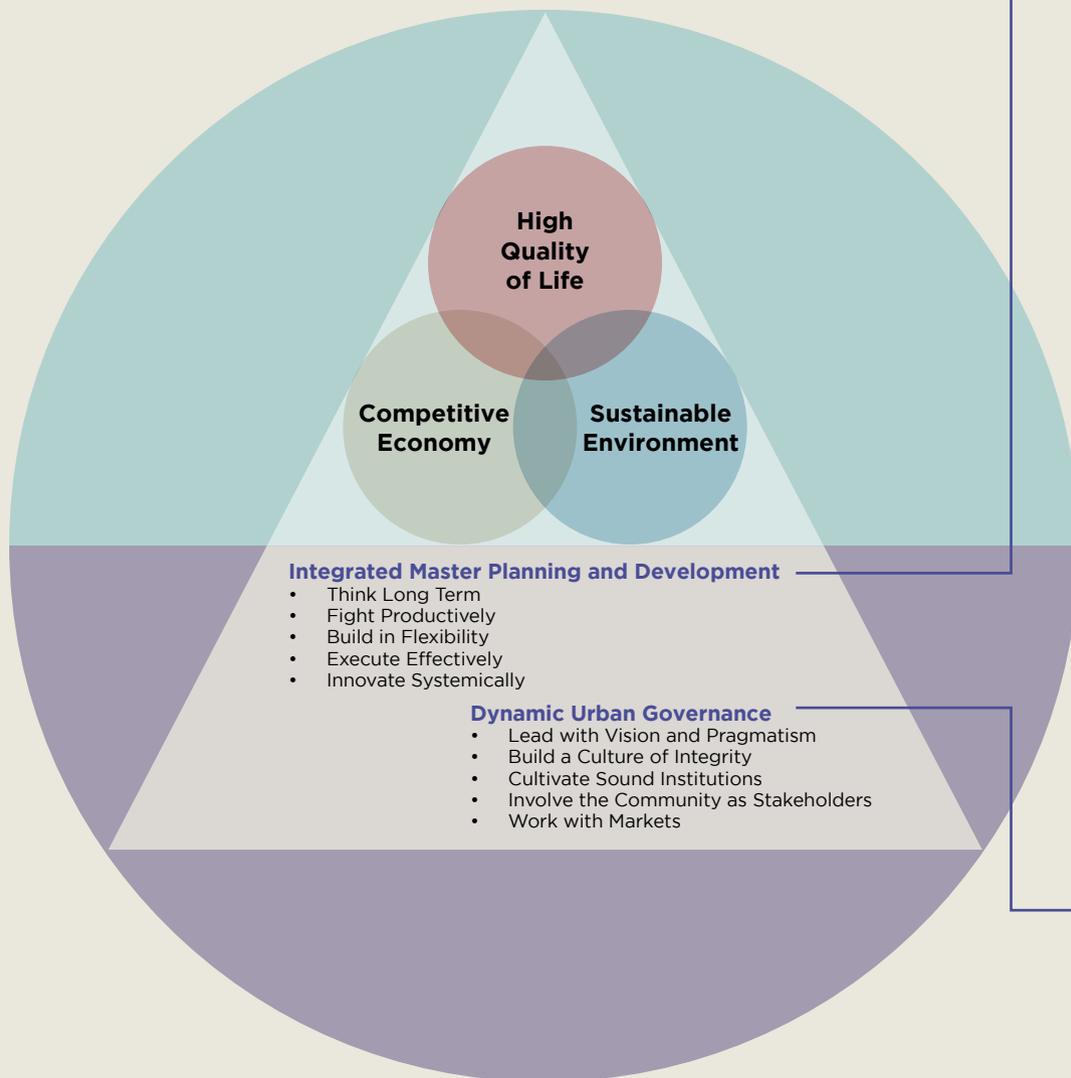
ACKNOWLEDGEMENTS

The Centre for Liveable Cities is grateful to the following interviewees for their contributions (in alphabetical order): Chan Yoon Kum, Dr Cheong Koon Hean, Chew Men Leong, Dr Chong Fook Loong, Marjorie Chong, Fong Chun Wah, Foo Ling Fang, Eugene Heng, Michael Koh, Kong Yit San, Pebble Lee, Ryan Lee, Corrinne Lim, Loh Ah Tuan, Michelle Low, Penny Low, Ng Hwee Yian, Seow Kah Ping, Mohinder Singh, David Tan, Tan Sze Tiong, Jeffrey Teo, Wong Kai Yeng, Wong Mun Summ and Yap Kheng Guan. The Centre also would like to share its appreciation to the countless officers in the various agencies and organisations who contributed to the review to ensure the factual accuracy of this publication.

The writer would also like to thank researchers Aloysius Teo, Xiao Chen Xu, Paul Niam and Grace Melissa Choi for their contributions to the book. This book is made possible with the patience and support of Gregory Lee, Brooklyn-media and Epigram. Lastly, the book could not have been completed without the guidance of Khoo Teng Chye, Dr Hee Limin and Michael Koh.

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 the Integrated Master Planning and Development, and Dynamic Urban Governance are reflected in the themes found in *Punggol: From Farmland to Smart Eco-Town*.



Integrated Master Planning and Development

Innovate Systematically

The entire Punggol Town is an innovation in itself. From the outset, the town was a living laboratory that trialled early concepts of green and sustainability solutions, smart technology and biophilic design. These were done at the town, district and building levels. Within the Punggol Master Plan, an area was set aside by the urban planners to pilot an innovative district with a focus on digital technology and to bring about more employment opportunities for the north eastern region.

To address the pain point of largely being a commuter town, the Punggol Digital District (PDD) was introduced as a town centre. It was designed to house industries in cybersecurity, smart living and smart-estate innovations. The Open Digital Platform (ODP) was established to provide a single platform for smart solutions. It also built in a Digital Twin, which provides a true-to-life 3D representation of the entire district, allowing for scenario simulations, testbedding of new technologies, and real-time monitoring. To ensure that the PDD continues as a hub for smart technologies, collaboration and sharing between academia, industry and enterprise are encouraged by design, for example, by co-locating the Singapore Institute of Technology with the JTC business park. See Chapters 4 (page 39), 5 (page 49) and 6 (page 79).

Execute Effectively

Prior to the 1990s, the rivers flanking Punggol were heavily polluted. As water security became increasingly urgent for Singapore, having Punggol and Serangoon Rivers as potable water sources became necessary. After the 1990s, the PUB, Singapore's National Water Agency, methodically took steps to clean the water by first phasing out key polluters, then dredging the rivers of pollutants, addressing potential leachate from the decommissioned Lorong Halus Dumping Ground, and finally cleaning and damming both rivers into reservoirs. Today, the Lorong Halus Dumping Ground has been redeveloped into a man-made wetland using bio- and phytoremediation techniques, while raw water from Punggol and Serangoon Rivers can be abstracted for treatment in the NEWater plants. See Chapter 2 (page 13).

Dynamic Urban Governance

Lead with Vision and Pragmatism

Punggol was designated as a new township in the 1991 Concept Plan, as planners recognised the unique opportunities to create an attractive waterfront township. Dubbed Punggol 21, the township was planned as a

new typology, suited for the 21st century. As the Asian Financial Crisis began in 1997, the development languished. Agencies then sought to revitalise the space by introducing sustainable technologies, smart features and a fourth waterway. This upgraded version was launched in 2007 as Punggol 21+. To address the need for more local economic vibrancy, Punggol's town centre was re-envisioned as the PDD in the 2010s. With that, Punggol would be a self-contained township. The successive improvements were a direct result of leaders and agencies working together to address setbacks and shortcomings. See Chapters 5 (page 49) and 6 (page 79).

Involve the Community as Stakeholders

Involving the community as stakeholders is crucial in cultivating a sense of rootedness for a new town. Residents in Punggol were involved not only in the Punggol North Development Taskforce to plan its continued development, they were also involved in the hundreds of community engagement events organised by the Housing & Development Board and other government agencies for more than a decade. Residents continue to be actively involved in actions that promote cleanliness, biodiversity and inclusivity, through not-for-profit or civic organisations such as Waterways Watch Society, Social Innovation Park and OtterCity. These continued community activities have cemented Punggol as being more than a town, but a home. See page 70.

OVERVIEW

Punggol is one of the newest townships in Singapore. Located on the north-eastern coast of Singapore and spanning just over 9 km², the town is home to 189,000 people.¹ Expected to grow to 250,000 people by 2030, Punggol has a relatively young population, with the highest percentage of children under five years of age in any town, at 9.9%.²

It has come a long way in the last 50 years. Once a fishing village, it was home to a number of plantations and farms in the 1950s. While well known for its rustic nature, it had been the site of Singapore's worst massacre, which took place during the Japanese Occupation. As Singapore industrialised, Punggol became the site for many of the more pollutive industries, including sewage and water treatment plants, a dumping ground, charcoal trading and pig farms. Over time, this impacted the quality of its waterways and coast, leading to foul smells and concerns over the degradation of the natural environment.



1. Punggol was home to many *kampungs* till the 1980s.

By the 1980s, Singapore's rapid growth increased demand for new residential communities. A new north-east corridor was planned, extending to Punggol on the north-east coast.

However, in order to establish Punggol as a new residential community, the issues caused by the presence of pollutive industries had to be addressed. Over time, all pollutive industries and facilities were either upgraded, relocated or phased out. This saw the end of certain industries in Singapore such as pig farming as Punggol was the last remaining site for pig farms. Following the departure or containment of pollutive industrial activities in the area, a costly process of environmental remediation began.



2. Changes in and around Punggol as captured by Landsat satellite imagery. The changing coastline as a result of land reclamation, and other developments, such as the closure of the Lorong Halus Dumping Ground and the damming of Punggol and Serangoon Rivers, can be seen clearly.

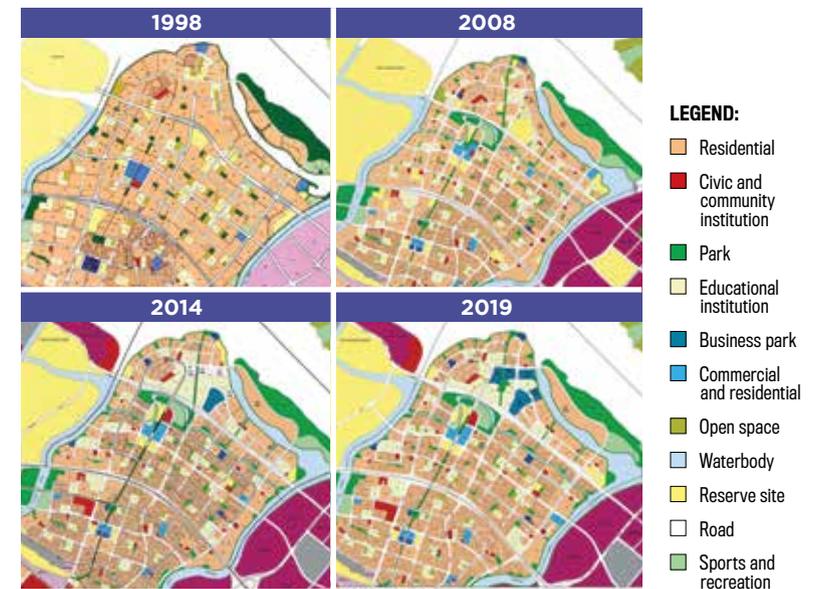
Extensive land and infrastructure works were also required before the development of housing could begin. Land was reclaimed to buttress the existing coastline, and add space for housing and recreation. Sewerage and drainage works were laid to accommodate the projected needs of the new town with hundreds of thousands of new residents. The new north-east MRT corridor was designed to ensure that Punggol residents had good access to other parts of Singapore via public transport.

Punggol New Town, however, was not to be an ordinary Housing & Development Board (HDB) public housing estate. At the launching ceremony in 1996, then Prime Minister Goh Chok Tong highlighted that Punggol was to set new standards in public housing design and planning. The plan was to “create a living environment that would appeal to a new generation of better educated, more sophisticated Singaporeans” of the 21st century.³ Dubbed “Punggol 21”, the town would “not just offer well-designed HDB flats, but an integrated, high-quality environment of recreational and social facilities.”⁴

Among the innovations, each precinct would comprise 1,000 to 3,000 dwelling units, instead of the 6,000 to 8,000 units in older public housing neighbourhoods. Dwellings in a precinct were to be clustered around its own green lung, designed to encourage interaction among residents. Most residents would be only 300 m away from a Light Rail Transit (LRT) stop. Car parks were integrated into lower levels of the residential blocks, unlike the open air or standalone car park blocks in other estates. The plan brought much excitement and interest when it was announced.

The Asian Financial Crisis in 1997-98, and subsequently the slowdown caused by the severe acute respiratory syndrome (SARS) in 2003, however, had a deleterious effect on the development of Punggol. Sales of housing slowed, and this led to delayed delivery of planned amenities. Residents had to commute well beyond its borders for work, shops and facilities. Underdeveloped transport networks led to congestion. Punggol languished as a new town, a far cry from the vision residents had been looking forward to.

Rather than leaving its subsequent development to chance, the HDB sought to reverse the downward trend. It re-envisioned Punggol under its Remaking Our Heartland initiative, relaunching it as “Punggol 21+” in 2007. A key component of the initiative was to bring the water “closer” to residents via a fourth waterway—the man-made My Waterway@Punggol. The new waterway multiplied the available green space, and even introduced water-based sports close to home. The private sector was invited to participate through design competitions that would integrate innovative features into the landscape. The northern part of Punggol underwent another master plan review process to optimise the recreational spaces afforded by the new waterway, as well as accommodate the new needs of the residents.



3. Changes and refinements made on the master plan over the years.



4. My Waterway@Punggol spurred a new master planning process that brought greenery and recreation facilities closer to residents.

In 2010, 14 years after Punggol 21 was first launched, it was designated an eco-town at the HDB's 50th anniversary. New frameworks were layered onto the town, including the Sustainable Development Framework, Smart HDB Town Framework, and Biophilic Town Framework. Each of these layers brought about new programmes and solutions that enhanced the environment, resulting in a greater infusion of nature into the town—both on the ground and vertically. A comprehensive network of cycle and pedestrian paths was built into the town to encourage more active lifestyles. As the population grew, there was rejuvenation in activities to develop more amenities and community facilities.

Punggol was also selected to be a testbed for new ideas and technologies for sustainable development and to create a greener living environment. It became a living laboratory, where Urban Environmental Modelling (UEM) was used to simulate wind flow and solar irradiance patterns and drive building designs that would maximise thermal comfort for residents. Active, Beautiful, Clean Waters (ABC Waters) design principles were applied to integrate water-retentive green spaces around residential buildings. Photovoltaic (PV) solar panels were deployed from the start, both on buildings and water surfaces. A unique identity was created for each precinct to foster community affinity for their new homes. Civil organisations were set up to facilitate greater involvement from residents in the betterment of their communities and further strengthen their pride of place.



5. The introduction of the waterway resulted in a new master planning process, as shown by this artist's impression of Punggol.

In 2012, Punggol was conceptualised as part of the larger master plan to be a Creative Cluster and Learning Corridor, which eventually led to Punggol Town being designated as the Punggol Digital District (PDD), to cater to industries in the digital space. Singapore Institute of Technology was invited to set up its new campus there, and was designed to integrate seamlessly with a planned JTC business park. JTC Corporation, the designated master planner of the PDD, also introduced several new smart infrastructures; one major inclusion was the locally developed Open Digital Platform (ODP). The ODP would allow more efficient integration with smart technologies. These new technologies were adopted with an eye on the future, where they could be deployed in other parts of Singapore. As such, Punggol was designated a "Strategic National Project", an important component in achieving Singapore's Smart Nation vision, which had been earlier announced in 2014.

Today, Punggol is a highly sought-after address—green, bustling and vibrant. The journey has not been an easy one. As with any grand, new urban development, it suffered its fair share of setbacks presented by the need for site remediation, the impacts of successive economic slowdowns, and a lack of timely infrastructure and amenities in its initial years. The keys to its success have been the persistence of a long-term vision, effective planning, interagency collaboration, innovation and built-in provisions for flexibility. This journey—with its challenges and the efforts to systematically overcome them—is documented in this Urban System Study on Punggol, which chronicles the complex nature of new town building, from pitfalls to opportunities, so that others may learn from it.



CHAPTER 1

PUNGGOL THE FARMING HINTERLAND

“

Punggol, also spelt Ponggol, means ‘hurling sticks’—a method of bringing down fruits off fruit trees—in Malay. This indicates that Ponggol was a renowned fruit-growing district.⁵

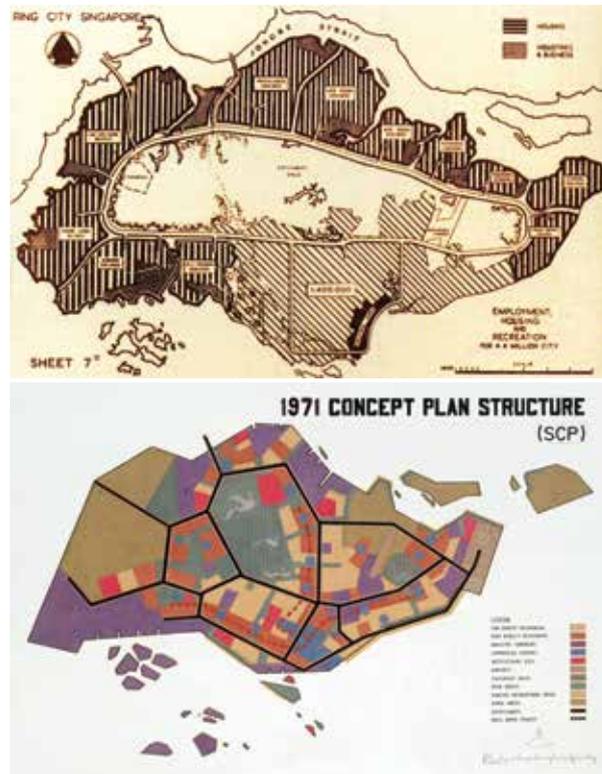
”

NATIONAL HERITAGE BOARD

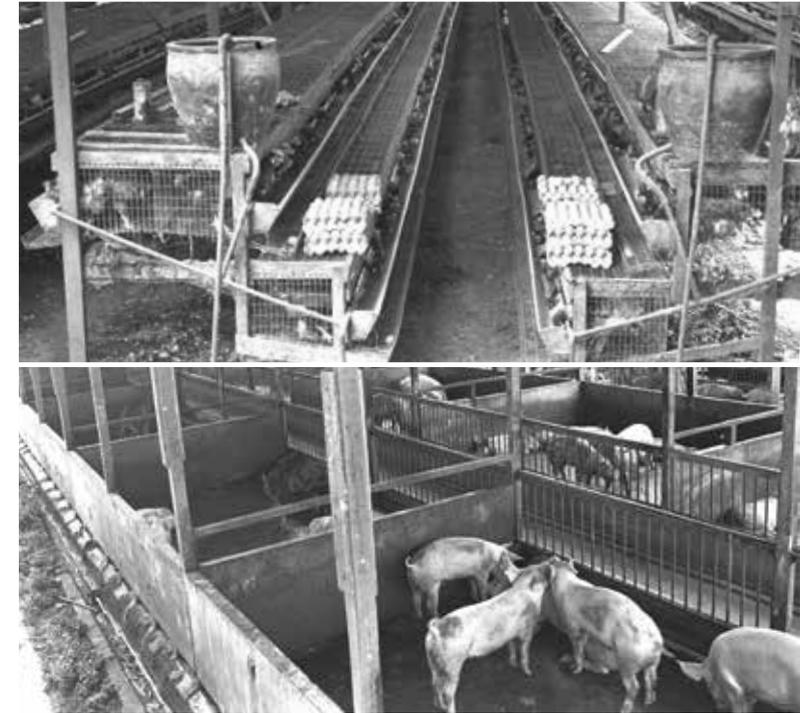
Punggol, located in the north-east of Singapore and sheltered by the Johor Strait and Pulau Ubin, is one of the oldest settlements in Singapore. It has been continuously inhabited for at least 400 years, housing fishing and trading communities; many planted vegetables and fruit trees for sustenance.⁶

By the mid-20th century, Punggol was mainly covered in rubber plantations.⁷ Its coasts were used extensively for recreation and fishing; it was a popular spot for seafood, boating and water sports.⁸ Punggol was also home to Singapore's first two zoos.⁹ In the dark days of the Second World War, it was one of the sites of the Sook Ching Massacre, where 400 Chinese civilians were killed by the Japanese military forces; the site is now a national heritage site. Post-war, from the 1950s to the 1970s, Punggol was dominated by vegetable, chicken, duck, fish and pig farms, as well as plantations.

Punggol's potential as a township was recognised early on. It was proposed that Punggol house 100,000 residents under the Koenigsberger's Ring City Plan of 1963; however, Punggol remained a rural designation under the 1971 Concept Plan. Up to the late 1980s Punggol was populated with farmlands that had few access roads.



6. Punggol remained designated as "rural" under the 1971 Concept Plan (bottom), even though the Koenigsberger's Ring City Plan of 1963 (top) had proposed it to have 100,000 residents.



7. Chicken (top) and pig (bottom) farms in Punggol during the 1970s and early 1980s. The latter featured automated feeding machinery and best practice waste management systems for that time.

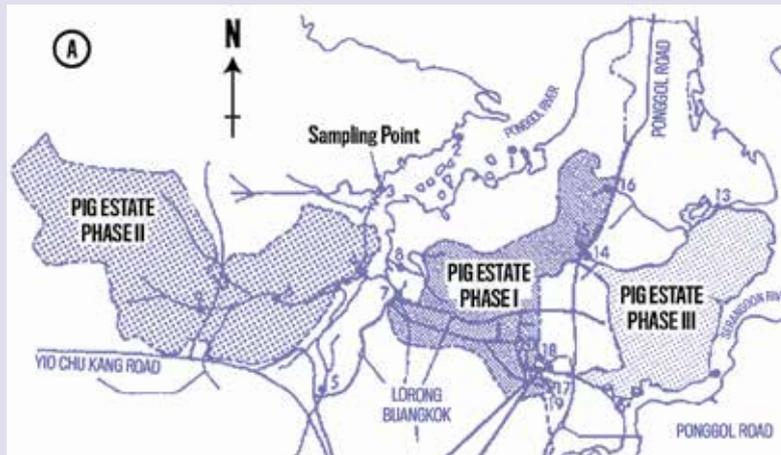
Of all the farming types, pig farming was among the most lucrative, due to the growing demand for pork as a protein source for Singapore's growing middle class.

In the mid to late-1970s, the government decided to consolidate all pig farms from the various parts of Singapore to Punggol and the neighbouring Jalan Kayu. This was to clear pollutive industries and activities from identified water catchment areas, such as in Kranji, to safeguard water quality for human consumption, as well as control odours that impacted liveability. Punggol, which was at that time outside of designated potable water catchments, was thus designated an intensive pig farming area for a 30-year period.¹⁰ The consolidation was implemented in three phases: Punggol Phase 1 Pig Farming Area (2.08 km²) (1974), Punggol Phase 2 Pig Farming Area (2.53 km²) (1975), and Punggol Phase 3 Pig Farming Area (1.89 km²) (1981).¹¹

The pig industry grew rapidly. By 1975, it was worth S\$249 million,¹² making it one of the most important and profitable economic activities in Singapore.

FARMS NEED PLANNING TOO! PHASING IN OF PIG FARMS

As big and small pig farms were relocated to Punggol from all over Singapore, the limited space needed to be maximised and efficiently allocated. Thus, land was released in phases.



8. Location of pig farming areas and the phases in which they were settled.

The first phase was developed in 1974 with minimal earthworks. Roads were not paved until a few years later, but concrete drains were installed to carry both rain runoff and farm effluent. Incoming farmers carried out their own earthworks at the farm lots before erecting their pig barns and family dwellings. It was planned with small lots to encourage family farms, but commercial pig farming was available on long-term leases. Farmers intensified usage of land with little regard for proper farm layout, sanitation or aesthetics. Farms were built on a 1% slope for waste removal by flushing.

The second phase was largely in the Jalan Kayu area, to the west of Punggol. Pigs started arriving in May 1977. Small farms were given temporary occupation licenses and farmers were obligated to renew their licenses periodically. These farmers also brought with them traditional practices, including old building materials and barns, and maintained previous housekeeping and husbandry practices. In October 1977, residents nearby lodged complaints about pig odours although the Standing Pig Population (SPP) had increased by only 1,000. One of the reasons for the greater

number of complaints was exposure—new farms could be seen easily from the road, whereas old farms were out of sight. To address this, the Primary Production Department planted fast-growing shrubs and trees along the full length of roads bordering the pig farming area to reduce sightlines.

The authorities learnt from the challenges of the Jalan Kayu farms, and applied the lessons to Phase 3, located on the eastern side of Punggol. The third phase was more akin to an industrial parkland for pig farming. Thick belts of trees were planted on both sides of the farmways and along the public highway to buffer the surrounding residential areas as a way to reduce complaints and disperse smell trajectories.



CHAPTER 2

REHABILITATING PUNGGOL

“

In the 1970s, there was a direction to keep Punggol as an area for pollutive industries and dirty activities, given its relatively rural and inaccessible nature. The Punggol area [stank] heavily due to the pig farms discharging untreated waste directly into the river, and it is amazing that Punggol River can be turned into a drinking reservoir now.¹³

”

WONG KAI YENG

Director of Planning and Policies,
Urban Redevelopment Authority (1994–96)

As Singapore's population grew over time, more space was needed for housing and industry. Areas in the north-east, including Punggol, were reconsidered for urbanisation and development.

