New Lands
Soils of Sand, Silt, and Scrap

Edited by Laura Cipriani

TU Delft OPEN
Publishing

Laura Cipriani is an assistant professor of landscape architecture at Delft University of Technology. Her current research addresses climate change issues, starting from the materiality of *water* and *soil*, and adopting *(co)design* approaches with living and non-living systems. Over the last two decades, she has taught at Venice University IUAV, Politecnico di Milano, National University of Singapore, Venice International University, and the University of Padua. She holds bachelor's and master's degrees in Architecture (Hons) from IUAV (2001), a Master's in Design Studies (Hons) from Harvard Design School (2004), and a Ph.D. in Landscape Urbanism from IUAV (2008). In 2008, Laura founded Superlandscape, a landscape and urban design firm.

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Text
Laura Cipriani edited, revised, and rewrote all the text.

Graphic Layout
Julian Adda with Laura Cipriani.

Keywords
Reclaimed lands, Land reclamation worldwide, Land of sand.

Published by
Published by TU Delft OPEN Publishing. A printed and less extensive version of this work is published by LetteraVentidue.

DOI https://doi.org/10.59490/mg.212
ISBN: 978-94-6518-168-4
November 2025

The Electronic Version of this Book is Available at
https://books.open.tudelft.nl

Cover Image
An excavator works in a sandy terrain. An areal view of an excavator on a construction site. Photo by Ian, Unsplash, 2025.

Funder Information
Mainstreaming Open Science Fund 2024.

Conf ict of Interest
No conflict of interest to disclose.

Data Access Statement
Existing data: this study brought together existing research data subject to licence restrictions from a number of different sources. Full details are available in the reference sections of each chapter of this book.

Peer Review Statement
This book has been peer reviewed. The peer review was double anonymous. The editor and the Publisher would like to thank the reviewers for their time and effort: Roberto Pasini and Arian Heidari Afshari.

To see a world in a grain of sand
And a heaven in a wild flower,
Hold infinity in the palm of your hand
And eternity in an hour.

William Blake

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5 | Galgeplaat

Location
Galgeplaat | Eastern Scheldt | Netherlands
Coordinates
51° 34' 6'' N | 3° 55' 50'' E
Area
0.19 km2
Diameter
0.45 km
Time
2008-2011

7 | Thulusdhoo Island

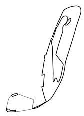
Location
Thulusdhoo | Maldives
Coordinates
4° 13' 1'' N | 73° 32' 30'' E
Area
0.33 km2
Length
1.58 km
Width
0.68 km
Time
2014-2016

11 | Baseco

Location
Baseco | Manila | Philippines
Coordinates
14° 35' 29'' N | 120° 57' 29'' E
Area
0.40 km2
Length
1.70 km
Time
1989-2009

2 | Leslie Spit

Location
Leslie Spit | Toronto |
Canada
Coordinates
43° 37’ 34” N | 79° 19’ 46” W
Area
2.00 km2
Length
5.00 km
Time
1955-1992

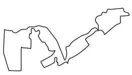


7 | Hulhumalé Island

Location
Hulhumalé | Maldives
Coordinates
4° 12’ 60” N | 73° 32’ 24” E
Area
4.32 km2
Length
2.40 km
Width
1.00 km
Time
1997-2015

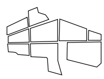
5 | Marker Wadden

Location
Marker Wadden |
Ijsselmeer | Netherlands
Coordinates
52° 34’ 59” N | 5° 22’ 10” E
Area
7.00 km2
Length
4.40 km
Time
2016-2021



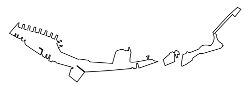
10 | Changxing Island

Location
Changxing Island |
Dalian | China
Coordinates
31° 24’ 30” N | 121° 41’ 28” E
Area
13.30 km2
Length
10.00 km
Time
2003-2007



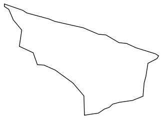
8 | Kuttanad

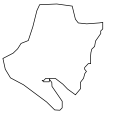
Location
Kuttanad |
Kerala | India
Coordinates
9° 20’ 17” N | 76° 24’ 41” E
Area
24.00 km2
Length
7.75 km
Time
1880-1945

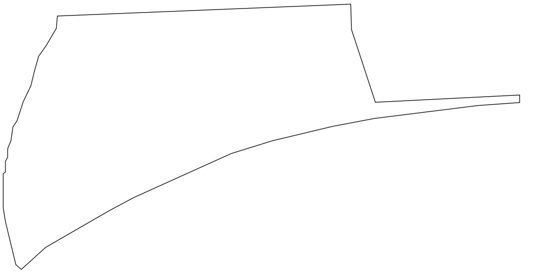


9 | Central and Wan Chai

Location
Central and Wan Chai |
Hong Kong | China
Coordinates
22° 16’ 59” N | 114° 10’ 4” E
Area
0.75 km2
Length
4,1 km
Time
1993-2019







6 | Otodo-Gbame

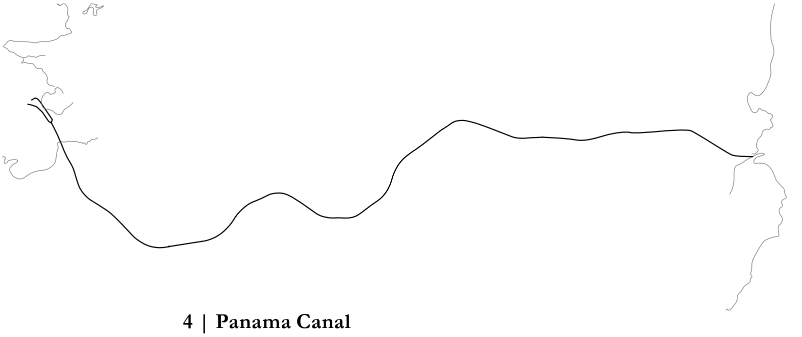
Location
Othodo-Gbame | Lagos |
Nigeria
Coordinates
6° 27' 50'' N | 3° 30' 48'' E
Area
0.56 km2
Length
0.80 km
Time
2000-2022

6 | Makoko

Location
Makoko | Lagos |
Nigeria
Coordinates
6° 30' 2'' N | 3° 23' 19'' E
Area
0.91 km2
Length
0.80 km
Time
1980-2020

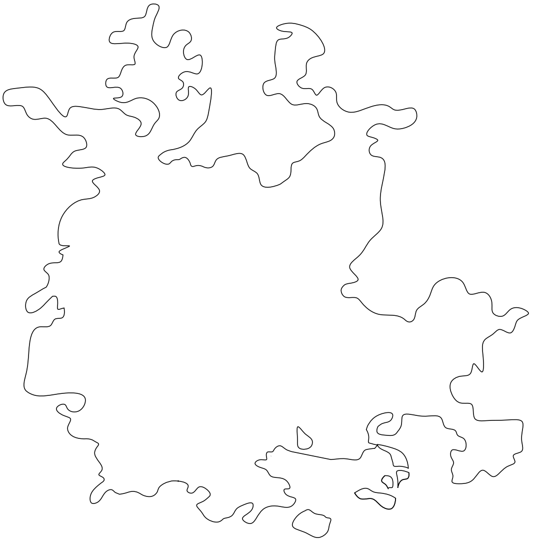
6 | Eko Atlantic City

Location
Eko Atlantic City | Lagos |
Nigeria
Coordinates
6° 24' 26'' N | 3° 25' 15'' E
Area
7,92 km2
Length
5.70 km
Time
2008-2019



4 | Panama Canal

Location
Panama Canal | Panama
Coordinates
9° 7’ 55’’ N | 79° 41’ 13’’ W
Area
1,432 km2
Length
65 km
Time
1821-2024



3 | Texcoco

Location
Texcoco | Mexico City | Panama
Coordinates
19° 26’ 19’’ N | 99° 9’ 2’’ W
Area
1,485 km2
Diameter
34 km
Time
XVI Century-2025

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Acknowledgments

Laura Cipriani

This book originates from the course *Urban Landscapes: Theory, Method, and Critical Thinking*, taught by Denise Piccinini and me as part of the master's program in landscape architecture at TU Delft during the 2021-22 and 2022-23 academic years. The idea for this project began during a visit to Melaka, Malaysia, in 2017, where I directly observed the scale and significance of land reclamation in today's world. Observing its effects on the landscape and local communities motivated me to explore similar stories worldwide with my students. Our aim was to identify common themes related to land reclamation. Despite the global rise in sea levels, this urgent issue continues to affect many countries, emphasizing the need for careful reflection.

I sincerely thank all the students and Denise for their vital contributions that made this project possible. Special thanks to Frederique Belliard, Just de Leeuwe, and Tanya Yankelevich at TU Delft Open Publishing for their guidance and valuable advice. I am grateful to the editorial team for managing the peer review process, along with the reviewers whose insights enriched this work. To Sari Naito, thank you for meticulously checking references and citations. I also want to thank the generous photographers—Muna Noor, David Stanley, Tania Anderson, Hugo Kempeneer, Hartmut Schwarzbach, and Adam Cohn—for their inspiring visuals. Julian Adda's talent in graphic design and patience in refining this work are greatly appreciated. I am also thankful to Gregory Bracken for coordinating the English revision and to the reviewer for their detailed final edits. This project was supported by the Mainstreaming OS Fund 2024 and TU Delft Open Publishing, whose financial assistance covered the design and photo acquisition. Their support adds special energy to this effort. To everyone who shared their passion and expertise along the way—thank you.

1 | Melaka Gateway
Location
Malacca City | Malacca | Malaysia
Coordinates
2° 10' 36" N | 102° 15' 24" E

2 | The Palm
Location
Palm Jumeirah | Dubai | United Arab Emirates
Coordinates
25° 7' 40" N | 55° 9' 12" E

3 | The World
Location
The World | Dubai | United Arab Emirates
Coordinates
25° 13' 41" N | 55° 9' 38" E

4 | Tuas Port
Location
Tuas Mega Port | Singapore
Coordinates
1° 15' 4" N | 103° 36' 59" E

5 | Fiery Cross Reef
Location
Fiery Cross Reef | Spratly Islands | South China Sea | China
Coordinates
9° 36' 42" N | 112° 57' 56" E

6 | Great Wall of Sand
Location
Spratly Islands | South China Sea | China
Coordinates
10° 0' 0" N | 114° 0' 0" E

7 | Marker Wadden
Location
Marker Wadden | Flevoland | The Netherlands
Coordinates
52° 35' 1" N | 5° 23' 16" E

8 | Mekong Delta
Location
Mekong Delta | Vietnam
Coordinates
9° 45' 3" N | 105° 13' 20" E

9 | Poyang Lake
Location
Poyang Lake | Yongxiu County | China
Coordinates
29° 11' 9" N | 116° 12' 16" E

10 | Ayeyarwady River
Location
Ayeyarwady River | Myanmar
Coordinates
20° 20' 55" N | 94° 54' 49" E

11 | Guangdong Province
Location
Guangdong | China
Coordinates
22° 51' 44" N | 113° 25' 8" E

12 | Guangxi Province
Location
Guangxi | Tianzhu | China
Coordinates
26° 50' 58" N | 109° 21' 7" E

13 | Fujian Province
Location
Fujian Province | China
Coordinates
26° 11' 35" N | 118° 13' 15" E

14 | Brahmaputra River Basin
Location
Brahmaputra | Kurigram | Bangladesh
Coordinates
25° 51' 5" N | 89° 50' 0.1" E

15 | Jinjiram River Basin
Location
Jinjiram River | Raomari Upazila | Bangladesh
Coordinates
25° 29' 42" N | 89° 50' 22" E

1 | Introduction

New Lands: From Sea to Sand, Silt, and Scrap

Laura Cipriani

Coastal land reclamation is the process of transforming water into land. Throughout history, humans have reclaimed land to expand ports, defend territories, and convert unhealthy wetlands for agriculture or urban development. What once was driven by survival and growth has now become a global phenomenon—a human-made geological process that reshapes continental edges. Today, in the face of a climate crisis and rising seas, we continue pushing into the ocean, turning water into land as if battling the tide of our own making.

This book starts with this paradox: the desire to create land while the planet is losing it. Through micro-stories, field observations, and personal encounters, it explores how reclamation impacts places and people. It examines the materials used to build these new territories—sand, silt, scrap—and the systems that move them across borders. It questions what kind of worlds we are creating on this unstable ground and what it means in the twenty-first century to stand on land that did not exist before.

When I first arrived at the reclaimed dunes of Melaka in Malaysia, I was captivated by the strange beauty of this unfinished landscape. The silver dunes, occasionally pierced by spontaneous vegetation, shimmered under the tropical light, their reflections mirrored in pools of stagnant water. It was an unreal scene—a place both new and ancient, simultaneously silent and violent. The sand formed this artificial coast, telling a story of human ambition hidden behind dreams of progress. What appeared, at first glance, to be a poem of beauty quickly revealed itself as a monument to arrogance—a beauty that would, inevitably, come at a cost.

With time and experience, my perception changed. I realized what was hidden behind the illusion of new land: it was not natural at all, but the result of a process as violent as it was unseen—one that reshaped not only coastlines but entire communities. The creation of new land in Melaka, like in many other places, involved the destruction of mangroves, harm to marine ecosystems, and erosion of local livelihoods (Cipriani, 2018, 2022). It was also a social and racial process, displacing communities, deepening inequalities, and transforming the social fabric. The so-called '*sand wars*' (Delestrac, 2013) were about more than just resources or real estate speculation; they also involved issues of power, identity, and exclusion. Inequality wasn't accidental — it was intentionally built into the design.

Coastal land reclamation is the process of turning water into land. Historically, humans reclaimed land to expand ports, defend territories, and convert unhealthy wetlands for agricultural or urban development. Yet what once was an act of survival or growth has become a planetary phenomenon—a human-driven geological process reshaping the edges of continents. Today, amid a climate crisis and rising seas, we continue to expand into the ocean, transforming water into land as if fighting the tide of our own making.

This book begins with that paradox: the desire to create land while the planet itself is losing it. Through micro-stories, field observations, and personal encounters, it explores how places and people are changed by reclamation. It examines the materials that construct these new territories—sand, silt, scrap—and the systems that move them across borders. It questions what types of worlds we are creating on this unstable ground, and what it means, in the twenty-first century, to stand on land that did not exist before.

'Land Reclamation' or 'Sea Grabbing'? A Definition and a Controversial Practice

Land reclamation involves turning areas from the sea into usable land. Historically, this practice has addressed various needs—such as converting floodplains into farmland and constructing artificial islands and coastal complexes—to support population growth, economic development, and sanitation improvements. Methods like draining wetlands, dredging sediment, and filling coastal zones with sand, earth, or waste have evolved through technological and engineering innovations, enabling the creation of new spaces in previously uninhabitable areas.

However, land reclamation raises significant environmental, social, and economic concerns. Altering natural ecosystems, displacing local communities, and changing coastal dynamics and shoreline profiles—especially in the face of climate change—make it a highly debated and controversial practice today.

The term itself reflects this complexity. Derived from the Latin '*reclamare*,' meaning 'to protest' or 'to claim,' the word initially conveyed a sense of opposition. Over time, its meaning shifted to 'to claim' or 'to assert,' and by the 19th century, it came to signify 'restoring unproductive land for human use.' Thus, 'land reclamation' essentially means transforming or reclaiming land for agriculture, construction, or infrastructure—reflecting a shift from protest to possession.

The terminology differs depending on the language. In German, the corresponding term is '*landgewinnung*,' which combines '*land*' (meaning 'land, soil, settlement') and '*gewinnung*' (meaning 'extraction, acquisition, development'), suggesting both a productive appropriation and an extractive process. In Dutch, the words '*landaanwinning*' or '*landwinning*' also relate to land acquisition or extraction. In the Romance languages, a different perspective prevails: the Italian '*bonifica*' derives from the Medieval Latin '*bonificare*' (meaning 'to make good'), which in turn derives from '*bonus*' (meaning 'good') and '*facere*' (meaning 'to do'). The focus is not on appropriation but on improvement—making a territory more fertile, healthy, and livable.