Shifting Out Pollutive Industries and Activities

Aside from pig farms, due to the relatively rural locations, catchments of Punggol and Serangoon Rivers housed many “pollutive” activities. Serangoon River received the discharge of treated effluent from the Kim Chuan Water Reclamation Plant (originally the Kim Chuan Sewage Treatment Works) built in 1948.¹⁴ The plant treated up to 282,000 m³ per day at its peak, treating sewage from areas east of Bukit Timah and the eastern parts of the island.¹⁵ The neighbouring Paya Lebar/Defu area (formerly Teck Hock Industrial Estate) was also known for its pollutive backyard industries, being designated by the government to house aluminium processing, furniture making, motor works, and food processing activities.¹⁶ Contaminated runoff from these industries were flushed into Serangoon River. As one research paper described:

A substantial amount of pollution was observed along the length of the [Serangoon] river, with refuse accumulating in several locations on the banks of the river...The stench of hydrogen sulphide was apparent throughout the length of the river and gas bubbles could be seen rising to the surface of the water. This was especially pronounced in the middle reaches of the river but improved nearer the mouth of the river.¹⁷

Another major polluter near Punggol was the 2.34-km² Lorong Halus Dumping Ground that was established in 1970 and built on the banks of Serangoon River at the site of the former Municipal Sludge Disposal Works. The Dumping Ground was also the location at which night soil was buried.¹⁸ Loh Ah Tuan, Deputy CEO, National Environment Agency (NEA) (2004–07), explained the siting of a dumping ground in Lorong Halus:

When Lim Chu Kang landfill, the only landfill then in the western part of Singapore, was running out of capacity to dispose of waste, it was decided [that] a new landfill would be built at Lorong Halus in the east. Also, the site at Lorong Halus was a swampy area, which could be used for disposing waste.¹⁹



9. The Lorong Halus Dumping Ground was commissioned in 1970 and was one of only two sanitary landfills in Singapore at that time.

By 1982, almost half of the waste generated from domestic premises in Singapore was disposed of at the Lorong Halus Dumping Ground, further contributing to the noxious odours in Singapore's north-east region.

Making the Tough Decisions: Phasing Out Pig Farms

By the 1980s and 1990s, more residents were moving into the region. Malodours from the combined waste streams, and its flotsam, resulted in regular complaints. Yap Kheng Guan, Director of Drainage, PUB (1992–2001), recalled that:

The Drainage Department would receive complaints of the smell, especially during periods of low tides and north-easterly winds, from residents of Seletar Hill.²⁰

At a national level, the planning department was tasked to address the placement of waste, water treatment, food production and economic activity even as environmental regulation increased. It could no longer leave Punggol as it was: accumulating more and more pollutive industries and infrastructure. Action had to be taken to reduce the contaminating elements.

To address the increasing pig waste, the Primary Production Department, under the Ministry of National Development, was tasked to introduce modern husbandry practices and install proper waste management facilities. In 1979, a decision was taken to set up waste treatment plants in all pig farms to reduce environmental pollution. In early 1980, an abattoir levy was charged on every pig to fund the construction of high-quality pig waste treatment facilities. Various initiatives were also undertaken to mitigate pollution, including experiments with high-rise pig farms, which ultimately proved to be unsuccessful.

Eventually, however, the decision was made to remove pig farms completely (see Box Story).

NO PLACE FOR PIGS

By the early 1980s, the stocking density of pigs was as high as 2,000 pigs per hectare. As malodorous smells could travel as far as 900 m, farms were thus required to be sited greater than 1,000 m away from the residential areas, which by 1983, was impossible in the remaining non-water catchment areas.²¹

There were many considerations on removing the pig farms, including the need for land for more housing and industrial estates, its negative impact on the water quality, its noxious smells, public health, and even the concerns of neighbouring Malaysia due to the sensitivity of pork waste in shared waters. This was argued against concerns for the desire for local food security and preference for fresh pork, as frozen pork was not widely accepted.²² Eventually, an argument was made that pork could be imported from surrounding nations. Loh Ah Tuan, then Deputy CEO of the NEA, had a more singular focus on the matter:

The issue was Pork versus Water. The decision was obvious—water. Pig farms, therefore, had to go.²³

In 1984, a decision was made to phase out the pig farms in Singapore. This was a blow to many in the industry and government agencies; many farmers had moved to Punggol after being assured that they could keep their livelihoods. To aid the process of phasing out pig farms, pig farmers were compensated; many turned to other types of farming or businesses. By 1989, all pig farms were phased out.

Fortunately for Singapore, importing pork had become more viable by that time. The neighbouring countries had agriculture-based economies and were keen to develop an export market to Singapore for meat, vegetables and poultry products.

In 1986, Punggol was designated for future housing and non-pollutive farming was allowed to continue only on temporary leases. This was firmed up in the 1991 Concept Plan when Punggol was zoned largely for residential use.

From Foul to Potable Water: Cleaning up Serangoon and Punggol Rivers

Singapore's water security is an issue of survival. Before independence, Singapore's water was mainly sourced from Malaysia, based on two Water Agreements with the government of the State of Johor in Malaysia. The first Water Agreement was signed in 1961, which granted Singapore the full and exclusive rights and liberty to draw off, take, impound and use all the water within the catchment areas of Gunung Pulai and Pontian, and the Tebrau and Skudai Rivers, until 31 August 2011.²⁴ Following its lapse, Singapore handed back the waterworks to Johor.²⁵ The second Water Agreement was signed in 1962, which grants Singapore the full and exclusive right and liberty to draw off, take, impound and use the water from the Johor River up to a maximum of 250 million gallons per day until 28 September 2061.²⁶ In return, Johor is entitled to a daily supply of treated water from Singapore not exceeding 2% of the total quantity of water supplied to Singapore on any given day. The two Water Agreements were guaranteed by both the governments of Malaysia and Singapore under the 1965 Separation Agreement, which was deposited with the United Nations.²⁷

Notwithstanding the Water Agreements being enshrined in the Separation Agreement, then Prime Minister (PM) Lee Kuan Yew recounted that Tunku Abdul Rahman, Malaysia's first PM, had said to the British High Commissioner in Kuala Lumpur, "If Singapore doesn't do what I want, I'll switch off the water supply."²⁸

As such, PM Lee took it as a priority to ensure Singapore's water security. He shared: "Every other policy had to bend at the knees for our water survival..."²⁹ In 1971, the Water Planning Unit was set up and placed under the Prime Minister's Office and was highly influential in deciding various factors of Singapore's development. In 1972, the Unit had drawn up its first Water Master Plan, which evolved into today's "Four National Taps".

The whole country was evaluated to capture and harness every drop of rainwater. PM Lee exhorted that "[it] should be a way of life to keep the water clean, to keep every stream, every culvert, every rivulet free from unnecessary pollution."³⁰ The 1972 Water Master Plan earmarked water catchments to be developed in order to maximise the yield from surface water sources to boost the drinking water supply in Singapore. In 1977, when PM Lee opened Upper Peirce Reservoir, he challenged the Ministry of the Environment (ENV) to clean up the Singapore River in 10 years. The Singapore River was cleaned up by 1987. Chan Yoon Kum, Director of Water Department, ENV (1995–2004) recalled:

After the Singapore River was cleaned up in 1987, PM Lee would ask [Chairman of the PUB] Lee Ek Tiang every few years about the feasibility of Marina water for potable water supply.³¹

Eventually, with the advent of NEWater, Singapore looked into increasing its local water supply by creating more reservoirs besides Marina Reservoir—PUB, Singapore's National Water Agency, studied the possibility of damming up Punggol and Serangoon Rivers to impound the surface runoff for water supply even though they were marginalised catchments. However, due to the presence of pollutive industries within these catchment areas, damming up the river mouths would only trap the pollutive runoff, as well as obnoxious leachate from the Lorong Halus Dumping Ground.³² That area was so polluted that some thought it was impossible. Then CEO of the PUB, Khoo Teng Chye, recalled Tan Gee Paw, Chairman of the PUB, saying to him, "I hope you're not mad enough to dam up the Serangoon River."³³

However, for Singapore's water survival, it had to be attempted. Agencies had to work hard to "clean" the catchment to reduce pollution over time. Both Punggol and Serangoon Rivers were dredged to remove contaminated and nutrient-rich organic sediments to prevent the continuous release of sediment-bound nutrients and pollutive contaminants.³⁴

As Chan further recalls:

Mr Tan Gee Paw took over as Chairman of the PUB in 2001 and pushed for the creation of more reservoirs, which tantamounted to retrofitting of catchments for drinking water supply. Agencies [had to prepare] a "negative list" so that for any catchments, if there were activities/developments in the negative list, they must be gotten rid of, so to speak, or relocated. If they are not [on] the negative list, we can try to make do and live with that.³⁵

Yap remembers the works that were carried out:

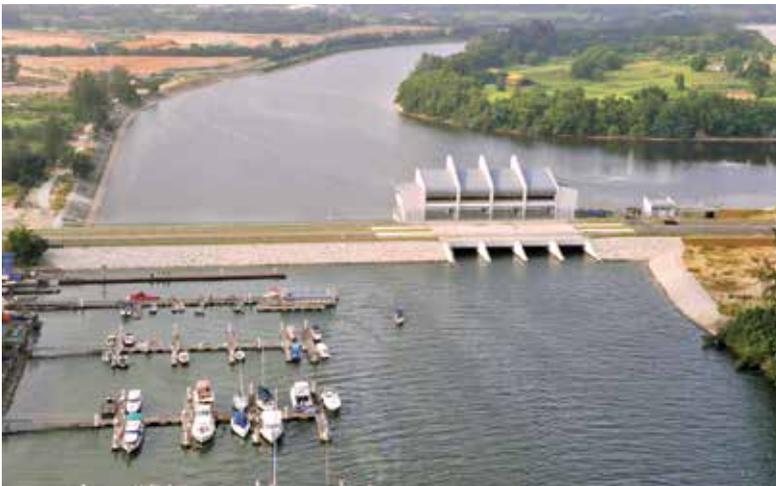
After the pig farms were phased out and Lorong Halus decommissioned, massive dredging works [began on] Serangoon River, [where the] first round between 2001 and 2002 took care of smells from tidal flats during low tides. In Punggol River, between 1999 and 2002, dredging work was also conducted, and river alignment and embankment strengthening too.³⁶

Eventually, in 2011, Punggol and Serangoon Rivers were both dammed to create Singapore's 16th and 17th reservoirs respectively. The two reservoirs are connected via My Waterway@Punggol (see Chapter 5).

Punggol and Serangoon Reservoirs were officially opened on 3 July 2011.³⁷ The water quality of both reservoirs has improved over the years; water from Serangoon Reservoir can now be blended with water from Punggol Reservoir and abstracted for drinking.³⁸

Wong Kai Yeng, Director of Planning and Policies, URA (1994–96), adds:

Punggol offered two important lessons—first, cleaning up a polluted area is not going to be easy or cheap; second, Punggol has shown that this can be done.³⁹



10. Punggol and Serangoon Reservoirs (above and below respectively) are the 16th and 17th reservoirs in Singapore.

ESTABLISHING DATA FOR A SYSTEMS-BASED APPROACH TO WATER

Part of the strategy to ensure water was collected in reservoirs was by damming rivers to create large bodies of freshwater over time. However, in the 1970s, there was little data, and certainly not enough to create models to understand the hydrological systems. While topographical and meteorological data existed, these were not available in a format that “talked” to each other. Tan Gee Paw, Chairman of the PUB (2001–17), explains:

In those days there were no powerful computers to do simulations. [The team had to do everything on its own.] I was thankful we had a computer in the PUB, a huge computer that occupied the whole room which was meant to print all the PUB bills. We had to start from scratch, and it took about two years. I remember asking the guy in charge of it, Lau Ping Sum, for permission to use it. He said yes without knowing I did not know a thing about computers! It was most challenging; and we worked late into the night, reading manuals on how to programme the computer and when we finally figured it out, we used it to start simulating rain runoff so we could see what happened in extreme events, and calculate the water yield in certain catchments. That is how our first water plan came to be.⁴⁰

Beyond MacRitchie, Peirce and Seletar Reservoirs, which were developed many decades before, the new dams created are Kranji, Pandan, Murai, Poyan, Tengeh, Sarimbun, and Lower Seletar Reservoirs.

INNOVATING SYSTEMATICALLY: URBAN CATCHMENTS

Typically, water catchments are designated in pristine, protected areas with low population densities. This is not possible for Singapore as land is scarce. However, to reduce water contaminants, an urbanisation catchment policy was introduced in 1983 to cap the density of housing in catchment areas to 34.1% and/or 196 dwelling units per hectare.

The PUB sought to prove that urban catchments, if properly managed, could maintain acceptable levels of water quality even with higher housing densities. They selected nine urban catchment areas located in Bedok, Tampines and Yan Kit, which fed into Bedok Reservoir through holding ponds and pumping stations, to demonstrate that the contamination levels of runoff within an urbanised environment were within acceptable ranges.⁴¹

The Sungei Seletar–Bedok Water Scheme, which was completed in 1986, was the first urban catchment where the stormwater collection system was specially designed to allow the more polluted dry weather flow and the “first flush” of the wet weather flow to bypass the collection facility, while the cleaner part of the stormwater runoff was diverted into a holding pond and pumped into Bedok Reservoir.⁴²

Chan Yoon Kum, Director of Water Department, ENV (1995–2004), recounts the journey:

When we [first] did the Sungei Seletar–Bedok urbanised catchment water scheme, we were also told we were crazy by the Americans to tap stormwater runoff from urbanised catchments for drinking water supply; CDM [an American engineering and construction company] had won the award in the United States for this water scheme as the consultants.

After 12 years of urbanised catchment, CDM was engaged to do a full study on the water quality. We actually found that urbanised water quality was not bad! Because of this finding, a paper was put up to the Cabinet in 1999 to lift the catchment policy cap.

Moreover, because of this, Punggol was able to be developed at a plot ratio of 3.4, allowing it to be the vibrant town that it is today.

We cannot look at Punggol and Serangoon in [a] vacuum. After the PUB developed the Sungei Seletar–Bedok Water Scheme successfully, we submitted a paper to the Cabinet, for “Selective

Stormwater Catchment of Punggol–Serangoon”. The paper captured the very spirit of what we did successfully in Bedok.⁴³

With the successful implementation of Bedok Reservoir, which collects stormwater runoff from an urbanised catchment, a similar stormwater collection scheme was planned in the late 1990s for Hougang, Sengkang and Punggol new towns. Given that the Punggol and Serangoon catchment areas are largely zoned for residential developments, stormwater runoff from these cleaner areas can be tapped for potable water supply before they flow into the rivers. Nonetheless, although the PUB was exploring the option for a selective stormwater collection system, they never lost sight of eventually transforming Punggol and Serangoon Rivers into reservoirs. This was made possible by progress made on two key fronts: (1) developments in pollution control and (2) advancement in water treatment technology.

Developments in Pollution Control

- With the completion of the Deep Tunnel Sewerage System (DTSS) Phase 1 project in 2008, the Kim Chuan Sewage Treatment Works (which had treated effluent discharged into Serangoon River) and Serangoon Sludge Treatment Works were decommissioned, thus removing two major sources of pollution.
- The development of Punggol as a residential town (Punggol 21) provided a compatible land use as an urban water catchment.
- The PUB imposed strict anti-pollution requirements and stepped up checks to ensure proper housekeeping in Defu Industrial Estate.
- A “Negative List” was established in 2005, which barred the setup of pollutive industrial activities in water catchment areas and facilitated the relocation of any activities in this list out of water catchments.
- A sewer rehabilitation scheme in Punggol–Serangoon was carried out from 2009 to 2011 at the cost of S\$57.9 million.

Advancement in Water Treatment Technology

- The advancement in membrane technology enabled the runoff from the full catchments of Punggol and Serangoon to be considered for water supply.

The completion of urban reservoirs such as Punggol, Serangoon and Marina Reservoirs enabled Singapore’s water catchment area to increase from half to two-thirds of the total land area, making Singapore one of the few countries in the world to harvest urban stormwater on a large scale for potable consumption.

Shifting Away From Dumping: Moving Towards Incineration

As the north-east corridor urbanised, residents complained of illegal dumping, foul smells, open fires and pollution of the surrounding natural habitat at the Lorong Halus Dumping Ground.

In the early 1990s, the ENV sought another dumping ground site in Punggol. The HDB, however, assessed that a dumping ground was incompatible with its plans to build an attractive waterfront residential housing community.

Hence, the ENV had to look for an alternate site. With few viable mainland options, an idea was conceived for an offshore dumping ground; Pulau Semakau was approved as a dumping ground site in 1994. With this, the plan was clear: once the Lorong Halus Dumping Ground was filled, it would be closed, leaving a better environment for the residential community.

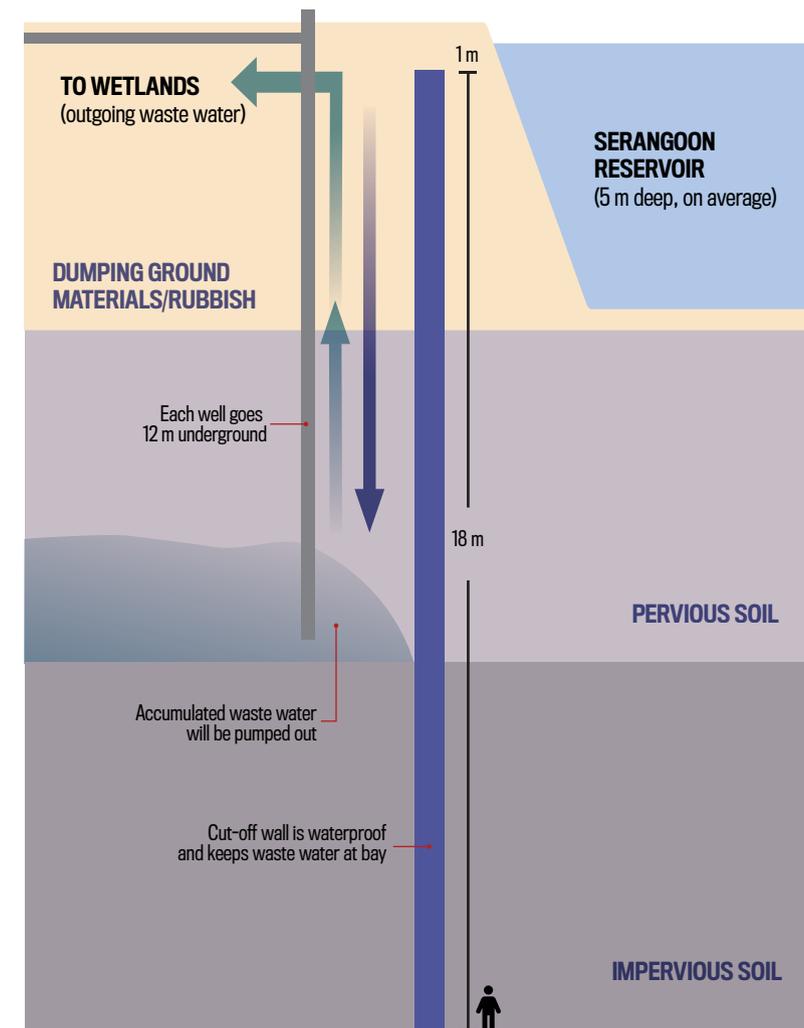
It was projected that the Lorong Halus Dumping Ground was to be filled by 1997, but its lifespan was extended to 1999 as Singapore had built more incineration plants from the 1970s onwards, which allowed for more refuse to be burnt instead of being buried.⁴⁴ Loh explains:

The first refuse incineration plant in Singapore was built at Ulu Pandan in 1979. By the time the 4th plant was built at Tuas South in 1999,⁴⁵ the combined total capacity of the four incineration plants at Ulu Pandan, Senoko, Tuas, and Tuas South was sufficient to incinerate all the refuse collected from domestic households daily. There was, therefore, no need to continue disposing domestic refuse at the Lorong Halus Dumping Ground. The Lorong Halus Dumping Ground was officially closed [on 31 March 1999 and] Semakau offshore sanitary landfill [for incinerator bottom ash] came into operation on 1 April 1999.⁴⁶

From Dumping Ground to Biodiverse Wetland: Remediation of Lorong Halus

With the decision to turn Punggol and Serangoon Rivers into reservoirs, it was critical that contaminated leachate from the neighbouring Lorong Halus Dumping Ground did not seep into the rivers. While the dumping ground was initially covered with earth, in 2006, major works were undertaken to address the leachate. First, a 6.4-km underground cut-off wall that was

18 m deep and 0.8 m thick was built as a barrier between the disused landfill and Serangoon Reservoir. Second, a network of leachate collection systems was installed along the edge of the disused landfill to collect and channel the leachate to a wetland for pre-treatment before discharge into the sewers.⁴⁷ A 0.09-km² site was secured to treat the leachate using a bio-remediation wetland system at Lorong Halus, where riparian plants are used as natural filters to separate contaminants from the leachate.



11. An 18-m deep cut-off wall was buried to prevent leachate from the Lorong Halus Dumping Ground from entering Serangoon Reservoir.

In contrast to chemical remediation, the bio- and phytoremediation system for the Lorong Halus Dumping Ground was able to fulfil multiple functions, including protecting water quality, enhancing biodiversity and greenery, and maximising land use. Designated as an Active, Beautiful, Clean Waters (ABC Waters) project site, the Lorong Halus Wetland has become an open park that functions as a site for biodiversity, recreation and education.



12. The Lorong Halus Wetland is an ABC Waters project that uses bio-remediation efforts to clean the leachate from the former dumping ground.

Even with the above efforts, more had to be done to address leachate. Chan describes some of these measures:

After the damming of Serangoon River to form Serangoon Reservoir, contaminants were still being leached from the Lorong Halus Dumping Ground despite the cut-off walls being effective, as a result of groundwater infiltration from areas that were beyond the boundary designated as the Lorong Halus Dumping Ground. Dredging of up to 3 m of a polluted benthic layer was conducted at Serangoon River following the advice of consultants. Lessons were learnt from the construction of Kranji Reservoir, where dredging was not conducted, and the leaching of organic contaminants continued for years. It is prudent to invest in mitigation measures first than to remedy the situation later.⁴⁸

The cleaning of Punggol took several decades. It required systematic remediation of land and water, the cost of not having the resources to keep the area clean from the start. Over time, the environment improved, but community-centric planning was needed to move Punggol from just a regular suburban township to what it is today.



13. A bio-remediation pond in the Lorong Halus Wetland.



CHAPTER 3

LAYING THE FOUNDATIONS FOR A RESIDENTIAL TOWNSHIP

“

When future demand is uncertain, how should we provide hard infrastructure which, once built, cannot be changed? One strategy is to plan for and invest in selected ‘no regrets’ infrastructure upfront, even if it might result in some redundancy and sub-optimisation.⁴⁹

”

CHEONG KOON HEAN

CEO, Housing & Development Board (2010–20)

While the 1971 Concept Plan had designated Punggol as a rural area, it was at the back of the minds of decision-makers that it would be urbanised at a later stage. To prepare the area for eventual development, the government laid the foundation for its development from the 1980s by preparing the land and transport for its future residents.

North-Eastern Reclamation Scheme

In March 1983, the government announced that it would undertake a reclamation project in which 2.77 km² of land would be reclaimed off Punggol at a cost of S\$136 million.⁵⁰ Parts of the reclaimed land were designated for industries, relocation of activities affected by public schemes, and intensive pig farming.⁵¹ In October 1984, another reclamation scheme at Singapore's north-eastern coast was approved by Parliament. About 6.85 km² of land was reclaimed in the shallow waters off Pasir Ris, Punggol and Jalan Kayu. Costing S\$874 million, the project was undertaken by the Housing & Development Board (HDB). Most of the newly reclaimed land was reserved for residential neighbourhoods, while smaller areas were planned for other uses, including industrial and recreational. The reclamation was to be carried out in four phases over a 9-year period from 1985 to 1993. To maximise the useful lifespan of Punggol fishing port, it was kept operational until the last phase.⁵² Reclamation of the foreshore near Coney Island, which was also slated for reclamation in the last phase, was deferred as the north-eastern sector land-use concept plan was not yet finalised.⁵³ Eventually, in 1996, 1.45 km² of foreshore near Coney Island was reclaimed, creating a 100 to 200 m wide water channel between Coney Island and Punggol on the mainland in the process.⁵⁴



14. A total of 2.77 km² of land was reclaimed in the 1980s to build up land stock for future housing needs.



15. Punggol's shoreline changed over the years as a result of reclamation and conversion of Punggol and Serangoon Rivers into reservoirs.

Integrating Transport With Land Planning

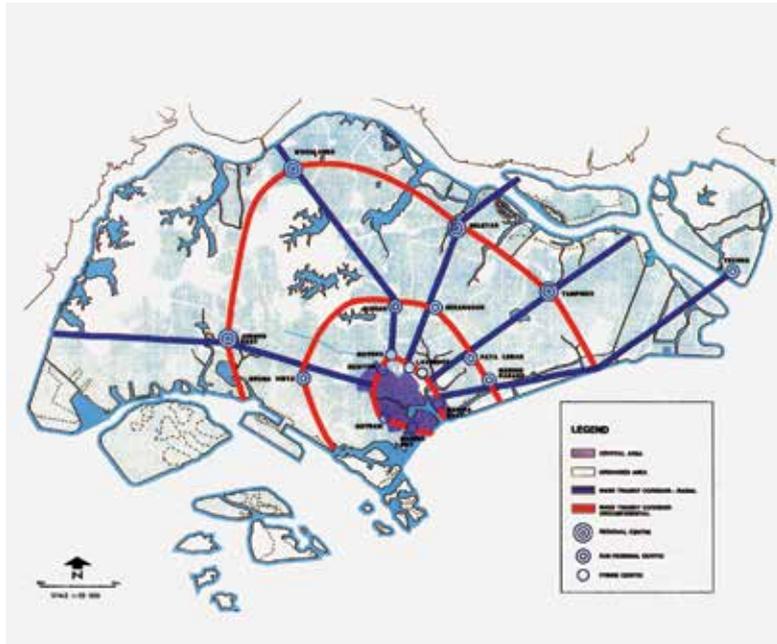
Land-use planning for Punggol started in the mid-1980s to convert the rural land designation to mainly residential. Among the foundations needed was transport networks. Mohinder Singh, Director of Planning, Land Transport Authority (LTA) (1996–2007) explains:

In 1981, the planning department embarked on the planning of the north-east region to supplement the 1971 Concept Plan. The plan was to develop HDB towns along the Upper Serangoon Road corridor all the way through Hougang to Sengkang and further north to Punggol. The idea was that farming will not be kept in the longer term there. This plan was formalised in the 1991 Concept Plan.

In 1985, there was a plan to develop an MRT [Mass Rapid Transit] line, the North East Line [NEL], which runs from HarbourFront all the way to Punggol. The MRT line was planned and designed by the MRTC [Mass Rapid Transit Corporation] at that time. Roads and future road plans had to be adjusted and reconfigured to accommodate the new MRT line. Plans for an expressway to serve the north-east region were also developed, and later built as the Kallang–Paya Lebar Expressway [KPE].⁵⁵

The plans of the 1980s were further consolidated in the 1991 Concept Plan. This formalised the revising of the “Ring Plan” of the earlier 1971 Concept Plan to a “Constellation Plan”. The aim was to “fan” commercial centres out to the heartlands so that jobs could be brought closer to homes. Singapore would have five regions—Central, North, Northeast, East, and West. Seletar would serve as the regional centre for Northeast but would only be activated when areas surrounding it are developed.

Following a government study in 1985, the development of a north-eastern corridor, which included the upcoming townships of Sengkang and Punggol, began.⁵⁶

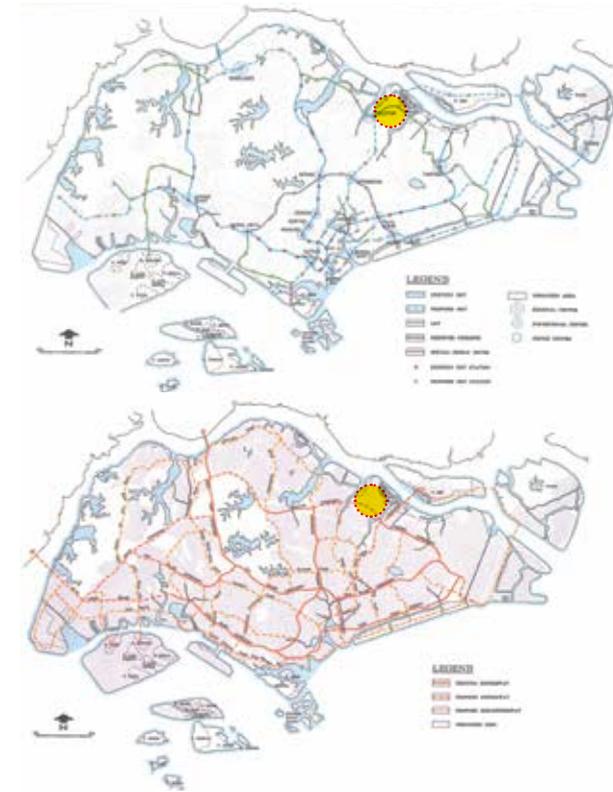


16. The Constellation Plan and new corridors, including the one towards Punggol.

Public Transport Network

The Punggol township was planned with an efficient and convenient public transport system, with Punggol MRT station connecting with the rest of Singapore via the NEL. The NEL construction commenced in 1997, six years after the 1991 Concept Plan. Singh recalls:

When the North East MRT line was planned up to Punggol, there was a discussion whether we should have the line extended westward towards Seletar, which was proposed to be a potential regional centre in the 1991 Concept Plan, or eastward. I think it was prudent planning that the option was left open as to which way the line should go, because as events turned out, the plans for Seletar were subsequently changed, and it was eventually decided for the line to be extended eastward, to the right-hand side.⁵⁷



17. Punggol's MRT and road networks were planned as part of the 1991 Concept Plan and modified over time as the master plan was refined.

A network of Light Rail Transit (LRT) lines, connecting to Punggol MRT station, was also planned to improve connectivity. Singh recalls the process:

The LRT system was not part of the 1991 Concept Plan. It was planned when the HDB, URA [Urban Redevelopment Authority] and LTA sat down and started looking at Punggol 21. I think this was probably in 1996 or thereabouts. Both LRT systems, the Sengkang and the Punggol LRT systems, were planned together. This was a very interesting period because this was a time when the LTA had just been set up, and the LTA planners were all very gung-ho to go and sit down with the URA and HDB and say, "Let's do something together." In fact, we actually sat across the table to look at a clean sheet of paper—about Sengkang and Punggol—to see how the LRT system should be configured and how the housing should be configured in order for each to be integrated to best serve each other.⁵⁸

This was in contrast to the Bukit Panjang LRT, which was constrained by existing buildings. In Punggol, residents would not need to walk more than 400 m to the LRT stations, which would be located conveniently near residential blocks. The LRT stations would also house shops for convenience.⁵⁹



18. The “butterfly wings” of the LRT network was planned so that most residents live within 200 to 400 m of an LRT station (less than 10 minutes’ walk).

While the LRT was integrated into the design of Punggol Town, its construction began in 1998, in the midst of the 1997 financial crisis. Further, the pace of development of Sengkang and Punggol Towns was expected to slow. As a result, funding was limited and low projected ridership was expected, which led to the decision for the LRT system to be built for only one car, even though it was originally designed as a 2-car system. Given that the lifespan of the Mechanical and Electrical (M&E) signalling system is about 15 to 20 years, the decision was to fit out for one car initially, but to be scalable for mixed-fleet operations in later years and to be changed out to a full 2-car system during replacement, if needed.

In the initial period of the Sengkang–Punggol LRT operation (2003–06), ridership was predictably low; the pace of development was further slowed due to the severe acute respiratory syndrome (SARS). Subsequently, Singapore went through a period of rapid growth in 2006–13, including the development of housing in Sengkang and Punggol at an accelerated pace, which has continued till today. The LTA thus introduced mixed-fleet operations in the mid-2010s to meet the growing demand. As the lifespan of M&E system is reaching 20 years, the LTA has planned a full 2-car system to be implemented in the mid-2020s, to cater for future projected growth.

In 1999, the LTA further developed a rapid transit master plan, which featured a “North Shore Line” that ran from Changi Airport all the way to the North-South Line Woodlands station, via Pasir Ris, Lorong Halus, Punggol Town, Seletar and Simpang. Today, the eastern segment of the North Shore Line alignment has been incorporated into the Cross Island Line (CRL)-Punggol Extension, a 7.3-km extension comprising four MRT stations linking Pasir Ris and Punggol.⁶⁰ Fong Chun Wah, Deputy CEO, Building Group, HDB (2016 to present), believes it was foresight that ensured the connection between the two lines had been part of the design:

Provisions for an interchange at Punggol MRT station with the CRL was catered and safeguarded for even before the completion of NEL, so when the line comes in, the connections will be quite simple as the connections were already talked about in long-term planning. This shows the importance of long-term planning.⁶¹

Road Network

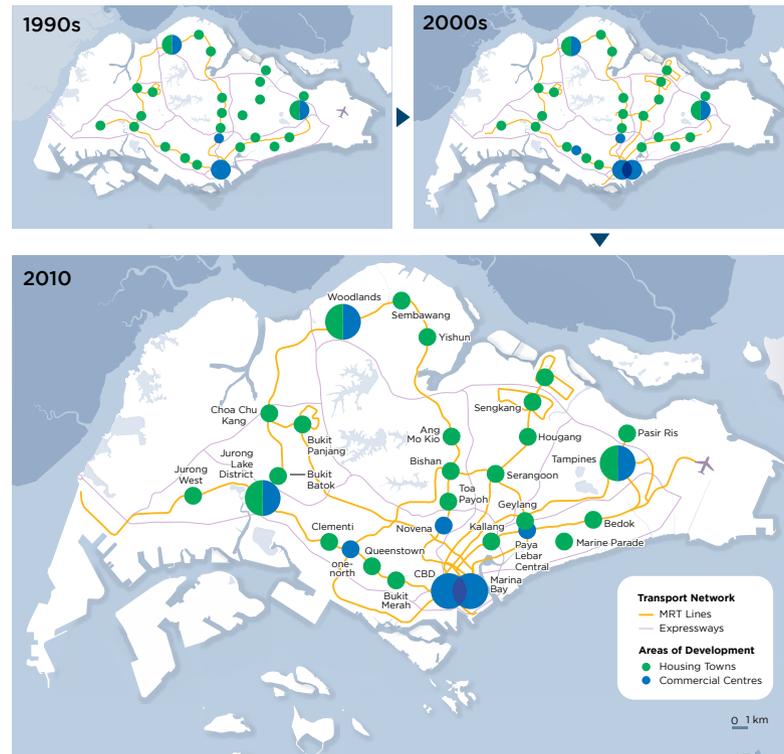
Planning Punggol’s road network had its challenges. Being a coastal town, flanked on three sides by water passages, Punggol’s access network was prone to bottlenecks at major access points—the expressways and bridges. Singh puts this into context:

One of the proposals was to actually develop a north[ern] road from Pasir Ris through Lorong Halus area, Punggol Town, Seletar town, Simpang, and then linking up to Admiralty Road West along the northern fringe of Woodlands town. And this corridor was planned to be a semi-expressway, located north of the Tampines Expressway [TPE]. It was planned for the semi-expressway to be aligned in a depressed section through Punggol Town, which was cheaper to build and operate compared to a tunnel option. To ensure that areas north and south of the semi-expressway remain connected, bridges would be built across it to carry the north-south roads. [However,] Lorong Halus development did not come about for quite a time, and even Seletar Air Base development did not come about until much later. So Punggol ended up with a town which is flanked by the two rivers with most of the transport infrastructure oriented towards the south and towards the TPE.⁶²

In 1985, the government decided to extend the Kallang Expressway northwards by 9.2 km to connect to the TPE, forming the KPE.⁶³ Nonetheless, due to differing views between the Ministry of Transport and Ministry of National Development on where the KPE should connect with the East Coast Parkway (ECP), modelling and simulation of the various alignment

alternatives had to be carried out; it was eventually agreed to build the interchange along the KPE and ECP between the Fort Road Interchange and Benjamin Sheares Bridge.⁶⁴

Eventually the KPE, which was fully opened in 2008, helped reduce traffic pressure on the parallel Central Expressway and improved connectivity to the north-eastern region.



19. Singapore's connectivity expanded as more townships and commercial centres emerged, including in and to Punggol.

Planning With Regional Concerns in Mind

Another concern was the potential cross boundary pollution from Malaysia, as Punggol is situated directly across the Straits from the Pasir Gudang heavy industrial region in Johor. Loh Ah Tuan, Deputy CEO, National Environment Agency (NEA) (2004-07), describes some of the concerns:

In planning Punggol, one of the environmental concerns was trans-boundary pollution from Sultan Ismail Power Station in Johor Bahru, and the pollutive heavy industries such as petrochemical plants, integrated steel mill, etc., in Pasir Gudang and Tanjong Langsat on the opposite side of the Straits of Johor. Prevailing north-east winds could carry air pollutants from the power plant and industries towards Punggol, affecting the ambient air quality in Punggol.⁶⁵

This directly impacted the planning and design of the town. Fong cites the following:

Trans-boundary pollution influences the planning of Punggol. For example, it was planned for the northern region of Coney Island to be greenery, while housing will face southwards.⁶⁶

The plans and designs contributed to a reduction in the impacts of pollution on Punggol Town.

The crucial development layers of land, water and transport took shape slowly. After more than a decade, the planning process was finally ready to enter into the next phase: planning for a vibrant township fit for the 21st century.



CHAPTER 4

A NEW TYPOLOGY: A HOUSING ESTATE FOR THE 21ST CENTURY

“

When Punggol 21 was first conceived in 1996, it was meant to be more than just another HDB new town. The HDB wanted to create a living environment that would appeal to a new generation of better educated, more sophisticated Singaporeans. Under this new concept of public housing, Punggol 21 would not just offer well-designed HDB flats, but an integrated, high quality environment of recreational and social facilities. Today, this vision has become a reality, Punggol 21 is now a landmark town.⁶⁷

”

GOH CHOK TONG
Prime Minister (1990–2004)

A New First for the HDB: A Waterfront Town

Punggol was unique: it was a chance to create a new type of town—one which could celebrate having water on three sides of the town—featuring three rivers and a coastline. Punggol was envisaged as a model for future towns, incorporating new ideas and offering varied lifestyle options for the 21st century. Fong Chun Wah, Deputy CEO, Building Group, Housing & Development Board (HDB), describes what makes Punggol special:

Punggol came as a new opportunity; we looked at it as a remarkably interesting town and it was to be developed over the next millennium. That means major works [had to] be done. A lot of thought was put into it together with the URA [Urban Redevelopment Authority] to look at what is the concept for Punggol, particularly as it was to be a waterfront town. Singapore did not really have a waterfront town that was almost surrounded by water.⁶⁸

Reimagining what a residential estate could look like required support from leadership. Fortunately, the HDB and URA had support from the top, which allowed the planners to explore more ideas. Seow Kah Ping, Dean of the URA Academy, recalls:

Lim Hng Kiang was the Deputy Secretary and subsequently became Minister for National Development. He was quite a prime mover for wanting to develop Punggol Town. In 1994, he sent Fong [Chun Wah] and myself [on] two trips: Fong went to the United States to study the waterways, and [I] went to look at the waterways in Korea and Japan. I think he wanted this to be a waterfront town.

So the HDB planned the southern side which is mainly the public housing side. And the northern side, the URA planned. But we met very frequently to synchronise the planning. So that was one or two years before 1996, taking the lesson from the study trips. Essentially, we were looking at what is the best way [to plan] for the new river—the third river that we wanted to create between Coney Island and the mainland—that probably [had a width of] 100 to 180 m.

So the concept that we proposed for the alignment of the [third] waterway was [that] the southern side [would] be much more urbanised—meaning straight lines; the northern side, the Coney Island side, [would be] a bit more sinuous, more wavy because of the rustic nature, the more recreational nature of Coney Island.

We went to quite [a lot of] detail into the waterfront treatment, the different treatments: vertical edges, slope revetments, sandy beaches and so on and so forth. So that is how we came up with this Punggol 21.⁶⁹

Michael Koh, Executive Fellow at the Centre for Liveable Cities (CLC) shares more details:

Canal inlets were planned at the northern part of Punggol fronting Coney Island to increase the water frontage and was modelled after Tanjong Rhu. It was also planned originally to have 2 marinas on either side of Punggol, to enable Punggol to attain a waterfront feel.⁷⁰

Seow adds:

We are trying to create something like a dock with the indentation and that will also allow the inner estates or those housing along this dock to have views of the water and to have views towards the new river, through the view corridors created.⁷¹

With the third river, total water frontage increased to 15 km, and many more people had access to water views. In total, 1.16 km² of land was reclaimed to create the new river between Punggol and Coney Island. The treatment of the coastline was given a lot of consideration, as Fong reveals:

How [do] you treat the water edge that is a very important public space? An important learning point in our studies was that the water edge must be accessible by the public. [We looked] at the different ways that various cities reclaim and treat the coastal line. So, if you look at the north coast, it is rocks; along the other edges, it is soft, so [had] put in effort to vary the coastal line condition.⁷²



20. Punggol 21 features three rivers—Punggol River, Serangoon River, and a third river being formed by Coney Island and the mainland. A sinuous coast was to feature on the Coney Island side, and a straight coast on the Punggol mainland side.



21. Punggol was planned to feature a continuous waterfront promenade that would meet with the new Punggol Marina; it was designed not only for walking and cycling, but also to hold water recreation activities such as dragon boating, kayaking, jet-skiing and sailing.

Planning for the 21st Century and the Needs of a Future Demography

Beyond looking at the town from a perspective of maximising its positive attributes, the town had to be planned for liveability and to suit the aspirations of a new generation of Singaporeans. Fong shares:

The next thing [we considered after the waterfront landscape] was: with new families moving in, what would be the lifestyle of people, going forward? Will the old town model of neighbourhoods with 4, 5 to 6,000 families per neighbourhood served by a neighbourhood centre still work? We found that [the] people's lifestyles [were] changing. Malls were starting to crop up so people were actually moving from neighbourhood centres to shop in malls.

So an important concept change was to have estates instead of neighbourhoods. That means instead of five to six thousand families in a neighbourhood, we would have two to three thousand in an estate, that is, sized down by half. And [we had two or three precincts per estate], more intimate and convenient for people.

And for each estate, most would have an LRT [Light Rail Transit] station, and also a cluster of shops rather than the big neighbourhood centre because neighbourhood shops [were] also not doing that well. And within the estate, there would be no public roads.

[Each estate would] also be served by a common green rather than a neighbourhood park. Because we shrunk the neighbourhood, everything would be more compact. And in fact, if you look at Punggol's plan, you will find that many estates have either a primary or secondary school, and it is almost self-contained, and these amenities are within walking distance.

[That was the] major change, looking at how people will live in [the] future, taking transportation and amenities within walking distance.⁷³

Thus, the new Punggol Town, which was planned for 96,000 families, would offer a good mix of housing types: 60% HDBs, 10% ECs (Executive Condominiums) and 30% private housing.⁷⁴

The HDB flats would be designed differently and could have a mix of types: 1/3 Standard, 1/3 Design-and-Build, and 1/3 Design Plus. Smaller, distinctly designed estates were built, with about 1,200 to 2,800 dwelling units sharing a common green, making it a more intimate precinct, each having a "green lung".

EXHIBIT 1 VARIOUS HDB DESIGN SCHEMES IN PUNGGOL.

| Standard | Design-and-Build ⁷⁵ | Design Plus ⁷⁶ |
|---|--|--|
| Comes in new designs and with better layouts than the typical HDB flats constructed earlier in other estates. | The Design-and-Build Scheme was introduced in 1991 to give give home buyers more choices. Private architects, engineers and contractors are invited to tender for the design and construction of public housing on land set aside within HDB estates. | The Design Plus Scheme was announced on 9 January 1996 to complement the Design-and-Build homes that are built with private sector expertise. Compared to standard flats, Design Plus flats have better design features and finishes, with varied units, blocks and layout plans that make for more unique and innovative designs. |

The mix of housing types was created to ensure a mix of socio-economic communities, encouraging greater social inclusion. A Special Housing Assistance Programme was created to help those from low-income households to own flats. Meanwhile, premium flats were built for those who desired higher quality housing and coastal sites were reserved for private housing, to mirror the success seen from Tanjong Rhu's redevelopment. Coney Island alone would be developed to house 2,000 units of low-rise housing. In an interview with CLC, Seow commented on the housing mix:

We were again translating the 1991 Concept Plan, you know, meeting the aspiration of Singaporeans who want to own private housing and all that, so Punggol was planned at that point in time to have a slightly higher proportion of private housing than other towns.⁷⁷

Planning for Viable Commercial Centres and Retail

Punggol also featured a new layout and density of commercial and retail spacing. Seow explains:

We were learning from the lessons of Sengkang [and] Pasir Ris. For example [in] Pasir Ris, when the White Sands Mall came up, the neighbourhood centres such as Elias Mall [and] Loyang Point started to experience [a] drop in shoppers' traffic because people wanted to go and try new things. The other thing is that neighbourhood centres are generally labour-intensive. You need a lot of manpower to run all those 60 to 80 shops in each neighbourhood, and the older generations were finding that their children were not that willing to take over. That prompted some rethinking about the neighbourhood centre.⁷⁸

Punggol was thus planned at that time without neighbourhood centres, but instead, with a Town Centre positioned around Punggol MRT station, with commercial centres to the east and west. To replace neighbourhood centres, local shop clusters were set up, usually next to LRT stations, each having a minimart or provision shop, a few services shops, and an eating house.



22. Punggol MRT station was to be integrated with the Town Centre and commercial facilities, making it more convenient for residents; Punggol LRT station was integrated into the facility as well.

A Town Planned to Enhance “Kampung Spirit” Through Recreation and Greenery

Against the backdrop of Singapore's demographic change with a more mature economy, the rise of IT-based industries and Singaporeans' demand for a better quality of life, Punggol was planned with the enhancement of the *kampung*, or community spirit, in mind. It was designed to be pedestrian-friendly with integrated car parks on the lower levels of HDB blocks, landscaping and footpaths, and the provision of covered walkways. Estates were to be constructed in clusters around a common green, acting as a meeting place for residents. Coney Island would serve as a regional park. While he was Prime Minister, Goh Chok Tong described the vision for Coney Island:

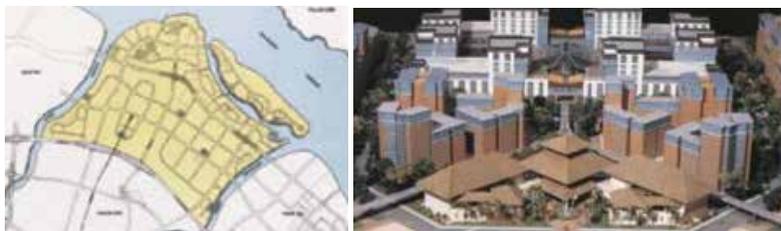
The centrepiece will be Coney Island. The HDB is currently reclaiming land for the island. When it is fully developed, this 102-ha island will be a recreational hub. Apart from the beach, there will be clubs, chalets, camping grounds, and a sea sports centre. Bridges will link Punggol 21 to Coney Island. Residents will be able to cycle, jog, or just take a leisurely walk across to enjoy the island's facilities.⁷⁹

Coney Island was planned to have its own sea sports centre and clubs. It was envisioned to have bridges that would allow residents to walk or drive to and from the mainland. Punggol was to have not one but two marinas, with some private residences enjoying canal living: Singapore's very own "Little Venice".



23. Punggol introduced Common Greens, which are gathering and meeting places, into estates. Coney Island was to be the Town's regional park.

Residents could easily access common facilities, which would be clustered, including schools, places of worship, and recreational and social venues.⁸⁰ It would also feature recreational clubs, something that was not common in other older residential estates.



24. The plan included six to eight recreation clubs (green nodes on map) to be run by SAFRA or the NTUC. Residents could become members to enjoy the facilities such as swimming pools, badminton and tennis courts, as well as gyms.

Excitement and Interest, Thwarted by the 1997 Asian Financial Crisis

When Punggol 21 was unveiled at the HDB-URA exhibition at Raffles City in October 1996, there was considerable interest. Seow recalls:

We had the exhibition in the Raffles City, the atrium, and we had people coming to ask us when they could book the units in Punggol. Even though, you know, Punggol is so far away at [that] point but people [were already interested to move in].⁸¹

However, the development of Punggol slowed down when the Asian Financial Crisis hit Singapore in 1997. The demand for housing fell sharply. In the early 2000s, even as residents started moving in, 31,000 units were still unsold; it eventually took more than five years for the HDB to sell them and for the rest of the residents to move in.⁸²

This resulted in Punggol being under-developed over the next few years. The development of both public and private housing was delayed due to poor demand. The small population meant that the establishment of amenities and services had to be deferred, and the area failed to attract retail shops. Only a few bus services operated, and access routes were limited; residents took more than an hour to get to the Central Business District. The residents also complained that the government's "waterfront living" was far from reality, as the first phase of housing was built inland, far from the waterfront. The Punggol dream seemed just that—a dream.



CHAPTER 5

REJUVENATING PUNGGOL: BREATHING NEW LIFE

“

I am always intrigued by the word 'home'. 'Home' is actually two words: 'HOpe' and 'MEmories'. Home is a place that is full of hope for the people who live there; we have shared interests, shared action and a shared memory, on which we deepen our sense of belonging. We need to have involvement to build social capital. A place without social capital is basically just a hotel, right?⁸³

”

PENNY LOW

Member of Parliament for
Punggol North (2000–15)

By the mid-2000s, Punggol New Town was languishing. Penny Low, then Member of Parliament (MP) for Punggol North (which is part of the Pasir Ris-Punggol GRC), recalls the situation:

There were probably just 2,000 [occupied] units. Very often, I would drive around the estate to count how many units were lit up—a telling sign of households that have moved in.

In my first week after the Elections, I was met with my very first appeal letter from more than 100 residents. Punggol was launched with the promise of “waterfront living”, but the Asian economic downturn of 1997 and the 9/11 attacks in 2001 had caused a plunge in the sale of flats, leading to an unprecedented situation where [the newly bought units] were priced lower than [when] the residents bought them years ago. This, coupled with the lack of common amenities like a bus service, clinic, shopping centre, coffeeshop and supermarket, led to fury brewing on the ground.⁸⁴

Some residents moved away as soon as their 5-year minimum occupancy period was over. Renters filled in as rents were cheaper. Punggol seemed destined to be a lacklustre suburb.

Building Momentum for Better Things to Come

Despite the challenges faced, many were not ready to give up on the dream that was Punggol. Low describes the efforts in the early 2000s to galvanise residents to be protagonists for change:

Because it was a new area, there were no grassroots leaders. I figured that if someone could organise this protest, then there must be very, very good leaders within. I asked the group of signatories to come and meet me and asked them to choose some five representatives to speak for the whole group and have a conversation about how best to develop the town.⁸⁵

In 2002, the Punggol Town Development Taskforce was set up, involving the decision-makers of the various government agencies and grassroots leaders. Low served as the chair for 13 years, when the Housing & Development Board (HDB) was the secretariat. The grassroots leaders were the voice of the community to highlight the services, facilities and amenities that were needed. In time, Low shares:

The residents became pseudo town planners. They would put forward ideas. The agencies were open-minded and professional too—they shared the blueprints and sought input upfront, rather than post. This allowed the residents to [input] their design ideas as well as amenity needs and wants into some of the projects.⁸⁶



25. The Punggol North Taskforce was a platform for agencies and grassroots leaders to work together to address the needs of Punggol residents.