These etymological differences highlight a cultural shift in how the practice is viewed. While land reclamation was once viewed as an inherently positive action—'doing good'—it is now debated, especially in light of global environmental transformations. Rising sea levels, identified by the IPCC as a major challenge of climate change, raise questions about the sustainability of artificial land elevation and humanity's ability to impose a stable order on nature. In this context, nature appears as a co-author of future transformations, resisting or redefining human efforts at appropriation and exploitation.

Right | The reclamation dunes in Melaka, Malaysia. Photo: Muna Noor, 2019.
Below | Nature is gradually reclaiming what the reclamation projects have taken in Melaka, Malaysia. Spontaneous vegetation is colonizing the sand with pioneer plants. Photo: Muna Noor, 2019.

In modern discussions, the term 'land reclamation' is often linked to 'sea grabbing.' While the former conveys a human-centered perspective of 'conquering land from the sea,' the latter reflects an ecological view, recognizing that such territories originally belong to the sea, its ecosystems, and the living organisms within, ranging from fish and shells to mangroves and coastal sediments. The act of seizing marine space is an illegal theft of resources from their rightful owners and marine inhabitants. This terminological contrast illustrates the tension between a utilitarian approach, which prioritizes human development, and an ecocentric vision, which emphasizes the importance, identity, and integrity of the natural world.

Taxonomies and Typologies

Developing a small taxonomic atlas of these 'new lands' marked the first step of this book. The cartography (Figure pp. 8-9) of past and current projects reveals a map of the phenomenon's reach across time and space: at least 162 interventions, spread across North America (21), South America (11), Europe (38), the Middle East (14), Africa (25), Asia (44), and Oceania (9), with the most recent stories coming from Asia. Although still evolving and incomplete, this taxonomy illustrates how land reclamation remains a dynamic and widespread practice, transforming the sea into land. If we included extraction sites—often hidden or illegal—in our maps, we might gain a better understanding of the scale of this phenomenon, which has significant geological implications.

The taxonomic map (Figures pp. 10-13) classifies 'new lands' crafted mainly through two methods: the 'fill' technique and the 'poldering' process—choices dictated by tools, soil, seabed, and purpose. The 'fill' method elevates the seabed or flat fields through earthworks or hydraulic transfer, using materials such as clay, soil, gravel, or waste to reach new heights. Hydraulic filling, with dredges and floating pipes, pulls sediments from the depths—though it often stirs the delicate balance of marine ecosystems and erodes coastlines.

Poldering, on the other hand, involves mechanical drainage—machines pumping water out of wetlands and marshes, enclosing the reclaimed land with dams.

Four main types of reclamation emerge from the collected data, each driven by purpose: agricultural efforts to regenerate arid or degraded soils; urban expansion to increase city footprints; industrial and infrastructural projects supporting logistics, manufacturing, and transit; and ecological reclamation, the most recent approach, focusing on restoring degraded ecosystems, supporting biodiversity, and creating recreational spaces.

The collected data show that historically, land reclamation was rooted in agriculture. Regions near the Po Delta in Italy and Dutch polders reveal how different eras shaped different patterns. Today, the focus has shifted: land is now reclaimed mainly for urban, commercial, industrial, and infrastructure projects. Iconic examples, such as Dubai's Palm Islands and The World archipelago, demonstrate this transformation, raising questions about scale, method, design, and placement. Ports and airports, like Singapore's Tuas Port and China's Fiery Cross Reef in the South China Sea—an artificial island with a military purpose—embody this modern shift. The 'Great Wall of Sand,' China's extensive reclamation efforts, hint at geopolitical ambitions woven into these landscapes. Beyond necessity, reclamation also reflects ecological and recreational aspirations. Projects like the Marker Wadden, discussed in Chapter 5, illustrate innovation—hydrogeological soil forging, water purification, and the creation of recreational lands from sand and silt.

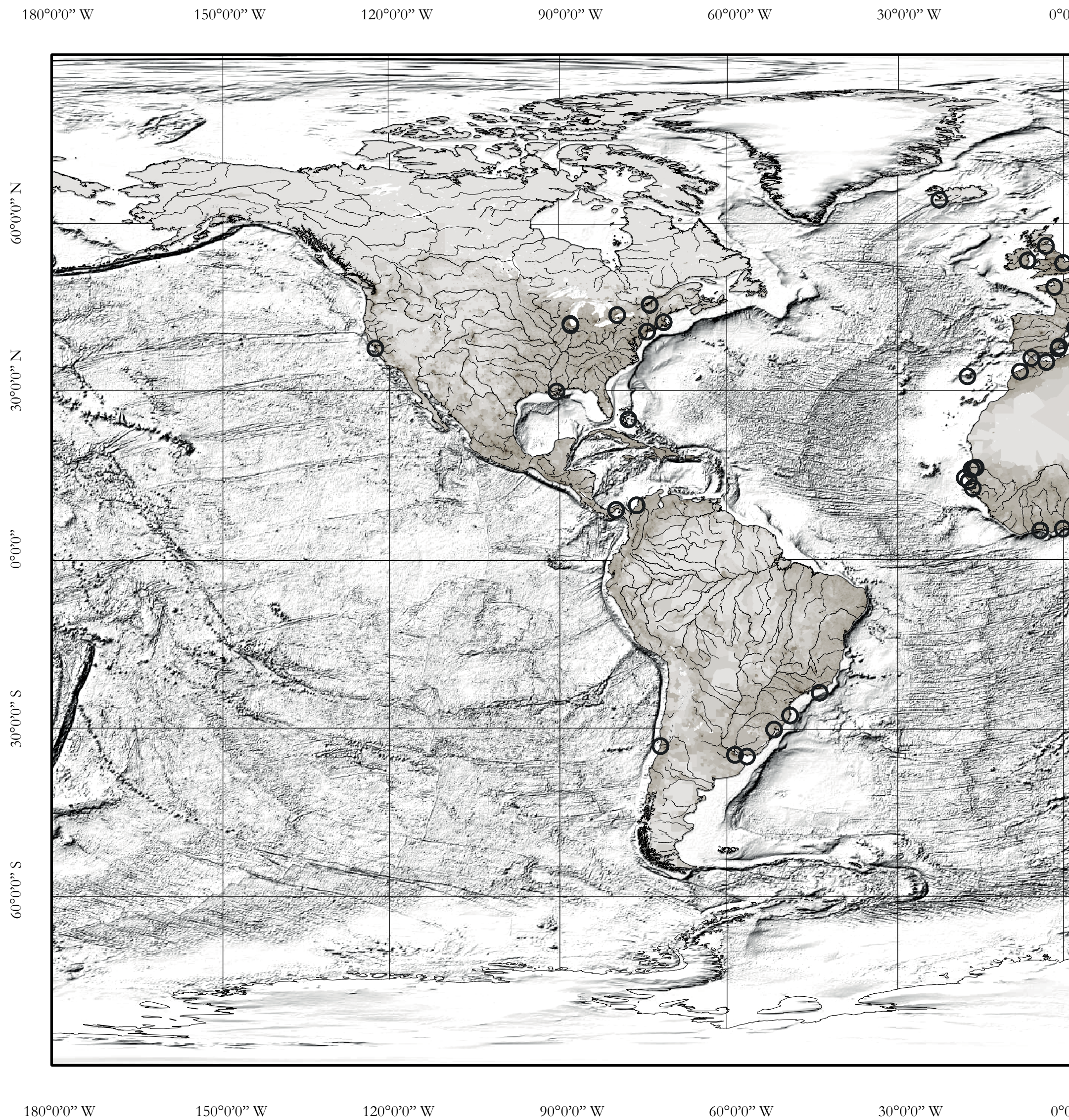
If this taxonomy sketches an expanding artificial archipelago, the next chapter is to explore the importance of materiality—how sand, silt, and waste come together to shape these new worlds.

Matter and Materiality: Sand, Silt, and Scrap

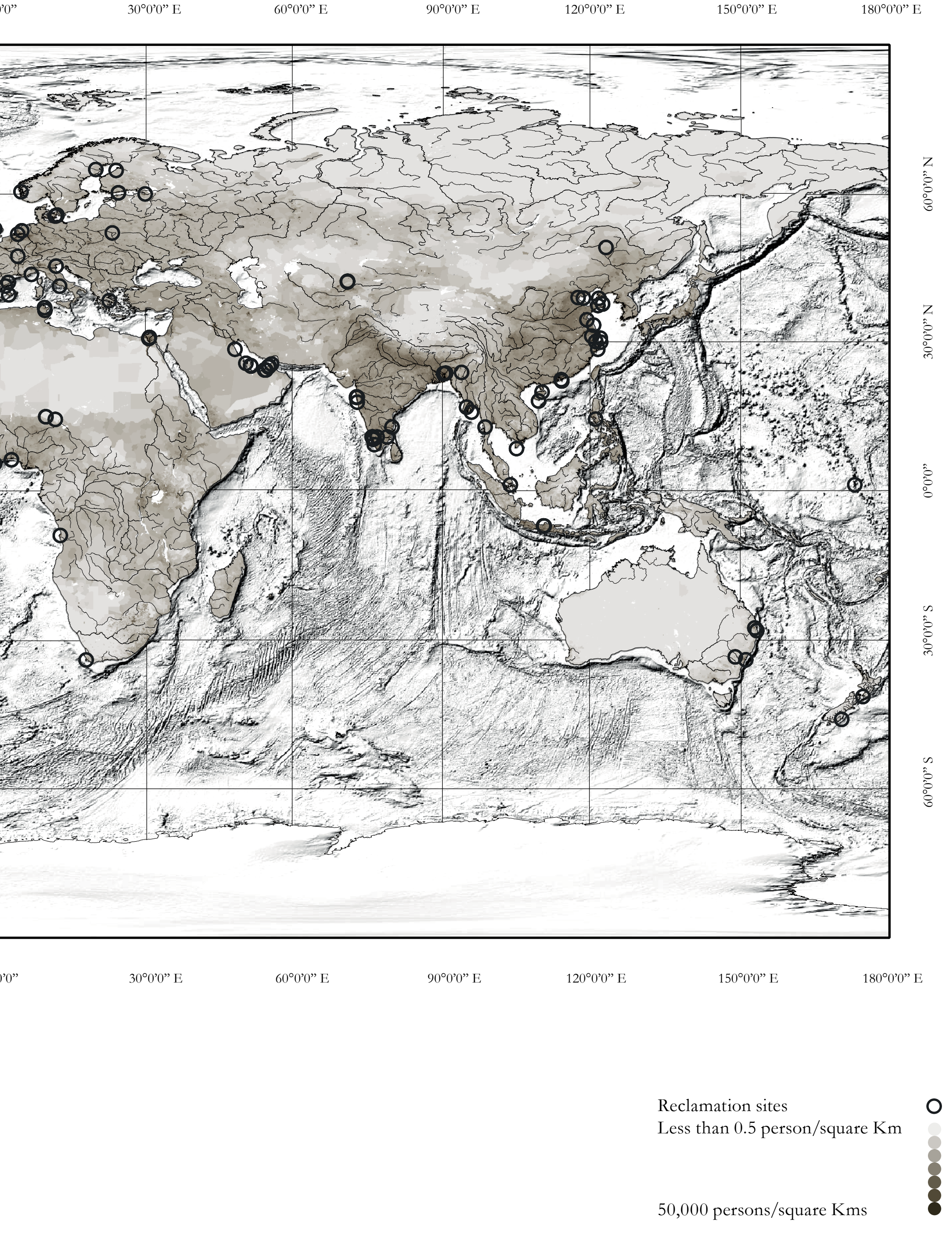
This book views *soil* as *matter*. Creating new land through reclamation is a physical process that involves specific materials, mainly sand, along with silt and waste, as we will see. Materiality is crucial for comprehending the intricate relationship between urbanization and landscape change (Cipriani, 2022). By examining processes such as extraction, transportation, and resource utilization, we can gain a deeper understanding of the environmental, political, and social impacts of urban growth. The concept of 'following the thing' is vital for understanding how urban environments are built and how landscapes change. Every decision in design and planning influences not only the physical site but also the resources used to develop it, such as asphalt for roads, bricks for walls, and the selection of tree species for avenues. These material choices have a ripple effect, impacting local ecosystems and affecting the populations that benefit from or are harmed by these developments.

Tracing the extraction and transportation of materials highlights the need to rethink physical space and human lives. For example, the materials used to create new land from the coast often damage marine and river environments, altering and polluting natural coastlines and sometimes disrupting local livelihoods and identities.

The concepts of matter and materiality must also be considered across different scales. Extraction, consumption, and transportation occur on

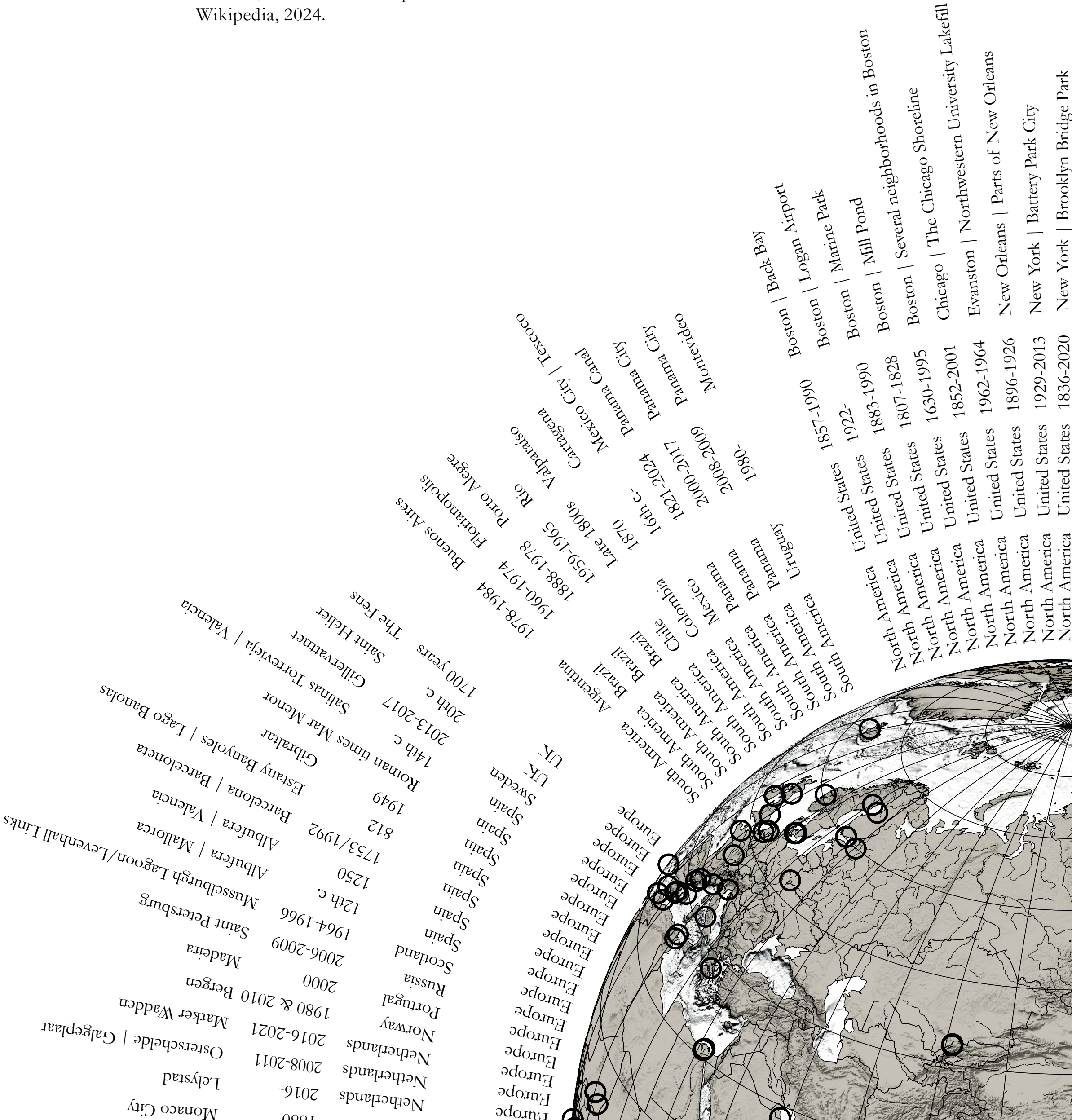


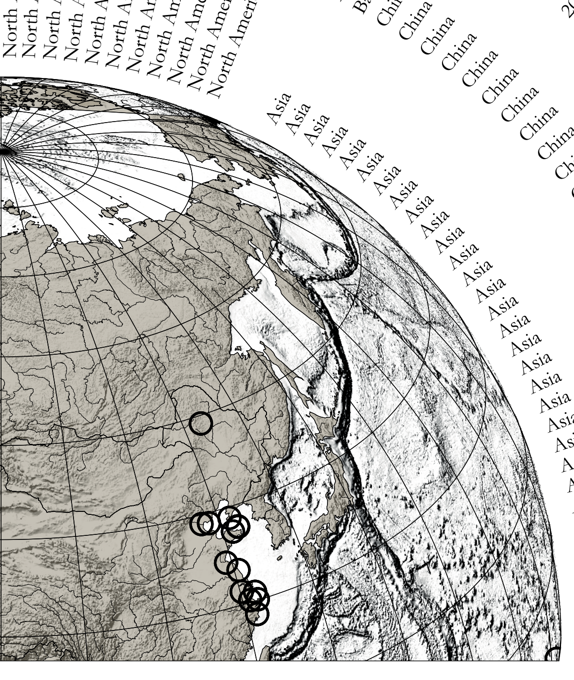
Above | The map shows land reclamation sites in relation to global population density. Author's work. Data: CIESIN and Columbia University, 2018; Wikipedia, 2024.