At the agency level, the HDB initiated a significant review of its master plan for the area. The Urban Redevelopment Authority (URA) consolidated plans for waterfront living through its Parks & Waterbodies Plan in 2002 to guide the development of parks and waterbodies over the next 15 years. This laid the foundation for the 4.9-km-long Punggol Promenade along the coastline to be a major recreational and leisure destination for residents living nearby and for the wider community.⁸⁷ At the same time, the Identity Plan was launched, which identified places with a sense of history and character, and suggested ways to retain and enhance these qualities. The community was engaged on proposals made in the Parks & Waterbodies and Identity Plan, and “Subject Groups” were convened to study the proposals in detail.

One of the Subject Groups was the “Parks & Waterbodies Plan and the Rustic Coast”.⁸⁸ Among the outcomes, Punggol Point was identified as a key area with rustic charm, given its laidback atmosphere that provided a retreat from urban Singapore.⁸⁹ Punggol Point would be linked with neighbouring coastal areas like Coney Island, Pasir Ris, Changi Point and Pulau Ubin⁹⁰ via a Park Connector Network (PCN). The coastal theme was also adopted in the streetscape plantings of Punggol, where plants species and landscape designs were curated to create a coastal identity.⁹¹

Identified as a potential heritage road in the 1990s, the old Punggol Road was retained and lined with wooded buffers that provide the ambience

of travelling through a tropical forest. The National Parks Board (NParks) worked with the HDB and Land Transport Authority (LTA) to realign the newly built Punggol Road, expunge the old Punggol Road, and convert the reclaimed road spaces into park spaces. Fong Chun Wah, Deputy CEO, Building Group, HDB, explains:

As we were developing other parts of Singapore, we found that it was very difficult to increase the capacity of a road without destroying its ambience. Hence, a decision was made to pedestrianise the old Punggol Road and make it a heritage trail, and re-plan the northern part of Punggol so that we do not have to designate Punggol Road as a major transport node but [pedestrianise it and] turn it into something that people can [use to] enjoy the ambience.⁹²



26. The old Punggol Road in the 1980s; the road was retained as part of the Punggol Heritage Trail.

Punggol Road was retained as a green corridor in Master Plan 2003 and was further expanded in subsequent master plans. As a result, NParks developed design guidelines for the surrounding developments to ensure that their designs integrate well with the greenery of the heritage road.⁹³

On 20 June 2003, Punggol Mass Rapid Transit (MRT) station was opened.⁹⁴ In the same year, the Punggol Temporary Bus Interchange was opened along with four new bus services. From 20 January 2005, the Punggol Light Rail Transit (LRT) lines were gradually rolled out according to demand. First, the East Loop was opened for uni-directional operation before it became fully operational in both directions in 2011. Afterwards, the West Loop was opened on 29 June 2014. These greatly alleviated the concerns of accessibility.

Slowly but surely, momentum was building towards a more liveable town. However, a greater “push” was needed to get it over the proverbial hill.

The Trickle That Led to a River: The Launch of Punggol 21+

By the mid-2000s, the HDB was tasked to study how to revitalise all towns in Singapore. Many public housing estates had reached their 20- or 30-year mark and necessitated renewal. The HDB thus conceptualised the Remaking Our Heartland initiative to inject vibrancy and sustainability into towns. One of the towns selected was Punggol. The new vision for Punggol, dubbed Punggol 21+, was announced by Prime Minister Lee Hsien Loong at the 2007 National Day Rally:

We started Punggol 21 in 1998. Every time I visit Punggol, they remind me: we had to slow down because of the financial crisis. But now, the demand is picking up again. I think it is time to get things back on track, but not just back on the old tracks. We have had time to study and to improve and upgrade the plan. So, this is “Punggol 21+”.⁹⁵

The prime strategy for this upgrade was to build in a new feature—a man-made waterway—and to re-design the areas surrounding it. During that time, in an effort to continuously strengthen Singapore’s water security, Punggol and Serangoon Rivers were to be dammed and turned into reservoirs, together with Marina Bay. This would increase the total water catchment area in Singapore from half to two-thirds of its land area. To address hydrological concerns, a pipeline had to be built between Punggol and Serangoon Reservoirs. Many saw this as a golden opportunity to bring water “closer” to the residents by surfacing this pipeline into another “river”.⁹⁶ Seow Kah Ping, Dean of the URA Academy, explains why the URA thought it was a good idea:

First, [Punggol] was supposed to be a waterfront town, but if you were in the [old] town centre, you [did not] experience the water, because the town centre was quite far: it is a few hundred metres from the waterway.

The second reason was...it was quite dense. Some open space will help to relieve the built environment.⁹⁷

The idea and vision were so compelling that, once seeded, it fired the imaginations of agencies. While this was an expensive additional feature (the final cost of the waterway was S\$250 million⁹⁸), and would involve additional maintenance costs, the agencies sought to figure out a way. To accommodate the waterway, the planned grid was “shifted” one road-width

northward.⁹⁹ This was possible as the northern part of the town had not yet been developed. Eventually named My Waterway@Punggol, the 4.2-km-long waterway became the longest man-made waterway in Singapore.¹⁰⁰ Yap Tiem Yew, Group Director, Building & Infrastructure Group, HDB, points out that:

The waterway has transformed Punggol into a sustainable waterfront town of the 21st century and redefined the notion of public housing. The design embraces the coastal heritage of the area and integrates seamlessly with the surrounding housing sites, creating a vibrant living environment for the community.¹⁰¹



27. Punggol 21+ introduced a fourth, man-made waterway created by connecting Punggol and Serangoon Rivers inland, bringing the waterfront closer to most residents.

Master Planning and Urban Design: Keys to a Great Town

The waterway spurred a new phase of comprehensive master planning of Punggol. The HDB led this master planning effort to review the land use and urban design. According to Cheong Koon Hean, CEO, HDB (2010–20):

The building programme had to triple. We had to open new land. The starting point must be to formulate a holistic master plan and urban design that sets out the vision for the town. Urban design guidelines

must be developed to guide all architects in their detail design of every parcel of development. Without the master plan, the developments will be uncoordinated, unintegrated, and worse, we will not achieve the vision and identity that we had set out for the town.

If we do a great plan, and ensure that we pay attention to good urban design and detail design, then the end product will be very good, and the entire town will be seamlessly integrated to achieve a quality environment.¹⁰²

Urban design was key to maximise the benefits from the waterway. Initially, the waterway was only to have a width between 22 and 25 m—10 m for the water (to enable two boats to bypass one another) and 6 m on either side for the Park Connectors,¹⁰³ which Cheong describes as such:

Punggol waterway is just a little *longkang* (drain); on its own, it is very tiny. So, planners have to be creative in expanding the sense of space along the waterway by “borrowing” greenery from the developments that are on either side of it. The design of the green spaces for each development [is] seamlessly integrated with the waterway. Furthermore, the different widths of green spaces and the lowering of heights of the buildings fronting the waterway [have] resulted in a varied and interesting urban landscape as one walks and cycles through the entire waterway.¹⁰⁴

Working in close collaboration with agencies such as the URA, PUB, Singapore’s National Water Agency, NParks, and others, the HDB carried out several case studies (including River Thames, River Seine and Singapore River) in the alignment of the waterway, and re-worked various options to improve its course. The HDB also intentionally varied the widths of the waterway, spanning 85 m at its widest at the town centre, which was its first Commercial and Residential zoned parcel. Eventually, the final alignment was planned to be more organic in form, resembling that of a natural river.

The residents, ranging from school-aged children to members of the community, also submitted ideas for the waterway through the HDB’s Call for Ideas exercise. Some of the ideas and feedback were eventually incorporated into the design and programming of the spaces along the waterway.

Full urban design guidelines were drawn up for the entire waterway corridor to ensure integration with the waterway and the developments on both ends. A series of seven footbridges across strategic locations along the waterway was introduced to ensure pedestrian connectivity. The HDB also worked out the ownership and maintenance arrangements with the

PUB and NParks for the waterway and its promenades flanking its entire course, with the subsequent decision on the housing mix concept along the waterway.



28. Residents and the wider community were engaged to contribute ideas for the waterway.

The construction of the Punggol Waterway, which began in 2009 and was completed in 2011, was an engineering feat. There were many challenges along the way, and the HDB had to come up with innovative and green solutions to maximise efficiency and yield cost savings. For instance, to safeguard the integrity of nearby MRT and LRT transit structures, diaphragm walls were constructed prior to excavation works. The diaphragm walls were eventually transformed into the “Heartwave Wall”—a 280-m-long scenic retaining wall with vertical greenery, water features and educational heritage panels reflecting Punggol’s history from the 1800s to the present.¹⁰⁵

The cooperation of the agencies was key to the successful implementation of all plans and urban designs. As Chong Fook Loong, Group Director, Research & Planning Group, HDB (2014 to present), reflects on his experience as the Project Director of Punggol:

[It is] a very interesting [collaboration], I must say, to build Punggol. You have the planning phase where agencies clustered together to build and plan Punggol first, the planning phase. And we have [a] very established steering committee chaired by the Chief Executives, working committees chaired by myself as Project Director of Punggol, [and] we have multi-agencies. So those processes and the setup were very critical.

In fact, if you ask me, the HDB townships [were] probably one of the best vehicles for multi-agencies coming together, to collectively build, plan, coordinate and develop together. Sometimes there are different views, and sometimes there are misalignments in terms of interest and all that, but when we work collectively as a team, things change because then we are all collectively driven by the same objective to build the best township in a sense, with everything working well. Otherwise, it is impossible.¹⁰⁶

Most importantly, residents have benefitted from having the waterway closer to their homes. Punggol resident Marjorie Chong shares:

When I visit my friend who lives along Punggol Waterway, and I look down from her apartment on the 10th storey, I can see otters swimming in the green waters of the waterway. This is a clear instance of the seamless integration of blue and green into the urban matrix. She [often shares she] feels very lucky to have the waterway right at her doorstep. Another friend lives 10 minutes away and loves cycling to the river for a refreshing break.¹⁰⁷



29. Residents only need to take a short walk to the waterway to enjoy continuous public pathways and the rest spots along it.

BUILDING INSTITUTIONAL CAPACITY TO RESPOND TO NEW NEEDS

By 2010, the HDB had already embarked on the development of 23 towns/estates, delivering nearly a million homes in 40 years. As the quality of life for Singaporeans improved, so too did their expectations for their homes.

Under new CEO Cheong Koon Hean, the HDB expanded their role, from simply being a builder of homes that met basic needs, to address changing expectations—that of urban design and sustainability. To do so, the HDB needed to expand its internal capabilities. Chong Fook Loong, Group Director, Research & Planning Group, HDB, explains how this change took place:

Dr Cheong, being a champion [of urban design and sustainability], injected tremendous amount of energy into the system. She took urban design even further. She [gave] us real resources. Then I was just running the team on planning and urban design, everything *bao ga liao* [Hokkien for doing everything, covering all roles]. But when she came in, she expanded that little team that I had into three other urban design departments. For us planners [and] architects, we were just totally filled with new energy, new fuel.¹⁰⁸

Aside from raising human resources, the HDB also developed tools to measure whether it was meeting these expectations. Cheong's approach to thinking about sustainability for the HDB was this:

When I joined the HDB, one of the first questions I asked was “What is so eco about Punggol?” To answer this, we worked on developing a sustainable development framework to define specifically our goals for a sustainable town and the strategies needed to achieve these goals. We also set out clear KPIs to assess whether we are attaining our goals. Without measurable KPIs, we will not know whether we are heading in the right direction.¹⁰⁹

With that, the HDB developed its own Sustainable Development Framework. Tan Sze Tiong, Director of Environmental Sustainability Research, Building & Research Institute, HDB (2016 to present), outlines how this framework was implemented:

The Framework maps out the desired outcomes we want to achieve. So, [while] much is on environmental sustainability, we also focus on the social and economic. For all desired outcomes, we mapped out clear KPIs, what we want to achieve, such as energy, water, waste and greenery. The outcome never changes, but the initiatives we plan to implement are being refined over the years due to the emergence of new technologies and successes from R&D [research and development] and successful testbeds.¹¹⁰



30. The HDB's comprehensive Sustainable Development Framework was drawn up to guide the development of Punggol as an eco-town, and has contributed to the outcomes in the national Sustainable Singapore Blueprint.

The KPIs were set in recognition that there is a need to continually track efforts and progress to ensure targets are not missed. Through these efforts and others, the HDB was able to continue to meet the housing aspirations of the evolving Singaporean.

Leveraging Talents: Involving the Private Sector

The waterway was an opportunity to bring in innovative ideas. Fong describes how competitions were leveraged as a means to seek out these ideas:

We had two competitions. One was the design of the waterway—how to integrate a waterway with a waterside promenade for walking and cycling—and a town park that will be managed by NParks. The engineering design and construction of the waterway was a challenge due to the very high existing terrain and the presence of an existing and running MRT station that needed to be protected. Soil conditions were also quite poor. The second competition was a housing design competition, to design and propose a new typology for housing along the waterway.¹¹¹

Despite awareness of the technical challenges that existed, Pebble Lee, Deputy Director, Planning Studio 3, Research & Planning Group, HDB, also recognised the opportunity it presented:

[We] wanted the first parcel along the waterway, to really set the standards, or the benchmark for all the other developments along the waterway corridor. So, there was this drive to do something special.¹¹²

The first competition, the Punggol Waterway Landscape Masterplan Design Competition, which was launched in May 2008, was won by Surbana Jurong, due to its incorporation of the history and heritage of Punggol and “mosaic of activities ranging from recreational, educational, adventurous and leisure to take place along both sides of the promenade and Town Park”.¹¹³ Surbana Jurong was also selected as the landscape master planner for Punggol Waterway, carrying out comprehensive geotechnical, environmental and infrastructure feasibility studies.¹¹⁴

The second competition, the Punggol Waterfront Housing Design Competition, was launched in December 2008¹¹⁵ and aligned to the theme Green Living by the Waters. This competition attracted submissions from 108 design firms across Asia, South America and Europe. Chong says:

[We] were very surprised, because we wanted a very localised competition among the architectural firms. But 40% came from [the] international category, they started to team up with locals.¹¹⁶

International architectural firm Group8asia, in partnership with a local firm, Aedas, was selected on 11 November 2009 as the winner, based on their resort-style design inspired by Asia’s rice fields and dense rainforests.¹¹⁷ The winning design offered 1,074 units of housing on a 0.049-km² site that featured roof gardens and open courtyards. Its terraced design maximised the proportion of units with views of Punggol Waterway. Lee explains:

Waterway Terraces won. It was very unique, because it had the stepping down terracing design that mimicked the look of rice field terraces. It really brought along the character of the waterway, because that set the tone for how the urban design, the character of each zone along the waterway corridor was developed later on.¹¹⁸



31. Waterway Terraces was the winning entry for the Punggol Waterfront Housing Design Competition for its distinctive terraced concept, which maximised rooftop gardens, open courtyards and waterway views.

Developing a Town of Unique Identities

In December 2020, the HDB announced that it would launch a town design guide for Punggol, to chart Punggol’s vision and distinctive identity, and to guide future developments. The guide would encompass the three planning scales: town, district and precinct.

The overall theme for Punggol Town is Water and Nature, drawing inspiration from its waterfront location and lush greenery. At the district scale, Punggol consists of 11 housing districts that fall into nine areas, each with a distinct sub-theme that corresponds to the overall town

theme. For example, residential developments within the sub-theme of Urban Terraces generally adopt terracing building forms that step down towards Punggol Waterway and Punggol Reservoir, capitalising on the scenic waterfront views.

At the precinct scale, the Urban Terraces sub-theme can be expressed through clean lines and layered roof designs. This is evident in the Waterway Cascadia project.¹¹⁹ In Waterway View, a development within the sub-theme of Undulating and Rustic, the precinct was designed to evoke the rustic past, given its history as a *kelong* (fishing village), with fishing basket-inspired pergolas and outdoor decks with columns resembling stilts. The blocks are also staggered to maximise views of the waterway.¹²⁰ With these guidelines, the various precincts will maintain their unique identities.



32. Waterway View was designed based on the Undulating and Rustic sub-theme concept.

Furthermore, other features were retained. For example, Matilda House, one of the oldest houses in Singapore, which was given conservation status by the URA in February 2000, was redeveloped as a clubhouse for the condominium, A Treasure Trove. Newly constructed bridges were also named to reflect Punggol's historically distinct identity, such as Kelong Bridge, Adventure Bridge and Wave Bridge.



33. Matilda House before government acquisition (left) and after conservation and integration as a clubhouse of A Treasure Trove condominium (right).



34. A number of unique bridges are located along the waterway, giving each section of the waterway a distinctive identity—(clockwise from top left) Lorong Halus Bridge, Adventure Bridge, Punggol Jewel Bridge and Punggol Walk Arc Bridge.

Providing Community Facilities and Amenities

The first plan for Punggol was designed when the popularity of malls was on the rise whereas that of local shops, including mom-and-pop shops, wet markets, hawker centres and other localised retail options, were projected to decline. Furthermore, the slow pace of development and occupancy of the housing projects resulted in the delay of commercial and retail facilities development. This led to a dearth of amenities in Punggol's residential areas. In particular, the shortage of childcare facilities in Punggol was of concern to residents, given the high proportion of families with young children.¹²¹ As part of the Remaking Our Heartland initiative, the HDB sought to address this. Fong shares the thought process behind this:

We always [review] what we have done and the feedback from residents. I think to have too few neighbourhood centres also does not quite work because people still want some cluster of a bigger centre. So we have gone back and [rethought] neighbourhood centres."¹²²

The HDB eventually introduced smaller commercial centres that are within 300 to 400 m of residential estates, and also created shop clusters near LRT stations, providing easy access and convenience for residents to meet their shopping needs on their way home. The HDB also learnt from other successful experiments elsewhere. The implementation of highly

integrated and consolidated services and facilities, for example, was inspired by Kampong Admiralty. The Oasis Terraces not only features shops, but a polyclinic and other social and community facilities as well. This building has now become an important community node.



35. Oasis Terraces, a new typology of community centres, provides an important space not only for recreation and sport, but also for community activities and events.

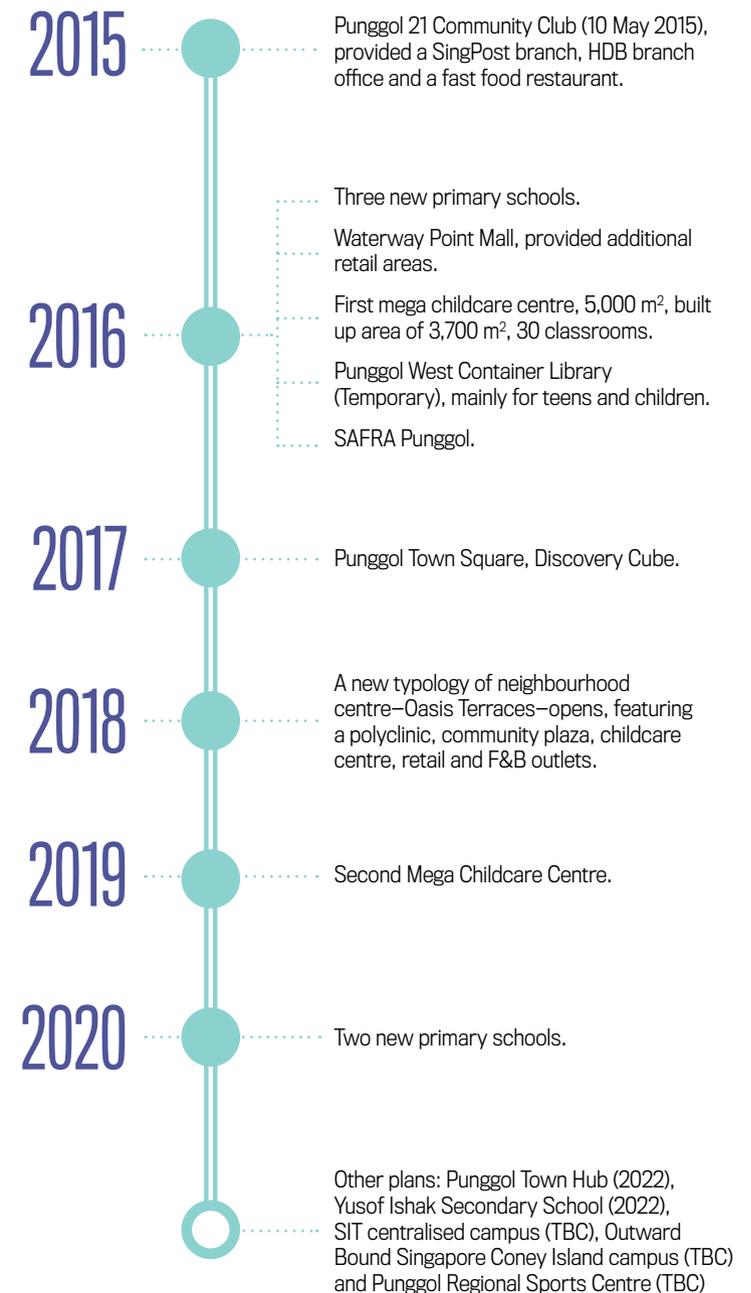
Over time, more facilities were built as the population increased.¹²³ The agencies' focus on providing high-quality greenery and amenities gained the residents' approval. When the new public housing precincts were announced, many balloted for a flat. Among the lucky balloters was Michelle Low, a newlywed and resident-to-be of the upcoming Punggol Point Cove development:

Punggol Point Cove [is] an attractive option as it will not be a development in silo. Instead, it will be developed in tandem with commercial developments, eateries, and in particular, the Punggol Digital District. The upcoming Punggol Town Hub will also bring in more community facilities, including a library. Schools are also plentiful in Punggol. Punggol Coast MRT station will also be a stone's throw away and offers a convenient connection to downtown.¹²⁴



36. Punggol's famed seafood restaurants at Punggol Point were also retained and redeveloped to suit the growing crowds.

EXHIBIT 2 COMMUNITY FACILITIES AND AMENITIES.





37. As the population increased, Punggol is now home to many regional facilities, including a mega childcare centre (NTUC First Campus' My First Skool at 2 Punggol Drive) (top), the SAFRA Club in Punggol (second from top), which provides recreational options, a new Punggol Town Hub and regional library (third from top), and Punggol Sports Centre (bottom), which features five pools and a 5,000-seater football stadium.

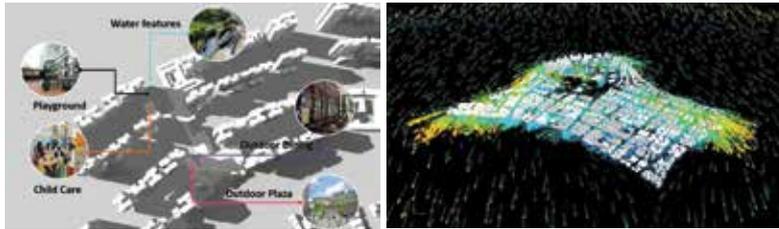
A Living Laboratory to Pursue Sustainable Green Living

Under the Remaking Our Heartland initiative, Punggol was also designated as one of the four “living laboratories” in Singapore to “test new ideas and technologies for sustainable development, integrating urban solutions to create a green living environment”.¹²⁵ Punggol was an opportunity for greenfield improvements—a living laboratory—while existing HDB estates, such as Yuhua and Teck Ghee, represented brownfield testing sites.¹²⁶

The first precinct where many sustainability features were piloted was Treelodge@Punggol, Singapore’s first eco-precinct. Incorporating environmental features that embrace Singapore’s tropical climatic conditions, the HDB employed both passive design strategies and green building technologies to achieve efficient energy use, and water and waste management. These features include solar panels, rainwater harvesting tanks, and integrated wash-basin cum toilet pedestals, for example.¹²⁷ Other successful energy-saving innovations include re-designed lifts with an energy regenerative system to recover 30% of energy (from kinetic movement and braking), motion sensor lights at staircases and car parks, as well as centralised recycling chutes.¹²⁸

Treelodge@Punggol comprises seven residential building blocks with a podium car park that enabled a generous provision of green spaces at the precinct level. All the residential blocks were generally located in a north-south axis orientation—windows facing the north-south direction and insulated gable end walls facing the east-west direction—to minimise heat absorption. At the same time, well-ventilated corridors and void decks at the first storey maximise cross ventilation for the block, allowing residents to enjoy a cool and airy environment.¹²⁹

Treelodge@Punggol was also the first HDB precinct to be designed using the Urban Environmental Modelling (UEM) tool, which allows the simulation and analysis of wind flow and solar irradiance patterns to provide maximum thermal comfort for residents. For example, using the UEM, planners identified shaded areas to site heat-sensitive community facilities like playgrounds and childcare centres, while areas that receive a large amount of heat from the sun throughout the day had intensified greenery introduced to minimise heat gain and cool the ambient temperature.¹³⁰



38. The UEM tool is able to simulate wind flow and irradiance patterns to aid design for maximising thermal comfort for residents (left); heat-sensitive community facilities are then located in shaded areas (right).¹³¹

Treelodge@Punggol was completed in December 2010 and was the first public housing project to win the Building and Construction Authority (BCA) Green Mark Platinum Award. In 2012, solar photovoltaic systems installed at Treelodge@Punggol generated sufficient green energy to meet the energy demand for its common services, including the corridor and staircase lighting, lifts and water pumps, resulting in a net-zero energy balance.¹³² Many of the initiatives trialed in the living laboratory of Punggol are now being implemented in other projects across Singapore.¹³³ Such initiatives contributed to the HDB's goals of developing better estates, and are consolidated in its Roadmap for Better Living document and Sustainable Development Framework.