30°0'0" E
60°0'0" E
90°0'0" E
120°0'0" E
150°0'0" E
180°0'0" E
60°0'0" N
30°0'0" N
0°0'0"
30°0'0" S
60°0'0" S
Reclamation sites
Less than 0.5 person/square Km
50,000 persons/square Kms

Below | The diagram presents a comprehensive global land reclamation taxonomy by continent, country, location, and construction period. Author's work. Data: Wikipedia, 2024.





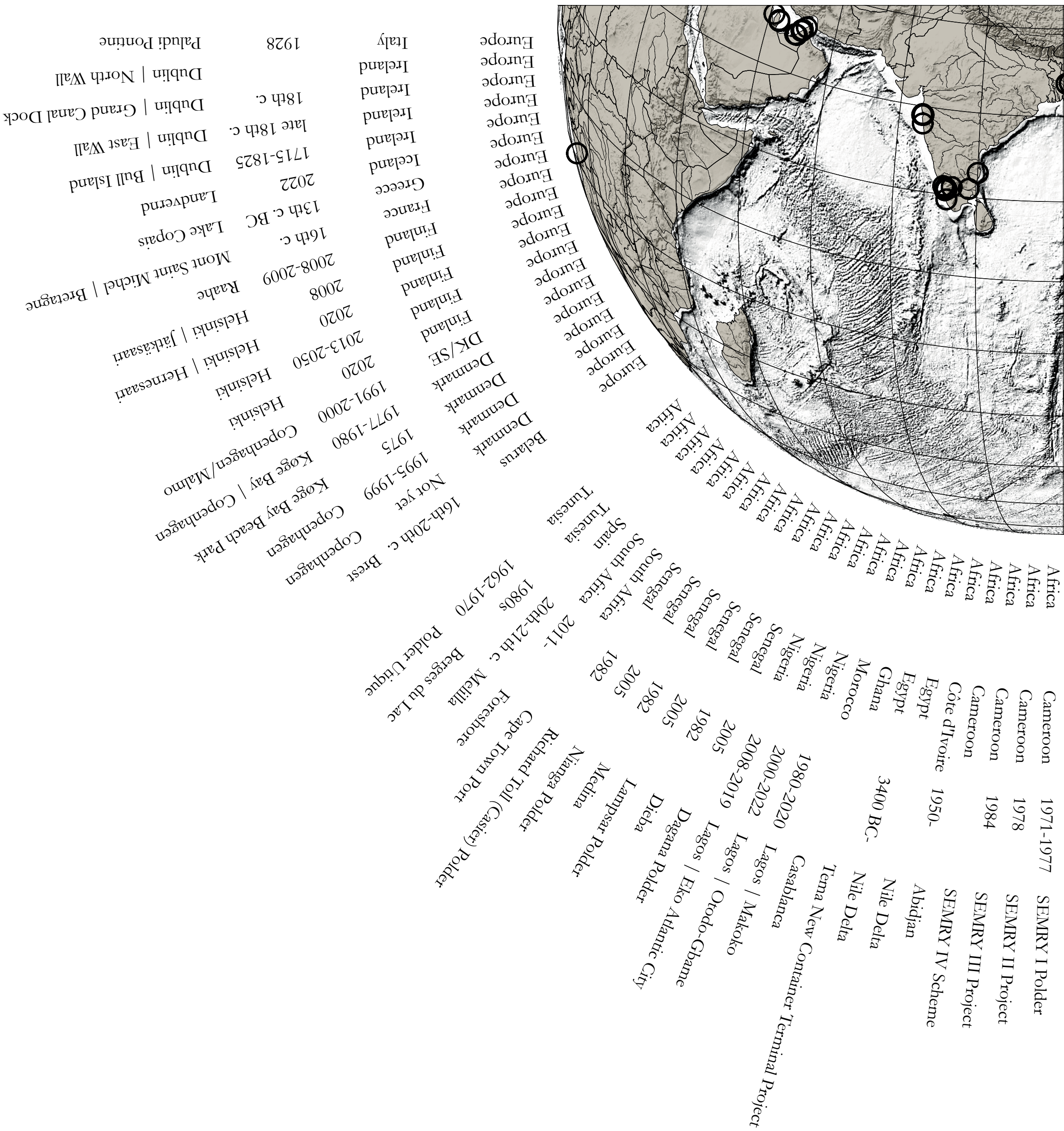
North America | United States | 1910-2010 | New York | Liberty State Park
North America | United States | 1850-1910 | San Francisco | Mission Bay
North America | United States | 1850-1959 | San Francisco | San Francisco Bay
North America | United States | 1936-1937 | San Francisco | Treasure Island
North America | Bahamas | 1964-1979 | Nassau | East Bay Street
North America | Canada | 1965-1970s | Montreal | Part of Nuns' Island
North America | Canada | 1965-1986 | Montreal | Part of Parc Jean-Drapeau
North America | Canada | 1965-1966 | Quebec | Notre Dame Island
North America | Canada | 1950-1970 | Toronto | Leslie Street Spit
North America | Canada | 1955-1992 | Toronto | Leslie Street Spit
North America | Canada | 1913-1919 | Vancouver

Asia (×31)

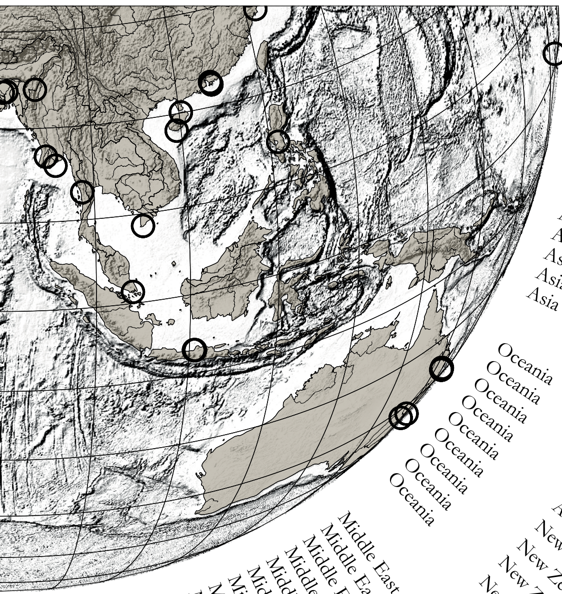
Bangladesh
Bangladesh
China (×18)
India (×11)

1964 -
2003-2007
2011-
2009-2030
2017-
2003-
2003-2011
1998-2004
1942-1958
2009-2020
2000-2006
2014-2016
2002-
2002-2020
2010-2017
2005-2030
2010-2020
2012-
2010-2020
1991
1782-1838
1880-1945
1708
1760-1790
1772-

Dhaka
Megha
Dalian | Changxing Island
Dongtai | Tiaozini
Haikou | South Sea Pearl Eco-Island
Hangzhou | Jinshan District
Hebei | Caofeidian
Hong Kong | Central and Wan Chai
Hong Kong | Hong Kong International Airport
Hong Kong | Kai Tak Airport Expansion Project
Hong Kong | Macao Bridge Artificial Island
Lianyungang | Xuwei New Area
Sanya | Phoenix Island
Shanghai | Nanhui New City
Shanghai | Yangshan Deep Water Port
Shenzhen | Quianhai
Taizhou | Binhai New Town
Tianjin | Eco-city
Wuxi | Taihu New Town
Yantai | Longkou New Islands
Byculla
Chelakkara
Chennai
Hornby Vellard
Kerala | Kuttanad
Mahim-Sion Causeway
Mazgaon
Mumbai
Nadathara Panchayat
Pazhayanur
Puthur



Above | The diagram presents a comprehensive global land reclamation taxonomy by continent, country, location, and construction period. Author's work. Data: Wikipedia, 2024.



Asia
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Asia
Asia

India
India
India
India
India
Indoneisa
Indoneisa
Maldives
Myanmar
Myanmar
Myanmar
Philippines
Singapore
Vietnam

1850-1945
2015-2020
2015-2020
1990s-2025
2019-
1975-1985
1989-2009
1990s-

Puthur
Puzhakkal
Thekkumkara
Thrissur
Kuttanad
Demak
Timbulsloko
Various islands | E.g. Thulusdhoo, Hulhum
Mawlaik
Pyapon
Ayeyarwady and Tanintharyi Regions
Manila | Baseco
Singapore
Ngoc Hien

Oceania
Oceania
Oceania
Oceania
Oceania
Oceania
Oceania
Oceania
Oceania

Australia
Australia
Australia
Australia
Australia
New Zealand
New Zealand
New Zealand
New Zealand

2010-2050
2017-
1956-
1788-2002
1800-1930
1857-2021
1800-

Brisbane
Gold Coast
Gold Coast Broadwater | Southern Moreton Bay, Southeast Queensland
New South Wales
Sydney
Auckland
Manukau Harbour | Mangere Inlet
Wellington
Dunedin

Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East
Middle East

Bahrain
Kuwait
Qatar
Qatar
UAE
UAE
UAE
UAE
UAE
UAE
UAE
UAE
UAE

2002-2008
2009-2014
2004-2018
1700-1900
1986-1992
2006-2021
2001-2006
2003-2012

Durrat al Bahrain
Kuwait | Al Khiran
Doha | Hamad International Airport
Doha | The Pearl
West Bay Lagoon
Abu Dhabi | Al Lulu Island
Abu Dhabi | Al Marjan Island
Abu Dhabi | Al Reem Island
Abu Dhabi | Burj Al Arab
Abu Dhabi | The Universe Islands
Abu Dhabi | Yas Island
Dubai | Palm Jumeirah - arcipelago
Dubai | Port Rashid
Dubai | The World Islands - archipelago

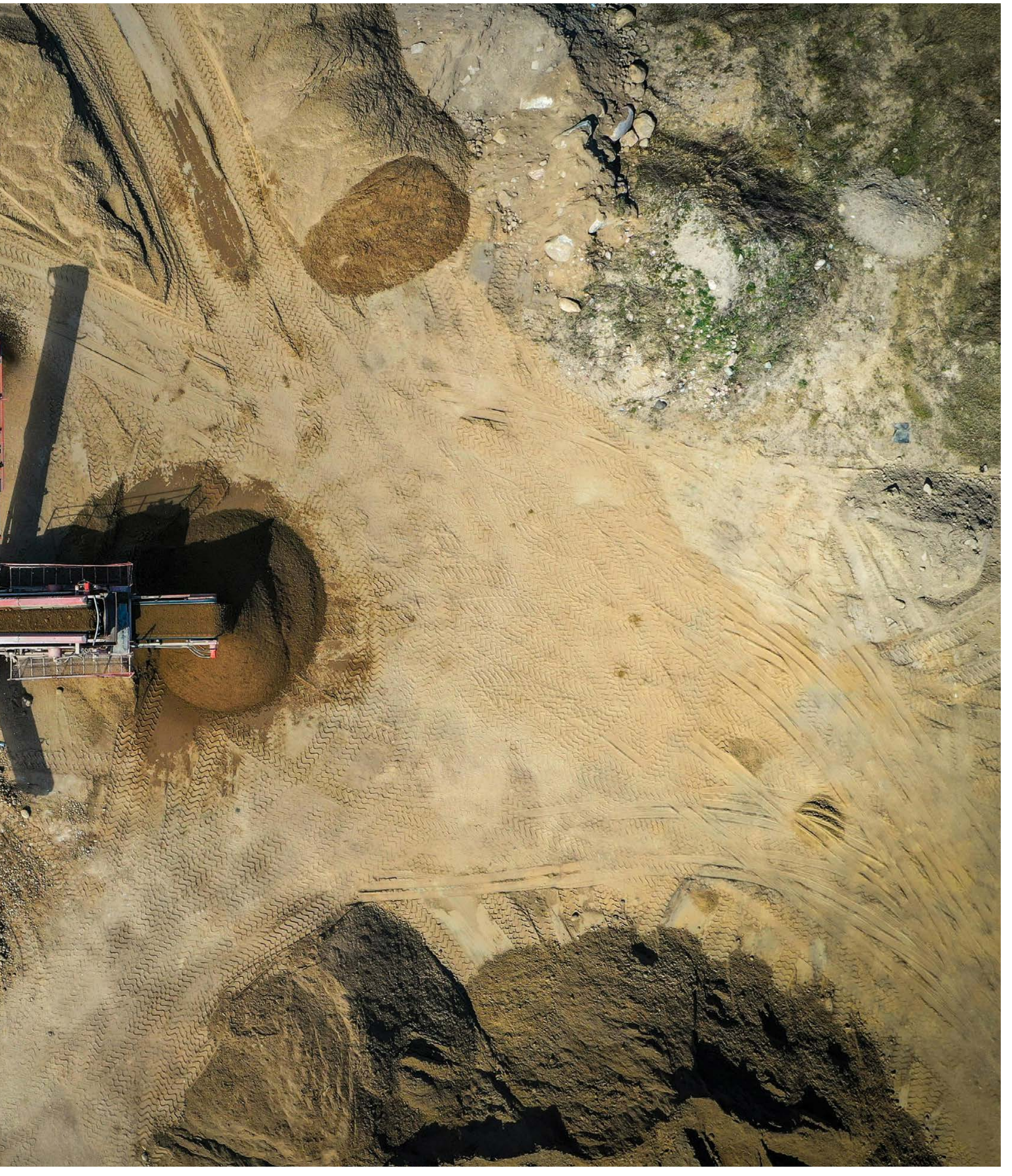
Africa
Africa

Angola
Cameroon

1971-1977

Luanda | Marginal da Corimba
Gambareye

Above | Aerial view of sand mining in Dźwierzuty, Poland. Photograph by Marcin Studio, 2020.



a planetary level, requiring transnational analysis, while also demanding detailed study of local urban contexts at various scales. For example, global sand flows raise questions related to '*planetary urbanization*' (Brenner and Schmid, 2012; 2015). Careful analysis of these sites can uncover unexpected phenomena that are not immediately visible. When we consider the global extraction and transportation of materials for land reclamation, it's clear that human activity resembles a silent geological process in progress. The maps and lists of new lands (Figures on pages 8-9 and 10-13) demonstrate the widespread nature of this phenomenon, even though the specific extraction sites often remain unknown or unrecorded.

Shifting our focus from the global to the local—as we will see in the book's chapters—helps highlight the environmental, political, and social impacts of each place. These micro-stories related to materiality add depth and nuance to our understanding of urban landscapes, revealing unexpected perspectives that emphasize their richness and complexity.

The creation of new lands involves utilizing various materials as construction resources. The book primarily focuses on three types of land used for reclamation.

First, *sand*, a natural resource that is becoming increasingly rare, poses a growing global problem with significant environmental and economic impacts (Delestrac, 2013; Pedruzzi, 2014; Beiser, 2018). It is essential to the construction industry because it is used to produce concrete by mixing it with cement, water, and gravel. Large quantities of sand are needed for buildings, highways, airports, and dams. Sand for artificial coastal projects is often obtained by dredging the seabed, natural islands, or nearby rivers. Occasionally, resources are acquired illegally, often through smuggling. Smuggling and illegal mining are typically transboundary environmental crimes, and they are especially problematic in Asia, where urbanization and a construction boom have increased demand for sand (UNEP, 2014; 2019). For example, Singapore has expanded its land area by 22% in just a few years, mainly by using sand from Malaysia, Cambodia, and Indonesia. The Mekong Delta in Vietnam, Poyang Lake in China and the Ayeyarwady River in Myanmar, as well as provinces such as Guangdong, Guangxi, and Fujian in China, and the Brahmaputra and Jinjiram river basins in Bangladesh, are some of the illegal sources of sand in Asia. Removing sand from these areas often damages the landscapes of the countries where it is extracted. This practice also causes widespread environmental damage, leading to socioeconomic problems like declining fisheries, soil erosion, water pollution, and the loss of native flora and fauna. Sand filling for land reclamation thus threatens the current environmental balance and risks the future of coastal regions, especially considering ongoing climate change.

The second material used in land remediation is *silt*. Silt is a type of fine-grained sediment composed of mineral particles larger than clay but smaller than sand. When discussing silt, the related 'material' is *water*: it is transported by flowing water and deposited as sediment, especially in coastal and river areas. If appropriately managed, silt can support land regeneration, wetland restoration, and improve soil fertility in reclaimed areas. The remediation sites of Marker Wadden and Galgeplaat in the Netherlands (Chapter 5) and Leslie Spit in Toronto (Chapter 2) serve as excellent examples of how the movement of fine sediment can drive remediation through hydrodynamic processes. Rob Holmes and Gena Wirth, in their recent book '*Silt Sand Slurry: Dredging, Sediment, and the Worlds We Are Making*,' explore the geographies of dredging and sediment along America's coastlines. Sediment often acts as invisible infrastructure that shapes and transforms land: '*It is collected, sorted, managed, and moved to reshape deltas, marshes, and beaches. Anthropogenic action now moves more sediment annually than 'natural' geologic processes — yet this global reshaping of the earth's surface is rarely discussed and poorly-understood*' (Holmes, Wirth and Milligan, 2024 , p. 389). Sediment management practices and shortsighted efforts to prevent dynamic ecosystem change can conflict with the need for adaptive sediment design.

The third material used in land remediation is *scrap*. 'Scrap' refers to discarded or leftover materials that can be recycled or repurposed for reuse. Waste materials, especially construction debris and metallic aggregates—whether brick, glass, plastic, metal, or rubber—are used in land remediation to create stable landforms, build artificial reefs, or reinforce coastlines. Although they can sometimes pose environmental risks, these marginal materials contribute to alternative aesthetics and designs within urban landscapes. The examples of Leslie Spit in Toronto (Chapter 2), the Makoko case in Lagos (Chapter 6), and the Baseco complex in Manila (Chapter 11) show that remediation can sometimes lead to unexpected forms of urbanization—informal landscapes where adaptation fosters a dynamic aesthetic and an evolving, open morphology. Between sand, silt, and scrap, matter tells a story: not just the substance shaping new lands but also the silent imprint of relationships between environments, economies, and societies. From here, our focus shifts from the tiny grains of materials to the stories they generate in different places.

Above | Aerial view of sand mining boats in Jaflong, Bangladesh. Photograph by David Stanley, 2016.
Right | Mining boats are transporting extracted sand in Jaflong, Bangladesh. Photograph by David Stanley, 2016.

Above | Sand mining workers in Bangladesh.
Photograph by Guduru Ajay Bhargav, 2018.

Book Structure and Common Themes

The book presents and analyzes ten land reclamation projects and the related landscape, urban, environmental, and social conflicts linked to the creation of new lands, both formal and informal: from the Leslie Spit in Toronto, Canada, to the Panama Canal, from Mexico City to the Marker Wadden and Galgeplaat experiments in the Netherlands, from the reclaimed lands of Lagos in Africa to those of the Maldives in Asia, from the city of Kuttanad in India to the Chinese examples of Hong Kong and Dalian, ending with the village of Baseco in Manila, Philippines. The micro-stories in the book are organized on a globe based on geographic coordinates and vary in size, location, type of reclamation, timeframe, historical context, and social and landscape characteristics. They are not meant to be an exhaustive overview, but rather to highlight a phenomenon that, in an era of climate change, rising sea levels, resource scarcity, and increasing economic and social inequalities, has become highly controversial. The aim is not to compare but to juxtapose lesser-known case studies that have been studied in academic literature and, due to their marginality and peculiarity, deserve attention.

Multiple issues related to reclamation will be addressed: ecological emergencies, urbanization, the political decisions behind the process, and the social impact of these changes. All chapters employ analytical and critical research methods, starting with a review of the limited existing literature, which often relies on journalistic and iconographic sources due to necessity and opportunity, resulting in a 'research by-through design' of reclamation projects. Images play a crucial role in this narrative, both as illustrations and primary sources. The visual language helps document what is often overlooked in official literature, conveying ideas and emotions that words sometimes cannot express. The pages reveal the silent, widespread influence of coastal reclamation, an ancient phenomenon that continues today despite the challenges posed by rising sea levels and the complexities of cultural and geographical contexts. Reclamation remains a dynamic, evolving, and continually growing process.

The book centers around several recurring themes, true leitmotifs: the relationship between design and informality, climate change and water, social conflicts, and new forms of grassroots participation.

Among these, the theme of *informal reclamation* stands out, examined from multiple perspectives. Here, not only are the limitations highlighted, but more importantly, the unexpected potential of what emerges spontaneously outside imposed patterns is also emphasized. In Chapter 2, the Leslie Street Spit, an artificial strip of land constructed with debris along the Toronto waterfront, gradually transforms into an 'accidental wilderness,' where natural life and biodiversity thrive, symbolizing a possible coexistence. In Chapter 6, the city of Lagos, Nigeria, is depicted as a mosaic of formal and informal land reclamation projects, reflecting the diverse social classes. Unlike traditional top-down planning methods, the Makoko neighborhood uses waste as the foundation for new lands, where life adapts to the water and creates a kind of African Venice, true to its original topography, authentic despite its contradictions. Finally, Chapter 11 takes us to Manila, to the artificial island of Baseco, where the rapid and unplanned growth of informal settlements reflects complex social, economic, and environmental dynamics. Here, land reclamation becomes a vital response to housing needs, creating a space built from below, where spontaneity, disorder, and irregularity shape new landscapes for survival.

The *formal design* of new land developments reveals, along with its potential, significant limitations—especially in the long term—and its unpredictability. Chapter 5 describes ecological engineering experiments conducted on the islands of Marker Wadden and Galgeplaat in the Netherlands, using the approach known as 'Building with Nature.' These ambitious ecological restoration projects, however, conflict with the inherent contradictions of their lifecycle: reconstructed nature requires ongoing and sometimes controversial human intervention to sustain what, in theory, should be self-sufficient. Chapter 10 shifts its focus to Changxing Island, near Dalian, China, where large-scale speculative projects have drastically transformed the natural coastal zones and impacted local fishing communities. Nonetheless, the 2009 global financial crisis altered the fate of the newly reclaimed island, leaving behind a 'ghost town' of unfinished factories and abandoned residential areas.

The topic of *land reclamation related to water* covers several chapters. The book examines both historical and recent land reclamation projects, highlighting human interventions that sometimes worsen rather than solve threats to landscapes, ecosystems, and communities. Chapter 3 recounts the extensive history of land reclamation in Mexico City, starting with the draining of Lake Texcoco and its surrounding wetlands. Uncontrolled urban growth and ongoing land reclamation have permanently altered the ancient water system, resulting in significant environmental issues, including land subsidence, water shortages, and increased flood risks. In this context, land reclamation becomes a source of ecological fragility, inequality, and deep social injustices. Chapter 7 discusses the complex situation in the Maldives through projects on the islands of Hulhumalé and Thulusdhoo. Here, tourism development and population growth conflict with the urgent need to adapt to rising sea levels. However, creating new artificial land disrupts sensitive natural coastal processes and damages valuable coral reefs, further increasing the archipelago's vulnerability. Finally, in Chapter 8, the focus shifts to Kuttanad, a wetland along Kerala's west coast in India, known for its rice farming. For decades, residents have lived with the water, but rising sea levels now force them to abandon their lands. The problems worsen as the sea slowly reclaims what was taken from it. Land reclamation, once a resource, is now a trap: Kuttanad recently experienced its worst floods in twenty years.

The theme of *social conflict* and the importance of *informed community participation* in land reclamation projects are discussed in two key chapters of the book. Chapter 4 examines the construction of the Panama Canal, one of the world's most strategic maritime links, which spans the Isthmus of Panama, connecting the Atlantic and Pacific Oceans. While celebrated as an engineering achievement, the canal also serves as a significant land reclamation project. The extensive excavation and dredging operations generated millions of cubic meters of soil, which were reused to modify and stabilize large areas of Panamanian territory, creating significant social and political impacts. Chapter 9 examines Hong Kong's long and complex history of land reclamation, driven by the need for urban growth in a region with mountainous terrain and limited flat coastal areas. The land reclamation projects in the Central and Wan Chai districts in 2003 marked a turning point, providing real opportunities for citizens to get involved in decision-making and significantly shifting the previously top-down approach. The chapter critically assesses the effectiveness of local community involvement in making future land reclamation efforts more inclusive and democratic, thereby promoting a shared and sustainable vision for territorial development.

Amidst this multitude of experiences, oscillating between experimentation and the unexpected, land reclamation emerges as a liminal and ongoing process, suspended between nature and artificiality, necessity and conflict. It manifests as a global practice that, while transforming places, continually questions collective destiny, since each new land embodies hopes and contradictions, promises of development and signs of vulnerability. Its strength lies precisely in this ambivalence, which urges us to look beyond individual cases and see, within the landscape's folds, the universal dimension of transformation.

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Land Reclamation Site Data

Location
Leslie Spit | Toronto | Canada
Coordinates
43° 37' 34" N | 79° 19' 46" W
Area
2.00 km2
Length
5.00 km
Time
1955-1992

2 | (Un)expected Wilderness

Nature Reclaims Toronto's Leslie Street Spit

Wenting Gao, Zhaolei Li, Jingxuan Tu, Qian Yao
Laura Cipriani, Denise Piccinini

The Leslie Street Spit is a five-kilometer artificial peninsula on Toronto's eastern waterfront, just a few minutes from the downtown core of Canada's most populous city. The term 'Spit' is a colloquial misnomer due to its artificial shape, which developed over seventy years of urban lake filling. Initial reclamation began in the mid-twentieth century, when it was constructed as a breakwater to support the existing Portland area. From the 1970s, the spit became a landfill primarily for the city's debris as the industrial sector declined. At the same time, it was unintentionally colonized by various types of flora and fauna. Today, it is recognized as one of the premier birdwatching locations in the city and serves as a crucial resource for both the local and international environment. This chapter examines the emergence of this 'accidental wilderness' and the evolving relationship between the urban and the wild on the Leslie Street Spit, which serves as a symbol of coexistence, and highlights the social and ecological implications of this process.

Introduction

The Leslie Street Spit is situated in the southern part of Toronto, Canada. This five-kilometer manmade cape extends from Toronto's eastern waterfront, just a few minutes from the downtown core of Canada's most populous city. The term 'Spit' is a colloquial name for this artificial land, which developed over seventy years through urban lake filling; formally, it is known as the Outer Harbour Eastern Headland. It was constructed outside Toronto's Inner Harbour as a harbor barrier. The site fell into disuse during the 1970s with the decline of the shipping industry, and it became the city's primary rubble landfill. Nature subsequently reclaimed the area, transforming it into a sanctuary for biodiversity and a largely passive recreation area known as Tommy Thompson Park. Today, the ecology of the Spit is often referred to as the 'public urban wilderness' or 'evolving laboratory.'

The history of Toronto's waterfront resembles that of other major port cities in several respects. The pier bustled with economic activity during the height of maritime transportation, and its development was spurred by increased demand for amenities that required extensive landfilling. As shipping declined and trucking emerged, these vast waterfront areas became less suitable for industrial use, necessitating new purposes for their development. Over the last century, Toronto's waterfront has experienced significant changes. Since the 1850s, the harbor's shoreline has extended nearly one kilometer south, first to Queens Quay Boulevard and then to the current water's edge. Early landfilling aimed to create space for water, rail, and road connections linking Central Canada to the global market. The Central Waterfront has been the focus of numerous initiatives over that time, one of which was the Harbour Commission's 1912 Plan. The Leslie Street Spit, which is identified as the area south of Unwin Street, is a crossroads for various territorial and jurisdictional boundaries. In addition to the underlying land, most of the Leslie Spit is categorized under the existing urban classification. The Ontario Ministry of Natural Resources owns the entire headland, which is divided into two sections. One section is managed by the Toronto and Region Conservation Authority (formerly the Metropolitan Toronto and Region Conservation Authority), while the other is leased by the Toronto Port Authority (previously the Toronto Harbour Commissioners).

This chapter aims to deepen our understanding of the balanced existence of urban wilderness in the context of future socio-natural developments, highlighting nature as a crucial force of, and impetus for, land reclamation. Our work draws on numerous sources of graphical and written information, and our study commenced with a comprehensive site analysis, literature review, and mapping process. The book *Sympathetic*

Landscapes: An Aesthetics for the Leslie Street Spit (Chan, 2014) and the publication 'Socio-cultural Influences on Urban Ecosystems' (Cardoso, 2007) were invaluable for gaining insights and organizing a timeline and cartographic study about the reclamation of Leslie Street Spit.

Our first subchapter, 'The Story of Reclamation,' presents the reclamation process in four parts: urbanization and industrialization; the construction of breakwaters and landfills; the turning point of accidental nature; and the coexistence of urban areas and wilderness, outlining the social and natural contexts that necessitated reclamation. The second subchapter, 'Between the Urban and the Wild,' explores social controversies. With many organizations involved in constructing the headland, debates between the public, the government, and various organizations have persisted over the decades, reflecting these groups' differing preferences regarding urban development and nature conservation in various periods. The relationships between urban areas and wilderness continue to be dynamic and uncertain, particularly given the challenges we face today.