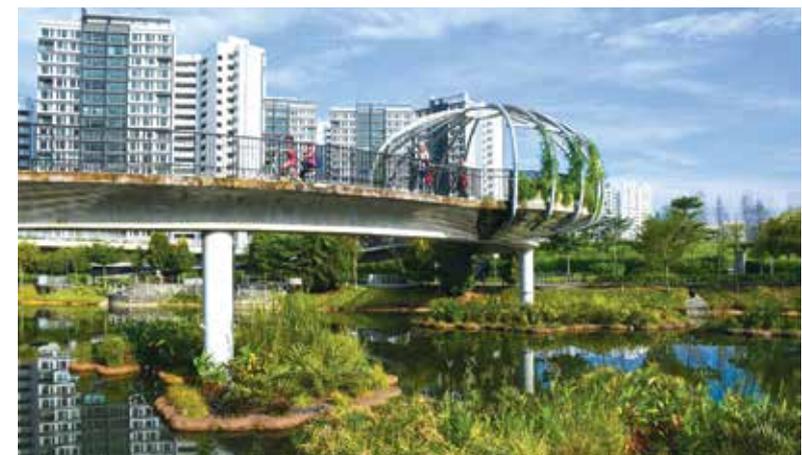
39. Treelodge@Punggol incorporated many sustainable innovations that were subsequently adopted in newer HDB precincts.¹³⁴

In addition, an Active, Beautiful, Clean Waters (ABC Waters) design was implemented in a holistic manner within a public housing precinct. ABC Waters design features, including bio-retention basins and vegetated swales, were integrated at Waterway Ridges. Rainwater runoff from roofs, roads, playgrounds and other areas in the precinct are harvested, and allowed to seep through plants and soil media slowly. Sediments, nutrients and other impurities in the runoff are removed by filtering through the plants and soil.



40. Bioswales with natural barriers including vegetation and boulders at Waterway Ridges were designed following the guidelines of the ABC Waters Programme.

In 2015, the HDB developed two green engineering innovations—the floating wetlands system and freshwater-tolerant mangroves—along the Punggol Waterway after testbedding them in its master laboratory at the Centre of Building Research. As a living laboratory, Punggol Waterway offered the HDB a unique opportunity to reintroduce mangroves, which had once lined the riverbanks around Punggol. Besides enhancing greenery along Punggol Waterway and improving its water quality, these green innovations also stabilise slope embankments and promote biodiversity.¹³⁵



41. The floating wetlands and mangroves, located along Punggol Waterway, contribute as natural water cleansers.

Infusing Warmth Into the Town, and a Sense of Ownership

Good planning, urban design and implementation are only one part of a successful new town. The other crucial factor is based on how much people feel at home there. To achieve this, the community must be imbued with warmth. Low describes her early interactions with the Punggol residents:

The first thing we said was, you have got to build this into a really nice and warm neighbourhood where everyone feels welcomed. One of the things they did was, every time a new neighbour moved in, they sent them some kopi [coffee] and home-made biscuits or cakes.¹³⁶

In time, Punggol became known for having several active Facebook, WhatsApp and Telegram chat groups facilitating neighbourliness. The creator of the Punggol Opal WhatsApp Group, Derek Tan, highlighted that he hoped to recreate the *kampung* spirit he experienced while living in Balestier as a child.¹³⁷ Among the activities organised by the group include buffets and neighbourhood patrols. Another neighbourhood, Waterway Cascadia, has a Facebook group connecting neighbours to volunteer help, such as for grocery shopping or to render handyman services.¹³⁸

Punggol's strong community spirit has also led to the creation of unique, regular, vibrant street parties and events. Aside from the weekly "block parties", mega events like the year-end countdown party, Mooncake Festival and Halloween parties attract more than 5,000 people to participate and become active citizens. The unique Racial and Religious Harmony Street Parade and Family Carnival often brings more than 10,000 people together to learn about each other's cultures. For example, the focus of one particular year may be related to marriage rites across cultures, while another year could be about customs associated with births. These themes facilitate cultural exchange and understanding.



42. Punggol is famed for its many community events, such as the Racial and Religious Harmony Street Parade and Family Carnival.

The HDB also continues to engage with the residents in Punggol. Since 2006, in partnership with agencies such as the People's Association, National Environment Agency, NParks and PUB, Singapore's National Water Agency, the HDB has conducted approximately 790 events with 138,000 participants. These are undertaken not only in physical engagement events, but also virtually. These events can be categorised as:

1. Activities to assist residents to settle in, e.g., MyNiceHome Roadshows and Welcome Parties.
2. Activities that encourage neighbourliness, e.g., the HDB Community Week, Good Neighbour Award, Heartland Ambassadors' Appreciation Ceremony, youth volunteer outreaches, Friends of the Heartland network, and the Outreach to Young and Youth (OHYAY) Programme.
3. Activities that encourage eco-living, e.g., eco-learning journeys.
4. Activities that activate and enliven heartland spaces, e.g., the opening of the Punggol Town Square in 2017, and the ongoing Lively Places Programme.

Through these, Punggol's residents have gradually made Punggol home.

PUNGGOL AS AN INCLUSIVE COMMUNITY

One indicator of the inclusivity of a community is often how it welcomes its disadvantaged residents.

Punggol is the site of the Social Innovation Park's (SIP) Social Entrepreneurship and Eco-Park Development (SEED@SIP) facility. The SIP was set up in 2006; however, it built SEED in Punggol in 2016. Its core vision is to build a more "inclusive, sustainable and mindful world" through social entrepreneurship. Penny Low, who founded SIP and was a former Member of Parliament for Punggol North, shares the background behind this:

In 2003, we had SARS; 2001, we had 9-11. In 1997, we had the financial crisis. So it was a series of downturns. Quite clearly, some people were hard hit. Jobs were hard to come by. And so we thought: why not build a social enterprise hub based on the spirit of self-help and mutual help, where we could include the marginalised in society, giving them a hand-up instead of a handout approach? Maintain their sense of dignity, "find their own fish" and even change the "fishing" industry instead?¹³⁹

Foo Ling Fang, Assistant Manager of SIP, adds:

It started with just one laptop and one volunteer. One of our platforms is the "Pop and Talent Hub"; we worked with many who came from marginalised backgrounds. We supported them from the ground up, providing a space where it is through a "hand up" rather than a "handout" approach. A "hand up" approach is really [about] providing a platform for people, regardless of background or disability, to showcase their ability and use their talents, whether it is to market a product, set up a business, or be social entrepreneurs themselves.¹⁴⁰



43. The SEED@SIP site (left) was developed into a social entrepreneurship space (right) through the capital that was raised from social investors.



44. SEED runs leadership programmes and provides a platform for social entrepreneurs to set up businesses.

SEED@SIP currently houses social entrepreneurs, container restaurants and urban farmers. It also raises awareness on social causes by running leadership programmes, forums and conferences that promote social innovation. Between 2019 and 2020, the SIP organised 31 activities involving 10,824 people, including its flagship LEAD with Nature programmes for children and youths, mindful leadership webinars for global and local corporate leaders, as well as inclusive community events and learning journeys.

The SIP plans to continue empowering communities through its programmes. Low explains:

Together with the public, private and people sector, SIP hopes to co-build a more inclusive, sustainable and mindful world. We imagine a world where even the marginalised are capable of earning their own livelihood, a world where self-help and mutual help are there to build community resilience so that come what may, it can overcome obstacles together. A society whose citizens build internal strengths and resilience will surmount any obstacles, to become even better than before.¹⁴¹

Building on *Kampung Spirit* With Civil Organisations

Punggol is also home to many civil organisations due to its community spirit. One of the first organisations to “settle” in Punggol was the Waterways Watch Society (WWS). It is a non-government, non-profit environmental organisation dedicated to promoting appreciation for and conservation of the waterways in Singapore by teaching residents how to enjoy and protect their environment.¹⁴² Eugene Heng, Chairman, WWS, describes how the WWS started their engagement with the community in Punggol:

NParks approached the WWS in 2013 to suggest setting up a branch office along Punggol Waterway, in anticipation of the growing resident population of Punggol and in recognition of the WWS’ stellar efforts in engaging the community in cleaning up Singapore’s waterways. The PUB and HDB were also supportive of having [a] WWS branch office set up along Punggol Waterway. The Public Hygiene Council (under the NEA) also provided some financial support to help jump-start our operation. The WWS invited members living in and around Punggol to lead the operations of the Punggol branch office, which was eventually launched on 23 February 2014.

In the early days, efforts to encourage residents to volunteer for the Punggol branch office were met with poor responses, given that it was still a young estate with few residents living there. Today, the Punggol branch office has approximately 120 to 130 volunteers, all mainly living around Punggol. The COVID-19 pandemic in 2020 sparked interest in outdoor activities and environmental sustainability, resulting in more than 70 to 80 Punggol residents signing up as volunteers for the WWS to help conduct environmental patrols every Wednesday morning and Saturday afternoon.

With the increase in population in Punggol, more residents are seen using the walking paths and facilities beside the waterways. Unfortunately, sad to say, we have observed an increase in littering around Punggol and its waterways over the past year. This includes finding many masks [that were] disposed irresponsibly by park and waterways visitors. The construction of an upcoming market and hawker centre opposite SAFRA Punggol will likely further exacerbate the littering situation along Punggol Waterway. The WWS is committed to raising environmental awareness among residents and students of Punggol by reminding them that this is their Punggol,

this is their Waterway, and that the fact that you may not find litter in the waterways does not mean littering is not a problem; it merely reflects the efforts of cleaners and our volunteers. Hopefully, this will be translated into socially responsible behaviour and discourage them from littering.¹⁴³



45. Residents are able to contribute to the maintenance of their homes by volunteering with the WWS, which keeps the various waterways of Punggol clean.

Residents have also been engaged in greening and biodiversity conservation. NParks partners volunteers and community groups in gardening and biodiversity conservation through the Community in Bloom (CIB) and Community in Nature (CIN) initiatives, respectively. Through the CIB, NParks supports grassroot organisations through programmes to foster an interest amongst residents in gardening. As of December 2020, there are 49 CIB gardens within Punggol. NParks has also recently launched a new allotment garden with 100 planters in Punggol Waterway Park, which opened to the public in January 2021.

Through the CIN, citizen scientist volunteers are trained to carry out biodiversity surveys across parks, including parks in Punggol such as Punggol Waterway and Coney Island Park. The collected data helps NParks to monitor and document the biodiversity found within Singapore’s green spaces. Besides citizen science activities, members of the public are able to participate in guided tours, such as the Ecolife Guided Tour at Coney Island Park, to learn more about the rich biodiversity and habitats in the area.¹⁴⁴ Many residents have also been involved in the One Million Trees movement launched in April 2020, as part of NParks’ plans to partner with the community in restoring nature into the city. There will be opportunities for residents in Punggol to undertake some of the tree-planting as NParks continues to intensify greenery in parks, park connectors, and streetscapes in Punggol. The residents will also be jointly involved in the design and development of the Punggol Heritage Trail as part of NParks’ Friends of the Parks initiative.

PUNGGOL: UNITING HEARTS BEYOND ITS BORDERS THROUGH OTTERS

Punggol embodies Singapore’s “City in Nature” through its accessible waterways and greenery, attracting not only locals but residents from all over Singapore. One of its most popular residents is of the furry sort—otters. Punggol is home to at least four otter families living in the Punggol and Serangoon rivers and along the coastline.

OtterCity is one of the nature groups that has taken on the mantle of guardians. The administrators of the group are also members of the Otter Working Group, chaired by the National University of Singapore (NUS) and NParks. As Jeffrey Teo, one of the founding members of OtterCity, explains:

OtterCity was created by interested members of the public. We started off as hobbyists enjoying the presence of wildlife. We decided that there are so many photos and videos that we had collected over the past few years, [we] might as well put [them] together and share [them] with like-minded people. Today we have about 100,000 followers on social media—it is growing at a rather quick pace.

We do not really have the concept of volunteers per se. Loosely speaking, the volunteers here are really volunteering their time and energy and passion to the subject itself. In this case, they are volunteering to the animals directly. So, it is a little bit of a different arrangement, in the spirit of true volunteering. We probably have close to 50 people that are very active on the ground, that can be activated in any situation.¹⁴⁵

Punggol falls under the North-east Otter Network, a grouping of resident volunteers. Marjorie Chong, a member of the group since 2019, noted:

Otters are indicators of water quality in our rivers. It was exciting when otters returned to Punggol after the rivers were cleaned up. In 2016, Max Khoo, a student researcher from the NUS who did a study on otters in Singapore, had to install remote camera traps to observe them. Fast forward [a] few years later, the otters have adapted to the urban spaces in Punggol and have been encountered at areas such as Coney Steps and Happy Hawkers at Waterway Point. It is always a magical sight when otters are spotted in Punggol Waterway, and you will see residents bringing their kids, following them, and just being entertained by the otters.¹⁴⁶

As Punggol continues to develop, there have been a few instances of conflict between human and otter activity, impacting on the latter’s survival. Chong continues:

Otters remain vulnerable to developments in Punggol, such as the upcoming Northshore HDB estate, which has led to road-widening works and increased vehicular traffic. Otters crossing from the sea into freshwater bodies along Seletar North Link Road hence face an increased risk of getting killed on the road. OtterCity identified the hotspots and patterns of otter road crossings and will be collaborating with the LTA to mitigate the risk of otter roadkill. Another upcoming project that OtterCity is involved [in] is the development of Outward Bound School at Coney Island. OtterWatchers, comprising residents together with the Otter Working Group, will liaise with the developer to monitor the locations of otter nesting grounds (holts) on Coney Island. The monitoring data will be used to plan the development accordingly to minimise disturbances to otter activities. For example, through discussions with Outward Bound School, the kayak docking area will be constructed away from its initially planned location to avoid impacting existing otter holts.

Over time, OtterCity aims to utilise the data on otters that it has collected over the years in a more predictive manner to mitigate disturbances to otter habitats from future development projects.¹⁴⁷



46. Otters are popular inhabitants in Punggol, attracted by its clean and green environment.

Efforts such as these inculcate a sense of pride, identity and ownership of local and non-local residents alike for Punggol's land and environment. Punggol has thus become a much-beloved home, and not just another suburban township.

CHAPTER 6

PUNGGOL: BEARING FRUIT AS A SMART AND SUSTAINABLE TOWN

“

The entire Punggol Town with its housing precincts and the digital district will serve as a living laboratory for public agencies and companies to test new ways of living, working and delivering services.¹⁴⁸

”

TEO CHEE HEAN

Coordinating Minister for National Security
and Deputy Prime Minister (2009–19)

Layering on Frameworks for a More Liveable and Sustainable Punggol

In 2010, Punggol was designated to be developed as an eco-town during the Housing & Development Board's (HDB) 50th anniversary commemoration, as part of its sustainable development blueprint. In the HDB's publication, *Punggol As Singapore's First Eco-Town for the Tropics*, it is described as:

Right from the planning stage, Punggol has been designed to promote sustainable living. Punggol Town is planned such that it has smaller, more intimate estates with common green, a wide range of quality housing with supporting facilities, and a well-integrated public transport network and enhanced accessibility for residents. In addition, one of the key green initiatives for Punggol is the introduction of a waterway traversing through the town. Leveraging on the waterway, Punggol will herald a new generation of eco-living concepts in the next decade and beyond.¹⁴⁹

A three-pronged approach was drawn up to develop Punggol as Singapore's first eco-town:

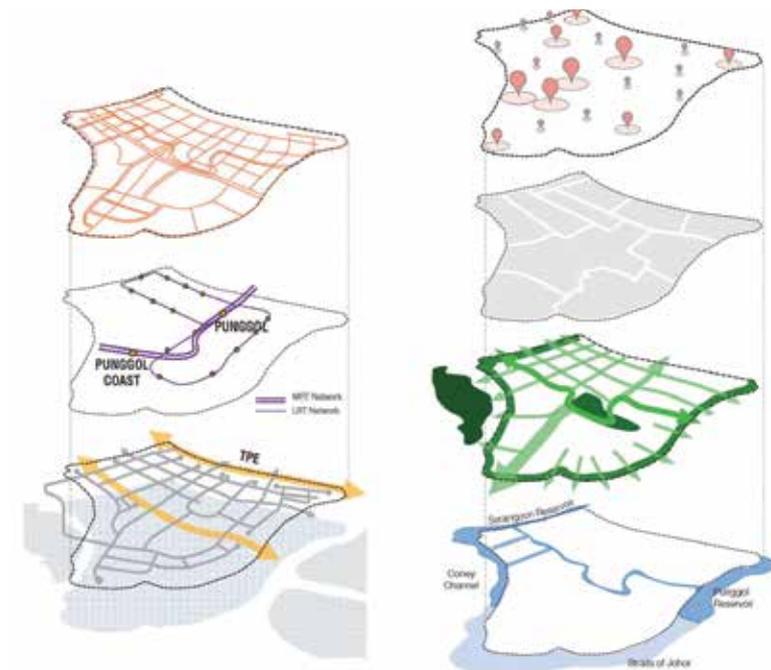
- (1) Introducing effective planning and design concepts to make it conducive for residents to adopt eco-lifestyles.
- (2) Exploiting urban solutions to achieve stretched environmental targets set.
- (3) Engaging, educating and enabling people to be part of the "go green" efforts.

Elements of the above were "layered" on Punggol to improve its vibrancy and sustainability. Fong Chun Wah, Deputy CEO, Building Group, HDB, elaborated on this:

To constantly improve the sustainability of Punggol, we introduced various frameworks to guide its development. In 2011, we introduced a comprehensive Sustainable Development Framework with clear KPIs and strategies on how we could achieve them. Next, the Smart HDB Town Framework was introduced as we wanted Punggol Northshore to be the first smart and sustainable district to testbed smart technologies from the design stage. Smart technologies would help to further stretch our sustainability goals. The HDB then worked on the Biophilic Town Framework with the NUS [National University of Singapore], NParks [National Parks Board] and URA [Urban Redevelopment Authority] from 2014 to 2018.

These HDB Town Frameworks will be applied to all other new towns in future. And the next area we want to make improvements in is the health, wellness and well-being of our residents, especially after COVID-19.

So, as we develop Punggol, we keep on layering new areas of improvement. We just keep in mind that the plan is never finished.¹⁵⁰



47. Some of the various "layers" that were applied on Punggol included accessibility, community spaces, distinctive districts, and green and blue recreational spaces.

Many of these frameworks came together in the Punggol Northshore development. Cheong Koon Hean, CEO, HDB (2010–20), explains:

Punggol Northshore was one of the projects that we did fully in-house. CoDE (the HDB's Centre of Design Excellence at the Building & Research Institute) was an initiative to rebuild the HDB's professional capacity and comprises multi-disciplinary project teams that are able to design, infuse and trial all the R&D [research and development] that we were doing. So, since it is in-house, our R&D ideas, including smart applications, are realised through the design and implementation of such new projects.¹⁵¹

Examples of smart technologies that were infused into Punggol Northshore include smart lighting, lifts, water metering, fans, waste management, and others, which allow increased efficiency and reduced energy use. It also includes smart parking facilities that calculate parking charges automatically through sensors and imaging technology. Season and visitor parking lots are also optimised, and car park barriers will no longer be necessary, avoiding the problem of malfunction, which may cause bottlenecks.

Punggol Northshore was also the first HDB project to adopt the Biophilic Town Framework in its design considerations. From the outset, the five key elements of neighbourhood landscape—soil, flora and fauna, outdoor comfort, water and people—were considered.¹⁵² To elaborate on this, Cheong adds:

The provision of green spaces and urban greenery is essential to create a quality living environment for our residents. In our public housing projects, we have integrated lush landscapes with high-rise buildings, collectively forming a mantle of greenery across each town. We will be expanding our greening efforts by strengthening the connection between our built environment and nature. The Biophilic Town Framework, which we have developed, provides a strong foundation for holistic planning and design of neighbourhood landscapes, so that our residents can enjoy a strong sense of place and well-being. This marks a new milestone in our journey towards well-designed, sustainable and community-centric towns under our Roadmap to Better Living in HDB Towns.¹⁵³



48. Green corridors are created at the Punggol Northshore development to enhance ecological balance and connectivity with existing green areas.

Close collaborations between NParks and the HDB have resulted in many of Punggol estates' multi-storey car park rooftops to be enhanced with lush greenery, and for community gardens to be integrated into developments such as Oasis Terraces. Through the Skyrise Greenery Incentive Scheme (SGIS), NParks encourages organisations to incorporate even more greenery, especially on rooftops and elevated spaces. NParks has also introduced a therapeutic garden in Punggol Waterway Park where visitors can experience the therapeutic and health benefits of plants. Therapeutic horticulture programmes, specially designed for seniors, have also been planned.

In addition, NParks has implemented Nature Ways, which are multi-tiered streetscape plantings that resemble the natural structure of forests. Examples of such plantings can be found along various roads in Punggol, including Punggol Road and Punggol East.¹⁵⁴ Kong Yit San, Assistant CEO, Park Management and Lifestyle Cluster, NParks, gives his perspective on this:

Under the City in Nature vision, we carry multi-tier planting for our streetscape. The plan is that a more naturalistic landscape will appear to mitigate the impacts of urbanisation and climate change and continue to make Singapore highly liveable. Some may perceive that multi-tiered planting is too pervasive or too much in the face. Other concerns, e.g., visibility lines when people need to cross the road may come into play too. So, our approach is to carry out landscaping in Punggol in a sensitive manner, to make it into one of many green places in Singapore.¹⁵⁵

As part of the plan to transform Singapore into a City in Nature, NParks announced rewilding plans to introduce more naturalistic landscapes that attract biodiversity, encourage ecological connectivity, and enhance sustainability through habitat enhancement and restoration efforts. Within Punggol, greenery in selected areas of Punggol East will also be allowed to establish naturally, as part of the rewilding plans. Typical groundcovers like grass have been replaced with biodiversity-attracting shrubs and were allowed to establish naturally. This approach reduces the need for regular mowing and allows biodiversity to thrive as landscapes become more natural with diverse species.¹⁵⁶

In 2019, the URA unveiled its plans for the Greater Rustic Coast, a 50-km continuous belt of green recreational space along the northern coast, as part of its Draft Master Plan 2019. The Greater Rustic Coast, which will add 10 km² of parks and park connectors, is planned to be progressively completed over the next 10 to 15 years, starting in 2019. It will link areas of heritage, biodiversity and recreation, including Coney Island, and is part of

a future key recreational corridor, which includes the Round Island Route and Rail Corridor.¹⁵⁷ Together, these will provide a significant boost for active mobility, as well as enhancing greenery and biodiversity.



49. Nature Ways have been established throughout Punggol on rooftops (top), in parks (middle) and along roadways (bottom).

Ensuring Greater Access and Connectivity

Over time, public transport connectivity in Punggol improved, with increased frequencies of Mass Rapid Transit (MRT) and Light Rail Transit (LRT) services. In October 2017, Punggol Bus Interchange was expanded from 1.2 to 2.0 ha to accommodate more bus services—both intra- and inter-town. The North East Line (NEL) will also be extended to the northern part of Punggol with the opening of Punggol Coast MRT station, which was brought forward from 2030 to 2024 to better serve the residents. A new MRT line, the Cross Island Line, will also link Punggol with Tampines and Changi.¹⁵⁸ This is planned for opening by 2030.

The road network was improved to ease traffic flow. New roads and interchanges were introduced to improve connectivity between Punggol and the surrounding towns.¹⁵⁹ As the population in Punggol is expected to grow, more roads are being planned to serve the new residents in the north of Punggol.

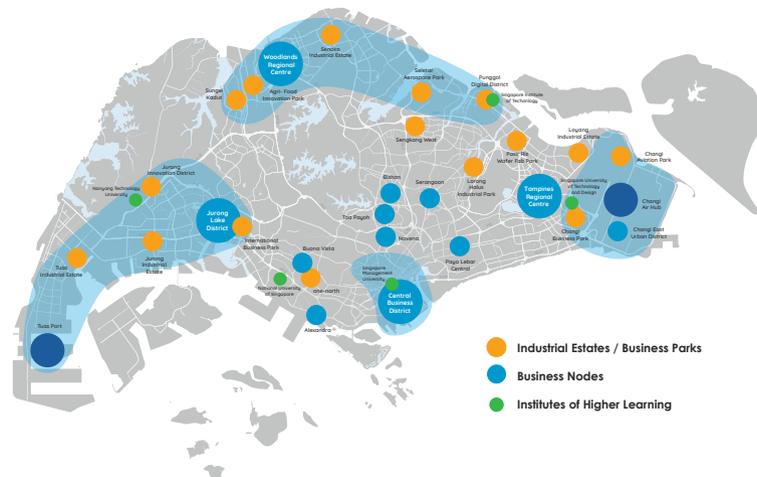
In addition, the Ministry of Transport (MOT) and Land Transport Authority (LTA) plan to pilot the deployment of autonomous buses and autonomous on-demand shuttles in Punggol in the early 2020s. This is part of a larger Autonomous Vehicle (AV) pilot deployment programme that aims to pilot autonomous buses and shuttles in the Jurong Innovation District and Tengah as well. The autonomous intra-town bus service will complement human-driven public bus services.¹⁶⁰

From a Commuter Town to Self-Contained Town: Punggol Digital District

Since its early days, Punggol has mainly been a commuter town. One of the reasons was the delays in Singapore's plans for decentralisation. In 1991, neighbouring Seletar was considered for a regional centre, but because of prioritisation and intensification of the Central Business District, this option was removed from Master Plan 2006. Punggol's own town centre development was also delayed as a result of the slowdown. Hence, Punggol's daytime population was low as most residents had to commute, many for an hour or more, for work.

In the 2010s, as part of Singapore's strategy to create new development areas islandwide to sustain long-term economic growth and bring good jobs and social amenities closer to residents, a new downtown and anchor for the north-east was planned for Punggol—the Punggol

Digital District (PDD). At the 2015 National Day Rally, Prime Minister Lee Hsien Loong announced plans for Punggol to be a Creative Cluster and Learning Corridor.¹⁶¹ It was to be part of Singapore's Northern Gateway of key employment nodes and infrastructure.