The Story of Reclamation

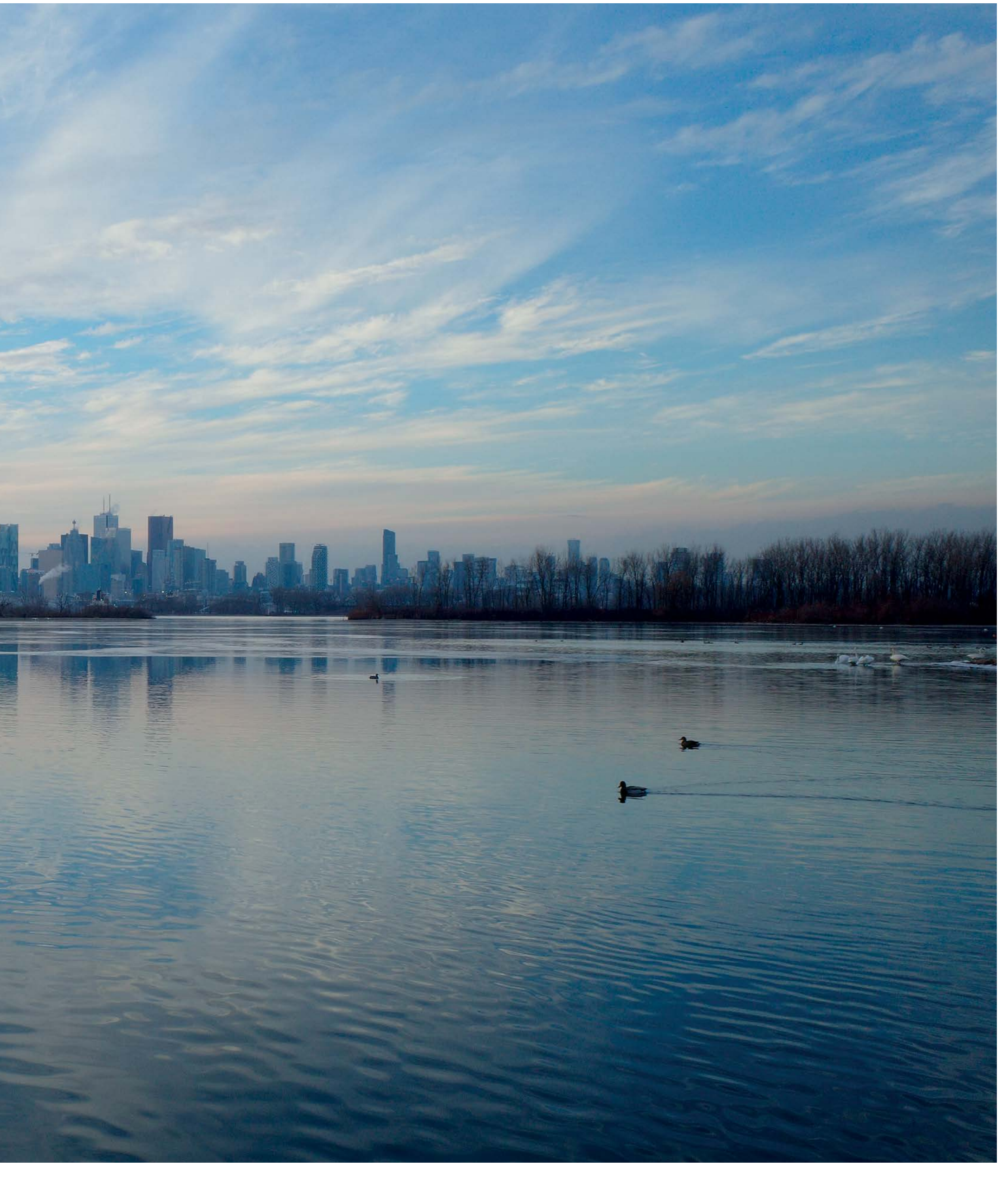
Urbanization and Industrialization

Geological factors such as lakes, river systems, and nearby ravines shaped Toronto's physical growth in the early twentieth century. Annexation, lake filling, and infrastructure development—including rail lines, streets, and bridges—expanded the city's external footprint. Technological advances allowed the construction of taller skyscrapers, enabling the metropolis to rise upward. A rapid population increase accompanied this expansion. Upland forests were cleared, except in the less habitable river and stream valleys and swampy regions.

Toronto has experienced two successive eras of development during its expansion. The first phase, from the late nineteenth century to the late twentieth century, saw rapid industrialization. The second is marked by a significant shift toward environmental protection, which continues today. Substantial development has occurred along Toronto's waterfront over the past 150 years. The demand for maritime, rail, and vehicle transportation, industrial facilities, residential real estate, and vibrant entertainment and tourism has driven this growth.

Land-use planning must now incorporate more ecological and environmental considerations. The industrialization of Toronto's waterfront is often blamed for harming the ecology and hydrology of the city's natural coastline. On the one hand, the Leslie Street Spit is an unavoidable by-product of regional industrialization. On the other, it possesses social and ecological values that affect the City of Toronto.

Above | The view of Toronto from Leslie Spit.
Photograph by Tania Anderson, 2021.



Toronto has been expanding, presenting excellent growth opportunities that have led to an influx of new residents and jobs. By the early 1940s, systematic metropolitan and regional planning for Toronto had begun to take shape. Large wartime industries had emerged throughout the metro area, necessitating regional coordination of physical infrastructure, land use, and housing. Before proper planning and the Metro were established, small dwellings were scattered among the townships surrounding the old City of Toronto. Toronto's urban expansion began to extend beyond its western and northern boundaries in a process that continues today. Over the next 30 years, the remaining Metro regions will be developed, primarily in Scarborough and in the northeast. Toronto began transforming into a post-suburban metropolis in 1971, when it became clear that traditional suburban expansion had a limited future unless the Metro's boundaries were broadened. Although much of the landform had been constructed (with minor modifications) by the 1900s, the land area significantly increased between 1974 and 1983, as sand and silt were dredged from the Outer Harbour to create the Leslie Street Spit. As a result, the lagoons and sand peninsulas that now comprise a large portion of Tommy Thompson Park's land base were formed.

Numerous reclamation proposals were suggested before the construction of the Leslie Street Spit. One of the most notable was the Harbour Commission's 1912 Plan. This conservative master plan incorporated several established master planning concepts and practices. The orange-shaded region in Fig. 3.5 indicates the proposed industrial district, while the green-shaded area represents the suggested parklands. The 1912 proposal included a new industrial zone for production and storage to be built on Ashbridge's Bay. Lake filling addressed issues of space and sanitation. Despite its extensive scope and brief design period, the 1912 waterfront plan was unanimously approved by all three levels of government without significant modifications or delays. The public and local press praised it as '*exciting and attractive*' (Desfor, 1988, p. 77, cited in Chan, 2014). The plan gained widespread support, partly due to its comprehensive integration of design elements and ideas from the City's previous waterfront proposals. Many concepts—such as filling Ashbridge's Marsh to generate low-cost industrial land—were already well known. Ashbridge's Bay, according to engineer Kivas Tully, was at that time a '*positive evil*' (Jackson, 2011, pp. 88-89, cited in Chan, 2014) and an endemic source of cholera, with the potential rehabilitation offering to profit the city. Nature was perceived as an imperfect and hazardous wilderness, needing civilizing and domesticating alteration to transform it into a productive and habitable area. Based on this consensus, two-thirds of the Port Grounds shoreline was designated for private industrial development. At the same time, the shipping industry and proposed public parklands were left '*subordinate to the issue of private development*' (O'Mara, 1976, p. 37, cited in Chan, 2014).

Construction: Breakwater and Landfill

The headland is formed of natural sediment and artificial stacks. Natural sediment in the Great Lakes includes four types of water movement: tide, seiche, current, and wave. Artificial stacks originate from the disposal of construction debris and from sand and silt obtained through dredging.

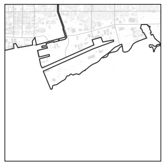
The Toronto region is one of Lake Ontario's six primary depositional areas. The 20-meter bathymetric contour typically defines the lakeward edge of Lake Ontario's nearshore zone. The sediment particles in Lake Ontario comprise clay and silt. Sediment deposition in Toronto arises from two sources: river runoff and the erosion of shoreline slopes. Due to the coastal arrangement of Toronto Bay, the inner harbor is replenished by materials flowing from the Don River. Meanwhile, glacial deposits eroded from the Scarborough Bluffs underlie the outer harbor facilities. As a result, sediment plumes surround the exterior of the Leslie Street Spit and inhabit its interior.

The first step in creating the Outer Harbour involved constructing a breakwater to mitigate wave force in coastal waters and thus ensure safe anchorage. The Leslie Street Spit acts as a natural barrier, allowing only minimal alluvial material from the Scarborough Bluffs to enter the East Gap navigation channel.

In 1959, the Harbour Commissioners commenced construction of the breakwater without a specific purpose. The idea for an Outer Harbour had initially been proposed in the 1920s but wasn't officially accepted until 1960. The Toronto Harbour Commission's argument persuaded the city that the Outer Harbour would enhance the Port's flexibility and financial capabilities. The Commission never viewed the Outer Harbour as an ultimate goal; instead, it saw it as a means to increase the commercial appeal of the Port Lands Industrial District. However, due to the containerization revolution of the 1960s, cargo businesses began shifting to East Coast ports, leading to a nearly 50% decrease in shipping in Toronto between 1969 and 1973. Consequently, the Outer Harbour was deemed unnecessary, and all commercial vessels stopping in Toronto continued to use the Inner Harbour, while the Outer Harbour became the exclusive province of pleasure boats.

During Toronto's 1960s construction boom, the Metropolitan Toronto Planning Board (1967) estimated that 500 truckloads of construction and demolition debris were dumped (Metropolitan Toronto Planning Board, 1967). According to the Toronto Harbour Commission, the cost of this technology was projected to be significantly lower than traditional breakwater construction methods at that time. Completing the concrete

1912
The Toronto Harbour Commissioners (THC) were founded in 1911 and produced the 1912 Waterfront Plan.



1959
The first reclamation began in the mid-twentieth century as a breakwater to serve the existing port.

Period 1
Urbanization
Breakwater
Landfill

1900

1950

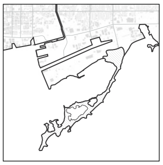
1958

1966

Social
Controversy 1

1911-1972
Urbanization led to controversy over man and nature. Some believed in conquering nature and a sanitized city, while others sought the old recreational connections to the waterfront.

Land Reclamation Timeline | Authors' work. Data: Toronto and Region Conservation Authority, 2024; Chan, 2014.



1977
Despite the unfavorable growing conditions, flora and fauna emerged unexpectedly. By 1977, 152 species of plants were identified.

1992
Tommy Thompson Park has been open to the public year-round on weekends and holidays since January 4, 1992.

1972
Starting in the 1970s, the spit became a landfill primarily for the city's debris due to industrial decline.

1987
Part of the Leslie Spit was used as a confined disposal facility for a dredging program due to its mole construction.

Period 2
Turning Point
Accidental
Nature

Period 3
Coexistence
Urban
Wilderness

1974

1982

1990

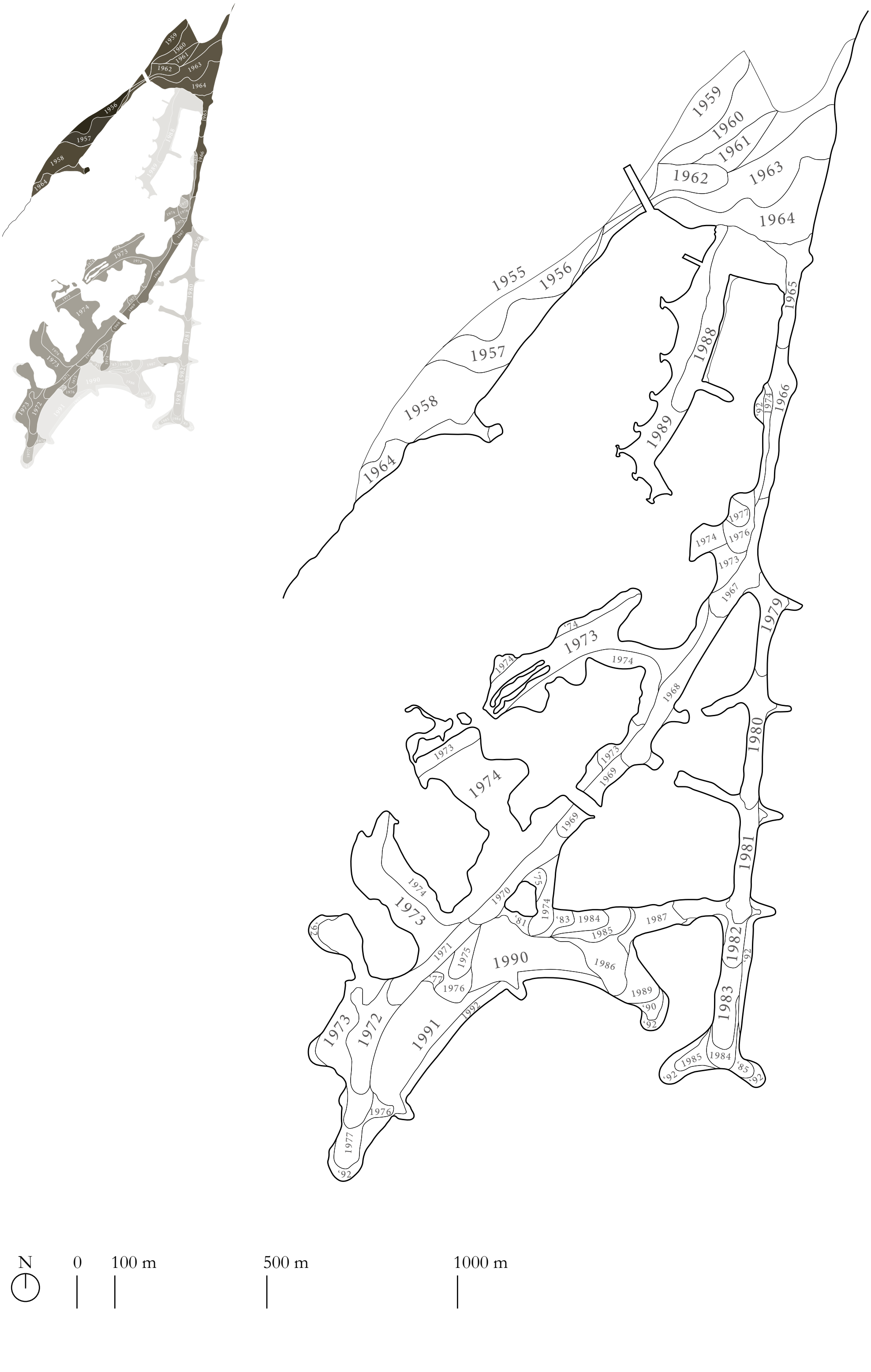
1998

Social
Controversy 2

1972-now
Transforming Leslie Street Spit into a space for both humans and nature sparked discussions among designers, stakeholders, and the general public. A choice must be made between passive or active recreation.

N 0 1 km 5 km 10 km

Leslie Street Spit Annual Growth | Map of annual growth of Eastern Headland between 1959 and 1992. Authors' work. Data: Toronto and Region Conservation Authority, 2024.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1976
1977
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'92
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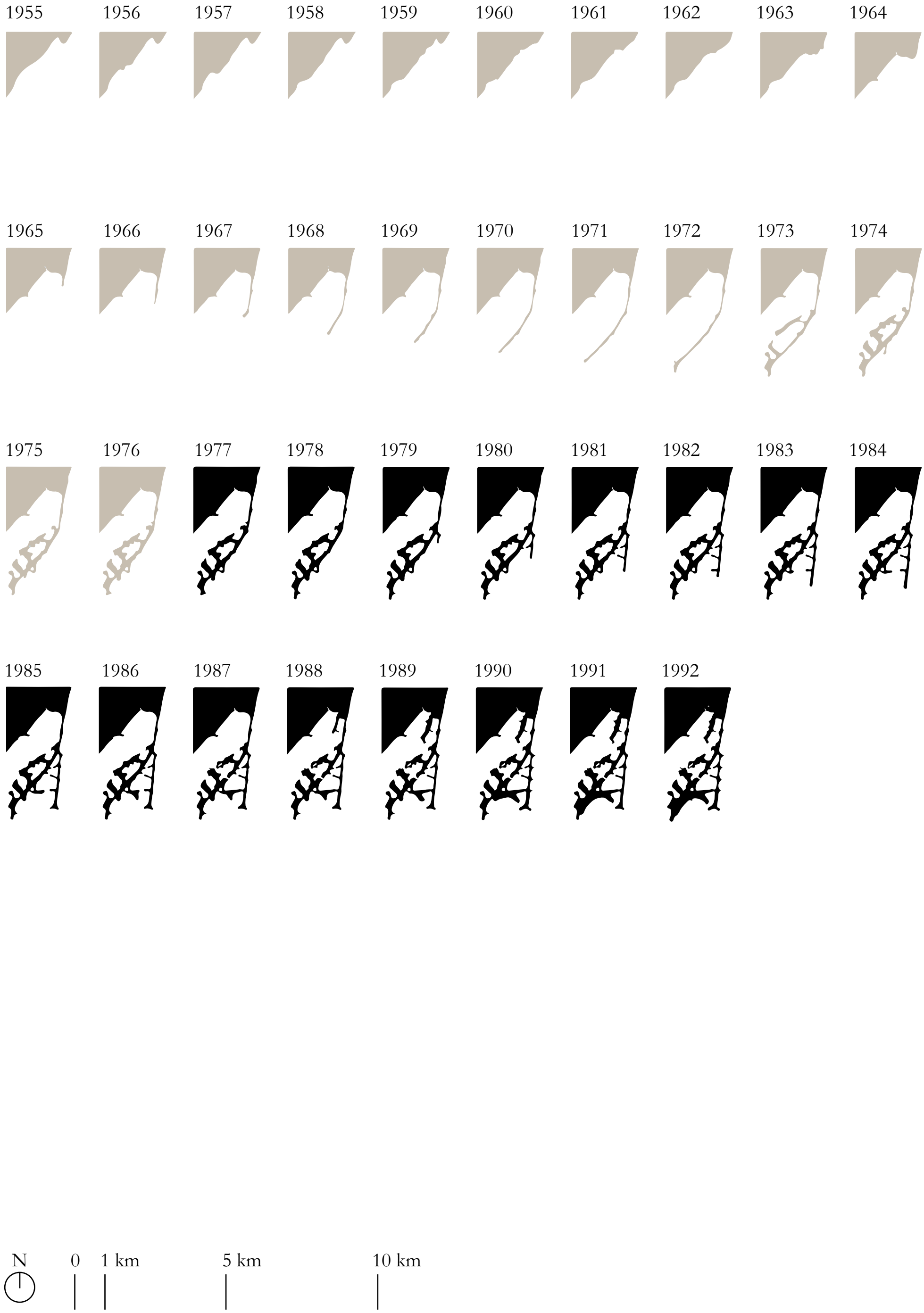
100 m
500 m
1000 m

Leslie Street Spit Annual Growth | Diagram of the annual growth of Eastern Headland from 1959 to 1992. Authors' work. Data: Toronto and Region Conservation Authority, 2024.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project was estimated to cost approximately $10 million, while using large stones and boulders would cost around $30 million. In contrast, the estimated cost of utilizing construction debris was only $1 million, accounting for just 10% of the concrete construction cost and 3.4% of the cost of using large stones and boulders.

In 1964, the rubble brought to the site had an irregular composition (Schopf and Foster, 2013). It contained substantial amounts of domestic waste, indicating that houses were demolished before being cleared of their contents, reflecting the lenient dumping regulations of the time. '*Originally the quality of the fill materials was not of concern and, at the earliest stages of the lake filling, the materials were comprised mostly of excavated earth, construction rubble, dredge spoils, and miscellaneous solid waste*' (MOE, 1984, p. 4, cited in Schopf and Foster, 2013). This included food waste, personal belongings, residential debris, and construction materials (Schopf and Foster, 2013).

Turning Point: Accidental Nature

In the early 1970s, the barren rubble substrates of the Spit did not seem hospitable to wildlife. The spine was constructed using heavy rubble and poor-quality soils from 1959 to 1978, while the peninsulas were built in the mid-1970s primarily from dredged sand. Despite these unfavorable growing conditions, people discovered various plant species thriving on the Spit. According to research by the Toronto and Region Conservation Authority (TRCA), by 1977, 152 plant species had been identified, and this number rose to over 400 by 1996. Many of these species are considered rare both nationally and provincially.

The dominant vegetation on the Headland includes eastern cottonwood, willow, sweet clover, chicory, viper's bugloss, common milkweed, native goldenrods and asters, horsetail sedges, rushes, and orchids. Rare plants at the Headland include Erect Knotweed (*Polygonum erectum*), Seaside Spurge (*Euphorbia polygonifolia*), Sea-rocket (*Cakile edentula*), and Slender Agalinis (*Agalinis tenuifolia*). Additionally, provincially rare species include Sea-spurry (*Spergularia marina*) and False Pimpernel (*Lindernia dubia var. anagrelide*) (Wilson and Cheskey, 2001). Many species at the Headland appeared spontaneously, while others were planted following the TRCA's guidance.

The predominant species are Eastern Cottonwood trees due to the Spit's proximity to Toronto Islands and Cherry Beach, to the west and southwest, where these species are abundant. Over time, wind-borne seeds colonized the Spit, leading to the establishment of new woodlands. Other plants that emerged independently likely infiltrated from various parts of the city, or had their seeds transported by birds. Alongside the lush plant growth, there is a steady influx of birds. Common Terns have reportedly inhabited the Leslie Street Spit since the 1970s, marking them the first of several species to arrive. A small number of Ring-billed Gulls soon followed. Later, other species, including the Double-crested Cormorant, Black-crowned Night-Heron, Herring Gull, Great Black-backed Gull, and Caspian Tern, colonized the peninsula in substantial numbers.

In 1984, the TRCA launched a gull management campaign when the breeding population of Ring-billed Gulls at the Eastern Headland soared to over 70,000 pairs and spread to more areas. This scheme restricted the gulls' nesting areas. It positively influenced the distribution of tern nests by reducing nesting competition from gulls in the control area while increasing rivalry outside that region.

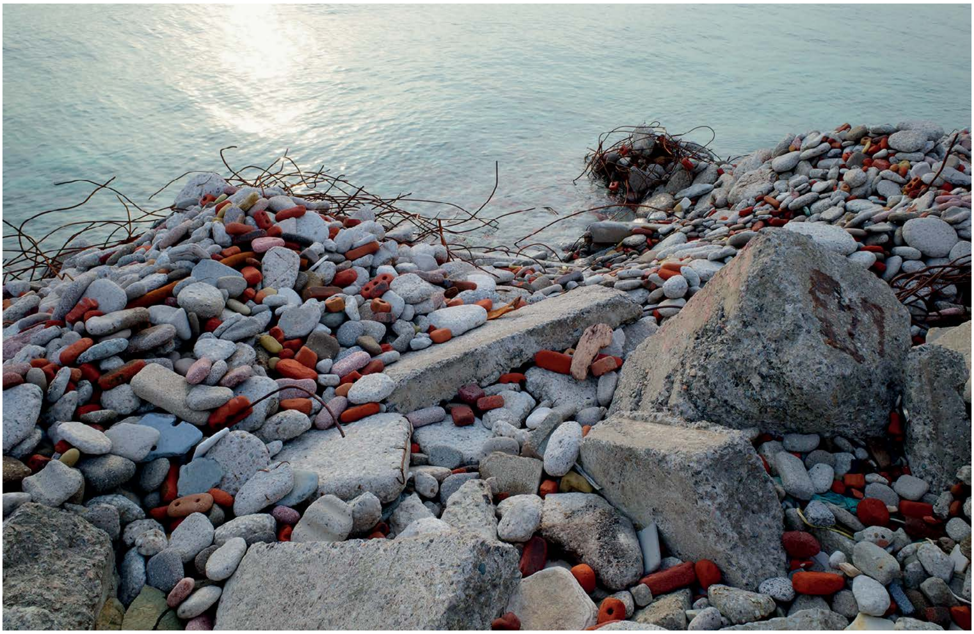
What caused this phenomenon? Understanding land reclamation behavior at this stage is crucial for exploring why plants and animals emerge as successful colonizers and inhabitants. Containerization, introduced in the mid-1950s but gaining popularity by the mid-1960s, became the world's leading shipping method. This revolutionized the shipping industry, enabling ships to load and unload goods at significant ports like Vancouver and Halifax while relying on trucking or rail for inland transportation.

By the 1970s, demand for Toronto as a commercial port on the Great Lakes had declined. The Port Commission's expansion plans became outdated, and the industry began to vacate the port area (Cardoso, 2007). However, in the same decade, Toronto had evolved into the fastest-growing city in North America, featuring developments such as a new city hall, a burgeoning business district, and an underground passageway system nearly 10 kilometers long.

As Toronto's inner core rapidly expanded, the need to dispose of construction debris persisted. This resulted in the leveling of large blocks of existing structures to make way for modern skyscrapers. Thus, Toronto embarked on the extensive task of reclaiming its waterfront.

Two primary types of reclamation occurred in this phase. The first action for reclamation is landfill. Three aspects of the lake filling resulted in the formation of the Leslie Street Spit: the creation of a harbor breakwater, four western peninsulas made from harbor dredge, and a rubble barrier in the east. The Eastern embankment, an armored breakwater with infrastructure features such as groins, beaches, bulkheads, and cells, was primarily filled. The dam was constructed to address a '*potentially serious erosion situation*' (Metropolitan Toronto and Region Conservation Authority, 1989, p. 30 cited in Chan, 2014) that endangered the structural stability of the Eastern Headland. The dam was positioned at an angle of N 5˚E to protect the existing headland from the wave energy of nearshore currents. The embankment experiences significant transverse and attrition erosion and requires regular refilling. However, the constructed shoreline is anticipated to settle into a gentler gradient over time, mimicking the dynamics of natural beaches. The Toronto Port Authority (TPA) oversees

Right | The tangled forest at Leslie Spit.
Photograph by Tania Anderson, 2022.
Below | Demolition waste and rebar at Leslie Spit.
Photograph by Tania Anderson, 2023.



the quality of all materials arriving at and departing from the Spit. Only broken or unreinforced concrete, bricks, ceramic tiles, and porcelain are permitted. In contrast, organic debris such as trash and wood; concrete pipes, piers, beams, light poles or pieces reinforced with rebar; and excavated materials like soil, clay, shale, and sand, are prohibited. These clean filler materials promote plant reproduction during this stage.

Another essential action for reclamation is dredging. In Toronto Harbour, only the Keating Channel, East Gap, and Ashbridge's Bay are dredged. The Keating Channel is a straight passage with a firm edge at the mouth of the Don River, which receives its sediment load from urban runoff and upstream erosion. Due to its proximity to Toronto, sediments from the Keating Channel and Ashbridge's Bay are contaminated by surface runoff and various point sources of pollution. Dredged material from these areas must be transported to the Leslie Street Spit, while material from the East Gap can be used to fill beaches (Chan, 2014). A local No. 50 clamshell dredge operates in the Keating Channel near the south end of the Cherry Street Bridge. Dredging occurs for six hours every weekday for at least two months each year. Unlike hydraulic dredges, which efficiently remove silt, the derrick manually dredges the channel's bottom. During the two hours it takes to fill a barge, this churns up the channel floor, creating an eight-hundred-foot mud cloud. The material scraped from the channel is a toxic black sludge called 'muck,' 'sand,' 'goo,' 'silt,' or 'bung' by deckhands. When completed, a tugboat transports it to the CDF (Confined Disposal Facilities) on the Leslie Street Spit, dumping it over previously deposited material. Deck workers force the barge's steel doors open with sledgehammers, resulting in a fifty-foot cloud as the sediment settles to the bottom of the cell. Sediment management is a challenging process, but the coast of Toronto presents an infrastructure issue that necessitates an infrastructure solution (Chan, 2014).

Dredging in the Toronto region is an effective temporary measure that protects riparian structures from flooding threats and maintains vessel depths in urban harbors and waterways. However, it adversely affects local ecosystems by disrupting sensitive benthic communities and releasing dormant pollutants from the lakebed back into the water column. Dredged material from urban harbors and waterways is often heavily contaminated by urban runoff, wastewater discharges, bypass events, industrial effluents, and landfills. Pollutants entering open waters can cause eutrophication—an ecosystem response to sudden increases in nutrient loading that decreases dissolved oxygen levels and disrupts breathing for large fish.

In 1987, Trow Consultants conducted a subsurface soil sampling survey on the Leslie Street Spit for the Ministry of Environment (MOE). They found that levels of mercury, lead, and PCB—compounds classified by the ministry as high-priority chemicals capable of bio-magnification and posing potential human health risks—had exceeded the values designated for Restricted Land Use. The investigation revealed these elements in the western embankment formed from dredged materials from Toronto.

The harbor generally showed modest contamination levels, but the eastern side, comprising construction rubble, surpassed the Restricted Land Use Guidelines at multiple sites. Soil surveys from the 1980s indicated that the quality of lake fill was poor and contained contaminant concentrations above acceptable levels for parkland use (Chan, 2014). If the lake fill becomes further polluted, it could adversely affect the surrounding aquatic environments.

Despite pollution in some areas, there is no doubt that this stage of the landfill and dredging project has generated new habitats for flora and fauna. Moreover, studies have shown that erosion caused by wave action also benefits plant and animal growth (Chan, 2014). This has mainly been observed at the tips of Peninsulas A, B, and C, as well as along the northern side of Peninsula D. A new dumping site has been established at the tip of Peninsula A; and at the tip of Peninsula C, an old barge has been partially submerged to create a wave breaker. Conversely, land losses in Peninsulas B and D have not yet been compensated.

The causes of natural environmental occurrences can be summarized as follows: shape, topographic variation, and orientation all contribute to various microclimates at Tommy Thompson Park (TTP), exposing and concealing potential habitats from specific extremes in conditions. Substrates also influence changes in sunlight and wind, affecting moisture regimes. These factors either support or hinder vegetation communities with distinct needs, affecting the wildlife that thrives in these environments. Consequently, primary succession occurred as erosive wind, waves, and ice broke down the construction rubble deposited along the eastern shoreline.

Coexistence: Urban Wilderness

In the late twentieth century, a comprehensive redesign of Toronto's waterfront transformed the shoreline into a weekend recreation destination. Simultaneously, an Environmentally Significant Areas Study (ESA) identified areas of environmental significance and provided recommendations for their management. With the study being revised and approved by the TRCA in 1992, the site is recognized locally and internationally as a vital ecological resource. The Metropolitan Toronto and Region Conservation Authority initiated the Phase-Master Plan for Tommy Thompson Park to fulfil the dual environmental preservation and recreation objectives.

The primary goal of Tommy Thompson Park is to foster ecological processes and maintain or improve environmental health through habitat enhancement projects. One of the most critical tasks is addressing silt pollution. Due to its mole construction, Leslie Street Spit proved to be an attractive site for Toronto's dredging program. Confined disposal facilities (CDF) are simple aquatic cells that improve water quality by preventing pollutants from dispersing through biological communities due to turbidity. Sediment traps were installed in Embayment C and beneath the pedestrian swing at the Cell #3 entryway to prevent the disposed material from re-entering the Outer Harbor and the lake beyond. As with the surficial soil assessment mentioned earlier, that recovering subsurface toxins for treatment or disposal were found to be challenging and not worth the risk of reintroducing them into the landscape.

Capping methods were a final strategy to limit the circulation of underground pollutants. Placing a clean-fill cap over the dredge (below lake level), followed by establishing a wetland ecosystem on the clean fill, was selected primarily for its economic, engineering, and environmental advantages. Clean-filling was inexpensive, widely accessible, and created an impermeable barrier that could be customized to sustain a healthy wetland ecosystem. The artificial wetland was a hemi-marsh—a complex blend of aquatic and terrestrial ecosystems—reflecting the historical environmental conditions of Ashbridge's Bay.

Adding 7.7 hectares of wetland creates a valuable natural resource in an urban area lacking its original marshland habitats. It provides new opportunities for public education, enjoyment, and environmental improvement. The wetland, formally known as the Cell #1 Watershed Creation Project, was a component of the Tommy Thompson Park Master Plan, initially intended for implementation between 1992 and 1996. However, the project was delayed due to insufficient funding. The wetland cap was ultimately constructed between 2003 and 2005, despite Cell #1 being filled in 1985.