50. The Punggol Digital District is one of the key employment and innovation nodes within the Northern Gateway, part of Singapore's long term planning initiatives to strengthen the economy.

The PDD was envisioned to anchor business innovation activities and house key growth sectors of the digital economy, thus leveraging on the larger Punggol Town as a living laboratory for cybersecurity, smart living and smart estates solutions. The plan provides for 210,000 m² of business park and mixed-use spaces from 2024, supporting 28,000 jobs upon completion.¹⁶² It was envisioned as a 24/7 business and activity node that will encourage social encounters, serve as a base for a mix of start-ups, big tech and local firms, and be driven by the talent and know-how drawn from the newly announced Singapore Institute of Technology (SIT) campus.^{163, 164}

JTC Corporation was appointed as the master planner and developer for the PDD. A key innovation was the integration of the business park with the SIT. Planned for opening in 2024, the campus was envisioned to allow open and seamless physical integration between the university and the adjacent JTC business park. David Tan, Assistant CEO, Development Group, JTC, shares how JTC's experience in other sites came in handy:

Learning from our master planning experience of one-north, we realised the difference it would make if academic spaces were more tightly integrated with business spaces. This realisation prompted us to push strongly for the integration of the SIT within the PDD

to facilitate closer collaboration and cross-fertilisation of ideas. So, lessons from one-north were applied in the PDD and lessons learnt in the PDD will similarly be applied in future districts.¹⁶⁵

Beyond this, JTC sought to pilot a new working model that featured closer work-academia integration, where students would have the flexibility to study on certain days or some hours a day, and enjoy job attachments at the business park for the rest of the day or week. Employees at the business park could also continue to upgrade their skills at the SIT.¹⁶⁶

After being designated Singapore's first Enterprise District, the PDD was given leeway to mix land use at the district level.¹⁶⁷ Instead of having land use controls imposed on individual land parcels, JTC was empowered to plan and holistically develop the district through controls being applied over the entire district.¹⁶⁸ Tan adds:

Land use within the PDD is planned on a district level, a departure from conventional land use policies set by the URA. While the URA still sets the total land use quantum, JTC is empowered to transfer the land use quantum across different buildings and land plots within the PDD. For example, JTC can perform land swaps between its buildings in the PDD's business park and the SIT's campus, thereby achieving tighter integration between the two.¹⁶⁹

JTC held a competition for a design master plan to encourage best-in-class innovation. WOHA, the architectural firm that won the competition, found innovative ways to integrate the two. Wong Mun Summ, the founder of WOHA, explained:

The Collaboration Loop [on the fifth level of the building] is a good example where the SIT and JTC's tenants will be linked with each other physically via bridges and walkways. But they will also be "woven" together by swapping out selected spaces, so there will be students in the business park buildings and companies on the SIT campus. This will be a way that we can facilitate the integration and collaboration between education and enterprise.¹⁷⁰

Beyond that, WOHA sought to integrate environmental sustainability, nature and community spaces into the core. Wong elaborated:

This master plan was based on the idea of "form follows systems", which meant facilitating relationships between different systems within the development. The design layers different functions on top of each other; at the top there is a massive solar canopy that has

the broadest surface area, sheltering what is underneath from the elements while also producing clean energy.

A major move was to incorporate a community park into the design. We saw this as an opportunity to conserve a substantial part of the existing secondary forest and allow people to connect to the location by integrating the Heritage Trail. We included urban connections in the plan and the Campus Boulevard because we saw the need to connect the campus to Punggol Town. The idea of preserving the secondary forest was well received by both residents and the government.

Placemaking and community are critical to this plan. We asked ourselves how local residents, office workers and students can engage with this built environment and how the built environment can promote engagement between user groups. We did not want the space to only be relevant for certain times during the day and week, so the way the spaces are used and allocated create activity and engagement of the community around the clock, as well as draw in local tourism on the weekend.¹⁷¹



51. The Punggol Digital District Master Plan, launched in 2018, featured greenways, solar roofs and 1 km² of pedestrian-free zone on the ground level.



52. The Collaboration Loop is a physical manifestation of the “interwoven” nature in which the business park companies and SIT students are integrated; business and education spaces are swapped between the two buildings.

Putting People on Top: A Car-Lite Punggol Digital District

Under Concept Plan 2013, there were plans to close the gaps between Park Connector Networks (PCNs) to encourage better accessibility for active mobility options. This tied in with the multi-agency National Cycling Plan, which involved the LTA, URA, NParks, HDB, PUB, Singapore’s National Water Agency, and Sport Singapore (SportSG). Punggol, which was already planned as an eco-town, will have a comprehensive cycling network totalling 50 km. This equates to a cycling network density of 5.2 km per km² of town area, which exceeds the world’s densest cycling network in Helsinki.¹⁷² The installation of bicycle racks also encourages residents to cycle.¹⁷³

The PDD Master Plan accelerated the vision of a township for active modes of commuting. The new underground Punggol Coast MRT station was integrated with land use in unprecedented ways. Tan points out:

This is the first time that JTC is building a three-in-one integrated development that links the SIT campus, JTC business park, and Punggol Coast MRT station. This [brought] about additional layers of complexity. JTC, the LTA and the SIT are collaborating closely in designing and ensuring seamless connectivity for all users.¹⁷⁴



53. Punggol's new economic centre was designed with connectivity, integration and interaction in mind.

Beyond that, the PDD is designed to be human- and community-centric. One of the main ways is by ensuring the whole district is a car-lite zone. An area of approximately 24 ha will be completely car-free and vehicles will be diverted to a common basement, leaving the ground level for pedestrians and cyclists.¹⁷⁵ This was made possible because of the URA's foresight in developing an Underground Special and Detailed Control Plan.¹⁷⁶ Wong explains:

You can move from the core area, where the community park is located, all the way to the waterfront without encountering a car.¹⁷⁷

The preservation of the secondary forest as the community park ensures that the town centre of the PDD is an attractive walking environment from the first day. Wong contextualises this as such:

Having lived through the pandemic in the last year, people place more importance than ever on having access to nature, so the preservation of this piece of nature is even more relevant now in the public opinion.¹⁷⁸



54. Seamless integration between the JTC business park and SIT in the Punggol Digital District with a common campus boulevard and sky bridges to foster interaction.

Establishing a Smart and Sustainable Town Infrastructure From the Ground Up

Aside from the physical form, a key success factor for Punggol was its ability to integrate digital infrastructure and smart technologies.

The first to be put in place was a governance structure. JTC put up a request for a Smart District Programme Office—the staff would be drawn from JTC, the Government Technology Agency (GovTech), Infocomm Media Development Authority (IMDA), and Cyber Security Agency of Singapore (CSA). The CSA would look after cybersecurity by providing consultancy services and advise JTC in the area of cyber-security threats and risks. The IMDA would ensure that the digital infrastructure was open enough for enterprises to participate, while GovTech would provide software developers and coders.¹⁷⁹ Aside from being overall in charge of the platform's development, JTC would also build in-house capabilities in the area of smart city technologies.¹⁸⁰

The second task was ensuring all the different “smart” technologies of various agencies—the HDB, LTA, NParks, and others—could all “talk” to each other. Ryan Lee, Director, Smart District Division, JTC (2018–20), recalls that:

JTC wanted to create a digital architecture whereby different technologies can “plug and play”—a horizontal platform anchored by a layer of multiprotocol middleware. JTC created a middleware or an information highway that uses a standard language, allowing different smart systems to understand and interact with each other. A centralised command and control layer allows JTC to send out instructions to systems connected to the platform to respond and react to evolving situations.¹⁸¹

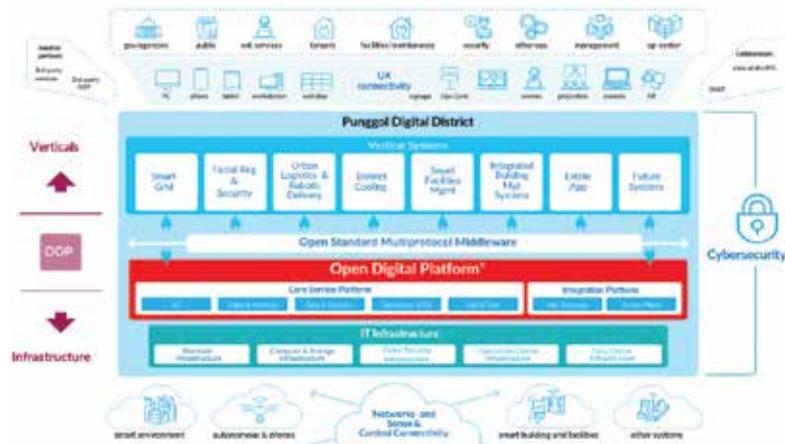
To do so, JTC realised that they needed a digital platform that would provide an avenue for all the smart systems to integrate. Eventually, it partnered with local companies to establish a useful “plug and play” platform after careful consideration of the need for continuity and security. Thus, the Open Digital Platform (ODP) was created as the foundation on which the smart technologies could be built upon. Tan adds:

When we were developing one-north, we realised that it is much more difficult to integrate digital systems when the physical infrastructure is already built. Learning from this experience, JTC will design and integrate the digital infrastructure within the physical infrastructure right from the start for our new estates. Boundaries do not exist in digital infrastructure, hence JTC will integrate the ODP

as comprehensively as possible across the entire Punggol Smart and Sustainable Town, including the PDD, SIT and HDB estates.¹⁸²

The PDD will see the full integration of digital infrastructure and smart technologies from the ground up through the ODP, the first business park to do so. The ODP would integrate various technologies horizontally on a single platform. This will yield synergies and facilitate open data sharing, provide opportunities for innovation in urban solutions, and create an open, agile and collaborative environment that is key to digital innovation.¹⁸³ Tan also explains:

The ODP will form the backbone of the Punggol Smart and Sustainable Town, allowing for the support of new operating models and services enabled by data sharing. It is not just a network platform—the ODP provides a systems platform as well. A tenant in the PDD who wishes to connect their IOT devices can simply hop on to the ODP communication network and access the systems platform at the same time. In short, JTC is building a road—a digital highway, for Punggol.¹⁸⁴

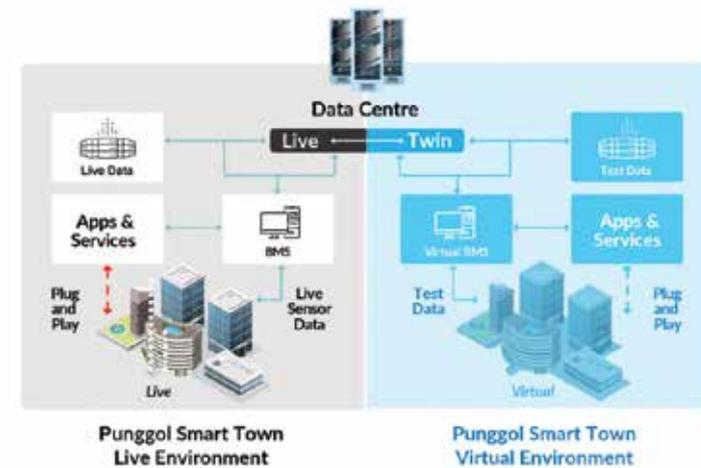


55. The Open Digital Platform allows the various smart technology components to communicate with each other.

A key feature of the ODP is the “Digital Twin”, a true-to-life 3D representation that enables estate and facility managers to navigate the entire built environment of the PDD in 3D and monitor various estate systems such as air conditioning or car park gantries almost in real-time. The Digital Twin can also be used to simulate scenarios in the PDD,

including contingencies such as crowding, and evaluate the effectiveness of mitigating actions.¹⁸⁵

Beyond information from the Digital Twin sources, a wide range of public government data through the use of Application Programming Interfaces (APIs) can be displayed. For example, information on the load and availability of public transport services, such as buses and taxis, coupled with route planning, and command and control capabilities, will allow planners to utilise the Digital Twin to visualise live travel patterns and make the necessary adjustments within the estate. Smart lamp posts decked with a suite of environmental sensors will also provide various sensor data, such as weather and air quality, to the Digital Twin. Eventually, JTC aims to make a publicly accessible version of the Digital Twin that will allow residents, students and workers to view selected data sources. JTC will allow the public to contribute data to the ODP.



56. The Digital Twin mirrors Punggol's live environment in a virtual platform, allowing for easy testbedding of new smart technologies.

Beyond Ones and Zeros: Smart Technology Delivering Real Value in Smart Towns

The ODP and its Digital Twin will allow for easy testbedding of new technologies. Businesses, workers, residents and students will be first to benefit from new conveniences such as smart lighting, toilets, wayfinding, and parking. It is already looking across domains to identify greater efficiencies. Tan explains how this is being done:

The team also took a 30,000 feet approach by first looking at cross-domain smart use cases. We acquired open data from various agencies, put them together to develop these use cases in the ODP and from there, [integrated] it with the district systems. One example is the Smart Grid.¹⁸⁶

As a smart and sustainable district, the PDD will set a new benchmark in district-level sustainability goals. Buildings within the PDD are targeted to achieve 30% higher energy efficiency than standard commercial buildings.¹⁸⁷ The PDD will also utilise a District Cooling System to achieve energy savings.¹⁸⁸ Overall, through the use of shared services and district-wide systems such as the District Cooling System, business costs in the PDD are expected to be reduced. Tan further highlights:

Today, Green Mark Platinum buildings can reduce energy consumption by up to 30%, while Super Low Energy certified buildings achieve energy consumption reduction of up to 40%. To go beyond and achieve energy savings exceeding 50%, you will need to employ smart technologies and artificial intelligence. As more companies embrace environmental sustainability as part of their Corporate Social Responsibility strategies, green real estate becomes increasingly attractive—that is the unique selling point we offer in the PDD.¹⁸⁹

Several smart resource capture technologies will also be deployed. Aside from trialling solar panels, the district also strives for zero water wastage by creating eco-ponds to collect rainwater for landscape irrigation. Pneumatic waste conveyance systems are being installed in residential and commercial buildings. Within the PDD, there is also an aim for 100% of food and horticulture waste to be recycled into fertiliser.¹⁹⁰

Punggol: Paving the Way for the Future of Singapore's Towns

Punggol has been the microcosm for various key initiatives to prepare Singapore for the future. In recognition of this, Punggol was designated the Strategic National Project for a Smart Nation in January 2020. It is seen as a vital component in achieving Singapore's Smart Nation vision, by driving the adoption of digital and smart city solutions throughout the country. The trials conducted in Punggol will be scaled to guide the development of future new towns and districts such as the Jurong Lake District, as well as the redevelopment of existing towns across Singapore.¹⁹¹

JTC is already finalising plans to take Punggol further into the future. It is planning new operating and service delivery concepts to enhance efficiencies in logistics. It is looking at smart transport systems to reduce congestions and commuting times. It is also looking at enhancing business environments through a “public-private-community partnership” approach between the government, businesses and academia to develop ideas, prototype solutions, overcome regulatory hurdles, and commercialise. It is also looking at options to reduce wastage and maximise resource efficiency.

Ultimately, however, the purpose of the smart eco-city, beyond creating efficiencies, is to improve the quality of life for all. Tan cites the following example:

Instead of giving yourself 24 hours a day, 7 days a week, why not give yourself 27 hours a day, 7 days a week—27/7 instead of 24/7? So, we are now trying to give three more hours back to people, to spend with their loved ones. And how can we do that?

A very simple way is by making the daily experience totally seamless. For example, I come to work, [and] the minute I get out from the MRT station, the camera identifies that it is me—David. I would have pre-ordered my breakfast the night before; upon detecting my entry into the PDD, a notification is sent to the F&B outlet to start preparing my breakfast. After it is done, it is put into a drone, which starts delivering the food to my floor [or the nearest floor]. When I reach the lobby, I do not even need to [show] my pass at the security because it is all facial recognition. At the lift lobby, the lift immediately recognises it is me and brings me to the floor. The lift waits for me; I don't wait for it. When I get to my office, the food is delivered, I enjoy my breakfast with my colleagues. Instead of spending time queueing at the hawker centre, running my errands, I save time along the way and spend it with those around me instead.

A tall order, but if I can even save one hour a day, let alone three, I have probably improved my quality of life!¹⁹²

A RESIDENT'S VOICE: FOO LING FANG,¹⁹³ PUNGGOLIAN OF 20 YEARS

I moved here with my parents in 2001 when I was very young, so I have lived here 20 years. We were one of the first few residents then. There was no MRT or LRT. One bus going in and out. One road going in and out. I went to school in neighbouring Sengkang as there were no schools here.

My family has seen the place develop over the years. Initially, if you can imagine, it was bare grasslands. Now, every LRT station has a coffeeshop and grocery store, and there is a clinic in every estate. At Punggol Plaza itself, there is a wet market; that is where people buy their groceries, their vegetables. So it is like a town hub in every area that you see.

At my block itself, we also have a mobile library. There is also a place where they serve seniors coffee and tea every day. So that is where people get together. My mom is very sociable, so she knows everyone in the neighbourhood. So ever since we moved in, we know pretty much everybody. We do like our block parties. There is a multipurpose hall in each estate, and so there are Children's Day, Youth Day, National Day, small events. [It] feels like there is always a festival going on with free goodie bags for the residents. It is very from the ground up as well. There are a lot of volunteers who volunteer with grassroots. They are very involved.

As for the waterway, I run and cycle there. At Coney Island as well. It is very convenient. If you visit the waterway, you will see there are always a lot of residents of all age groups.

I do not think there is anywhere in Singapore that is nicer than this. I do not think I have seen any towns that are similar.



57. Encouraging the activation of Punggol's many recreational and public spaces is key to ensuring a vibrant and loveable town.

The Fruits of Punggol

Punggol has lived up to its name. As Chong Fook Loong, Group Director, Research & Planning Group, HDB, explains:

The actual meaning of "Punggol" in Malay is "the hurling stick at the fruit trees to bring down the fruits". That is Punggol. So actually, we harvested a lot of fruits in Punggol Town, metaphorically speaking. In planning and design, we harvested a lot of fruits and ideas. We were very active, we kept throwing the sticks against all the fruits to bring them down, from sustainability to the waterway, to the community, to smart [technology], and everything else. It is just incredible, there were endless actions in our path.¹⁹⁴

It was a multi-decade journey, and the success could not have been possible without some adversity along the way. The key is to see opportunities in every adversity, as Chong continues:

So, that original vision did not pan out. But [in] hindsight, it worked. Had it panned out, we would not have space to put the waterway in. But because it slowed down, we were able to review and do an even better plan, because when it slowed down, the building programme was not so [affected]. The LRT was only running on the eastern loop. The western loop was completed, but not running because there was nobody to service. So, with that, we were able to weave through the waterway.¹⁹⁵

Through it all was the collective vision for a liveable and sustainable home that carried the planners, designers, engineers, stakeholders and community through the hard times, to get to where it is today. As Chong concludes:

The vision can change a lot of things about the way we see things in life. We cannot just say "eco, eco, eco", but if the people are not "eco" about it, then it is totally against the grain. People must believe in it. They must walk the talk; everybody excited—catalysts—[and] moving in the right direction, so to speak. The alignment must be very strong. So can you imagine the alignment of the vision of building Punggol Waterway, a tropical eco-town vision, all the way down to all the physical parts of it, plus urban design, and also the people engagement, behavioural aspect, [and] everything aligned. [Vision is] very powerful!¹⁹⁶

With the vision, there must come a clear process for implementation and avenues for constructive discussion to bring all to alignment. Cheong provides some insight into how the vision could be realised:

The vision has to be cascaded into real implementation by a proper process. So we need to have a visionary master plan, complemented by good urban design, and work at a very detailed level with each and every consultant, to make sure that it can bring out what the plan was meant to achieve. Township development takes 10, 20 years to implement. The challenge is to ensure that there is a process that will enable the ideas to be realised, beyond the changes in staff and management who originally worked on the plan.

So the process must make sure that even as you pass it on to different people working on different parts of the plan over time, you can, in 20 years' time, say, "Yeah, that is how we envisaged the plan would turn out."¹⁹⁷

The plan, however, has to be dynamic while keeping to the vision. Cheong explains:

Having said that, you cannot get stuck in a blueprint mode either. You must be aware of the changing context, changing technology [and] changing lifestyles. So, you should keep tweaking your plan. It is an iterative process. And we should not be afraid to change if we really need to.¹⁹⁸

As plans change, the collaborative spirit between the different implementing stakeholders must be maintained. To do so, sound governance mechanisms must exist to ensure there are productive "fights" to bring about the changes. The master planner plays a key coordinating role. Pebble Lee, Deputy Director, Urban Planning Studio 3, Research & Planning Group, HDB, shares:

Definitely, there will be differences [in] ideas and viewpoints. But everyone is doing what they want for the best, from their own point of view. Despite all the objections to some of the ideas along the way, you just have to persevere.

It really helps if you have a strong team management to really push all these ideas through. It does not come easy on all fronts, whether it is by design, planning, technologies, or even the community programmes we have on the ground. It needs a master planner—a *master champion*—to push it through.¹⁹⁹

Punggol's success can thus be attributed to the strength of the system that was put in place. Cheong identifies how this was achieved:

Your processes must institutionalise the plan. There must be an institution [that] will be the keeper and champion of that plan. We can come and go, but the processes in this institution will make sure that the vision keeps pace with changing circumstances and yet will be realised.²⁰⁰

The joint efforts of many in the development of Punggol have been recognised, not only locally, but internationally. In May 2021, Punggol won the Urban Land Institute's Asia Pacific Award for Excellence for its outstanding planning, design, sustainable development, habitat restoration, and enhancement efforts, and its success in bringing communities together.

Punggol will continue to develop over the next few years, but there is confidence that the vision, implementation process, adaptability, collaborative process, and institutionalised leadership will carry it through to achieve what it was first envisioned to be—a loveable, smart eco-town.



58. Punggol's development journey was decades in the making but it is now a loveable and smart eco-town.

POST-SCRIPT

What makes a city smart? Around the world, many cities call themselves smart cities, each describing their own unique proposition of “smart”, or “smartness”. Some are filled with cameras and sensors that can monitor different aspects of the city in real time. Others visualise the physical city infrastructure within the confines of a virtual or digital twin, on which different governing agencies rely to plan for the future. Underlying all smart cities, however, lies one common thread—the collection and use of data within the living context of a city. Analysing and leveraging such data can enhance a city’s efficiencies and ability to tackle the increasing number of challenges faced. Ultimately, all smart cities aim to create a more conducive living environment for their inhabitants, while allowing a glimpse into the future and its possibilities. With growing urban complexities brought about by population growth, technological advances and increasing social expectations, the “smartness” of cities enable each to continue to meet its individual challenges of uncertain tomorrows, and create its own unique identity.

As I pen this post-script, the world is gripped in the midst of its biggest healthcare crisis in a century. The COVID-19 pandemic has disrupted lives and livelihoods, upending decades of city growth and living. If nothing else, the pandemic has exposed how cities must be even “smarter” in the future to tackle the unseen issues of today. Our modern cities, the living laboratories for tomorrow’s generation, will therefore have to remain constantly nimble and adaptable in order to thrive going forward. How we define and design smart cities to leverage technology will be key. In our small way, we hope that the vision, structure and organisation of Punggol will help Singapore establish the cornerstone of a holistic Smart Nation for Singapore—a nation where the infrastructure, systems and data come together within an overarching framework to forge sustainable solutions to counter the trials of tomorrow.

The Punggol Digital District (PDD)—the most recent development in Punggol—is part of the Smart Nation vision. PDD’s aspiration, in a nutshell, is built on two pillars—“smart” and “digital”. It aims to be the first smart digital district in Singapore. At its core, “smart” is derived from sustainable infrastructure and buildings equipped with new technologies that allow surrounding data to be captured seamlessly. “Digital” is realised through the use of JTC Corporation’s unique Open Digital Platform, where city and business solutions are analysed before decisions are made—a catalyst to enable greater innovation. Some of us may remember that the Punggol area was once a laid-back fishing village in the north-eastern part of Singapore. When completed, the PDD will leapfrog Punggol into the future as a smart town, an innovative, vibrant area fuelled by a strong talent pipeline. Ultimately, the dream is to build a complete and seamless ecosystem of work, live and play—where businesses have the right environment to flourish and co-create solutions for a digital future, and where residents have access to efficient services supported by sustainable systems and can enjoy comfortable enriched living.

Could the example of Punggol herald what the future of Singapore may be? As Punggol leads the way in turning our Smart Nation vision into reality, it demonstrates that what seems impossible can be possible. It is a daunting journey, but also an exciting one.

Tan Boon Khai

Chief Executive Officer
JTC Corporation

TIMELINE

PUNGGOL: DEVELOPMENT MILESTONES

Pre-1819

Area is home to the Orang Laut (nomadic sea people).

1819-1900s

Settlement of Chinese migrants engaged in farming and plantations.

1844

First record of "Pongul" in John Turnbull Thompson's survey.

1928

Basapa Zoo, Singapore's only zoo at the time, moves from Serangoon Road to Punggol seafront.

1942

Punggol Beach is a point of entry for the invasion by Japanese forces. The Sook Ching Massacre takes place on 28 February.

1970

Opening of Lorong Halus Dumping Ground.

1971

Punggol is designated "Rural" under the 1971 Concept Plan.

1974-1975

Establishment of Punggol Pig Farming Area (Phase 1).

1975-1976

Establishment of Punggol Pig Farming Area (Phase 2).

1983

Announcement of a 277-ha land reclamation scheme in Punggol.

1984

Announcement of a 685-ha land reclamation scheme in Pasir Ris/Jalan Kayu.

Announcement that pig farms will be phased out in Punggol.

1989

Pig farms are phased out.

1991

Punggol is designated as a residential area in the 1991 Concept Plan.

1996

The Punggol 21 vision is unveiled by then Prime Minister (PM) Goh Chok Tong.

1997-1998

The Asian Financial Crisis slows down the development of Punggol 21.

1999

Closure of Lorong Halus Dumping Ground.

2001

Official opening of Punggol 21 by then PM Goh.

2002

Launch of the Parks & Waterbodies Plan and Identity Plan by the Urban Redevelopment Authority (URA), which includes sites in Punggol.

2003

Opening of the North East Line (NEL), Punggol Mass Rapid Transit (MRT) and Punggol Temporary Bus Interchange.

The severe acute respiratory syndrome (SARS) causes Punggol's development to slow again.



2005

Opening of Punggol Light Rail Transit (LRT).

2007

Announcement of the ABC Waters Project at Lorong Halus Wetland and the launch of PUB, Singapore's National Water Agency's Punggol-Serangoon Reservoir Scheme.

Launch of Treelodge@Punggol.

Announcement of Punggol 21+ during PM Lee Hsien Loong's National Day Rally (NDR) speech. Punggol 21+ is to be part of the Housing & Development Board's (HDB) Remaking Our Heartland programme.

2008

The HDB launches two design competitions: the Punggol Waterway Landscape Design and the Punggol Waterfront Housing Design Competition.

2010

Launch of the HDB's Waterway Terraces along My Waterway@Punggol.

Punggol is designated to be developed as an Eco-Town during the HDB's 50th anniversary commemoration.

Punggol Master Plan further refreshed to take into account additional urban design and sustainability goals.

2011

Opening of Lorong Halus Wetland and Riverside Walk and My Waterway@Punggol.

2012

Opening of the 26-km North Eastern Riverine Loop along the coastline of Punggol.

Punggol is awarded the Grand Prize (Environmental Sustainability) at the 2012 American Academy of Environmental Engineers Excellence in Environmental Engineering Awards, is the Global Grand Winner for the Planning Category & Superior Achievement Winner in the 2012 IWA Global Project Innovation Awards, and wins the Gold Award at the 2012 International Award for Liveable Communities under the Project Built section.

2013

Punggol wins the Gold Award (Public Amenities & Infrastructure) at the FIABCI Prix d'Excellence Awards, a Merit at the American Society of Civil Engineers Outstanding Civil Engineering Awards, and the 2013 International Architectural Award from the Chicago Athenaeum.

2014

Announcement of the Smart HDB Town Framework. Punggol Northshore, envisioned to be "a smart and sustainable district", is selected to be the first new public housing estate to testbed selected smart technologies.

Punggol is the Asia Gold Winner at the Green Apple Awards for The Built Environment-My Waterway@Punggol.

2015

Opening of Punggol 21 Community Club and the 50-ha Coney Island Park.

Announcement of the Punggol Digital District (PDD) during PM Lee's NDR speech.

2017

Punggol wins the Environmental Sustainability Honour Award (American Academy of Environmental Engineers & Scientists) for A Biophilic Waterway@Punggol-Innovative Floating Wetlands and Freshwater-Tolerant Mangroves.

Announcement of the NEL Extension to the new Punggol Coast MRT station in Punggol North, to be completed before 2025.

2018

Release of the PDD Master Plan.

2019

Unveiling of the URA's plan for the Greater Rustic Coast belt, a 50-km continuous belt of green recreational

Punggol wins the Singapore Institute of Planners' Gold award for the "Best Planning" category, space along the northern coast, as part of its 2019 Draft Master Plan.

2020

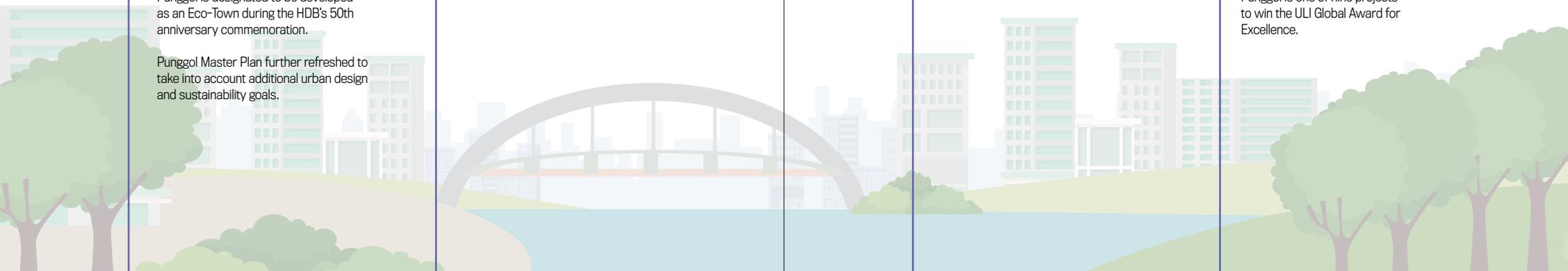
Punggol is designated as a "Strategic National Project" for Singapore's Smart Nation vision.

Announcement that Punggol MRT station is to be linked with the Cross Island Line.

2021

Punggol receives the Urban Land Institute (ULI) Asia Pacific Award for Excellence.

Punggol is one of nine projects to win the ULI Global Award for Excellence.



ENDNOTES

- 1 Housing & Development Board, "Punggol", 1 August 2020, <https://www.hdb.gov.sg/about-us/history/hdb-towns-your-home/punggol>
- 2 Singapore Department of Statistics, "Population Trends 2019", Department of Statistics, Ministry of Trade and Industry, <https://www.singstat.gov.sg/-/media/files/publications/population/population2019.pdf>
- 3 Ministry of Information and the Arts, "Speech by Prime Minister Goh Chok Tong at the Official Opening of Punggol 21 on Sunday, 8 July 2001, at 10.30 AM", Press Release, 8 July 2001, <https://www.nas.gov.sg/archivesonline/data/pdfdoc/2001070803.htm>
- 4 Ibid.
- 5 National Heritage Board, "A Vegetable Farm at Punggol", <https://www.roots.gov.sg/Collection-Landing/Listing/1105897>
- 6 Abigail W.Y. Ng, "Singapore's Baby Town Punggol: Some Interesting Things to Know About Other URA Planning Areas", *The Straits Times*, 9 June 2017.
- 7 M. Omar and A. Ong, "Punggol Reclamation", *Singapore Infopedia*, 2008, https://eresources.nlb.gov.sg/infopedia/articles/SIP_1011_2008-10-28.html
- 8 Ibid.
- 9 Sharon Teng, "Punggol Zoo", *Singapore Infopedia*, 14 March 2016, https://eresources.nlb.gov.sg/infopedia/articles/SIP_2016-03-14_140006.html
- 10 E. Paul Taiganides, *Pig Waste Management and Recycling: The Singapore Experience* (Ottawa: International Development Research Centre, 1992), 9, <https://hdl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/11104/IDL-11104.pdf?sequence=1>
- 11 Ibid.
- 12 Agri-Food and Veterinary Authority of Singapore, "Celebrating AVA's Excellence through the Years", *Food For Thought*, 27 February 2020, [https://www.sfa.gov.sg/food-for-thought/article/detail/celebrating-ava-s-excellence-through-the-years-\(2000-2015\)](https://www.sfa.gov.sg/food-for-thought/article/detail/celebrating-ava-s-excellence-through-the-years-(2000-2015))
- 13 Chan Yoon Kum, Fong Chun Wah, Kong Yit San, Loh Ah Tuan, Mohinder Singh, Seow Kah Ping, Wong Kai Yeng, Yap Kheng Guan, Michael Koh and Khoo Teng Chye, "Group Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 8 July 2020, transcript, accession number CLC/051/2020/003.
- 14 The Kim Chuan Water Reclamation Plant received sewage from new towns such as Toa Payoh, Bishan, Whampoa, Kallang, Serangoon, Hougang, and Eunos.
- 15 Ibid.
- 16 Housing & Development Board, *Annual Report 1977/78* (Singapore: Housing & Development Board, 1978), 51.
- 17 Nigel K.C. Goh and Beverly P.L. Goh, "A Study of the Hydrobiological Conditions of the Sungei Serangoon", in *Coastal Living Resources: Proceedings of a Symposium on the Assessment of Living Resources in the Coastal Area of Singapore* (Singapore: National University of Singapore, 1990).
- 18 Dan Koh, "Lorong Halus", *Singapore Infopedia*, 16 November 2016, https://eresources.nlb.gov.sg/infopedia/articles/SIP_2016-11-30_193336.html
- 19 Chan et al., CLC Group Interview.
- 20 Ibid.
- 21 Taiganides, *Pig Waste Management and Recycling*, 6.
- 22 Ibid., 13.
- 23 Chan et al., CLC Group Interview.
- 24 "Tebrau and Scudai Rivers Water Agreement, Clauses 4(ii) and 8", 1961 Water Agreement.
- 25 Centre for Liveable Cities, *Water: From Scarce Resource to National Asset* (Singapore: Centre for Liveable Cities, 2020), <https://www.clc.gov.sg/docs/default-source/urban-systems-studies/uss-water-revised.pdf>
- 26 "Johore River Water Agreement, Clause 5(i)", 1962.
- 27 Ibid.
- 28 Lee Kuan Yew, "Public Dialogue at Singapore International Water Week (SIWW)", March 2008.
- 29 Ibid.
- 30 Felicia Choo, "5 Interesting Facts About the Singapore River Clean Up", *The Straits Times*, 5 July 2014, <https://www.straitstimes.com/singapore/5-interesting-facts-about-the-singapore-river-clean-up>
- 31 Chan et al., CLC Group Interview.
- 32 PUB, Singapore's National Water Agency, "Email Correspondence with CLC", Centre for Liveable Cities, Ministry of National Development, 6 August 2020.
- 33 Khoo Teng Chye, "Informal Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 14 May 2020.
- 34 PUB, Email Correspondence with CLC, 6 August 2020.
- 35 Chan et al., CLC Group Interview.
- 36 Ibid.
- 37 Esther Wong, "Two New Reservoirs to Boost Singapore's Water Supply", *TODAY*, 4 July 2011.
- 38 PUB, "Email Correspondence with CLC", Centre for Liveable Cities, Ministry of National Development, 22 December 2020.
- 39 Chan et al., CLC Group Interview.
- 40 Jessica Cheam, *Forging a Greener Tomorrow: Singapore's Environmental Journey From Slum to Eco-City* (Singapore: Straits Times Press, 2012).
- 41 M.F. Lee, "The Sungei Seletar/Bedok Water Scheme", *PUB Digest*, 3.28, June 1985.
- 42 PUB, Email Correspondence with CLC, 22 December 2020.
- 43 Chan et al., CLC Group Interview.
- 44 Alan Lim, "End of the Line for Dump", *The Straits Times*, 1 April 1999, <https://eresources.nlb.gov.sg/newspapers/digitised/issue/straitstimes19990401-1>
- 45 The Tuas South Incineration Plant was officially opened in 2000 but started operating in 1999.
- 46 Chan et al., CLC Group Interview.
- 47 PUB, Email Correspondence with CLC, 22 December 2020.
- 48 Chan et al., CLC Group Interview.
- 49 Cheong Koon Hean, "How Can We Better Chart Singapore's Urban Future?", *TodayOnline*, 17 April 2018, <https://www.todayonline.com/commentary/how-we-can-better-chart-singapores-urban-future>
- 50 Aw Chin Lee, *Land Reclamation in Singapore: Methods and Costs* (Singapore: National University Singapore, 1993), <https://scholarbank.nus.edu.sg/handle/10635/154347>
- 51 "Land Reclamation Off Punggol", *The Straits Times*, 5 March 1983, <https://eresources.nlb.gov.sg/newspapers/digitised/issue/straitstimes19830305-1>
- 52 "Reclamation Project Approved", *The Straits Times*, 20 October 1984, <https://eresources.nlb.gov.sg/newspapers/digitised/issue/straitstimes19841020-1>
- 53 Housing & Development Board, *Annual Report, 1990/91* (Singapore: Housing & Development Board, 1991), 48.
- 54 Parliament of Singapore, "Estimates of Expenditure for the Financial Year 1st April, 1997 to 31st March, 1998", Singapore Parliamentary Report Vol. 67, Col. 1123, 28 July 1997, https://sprs.parl.gov.sg/search/topic?reportid=006_19970728_S0002_T0004

- ⁵⁵ Chan et al., CLC Group Interview.
- ⁵⁶ Centre for Liveable Cities, *Integrating Land Use & Mobility: Supporting Sustainable Growth* (Singapore: Centre for Liveable Cities, 2018), <https://www.clc.gov.sg/docs/default-source/urban-systems-studies/uss-integ-land-use-mobility.pdf>
- ⁵⁷ Chan et al., CLC Group Interview.
- ⁵⁸ Ibid.
- ⁵⁹ CLC, "Integrating Land Use & Mobility".
- ⁶⁰ Ibid.
- ⁶¹ Chan et al., CLC Group Interview.
- ⁶² Ibid.
- ⁶³ Mohinder Singh, "Email correspondence with CLC", Centre for Liveable Cities, Ministry of National Development, 19 November 2020.
- ⁶⁴ Ibid.
- ⁶⁵ Chan et al., CLC Group Interview.
- ⁶⁶ Ibid.
- ⁶⁷ MITA, "Speech by Prime Minister Goh Chok Tong".
- ⁶⁸ Chan et al., CLC Group Interview.
- ⁶⁹ Ibid.
- ⁷⁰ Ibid.
- ⁷¹ Ibid.
- ⁷² Ibid.
- ⁷³ Ibid.
- ⁷⁴ Urban Redevelopment Authority and Housing & Development Board, *Punggol 21: A Waterfront Town of the 21st Century* (Singapore: Urban Redevelopment Authority, 1996), 12.
- ⁷⁵ Housing & Development Board, *Annual Report 1991/92* (Singapore: Housing & Development Board, 1992), 13, 28.
- ⁷⁶ Housing & Development Board, *Annual Report 1995/96* (Singapore: Housing & Development Board, 1996), 13, 39.
- ⁷⁷ Chan et al., CLC Group Interview.
- ⁷⁸ Ibid.
- ⁷⁹ HDB, *Annual Report 1995/96*.
- ⁸⁰ Sumiko Tan, *Home. Work. Play* (Singapore: Urban Redevelopment Authority, 1999), 50.
- ⁸¹ Chan et al., CLC Group Interview.
- ⁸² Mah Bow Tan, *Reflections on Housing a Nation: A Collection of Commentaries* (Singapore: Ministry of National Development, 2011), 29–31.
- ⁸³ Penny Low, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 28 April 2021, transcript, accession number CLC/051/2021/012.
- ⁸⁴ Ibid.
- ⁸⁵ Ibid.
- ⁸⁶ Ibid.
- ⁸⁷ Jurong Lake District, "Factsheet on Punggol Promenade", <https://www.jld.gov.sg/-/media/User%20Defined/URA%20Online/media-room/2009/aug/pr09-51a.pdf>
- ⁸⁸ Centre for Liveable Cities, *Past, Present and Future: Conserving the Nation's Built Heritage* (Singapore: Centre for Liveable Cities, 2019), <https://www.clc.gov.sg/docs/default-source/urban-systems-studies/uss-conserving-the-nations-built-heritage.pdf>
- ⁸⁹ Jurong Lake District, "Factsheet on Punggol Promenade".
- ⁹⁰ Ansley Ng, "Horse-Riding to be Part of Punggol's 'Rustic Charm'", *TODAY*, 21 December 2006.
- ⁹¹ Kong Yit San, "Email Correspondence with CLC", Centre for Liveable Cities, Ministry of National Development, 27 November 2020.
- ⁹² Chan et al., CLC Group Interview.
- ⁹³ Kong, Email Correspondence with CLC.
- ⁹⁴ Goh Chin Lian, "It's a Smooth Ride on NEL-Mostly", *The Straits Times*, 21 June 2003.
- ⁹⁵ Lee Hsien Loong, "National Day Rally", Prime Minister's Office, 19 August 2007, <https://www.pmo.gov.sg/Newsroom/pm-lee-hsien-loongs-national-day-rally-speech-2007-english>
- ⁹⁶ Housing & Development Board, "Remaking Our Heartland' Punggol 2007 Exhibition", 2007, <https://www20.hdb.gov.sg/f10/f10349p.nsf/hdb/rohweb/img/punggol/2007-rohexhibition.pdf>
- ⁹⁷ Chan et al., CLC Group Interview.
- ⁹⁸ Housing & Development Board, *Discover Punggol* (Singapore: Housing & Development Board, 2017).
- ⁹⁹ Chan et al., CLC Group Interview.
- ¹⁰⁰ Housing & Development Board, "My Waterway@Punggol—Singapore's Longest Man-Made Waterway", American Academy of Environmental Engineers and Scientists, 2012, <https://www.aees.org/e3scompetition/2012grandprize-environmentalsustainability.php>
- ¹⁰¹ Surbana Jurong, "Surbana Jurong & Its Clients Garner Five of the 50 Awards at IES-SG50 Competition", Surbana Jurong, Press Statement, 1 July 2016, <https://surbanajurong.com/wp-content/uploads/2017/09/Press-statement-Surbana-Jurong-and-its-clients-garner-five-of-the-.pdf>
- ¹⁰² Cheong Koon Hean, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 21 April 2021, transcript.
- ¹⁰³ Chan et al., CLC Group Interview.
- ¹⁰⁴ Cheong, CLC Interview.
- ¹⁰⁵ HDB, "Discover Punggol".
- ¹⁰⁶ Chong Fook Loong, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 6 May 2021, transcript, accession number CLC/051/2021/013.
- ¹⁰⁷ Marjorie Chong and Jeffrey Teo, "Interview with Ottercity by CLC", Centre for Liveable Cities, Ministry of National Development, 8 December 2020, transcript, accession number CLC/051/2020/007.
- ¹⁰⁸ Chong Fook Loong, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 6 May 2021, transcript, accession number CLC/051/2021/013.
- ¹⁰⁹ Cheong Koon Hean, Pebble Lee, Corrinne Lim, Ng Hwee Yian and Tan Sze Tiong, "Group Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 23 April 2021, transcript accession number CLC/051/2020/010.
- ¹¹⁰ Cheong et al., CLC Group Interview.
- ¹¹¹ Fong, CLC Interview.
- ¹¹² Cheong et al., CLC Group Interview.
- ¹¹³ Housing & Development Board, "Shaping My Punggol: Announcing Punggol Waterway Competition Results And Launch Of Housing Design Competition", Press Release, 12 December 2008, <https://www.nas.gov.sg/archivesonline/data/pdfdoc/20081219003.htm>
- ¹¹⁴ HDB, "My Waterway@Punggol".
- ¹¹⁵ Housing & Development Board, "First Public Housing @ Punggol Waterway Waterfront Housing Design Competition", [https://www20.hdb.gov.sg/f10/f10349p.nsf/hdb/rohweb/img/punggol/2008-\(12-21%20Dec\)-Launch%20of%20Punggol%20Housing%20Design%20Competition.pdf](https://www20.hdb.gov.sg/f10/f10349p.nsf/hdb/rohweb/img/punggol/2008-(12-21%20Dec)-Launch%20of%20Punggol%20Housing%20Design%20Competition.pdf)
- ¹¹⁶ Chong, CLC Interview.
- ¹¹⁷ Maggie Chong and Dylan Loh, "1st Public Housing Project Along Punggol Waterway to Have Eco-Friendly Features", *Buying Singapore Properties*, 17 November 2009, <http://buysingaporeproperties.blogspot.com/2009/11/1st-public-housing-project-along.html>
- ¹¹⁸ Cheong et al., CLC Group Interview.
- ¹¹⁹ Michelle Ng, "From Rural Village to Waterfront Town: How Punggol Got Its Distinct HDB Town Identity", *The Straits Times*, 7 October 2020, <https://www.straitstimes.com/singapore/housing/from-rural-village-to-waterfront-town-how-punggol-got-its-distinct-hdb-town>
- ¹²⁰ Rachel Au-Yong, "Waterway View, Punggol BTO with 'Kelong'-Inspired Design, Takes Home Top HDB Award", *The Straits Times*, 2 September 2018, <https://www.straitstimes.com/singapore/waterway-view-punggol-bto-with-ke-long-inspired-design-takes-home-top-hdb-award>

- ¹²¹ Parliament of Singapore, "Shortage of Childcare Facilities in Sengkang and Punggol", Singapore Parliamentary Report Vol. 90, 13 May 2013, <https://sprs.parl.gov.sg/search/sprs3topic?reportid=oral-answer-255>
- ¹²² Chan et al., CLC Group Interview.
- ¹²³ Chong Fook Loong, "More Facilities In the Pipeline", *TODAY*, 23 September 2009, 48, <https://eresources.nlb.gov.sg/newspapers/Digitised/Article/today20090923-2.2.575>
- ¹²⁴ Michelle Low, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 22 December 2020, transcript, accession number CLC/051/2020/008.
- ¹²⁵ Housing & Development Board, "HDB to Develop Punggol as Singapore's First Eco-Town for the Tropics", Press Release, 28 January 2010, https://www.nas.gov.sg/archivesonline/data/pdfdoc/20100204009/punggol_eco-town_28_jan.pdf
- ¹²⁶ Cheong Koon Hean, "IPS-Nathan Lecture Series: Seeking a Better Urban Future, Lecture III: Shaping the Future of Heartland Living", 23 April 2018, https://lkyspp.nus.edu.sg/docs/default-source/ips/ips-nathan-lectures_lecture-iii_shaping-the-future-of-heartland-living_110918.pdf
- ¹²⁷ Housing & Development Board, *Annual Report 2012/2013* (Singapore: Housing & Development Board, 2013), 17–8, https://sprs.parl.gov.sg/search/topic?reportid=006_19970728_S0002_T0004
- ¹²⁸ Cindy Co, "After the Success of Singapore's First Eco-Town Punggol, What Next for HDB Green Living?", *Channel News Asia*, 22 October 2020, <https://www.channelnewsasia.com/news/singapore/hdb-green-towns-punggol-solar-energy-climate-change-13329468>
- ¹²⁹ Lau Joo Ming, Teh Poh Suan and Winston Toh, "HDB's Next Generation of Eco-Districts at Punggol and Eco-Modernisation of Existing Towns", *IES Journal Part A: Civil & Structural Engineering*, 3.3 (2010): 203–9, <https://www.tandfonline.com/doi/full/10.1080/19373260.2010.491259>
- ¹³⁰ Housing & Development Board, "HDB Clinches Prestigious Engineering Award for Its Urban Environment Modelling Tool, To Be Used in the Planning of New Housing in Punggol, Bidadari and Tampines North", Press Release, 23 July 2015, <https://www20.hdb.gov.sg/fi10/fi10296p.nsf/PressReleases/885C1F75EEFA7E848257E8B002623E6>
- ¹³¹ Ibid.
- ¹³² HDB, *Annual Report 2012/2013*, 17–8.
- ¹³³ Cheong, "IPS-Nathan Lecture Series".
- ¹³⁴ Archnet, "Treelodge @ Punggol, Singapore", 2011, https://archnet.org/sites/7108/media_contents/83839
- ¹³⁵ HDB, "My WaterWay@Punggol".
- ¹³⁶ Penny Low, CLC Interview, 28 April 2021.
- ¹³⁷ Lim Yi Han, "New Punggol Residents Bond in WhatsApp Chat", *The Straits Times*, 3 January 2016, <https://www.straitstimes.com/singapore/new-punggol-residents-bond-in-whatsapp-chat>
- ¹³⁸ Jalelah Abu Baker, "The Estate in Punggol That is Keeping the Kampung Spirit Alive", *Channel News Asia*, 22 June 2019, <https://www.channelnewsasia.com/news/singapore/punggol-estate-keeping-kampung-spirit-alive-11355736>
- ¹³⁹ Penny Low, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 27 April 2021, transcript, accession number CLC/051/2020/011.
- ¹⁴⁰ Foo Ling Fang, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 27 April 2021, transcript, accession number CLC/051/2021/011.
- ¹⁴¹ Penny Low, CLC Interview, 27 April 2021.
- ¹⁴² Susan Long, "Saving and Being Saved By the Waterways", *The Straits Times*, 2 September 2014, <https://www.straitstimes.com/singapore/saving-and-being-saved-by-the-waterways>
- ¹⁴³ Eugene Heng, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 10 November 2020, transcript, accession number CLC/051/2020/005.
- ¹⁴⁴ Kong, Email Correspondence with CLC.
- ¹⁴⁵ Chong and Teo, CLC Interview.
- ¹⁴⁶ Ibid.
- ¹⁴⁷ Ibid.
- ¹⁴⁸ Lester Wong, "Punggol Digital District to Have More Jobs Close to Green, Smart Homes", *The Straits Times*, 18 January 2020, <https://www.straitstimes.com/singapore/punggol-digital-district-to-have-more-jobs-close-to-green-smart-homes>
- ¹⁴⁹ HDB, "HDB to Develop Punggol as Singapore's First Eco-Town for the Tropics".
- ¹⁵⁰ Chan et al., CLC Group Interview.
- ¹⁵¹ Cheong et al., CLC Group Interview.
- ¹⁵² Housing & Development Board, "Homes At One With Nature", Press Release, 18 July 2018, <https://www.hdb.gov.sg/cs/infoweb/about-us/news-and-publications/press-releases/homes-at-one-with-nature1>
- ¹⁵³ Ibid.
- ¹⁵⁴ Kong, Email Correspondence with CLC.
- ¹⁵⁵ Chan et al., CLC Group Interview.
- ¹⁵⁶ Kong, Email Correspondence with CLC.
- ¹⁵⁷ "Greater Rustic Coast", *The Straits Times*, 26 May 2019, <https://www.straitstimes.com/lifestyle/greater-rustic-coast>
- ¹⁵⁸ Land Transport Authority, "Cross Island Line–Punggol Extension: Better Rail Connectivity for Punggol and Pasir Ris Residents", News Release, 10 March 2020, https://www.lta.gov.sg/content/ltagov/en/newsroom/2020/march/news-releases/Cross_island_line_Punggol_extension.html
- ¹⁵⁹ Land Transport Authority, "New Link Road Connecting Punggol Central to KPE/TPE to Open Ahead of Schedule", News Release, 8 November 2018, <https://www.lta.gov.sg/content/ltagov/en/newsroom/2018/11/2/new-link-road-connecting-punggol-central-to-kpe-tpe-to-open-ahead-of-schedule.html>
- ¹⁶⁰ Ministry of Transport, "Joint Media Release by LTA and MOT: Autonomous Vehicles to Transform Intra-Town Travel by 2022", 22 November 2017, <https://www.mot.gov.sg/news-centre/news/Detail/joint-media-release-by-lta-and-mot-autonomous-vehicles-to-transform-intra-town-travel-by-2022/>
- ¹⁶¹ Lee Hsien Loong, "National Day Rally 2015", Prime Minister's Office, Singapore, 23 August 2015, <https://www.pmo.gov.sg/Newsroom/national-day-rally-2015>
- ¹⁶² Linette Lai and Toh Yong Chuan, "Masterplan for 'Digital District' in Punggol North Launched; Area to Generate up to 28,000 Tech Jobs", *The Straits Times*, 21 January 2018, <https://www.straitstimes.com/singapore/masterplan-for-digital-district-in-punggol-north-launched-area-to-generate-up-to-28000>
- ¹⁶³ Ministry of National Development, "Urban Sustainability R&D Congress 2019 Detailed Breakout Track Schedule", 24 July 2019, <https://www.mnd.gov.sg/docs/default-source/default-document-library/detailed-breakout-day-2.pdf>
- ¹⁶⁴ JTC Corporation, "Punggol to be a Full-Fledged Smart Town–Punggol Will Demonstrate Future Living in Singapore", 17 January 2020, Press Release, [https://www.jtc.gov.sg/news-and-publications/press-releases/Pages/20200117\(PR1\).aspx](https://www.jtc.gov.sg/news-and-publications/press-releases/Pages/20200117(PR1).aspx)
- ¹⁶⁵ Ibid.
- ¹⁶⁶ David Tan, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 23 November 2020, transcript, accession number CLC/051/2020/006.
- ¹⁶⁷ Ibid.
- ¹⁶⁸ Urban Redevelopment Authority, *Skyline Issue 7* (Singapore: Urban Redevelopment Authority, 2017), 16, https://www.ura.gov.sg/-/media/Corporate/Resources/Publications/Skyline/Skyline-PDFs/Skyline_Issue_07.pdf
- ¹⁶⁹ Tan, CLC Interview.
- ¹⁷⁰ Wong Mun Summ, "Email Correspondence with CLC", Centre for Liveable Cities, Ministry of National Development, 25 January 2021.
- ¹⁷¹ Ibid.
- ¹⁷² Co, "What Next for HDB Green Living?"