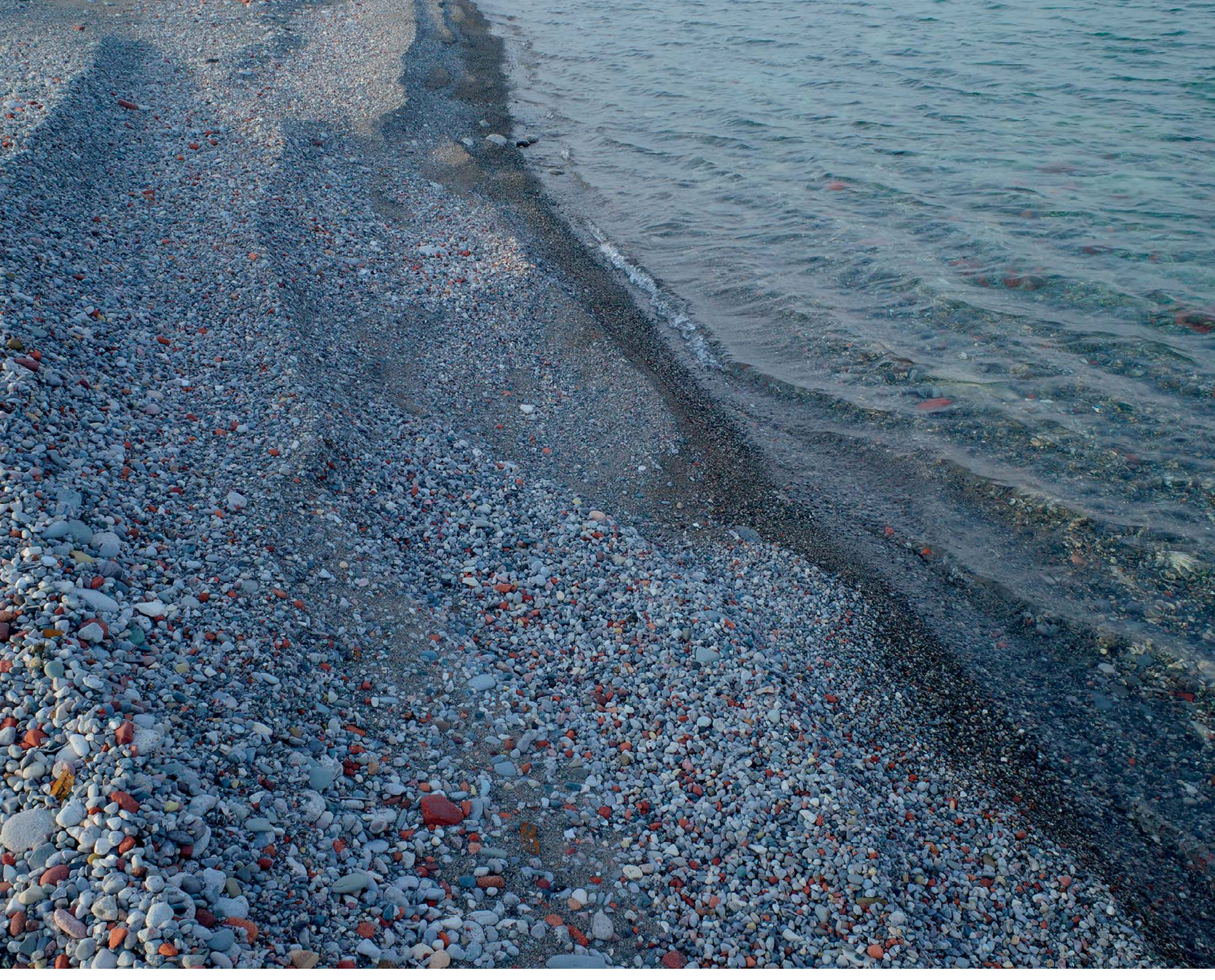
After years of planning, Tommy Thompson Park opened to the public. Leslie Street Spit operated as a regulated construction site during the week and a public environmental reserve on weekends. The site's proximity to the mouth of the Don River, its location five kilometers into Lake Ontario, and a combination of pleasant features such as meadows, woodlands, barrier beaches, and wetlands have contributed to the rich biodiversity in the area. These characteristics have allowed Tommy Thompson Park to attract over 300 species of birds as a stopover and staging point for migrating species, as well as providing habitat for various local, breeding, and overwintering birds. Colonial waterbirds represent the largest bird group to date. This is one of the most significant Ring-billed Gull breeding grounds in the world, supporting roughly 6% of the species' global breeding population and up to 30% of Canada's Black-crowned Night Herons (IBA Canada, no date).

During the spring and early summer, Ring-billed Gulls, Herring Gulls, Common Terns, and Caspian Terns can be seen nesting along the shoreline. At the same time, Black-crowned Night Herons and Double-crested Cormorants can be found in the Cottonwood trees of the western peninsula. With 800 to 1,000 Black-crowned Night Heron nests, this is Ontario's largest known Black-crowned Night Heron colony. Other birds, including songbirds, shorebirds, and raptors, can be observed and heard as they migrate between their nesting and wintering grounds during spring and autumn. In winter, Tommy Thompson Park is frequented by various owl species, such as great horned owls, saw-whet owls, and snowy owls, and thousands of overwintering waterfowl (Toronto and Region Conservation Authority, 2006).

As a result, Tommy Thompson Park has been recognized as an Important Bird Area of global significance. In 2003, the TRCA and the Toronto Bird Observatory formed a partnership that led to the establishment of the Tommy Thompson Park Bird Research Station (TTPBRS). The mission of the TTPBRS is to support the protection and preservation of migratory birds and their habitats. A small building was constructed to house the research station laboratory and facilitate the achievement of this goal (Cardoso, 2007). However, challenges persist, including species invasion. Many invasive species are present in the Headland. Some of the more prevalent species include Dog-strangling Vine, a non-native herbaceous perennial; Japanese Knotweed, another non-native plant that spreads through creeping rhizomes; and Phragmites australis, along with Purple Loosestrife, both of which are thought to threaten wetlands. Additionally, cormorants are central to a long-standing debate at Tommy Thompson Park; their population soared to 23,000 in 2004. This large number of cormorants has devastated stands of the most mature cottonwood trees on the peninsulas they inhabit, as cormorant guano is particularly acidic. They also outcompete other colonial nesting birds for nesting space, including the Black-crowned Night Herons. As a result, resource managers continue to grapple with the appropriate course of action regarding these birds.

In addition to enhancing ecological health, the TRCA aims to consider the many other beneficial features and programs that could be implemented to the public's advantage. These include opportunities for recreation, education, and interpretation. Tommy Thompson Park offers opportunities to experience the phenomenon of migration and explore local urban wildlife habitats, among other educational possibilities. Numerous student projects have taken place, such as 'Animal Detectives,' 'Get the Scoop on Soil,' and others. Alongside its academic functions, many groups of Recreation Seekers have been drawn to TTP for recreational purposes over the years. The Ontario Sailing Association, the Aquatic Park Sailing Club, and the Toronto Cycling Committee are just a few examples of these organizations. Since 1976, the Aquatic Park Sailing Club has contributed funds annually to serve park visitors and sailing

Right | Brick Beach in Leslie Spit.
Photograph by Tania Anderson, 2023.



Sediment Transport | The sediment bodies in Lake Ontario are illustrated in the upper diagram. Data: Chan, 2014. The main diagram depicts the annual sediment transport of sand in the Toronto region. Authors' work. Data: Metropolitan Toronto and Region Conservation Authority, 2022.

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club members on weekends and holidays. To mitigate beaver damage, the Aquatic Park Sailing Club also assists TRCA employees with various projects, including waste clean-up and tree-wrapping. It also provides funds for shoreline reforestation and enhancement efforts near their clubhouse. Now, through human intervention and natural processes, urban areas and wilderness coexist, maintaining a dynamic and relatively balanced state. The park can play a significant role in the future as a model for urban open space, exemplifying healthy ecosystems, a paradigm of diversity and sustainable development, or a foundation for urban parks and open space policy planning. Tommy Thompson Park has been labeled 'Toronto's most modern park,' and this description remains true nearly three decades later. As urban areas become increasingly complex, models of urban land use like Tommy Thompson Park will be increasingly in demand to examine their effects on the ecological health of open spaces, the greater region they inhabit, the impact of recreational open space development on overall urban functionality, and quality of life concerns for city dwellers.

Between the Urban and the Wild

Social Controversy

During the development of Leslie Street Spit, various stakeholders, interest groups, and non-governmental organizations engaged in debate. The site's ecological and cultural diversity and complexity today reflect different understandings of nature across various periods and among diverse populations. By examining these controversies over time, we gain insight into the profound social significance of Leslie Street Spit and explore people's understanding of nature's needs. At the same time, from a landscape architect's perspective, achieving a balance between humans and nature remains a topic deserving our continued attention.

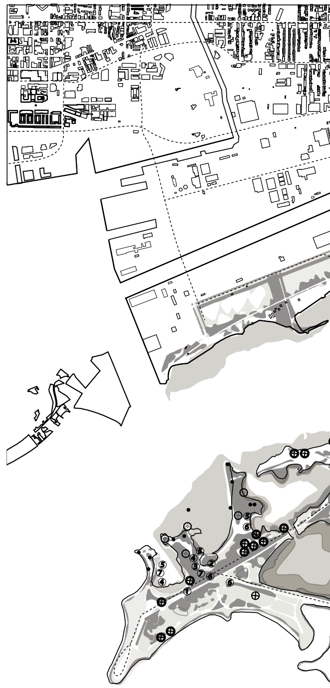
For City Development or Public Recreation

The city utilized waterfronts differently during its rapid urbanization and industrialization; however, before privatization, they served as ideal weekend getaways for residents. In winter, Torontonians reveled in the frozen waters of Toronto Bay. The natural waterfront sparked enthusiasm for such activities as sleighing, skating, and walking. Consequently, changes to the waterfront resulted in polarized opinions. On the one hand, people experienced reduced access to the waterfront, intensifying their desire to connect with nature; on the other, nature was seen as a source of disease and a symbol of unsanitary conditions due to urban sewage and industrial waste. These opposing sentiments arose from urban development, yet upon deeper examination, they are influenced by traditional views of nature and rapid growth.

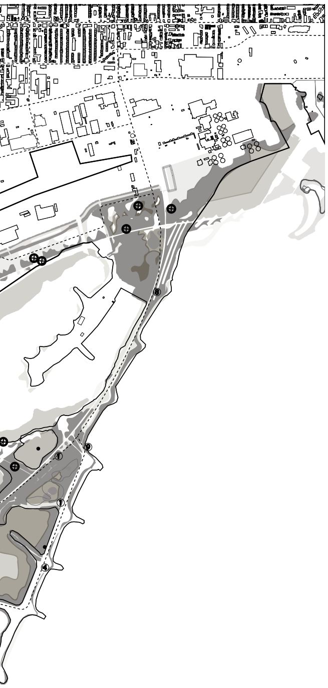
After years of directing sewage and agricultural and industrial wastewater into Ashbridge Bay, this once-thriving swamp devolved into an unsanitary sewage pool. It was considered a health and safety risk. In a 1911 referendum, a public appeal by the Trust Committee raised a 'waterfront issue' to convince the public of the necessity for the Toronto Harbour Commission (THC). Established in 1911, THC is a federal Port Authority independent of the Toronto City Council and not subject to provincial regulations. The campaign claimed that Ashbridge's Bay was a perilous cesspool that required filling in. This concept was widely disseminated due to shipping industry needs, leading to a negative public perception of marshlands.

Despite being a vibrant ecological habitat for various flora and fauna, Ashbridge's Bay was viewed as contributing to local diseases. This perception overlooked the underlying causes of the deteriorating conditions in Ashbridge's Bay. The community's concerns fueled a desire for an urban development scheme that promised a brighter future. Although the marsh was considered irreplaceable until the 1930s, the city announced plans for its complete removal to facilitate the construction of the Port Lands Industrial District. At that time, the loss of the marsh was seen as a progressive move toward a cleaner, sanitized city.

In contrast to this aversion to nature, there were also worries that urban growth would limit public waterfront access. Early on, residents purchased many waterfront parcels of land for private property, restricting access. In 1817, some York residents expressed concerns about the rise of privately owned waterfront properties and proposed the construction of public walkways, although their efforts ultimately failed to sway the stakeholders. It was not until 1972 that the public was granted limited access to the Eastern Cape on Sundays due to the declining shipping industry. Before this, the Cape was visited only by curious onlookers or a few interested groups. These individuals could sneak onto the property and persuade the Toronto Harbor Commission to allow them entry under supervision. In the mid-19th and early 20th centuries, after railway companies took over most of Toronto's waterfront properties, the railroads posed another challenge for those drawn to the waterfront. Physical barriers and safety concerns hindered access from the city to the waterfront, and the rail crossings resulted in numerous fatalities during that time. Since the mid-1960s, the Gardiner Expressway has again severed the connection between the Toronto waterfront and the city.



Vegetation Distribution | The map on the left illustrates the current distribution of vegetation. Authors' work. Data: Waterfront Toronto, 2008.
Bird Species | The map in the middle depicts the bird species found at Leslie Street Spit. Authors' work. Data: Snober, 2018.
Other Wildlife | The map on the right shows the distribution of other wildlife at Leslie Street Spit. Authors' work. Data: Waterfront Toronto, 2008.



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Wetland or marshland
Aquatic habitat
Woodland
Mixed shrubs
Locally rare mammals
Locally rare frogs
Locally rare turtiles
Locally rare snakes

Common Tern ①
Great Egret ②
Caspian Tern ③
Ring-billed Gull ④
Double-crested Night-Heron ⑤
Black-crowned Night-Heron ⑥
Herring Gull ⑦
Butterflies ⑧
Migratory songbirds ⑨
Provincially significant water
Locally rare birds
Other colonial water birds

Passive or Active Recreation

Beyond the social controversy regarding the relationship between humans and nature amid urban development, the transformation of Leslie Street Spit into a recreational area has sparked debates among designers, policymakers, and the public. In 1972, the THC decided to develop an Aquatic Park for public use, as some expanded port facilities would no longer be necessary. In 1973, the Province of Ontario assigned the task of overseeing the planning and development of Aquatic Park to the TRCA. However, during the design phase, park users and the public were not allowed to propose design ideas despite many having used the Headland (Cardoso, 2007). The lack of public engagement in the design process led to dissatisfaction among citizens. Ultimately, the Aquatic Park concept did not receive positive feedback (Cardoso, 2007). The focus of the aquatic park centers on intensive recreational activities, and its design approach prioritizes human needs while neglecting ecological considerations. Regarding vegetation planning and design, the 'do nothing policy' was initially dismissed as it was perceived as time-consuming and visually unappealing (Cardoso, 2007). Furthermore, traditional landscaping methods for parks were abandoned due to their high maintenance costs and uninspired layouts. Instead, a strategy favoring the 'creation of distinctive natural ecotypes' was embraced. This was recognized as a '*non-conventional park landscaping approach*' (Cardoso, 2007, p. 98). From the beginning of Aquatic Park's planning, investigations into flora and fauna revealed the remarkable nature of Leslie Street Spit. Based on data compiled from an environmental survey in 1978 and a subsequent ecological study in 1982, a new master plan grounded in environmental principles was deemed necessary. '*Since the beginning of the TRCA planning process for Aquatic Park in 1974, site conditions have changed dramatically due to natural succession. Therefore, the TRCA determined it appropriate to initiate a new master planning exercise for Aquatic Park*' (Cardoso, 2007, p. 100). There are two significant differences between these two plans. First, the latter addresses the Aquatic Park's shortcomings and incorporates all stakeholders' perspectives and suggestions regarding the future development of the Eastern Headland. Second, unintended nature raises awareness of the impacts of nature and ecology on Leslie Street Spit. Conservation design, defined as '*the purposeful act of planning and designing for various wildlife habitats to aid in restoring rare, endangered, or significant plant and animal species*' (Chipperfield et al., 2000, p. 1), allows designers to '*act as accelerators in the natural successional process*' (Cole, 1986, p. 423).

The future of Leslie Street Spit has also sparked significant public controversy. Founded in 1977, the Friends of the Spit is a public organization that seeks to maintain the site's accessibility amidst disputes over its development and management. Originating from a group of birdwatchers, naturalists, and cyclists from Beach Riverdale, the group now has around 1,200 members, primarily residents and representatives from various organizations and park users throughout the region. In the long term, their ultimate goal is to allow the Spit to thrive naturally, free from development and privatization, thus preserving the natural urban wilderness of Leslie Street Spit. '*Our commitment is to the "passive" recreational use of the Spit*' (Carley, 2013), as the group briefly stated in 1978 to the TRCA. Alongside other nature-focused organizations, such as the Toronto Ornithological Club, the Toronto Field Naturalists, the Toronto Bird Observatory, and the Toronto Entomologists Association, the Friends of the Spit consistently advocate for their belief in nature. For instance, they have voiced their opposition to the active recreation plan. The original Aquatic Park plan, which included a hotel, amphitheater, government docks, private yacht clubs, parking for 2,000 cars, a water-skiing school, camping, and numerous other recreational facilities, led to their discontent, prompting a brief call for the abandonment of this plan by the end of January 1978. The Friends devoted significant time and effort to opposing active recreation. By the summer of 1978, 50 mooring spaces had been established on the Spit by the THC, and sailors sought vehicular access to their boats (Carley, 2013).