- 173 Ibid.
- 174 Tan, CLC Interview.
- 175 Wong, Email Correspondence with CLC.
- 176 Derek Wong, "Underground Plans for Three Districts Revealed", *The Straits Times*, 28 March 2019, <https://www.straitstimes.com/singapore/underground-plans-for-three-districts-revealed>
- 177 Chan et al., CLC Group Interview.
- 178 Ibid.
- 179 Tan, CLC Interview.
- 180 Ryan Lee, "Interview by CLC", Centre for Liveable Cities, Ministry of National Development, 16 September 2020, transcript, accession number CLC/051/2020/004.
- 181 Ibid.
- 182 Tan, CLC Interview.
- 183 Lee, CLC Interview.
- 184 Tan, CLC Interview.
- 185 GovtTech Singapore, "Building an Operating System for Punggol Digital District", 5 February 2020, <https://www.tech.gov.sg/media/technews/building-an-operating-system-for-punggol-digital-district>
- 186 Tan, CLC Interview.
- 187 Ibid.
- 188 Ibid.
- 189 Ibid.
- 190 Ibid.
- 191 JTC, "Punggol to be a Full-Fledged Smart Town".
- 192 Tan, CLC Interview.
- 193 Foo, CLC Interview.
- 194 Chong, CLC Interview.
- 195 Ibid.
- 196 Ibid.
- 197 Cheong et al., CLC Group Interview.
- 198 Ibid.
- 199 Ibid.
- 200 Ibid.

BIBLIOGRAPHY

Books, Journals, Conference Proceedings

- Aw, Chin Lee. *Land Reclamation in Singapore: Methods and Costs*. Singapore: National University Singapore, 1993. <https://scholarbank.nus.edu.sg/handle/10635/154347>
- Cheam, Jessica. *Forging a Greener Tomorrow: Singapore's Environmental Journey From Slum to Eco-City*. Singapore: Straits Times Press, 2012.
- Goh, Nigel K.C. and Goh, Beverly P.L. "A Study of the Hydrobiological Conditions of the Sungai Serangoon". *Coastal Living Resources: Proceedings of a Symposium on the Assessment of Living Resources in the Coastal Area of Singapore*. Singapore: National University of Singapore, 1990.
- Lau, Joo Ming, The, Poh Suan and Toh, Winston. "HDB's Next Generation of Eco-Districts at Punggol and Eco-Modernisation of Existing Towns". *IES Journal Part A: Civil & Structural Engineering*, 3.3 (2010). <https://www.tandfonline.com/doi/full/10.1080/19373260.2010.491259>
- Mah, Bow Tan. *Reflections on Housing a Nation: A Collection of Commentaries*. Singapore: Ministry of National Development, 2011.
- Taiganides, E. Paul. *Pig Waste Management and Recycling*. Ottawa: International Development Research Centre, 1992, 9.
- Tan, Sumiko. *Home. Work. Play*. Singapore: Urban Redevelopment Authority, 1999.
- Urban Redevelopment Authority and Housing & Development Board. *Punggol 21: A Waterfront Town of the 21st Century*. Singapore: Urban Redevelopment Authority, 1996.

Government Publications, Singapore Parliamentary Reports

- Centre for Liveable Cities. *Integrating Land Use & Mobility: Supporting Sustainable Growth*. Singapore: Centre for Liveable Cities, 2018. <https://www.clc.gov.sg/docs/default-source/urban-systems-studies/uss-integ-land-use-mobility.pdf>
- _____. *Living with Water: Lessons from Singapore and Rotterdam*. Singapore: Centre for Liveable Cities, 2019. <https://www.clc.gov.sg/docs/default-source/books/living-with-water.pdf>
- _____. *Past, Present and Future: Conserving the Nation's Built Heritage*. Singapore: Centre for Liveable Cities, 2019. <https://www.clc.gov.sg/docs/default-source/urban-systems-studies/uss-conserving-the-nations-built-heritage.pdf>
- _____. *Water: From Scarce Resource to National Asset*. Singapore: Centre for Liveable Cities, 2020. <https://www.clc.gov.sg/docs/default-source/urban-systems-studies/uss-water-revised.pdf>
- Housing & Development Board. *Annual Report 1977/78*. Singapore: Housing & Development Board, 1978.
- _____. *Annual Report 1990/91*. Singapore: Housing & Development Board, 1991.
- _____. *Annual Report 1991/92*. Singapore: Housing & Development Board, 1992.
- _____. *Annual Report 1995/96*. Singapore: Housing & Development Board, 1996.
- _____. *Annual Report 2012/2013*. Singapore: Housing & Development Board, 2013.
- _____. *Discover Punggol*. Singapore: Housing & Development Board, 2017.
- _____. "HDB to Develop Punggol as Singapore's First Eco-Town for the Tropics". Housing & Development Board. Press Release, 28 January 2010. https://www.nas.gov.sg/archivesonline/data/pdfdoc/20100204009/punggol_eco-town_28_jan.pdf
- _____. "My WaterWay@Punggol: A Living Laboratory for Urban Living Solutions". *City Green*, Issue 15, NParks. November 2017.
- "Johore River Water Agreement, Clause 5(i)", 1962 Water Agreement.
- Ministry of National Development. "Urban Sustainability R&D Congress 2019 Detailed Breakout Track Schedule". 24 July 2019. https://www.mnd.gov.sg/docs/default-source/default-document-library/detailed-breakout-day-2_pdf.pdf
- Parliament of Singapore. "Estimates of Expenditure for the Financial Year 1st April, 1997 to 31st March, 1998". Singapore Parliamentary Report Vol. 67, Col. 1123, 28 July 1997. https://sprs.parl.gov.sg/search/topic?reportid=006_19970728_S0002_T0004

- _____. "Shortage of Childcare Facilities in Sengkang and Punggol". Singapore Parliamentary Report Vol. 90, 13 May 2013. <https://sprs.parl.gov.sg/search/sprs3topic?reportid=oral-answer-255>
- Singapore Department of Statistics. "Population Trends 2019". Department of Statistics, Ministry of Trade and Industry, 2019. <https://www.singstat.gov.sg/-/media/files/publications/population/population2019.pdf>
- "Tebrau and Scudai Rivers Water Agreement. Clauses 4(ii) and 8", 1961 Water Agreement.
- Urban Redevelopment Authority. *Skyline Issue 7*. Singapore: Urban Redevelopment Authority, 2017. https://www.ura.gov.sg/-/media/Corporate/Resources/Publications/Skyline/Skyline-PDFs/Skyline_Issue_07.pdf
- Urban Redevelopment Authority and Housing & Development Board. *Punggol 21: A Waterfront Town of the 21st Century*. Singapore: Urban Redevelopment Authority, 1996, 12.
- Interviews, Speeches, Lectures, Oral Histories, Press Releases**
- Chan, Yoon Kum, Fong, Chun Wah, Kong, Yit San, Loh, Ah Tuan, Singh, Mohinder, Seow, Kah Ping, Wong, Kai Yeng, Yap, Kheng Guan, Koh, Michael and Khoo, Teng Chye. "Group Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 8 July 2020. Transcript, accession number CLC/051/2020/003.
- Cheong, Koon Hean, Pebble Lee, Corrinne Lim, Ng Hwee Yian and Tan Sze Tiong. "Group Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 23 April 2021, transcript, accession number CLC/051/2020/010.
- Cheong, Koon Hean. "IPS-Nathan Lecture Series: Seeking a Better Urban Future, Lecture III: Shaping the Future of Heartland Living". 23 April 2018. https://lkyspp.nus.edu.sg/default-source/ips/ips-nathan-lectures_lecture-iii_shaping-the-future-of-heartland-living_110918.pdf
- Chong, Fook Loong. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 6 May 2021. Transcript, accession number CLC/051/2021/013.
- Chong, Marjorie and Teo, Jeffrey. "Interview with Ottercity by CLC". Centre for Liveable Cities, Ministry of National Development, 8 December 2020. Transcript, accession number CLC/051/2020/007.
- Foo, Ling Fang. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 27 April 2021. Transcript, accession number CLC/051/2020/011.
- Foo, Ling Fang. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 28 April 2021. Transcript, accession number CLC/051/2020/012.
- Heng, Eugene. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 10 November 2020. Transcript, accession number CLC/051/2020/005.
- Housing & Development Board. "HDB Clinches Prestigious Engineering Award for its Urban Environment Modelling Tool, to be Used in the Planning of New Housing in Punggol, Bidadari and Tampines North". Press Release, 23 July 2015. <https://www20.hdb.gov.sg/f110/f10296p.nsf/PressReleases/885C1F75EEFA7E848257E8B002623E6>
- _____. "HDB to Develop Punggol as Singapore's First Eco-Town for the Tropics". Press Release, 28 January 2010. https://www.nas.gov.sg/archivesonline/data/pdfdoc/20100204009/punggol_eco-town_28_jan.pdf
- _____. "Homes at One with Nature". Press Release, 18 July 2018. <https://www.hdb.gov.sg/cs/infoweb/about-us/news-and-publications/press-releases/homes-at-one-with-nature1>
- _____. "Shaping My Punggol: Announcing Punggol Waterway Competition Results And Launch Of Housing Design Competition". Press Release, 12 December 2008. <https://www.nas.gov.sg/archivesonline/data/pdfdoc/20081219003.htm>
- JTC Corporation. "Punggol to be a Full-Fledged Smart Town—Punggol Will Demonstrate Future Living in Singapore". Press Release, 17 January 2020. [https://www.jtc.gov.sg/news-and-publications/press-releases/Pages/20200117\(PRI\).aspx](https://www.jtc.gov.sg/news-and-publications/press-releases/Pages/20200117(PRI).aspx)
- Land Transport Authority. "Cross Island Line—Punggol Extension: Better Rail Connectivity for Punggol and Pasir Ris Residents". News Release, 10 March 2020. https://www.lta.gov.sg/content/ltagov/en/newsroom/2020/march/news-releases/Cross_island_line_Punggol_extension.html
- _____. "New Link Road Connecting Punggol Central to KPE/TPE to Open Ahead of Schedule". News Release, 8 November 2018. <https://www.lta.gov.sg/content/ltagov/en/newsroom/2018/11/2/new-link-road-connecting-punggol-central-to-kpe-tpe-to-open-ahead-of-schedule.html>
- Lee, Hsien Loong. "National Day Rally". Prime Minister's Office. Transcript, 19 August 2007. <https://www.pmo.gov.sg/Newsroom/pm-lee-hsien-loongs-national-day-rally-speech-2007-english>
- _____. "National Day Rally 2015". Prime Minister's Office. Transcript, 23 August 2015. <https://www.pmo.gov.sg/Newsroom/national-day-rally-2015>

- Lee, Kuan Yew. "Public Dialogue at Singapore International Water Week (SIWW)". Transcript, March 2008.
- Lee, M.F. "The Sungei Seletar/Bedok Water Scheme". *PUB Digest*, 3, June 1985.
- Lee, Ryan. "Interview by Centre for Liveable Studies". Centre for Liveable Studies, Ministry of National Development, 16 September 2020. Transcript, accession number CLC/051/2020/004.
- Low, Michelle. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 22 December 2020. Transcript, accession number CLC/051/2020/008.
- Low, Penny. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 27 April 2021. Transcript, accession number CLC/051/2020/011.
- Low, Penny. "Interview by CLC". Centre for Liveable Cities, Ministry of National Development, 28 April 2021. Transcript, accession number CLC/051/2021/012.
- Ministry of Information and the Arts. "Speech by Primer Minister Goh Chok Tong at the Official Opening of Punggol 21 on Sunday, 8 July 2001, at 10.30 AM". Press Release, 8 July 2001. <https://www.nas.gov.sg/archivesonline/data/pdfdoc/2001070803.htm>
- Ministry of Transport. "Autonomous Vehicles to Transform Intra-Town Travel by 2022". Joint Media Release by Land Transport Authority and Ministry of Transport, 22 November 2017. <https://www.mot.gov.sg/news-centre/news/Detail/joint-media-release-by-lta-and-mot-autonomous-vehicles-to-transform-intra-town-travel-by-2022/>
- Surbana Jurong. "Surbana Jurong & Its Clients Garner Five of the 50 Awards at IES-SG50 Competition". Press Statement, 1 July 2016. <https://surbanajurong.com/wp-content/uploads/2017/09/Press-statement-Surbana-Jurong-and-its-clients-garner-five-of-the-.pdf>
- Tan, David. "Interview by Centre for Liveable Cities". 23 November 2020. Transcript, accession number CLC/051/2020/006.

Newspapers, Magazines

- Abu Baker, Jalelah. "The Estate in Punggol That is Keeping the Kampung Spirit Alive". *Channel News Asia*, 22 June 2019. <https://www.channelnewsasia.com/news/singapore/punggol-estate-keeping-kampung-spirit-alive-11355736>
- Au-Yong, Rachel. "Waterway View, Punggol BTO with 'Kelong'-Inspired Design, Takes Home Top HDB Award". *The Straits Times*, 2 September 2018. <https://www.straitstimes.com/singapore/waterway-view-punggol-bto-with-kelong-inspired-design-takes-home-top-hdb-award>
- Cheam, Jessica. "Resort-style Design for Waterfront Flats". *The Straits Times*, 12 November 2009.
- Cheong, Koon Hean. "How Can We Better Chart Singapore's Urban Future". *TodayOnline*, 17 April 2018. <https://www.todayonline.com/commentary/how-we-can-better-chart-singapores-urban-future>
- Chong, Fook Loong. "More Facilities In the Pipeline". *TODAY*, 23 September 2009. <https://eresources.nlb.gov.sg/newspapers/Digitised/Article/today20090923-2.2.57.5>
- Chong, Maggie and Loh, Dylan. "1st Public Housing Project Along Punggol Waterway To Have Eco-Friendly Features". *Buying Singapore Properties*, 17 November 2009. <http://buysingaporeproperties.blogspot.com/2009/11/1st-public-housing-project-along.html>
- Choo, Felicia. "5 Interesting Facts About the Singapore River Clean Up". *The Straits Times*, 5 July 2014. <https://www.straitstimes.com/singapore/5-interesting-facts-about-the-singapore-river-clean-up>
- Co, Cindy. "After the Success of Singapore's First Eco-Town Punggol, What Next for HDB Green Living?" *Channel News Asia*, 22 October 2020. <https://www.channelnewsasia.com/news/singapore/hdb-green-towns-punggol-solar-energy-climate-change-13329468>
- Goh, Chin Lian. "It's a Smooth Ride on NEL—Mostly". *The Straits Times*, 21 June 2003.
- Heng, Janice and Yeo, Sam Jo. "Bumper Profits for Early BTO Flats". *The Straits Times*, 7 July 2015. <https://www.straitstimes.com/singapore/housing/bumper-profits-for-early-bto-flats>
- Lai, Linette and Toh, Yong Chuan. "Masterplan for 'Digital District' in Punggol North Launched; Area to Generate up to 28,000 Tech Jobs". *The Straits Times*, 21 January 2018. <https://www.straitstimes.com/singapore/masterplan-for-digital-district-in-punggol-north-launched-area-to-generate-up-to-28000>
- Lim, Alan. "End of the Line for Dump". *The Straits Times*, 1 April 1999. <https://eresources.nlb.gov.sg/newspapers/digitised/issue/straitstimes19990401-1>
- Lim, Yi Han. "New Punggol Residents Bond in WhatsApp Chat". *The Straits Times*, 3 January 2016. <https://www.straitstimes.com/singapore/new-punggol-residents-bond-in-whatsapp-chat>

- Long, Susan. "Saving and Being Saved By the Waterways". *The Straits Times*, 2 September 2014. <https://www.straitstimes.com/singapore/saving-and-being-saved-by-the-waterways>
- Ng, Abigail W.Y. "Singapore's Baby Town Punggol: Some Interesting Things to Know About Other URA Planning Areas". *The Straits Times*, 9 June 2017.
- Ng, Ansley. "Horse-Riding to be Part of Punggol's 'Rustic Charm'". *TODAY*, 21 December 2006.
- Ng, Michelle. "From Rural Village to Waterfront Town: How Punggol Got its Distinct HDB Town Identity". *The Straits Times*, 7 October 2020. <https://www.straitstimes.com/singapore/housing/from-rural-village-to-waterfront-town-how-punggol-got-its-distinct-hdb-town>
- The Straits Times. "Greater Rustic Coast". *The Straits Times*, 26 May 2019. <https://www.straitstimes.com/lifestyle/greater-rustic-coast>.
- _____. "Land Reclamation off Punggol". *The Straits Times*, 5 March 1983. <https://eresources.nlb.gov.sg/newspapers/digitised/issue/straitstimes19830305-1>
- _____. "Reclamation Project Approved". *The Straits Times*, 20 October 1984. <https://eresources.nlb.gov.sg/newspapers/digitised/issue/straitstimes19841020-1>
- Wong, Derek. "Underground Plans for Three Districts Revealed". *The Straits Times*, 28 March 2019. <https://www.straitstimes.com/singapore/underground-plans-for-three-districts-revealed>
- Wong, Esther. "Two New Reservoirs to Boost Singapore's Water Supply". *TODAY*, 4 July 2011.
- Wong, Lester. "Punggol Digital District to Have More Jobs Close to Green, Smart Homes". *The Straits Times*, 18 January 2020. <https://www.straitstimes.com/singapore/punggol-digital-district-to-have-more-jobs-close-to-green-smart-homes>

Websites

- Agri-Food and Veterinary Authority of Singapore. "Celebrating AVA's Excellence Through the Years". *Food For Thought*, 27 February 2020. [https://www.sfa.gov.sg/food-for-thought/article/detail/celebrating-ava-s-excellence-through-the-years-\(2000-2015\)](https://www.sfa.gov.sg/food-for-thought/article/detail/celebrating-ava-s-excellence-through-the-years-(2000-2015))
- Archnet. "Treelodge @ Punggol, Singapore". 2011. https://archnet.org/sites/7108/media_contents/83839
- GovtTech Singapore. "Building an Operating System for Punggol Digital District". 5 February 2020. <https://www.tech.gov.sg/media/technews/building-an-operating-system-for-punggol-digital-district>
- Housing & Development Board. "First Public Housing @ Punggol Waterway Waterfront Housing Design Competition". 2008. [https://www20.hdb.gov.sg/fi10/fi10349p.nsf/hdb/rohweb/img/punggol/2008-\(12-21%20Dec\)-Launch%20of%20Punggol%20Housing%20Design%20Competition.pdf](https://www20.hdb.gov.sg/fi10/fi10349p.nsf/hdb/rohweb/img/punggol/2008-(12-21%20Dec)-Launch%20of%20Punggol%20Housing%20Design%20Competition.pdf)
- _____. "My Waterway@Punggol—Singapore's Longest Man-Made Waterway". American Academy of Environmental Engineers and Scientists, 2012. <https://www.aaees.org/e3scompetition/2012grandprize-environmentalsustainability.php>
- _____. "Punggol". 1 August 2020. <https://www.hdb.gov.sg/about-us/history/hdb-towns-your-home/punggol>
- _____. "Punggol Waterfront Housing Design—Terraces On the Water". <https://www20.hdb.gov.sg/fi10/fi10349p.nsf/hdb/rohweb/img/punggol/Winning%20Entry-Group8asia%20Co%20Ltd%20&%20Aedas%20Pte%20Ltd.pdf>
- _____. "Remaking Our Heartland' Punggol 2007 Exhibition". 2007. <https://www20.hdb.gov.sg/fi10/fi10349p.nsf/hdb/rohweb/img/punggol/2007-rohexhibition.pdf>
- Jurong Lake District. "Factsheet on Punggol Promenade". <https://www.jld.gov.sg/-/media/User%20Defined/URA%20Online/media-room/2009/aug/pr09-51a.pdf>
- Koh, Dan. "Lorong Halus". *Singapore Infopedia*, 16 November 2016. https://eresources.nlb.gov.sg/infopedia/articles/SIP_2016-11-30_193336.html
- Ministry of National Development. "Urban Sustainability R&D Congress 2019 Detailed Breakout Track Schedule". 24 July 2019. <https://www.mnd.gov.sg/docs/default-source/default-document-library/detailed-breakout-day-2.pdf>
- National Heritage Board. "A Vegetable Farm at Punggol". 22 September 2020. <https://www.roots.gov.sg/Collection-Landing/listing/1105897>
- Omar, Marsita and Ong, Alex. "Punggol Reclamation". *Singapore Infopedia*, 2020. https://eresources.nlb.gov.sg/infopedia/articles/SIP_1011_2008-10-28.html
- Teng, Sharon. "Punggol Zoo". *Singapore Infopedia*, 14 March 2016. https://eresources.nlb.gov.sg/infopedia/articles/SIP_2016-03-14_140006.html

IMAGE CREDITS

(Page numbers indicated below)

Alpha, Flickr, CC BY-NC 2.0

64 (Illustration 36, right)

avcorpus, Flickr, CC BY-NC-ND 2.0

63 (top left)

Casual Chin, Flickr, CC BY-NC 2.0

38

Centre for Liveable Cities

25, 32, 33, 34 (inset), 36

Deoma12, CC BY-SA 4.0

64 (Illustration 35)

E. Paul Taiganides, Pig Waste Management and Recycling: The Singapore Experience

10

Elyssa Ludher

Cover, 62 (Illustration 32)

Erwin Soo, Flickr, CC BY 2.0

63 (top right)

Glynis Lee

70 (right)

Housing & Development Board

4, 5, 28, 30, 42 (Illustration 20), 45, 46, 54, 56, 57, 59, 61, 68, 69 (Illustration 41), 81, 82

Jiew Peng Lim, Flickr, CC BY-NC-ND 2.0

63 (bottom left)

Jimmy Tan, Flickr, CC BY 2.0

34

Jnzl's Photos, Flickr, CC BY 2.0

63 (bottom right)

JTC Corporation

88, 92, 93

Khong Kwok Wai

51

National Archives of Singapore

1, 9

National Environment Agency

12, 15

National Heritage Board

64 (Illustration 36, left)

National Library Board

6

National Parks Board

84

NTUC First Campus' My First Skool

66 (top)

NUS Libraries Historical Maps of Singapore

31

OtterCity

77 (left)

People's Association

66 (second from bottom, bottom)

PUB, Singapore's National Water Agency

20, 26

Punggol 21 Community Club

70 (left)

Ravenblack7575, Flickr, CC BY-NC-ND 2.0

27

SAFRA

66 (second from top)

Sim Lian Group Limited

62 (Illustration 33, right)

Singapore Institute of Technology

89

Singapore Sports Council, Flickr, CC BY-NC-ND 2.0

96

Social Innovation Park

72, 73

Surbana Jurong

69 (Illustration 40)

Sylvia Loh

77 (right)

tee_eric, Flickr, CC BY 2.0

42 (Illustration 21, left), 48, 99

Urban Redevelopment Authority

3, 8, 52 (left), 86

USGS Earth Explorer

2-3

Waterways Watch Society

75

Weixiang Ng, Flickr, CC BY-NC-ND 2.0

62 (Illustration 33, left)

William Cho

42 (Illustration 21, right)

WOHA and Digital Mirage

52 (right), 90 (Illustration 53)

WOHA and Obilia

90 (Illustration 54)