Meetings with THC officials resulted in a compromise: sailors could operate on the Spit outside public hours (Carley, 2013). This compromise seemed unavoidable and remains in effect today. Furthermore, Friends of the Spit participated in the public hearings concerning Tommy Thompson Park in 1989. Although they opposed the Sailing Club at Embayment C, the revised plan was successfully executed. Organizations like the Ontario Sailing Association, the Aquatic Park Sailing Club, and the Toronto Cycling Committee have been drawn to TTP over the years for recreational activities. Their primary emphasis on recreation has previously led to land-use conflicts among various user groups. However, the Aquatic Park Sailing Club currently assists TRCA staff with several projects, including refuse cleanup and tree-wrapping to prevent beaver damage. They have also funded shoreline naturalization and enhancement initiatives around their clubhouse (Toronto and Region Conservation Authority, 2006).

In the ongoing debate between passive and active recreation, passive recreation is currently the option most suitable for everyone. Nevertheless, viewing the issue from an alternative perspective, such as that which emphasizes biodiversity, may yield a different conclusion. According to Kowarik (2005), the Leslie Street Spit is a semi-natural wilderness that can no longer self-sustain and requires human management. Active control is essential to mitigate invasive species for the benefit of native plants and animals. Even if an agreement is reached, the debate and controversy will likely continue as more stakeholders and affiliated groups engage in the discussion.

The Urban Wilderness and Its Ambiguity

Throughout the nineteenth and early twentieth centuries, the meaning of wilderness in Canada was closely linked to ideas of separation and control. For many European settlers, nature appeared as a vast and untamed adversary—an environment to conquer, tame, and turn into productive land. Early writings describe this wilderness as unfamiliar and threatening, with its vastness seen as a danger rather than an asset (Cardoso, 2007). In contrast, Indigenous communities had long developed ways of life based on reciprocity and respect for natural systems, recognizing their interconnectedness with the land. However, with industrialization, the settler view became dominant, and the physical and psychological gaps between the city and nature widened. Expanding railroads, port facilities, and expressways created tangible barriers, making nature seem outside urban life—something to visit, not to live within.

This historical divide fostered a cultural imagination where 'city' and 'nature' were seen as opposites. Despite the growing popularity of the back-to-nature movement, most urban Canadians still believed that true wilderness existed only beyond city limits. However, the Leslie Street Spit quietly challenges this division. It is both inside and outside the city: a landscape formed from industrial waste that now supports diverse ecosystems. Its existence questions whether the boundary between urban and natural ever truly existed—or if it was simply a conceptual line meant to emphasize human distinction.

The challenge of defining nature lies at the core of this paradox. As Macnaughten and Urry argue, there is '*no singular nature as such, but a diversity of contested natures*' (Macnaughten and Urry, 1998, p. 1). The word itself carries meanings shaped by time, culture, and perception. In landscape theory, these layers are often described as a continuum: '*First Nature*,' the realm of wilderness; '*Second Nature*,' the domain of cultivation and urbanization; and a '*Third Nature*,' a hybrid state where human and non-human processes intertwine (Hunt, 2000). The Leslie Street Spit fits into this third condition—a terrain of ambiguity and adaptation. It is what Jordan III (2000, p. 24, cited in Cardoso, 2007) called '*a landscape of ambiguity*,' neither fully natural nor fully artificial. As Johnson states: '*The meanings and connotations associated with wilderness are not inherent or absolute; rather, any label assigned to wilderness reflects the subjectivity of the perceiver*' (Johnson et al., 2004, p. 612). Walking its paths means experiencing this uncertain space, where industrial ruins and the rebirth of life coexist, each shaping the other in ways that resist simple labels.

In this context, the Spit's value extends beyond its ecological role; it becomes a symbol of coexistence. French landscape architect Gilles Clément described such places as the '*Third Landscape*' (Clement, 2004)—areas neglected or left to chance, where spontaneous processes continue beyond human control. At the Spit, fragments of demolished buildings, broken concrete, and dredged sediments have become the foundation for renewal. The site functions both as a memorial to the city's industrial history and as a living record of ecological succession. Its hybrid ecosystems—cottonwood forests seeded from the Toronto Islands, lagoons hosting amphibians and migratory birds, and meadows full of invasive and native species—demonstrate the creative tension between disturbance and renewal.

Ultimately, the Leslie Street Spit teaches us to see the urban landscape as a living dialogue between memory and change. Beneath every layer of rubble lies the residue of the city's past; above it, new ecologies develop in unpredictable rhythms. This interaction reminds us that change is not an interruption of nature but its defining condition. The Spit's evolving character—its capacity to support life amid decay—offers a profound lesson for designers, planners, and citizens alike: that sustainability comes not from control but from learning to live within uncertainty. The lesson is both practical and philosophical: to design not fixed forms but adaptable frameworks; to see intervention as dialogue, not domination. Working with nature means engaging with processes that go beyond prediction. It means learning to interpret the landscape as a teacher, understanding that each ecological response has its own intelligence. Here, in this constantly shifting space between the urban and the wild, the city finds not only a reflection of its own history but also a glimpse of its potential future.

Conclusions

The Leslie Street Spit began as an industrial project—an extension of land into water, built to serve the needs of a growing port city. Over time, this man-made headland surpassed its original purpose, evolving into a landscape of change and discovery. What was once a dumping ground for rubble is now a sanctuary for birds, plants, and people—a living symbol of how ecological and cultural processes are connected. In its transformation, we see not only Toronto's waterfront history but also a broader reflection on how cities and nature continuously influence each other.

The first part of this chapter described the Spit's development through physical efforts like filling in the lake, constructing breakwaters, and layering debris. These actions—industrial, systematic, and pragmatic—were driven by the logic of urban growth. But beneath this logic, nature's quiet persistence altered the story. Seeds carried by the wind, birds arriving by chance, and water reshaping the shoreline began a new narrative—one outside of human planning. Over decades, the Leslie Street Spit became an unintended experiment in ecological succession, demonstrating how

Above | One of the roads in Leslie Spit. Photograph by Tania Anderson, 2023.
Right | The (un)expected wilderness of the tangled forest at Leslie Spit. Photograph by Tania Anderson, 2022.

disturbance can also lead to renewal.

The second part of the chapter shifted focus to the social and philosophical aspects of this evolving landscape. Here, the Spit emerged as a place for dialogue—between developers and conservationists, planners and residents, the pragmatic and the poetic. Debates about its future reflected changing cultural ideas of what 'nature' means in an urban setting. For some, the Spit was seen as a blank canvas waiting for improvement; for others, it was a rare opportunity to observe wilderness developing on its own terms. This tension, between intervention and reverence, continues to shape the Leslie Street Spit today.

What the Spit ultimately shows is that landscapes are not static but dynamic systems of negotiation. Human and more-than-human forces weave together over time, creating hybrid terrains that challenge the lines between artificiality and authenticity. The Spit's cottonwoods, migrating birds, and even invasive species tell parallel stories of adaptation and survival. They demonstrate that resilience isn't about restoring a lost balance but about the ability to endure amid uncertainty—thriving in conditions of change.

In this sense, the Spit becomes more than a case study in urban ecology; it is a pedagogical landscape. For planners, designers, and residents alike, it offers a model of learning through observation—of allowing the landscape itself to teach the rhythms of growth, decay, and renewal. It shows that stewardship can mean restraint as much as action, and that when design is attuned to natural processes, it becomes a conversation rather than a command.

This perspective has profound implications for the future of cities. As urbanization intensifies and climate instability accelerates, the idea of a stable, controlled environment becomes increasingly unrealistic. The Leslie Street Spit stands as a symbol of adaptation—proof that even landscapes born of waste and neglect can develop into vibrant ecosystems when given space and time. Its ongoing transformation encourages us to embrace change as a creative force rather than a threat, and to seek urban life forms that coexist with rather than compete against the natural world.

Ultimately, the Leslie Street Spit invites us to rethink our role in the story of the city's environments. It challenges us to see ourselves not as masters of restoration but as participants in a shared ecology of becoming. Its evolution—unexpected, uneven, and ongoing—reminds us that wilderness can exist wherever patience, humility, and care allow it to return. In this way, the Leslie Street Spit is more than reclaiming land; it's living proof that nature, even when unexpected, remains the most enduring and transformative designer.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2022-23. During the course, Wenting Gao, Zhaolei Li, Jingxuan Tu, and Qian Yao wrote the initial paper, supervised by Laura Cipriani and Denise Piccinini. Wenting Gao, Zhaolei Li, Jingxuan Tu, and Qian Yao prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the chapter. Finally, a native English speaker reviewed the text.

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Land Reclamation Site Data

Location
Texcoco | Mexico City | Panama
Coordinates
19° 26' 19" N | 99° 9' 2" W
Area
1,485 km2
Diameter
34.00 km
Time
XVI Century-Today

3 | Dry Lake's Crying

The Plight and Struggle of Mexico City

Hao Wang, Xinyi Wang, Yiwen Wang, Huiyuan Zhang
Laura Cipriani, Denise Piccinini

Mexico City is the capital of and largest city in Mexico. With a population of 21.8 million, it is the second most populous city in the Americas. The Spanish established the city in the 16th century on the site of an Aztec settlement, an island in the middle of a lake called Texcoco. Over time, the canal system created by the Aztecs was drained along with the lake and surrounding wetlands to create more land suitable for development. Excessive land reclamation and uncontrolled urban expansion have disrupted the original, sustainable water system, leading to environmental issues such as land subsidence, water shortages, and flooding risks. These challenges pose a threat to the affected residents. Issues like disease, violence, and socio-spatial inequality are prevalent in poorer neighborhoods. Conversely, wealthier areas, which have access to resources and political influence, can better shield themselves from the effects of sinking land and flooding. This chapter analyzes how land reclamation generated serious environmental risks affecting urban spatial development and further exacerbating social inequality and injustice.

Introduction

Seven hundred years ago, when the Aztecs constructed their floating gardens on Lake Texcoco, the area upon which Mexico City would later be built was known as the 'Venice of the New World' due to its beauty and the harmonious balance between water and built environments. Settlers gradually drained the once-thriving lakes that watered the plains. In the 16th century, Spanish conquerors expedited this process, which centuries later resulted in a stark landscape of concrete, asphalt, and steel that replaced the lakes and marshes. Today, Mexico City confronts numerous serious environmental threats, including land subsidence, flooding, and water shortages. Most of these issues arise because the city was established on a dry lakebed without a proper drainage system.

This chapter examines the narrative of land reclamation in Mexico City and its implications for serious environmental risks, which affect urban spatial development and further deepen social inequality and injustice. The first subchapter, 'Threats on the Lakebed,' examines the city's three main natural threats arising from land reclamation: subsidence, flooding, and water scarcity. Due to the overexploitation of groundwater and the hardening of the ground, the city's clay subsoil layers are increasingly unable to replenish the groundwater system. Furthermore, soil subsidence is occurring at an alarming rate, leaving the infrastructure incapable of managing the growing urban demands. Because the city is located at the bottom of a valley, proper drainage is problematic, meaning that heavy rain causes many areas to suffer from flooding. At the same time, Mexico City, one of the largest metropolitan areas in the world, has a tremendous demand for water. The city relies on reservoirs located hundreds of kilometers away for its water supply. With dwindling groundwater and water supply infrastructure damage, a significant portion of the population faces water shortages.

The second subchapter, 'Struggling in a Fragmented City,' highlights how the natural threats from land reclamation exacerbate social issues such as disease and violence while exposing their unequal societal-spatial distribution. By overlaying these natural challenges with income distribution levels, we make a comparative study of two neighborhoods: a low-income neighborhood affected by all three natural threats, and a high-income neighborhood unaffected by these issues. In vulnerable communities, land subsidence, flooding, and inadequate urban sewage infrastructure have increased the population's susceptibility to disease. Severe water shortages amplify tensions among residents and incite mass protests, prompting criminal gangs to exploit water resources and create disparities in water access, further privatizing and restricting access to water sources. Various forms of violence have surged in these neighborhoods, undermining the government's regulatory capacity. Inequalities in these areas continue to grow alongside environmental degradation.

Threats on the Lakebed

Mexico City has a rich history of land reclamation as the existing lake, known as Lake Texcoco, was gradually reclaimed in response to the city's growth during the Aztec, Colonial, Mexican, and Modern eras. In the 14th century, the Aztecs established Tenochtitlán on an artificial island by depositing soil into Lake Texcoco. From that initial settlement, they constructed dikes and canals to better manage floods and to redirect water away from the city. During this time, the Aztecs also developed 'chinampas'—floating islands created at varying elevations, planted with diverse crops—and harvested fish from the waters surrounding these islands. This sustainable farming technique helped to stabilize the soil and prevent erosion. With the arrival of the Spanish in 1521, both the city and its surroundings underwent significant transformations. The conquistadors drained the lakes and canals and constructed aqueducts to transport water from nearby springs. The Spanish also built colonial structures on the drained lakebed using the 'tepetate' technique, which involved compacting volcanic rock and lava for foundations. This method resulted in poorly drained soils with low fertility, heightening erosion risks, as well as landslides.

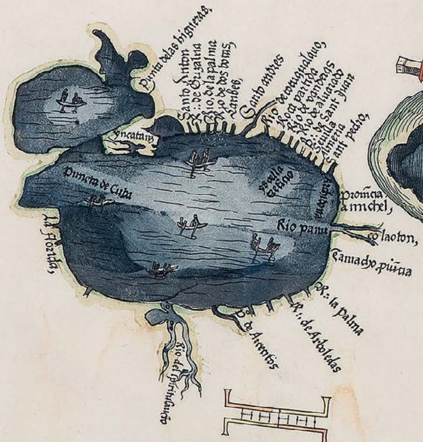
The municipality of Mexico City, originally known as México Tenochtitlán, was founded in 1524 and officially named Ciudad de México (Mexico City) in 1585. During its time as part of the Spanish empire, it served as the region's political, administrative, and financial center. The federal district was established in 1824 after Mexico gained independence from Spain.

Establishing the Federal District of Mexico in 1824 marks a pivotal moment in Mexican history. During this period, Mexico underwent significant growth characterized by extensive urban expansion and increasingly uneven development within cities due to war and political turmoil. This population surge intensified the demand for drinking water, causing people to draw heavily (and often illegally) from groundwater sources, significantly contributing to urban subsidence issues.

As of 2020, Mexico City has a population of 9,209,944 and covers an area of 1,495 square kilometers. Greater Mexico City, as defined by federal and state governments, has a population of 21,804,515, making it the sixth-largest metropolitan area in the world. It is recognized as the second-largest urban agglomeration in the Western Hemisphere, following São Paulo, and the largest Spanish-speaking city in the world. With a GDP

Right | Mexico City was established on an island in Lake Texcoco. This is the earliest European map of Tenochtitlan, the capital of the Aztec Empire, created in 1524. Map by Friedrich Peypus, 1524.

Res fuerat quondam pręstans, & gloria summa
Orbis subiectis Cesaris Imperio,
Hic longe pręstat, cuius nūc Orbis Eous,
Et Nouus, atq; alter panditur Auspitys,



Quilibet punctus magnus continet leucas duodecim cū dimidia, ita q̄ duo magni puncti continent viginti quinq; leucas, Cōtinet autē leuca quatuor Italica miliaria, ita q̄ omnes puncti qui hic cōspiciuntur continent centum leucas.

of $411 billion in 2011, Mexico City ranks as one of the most productive urban areas globally, accounting for approximately 15.8% of the country's economic output. This figure rises to 22% when one includes the broader metropolitan area.

Today, Mexico City has a complex system for water and drainage designed to meet the needs of the metropolis. However, these systems face challenges related to severe flooding, soil subsidence, and water shortages. Over the past few decades, Mexico City has expanded from 120 square kilometers to over 1,500 square kilometers, with its population increasing from 4 million to over 20 million. Nonetheless, the rate of urbanization and the extent of modernization are not always positively correlated. Slums and issues of violence and disease affect numerous areas, with these challenges closely tied to the city's unsustainable land reclamation history.

This subchapter explores how land development has triggered these environmental challenges, particularly land subsidence, flooding, and water shortages. The first section, 'A Sinking City,' concentrates on the issue of land subsidence. The second section, 'The Street is Full of Water,' highlights the flooding problem. The third section, 'Here You Have to Chase a Dewdrop,' addresses the water shortage concern. Throughout this discussion, various sections compare the situation before and after reclamation to illuminate the environmental issues. In the concluding section, we examine the interaction of the three environmental problems in the city, and study the relationship between high-risk ecological areas and reclamation zones.

A Sinking City: Land Subsidence

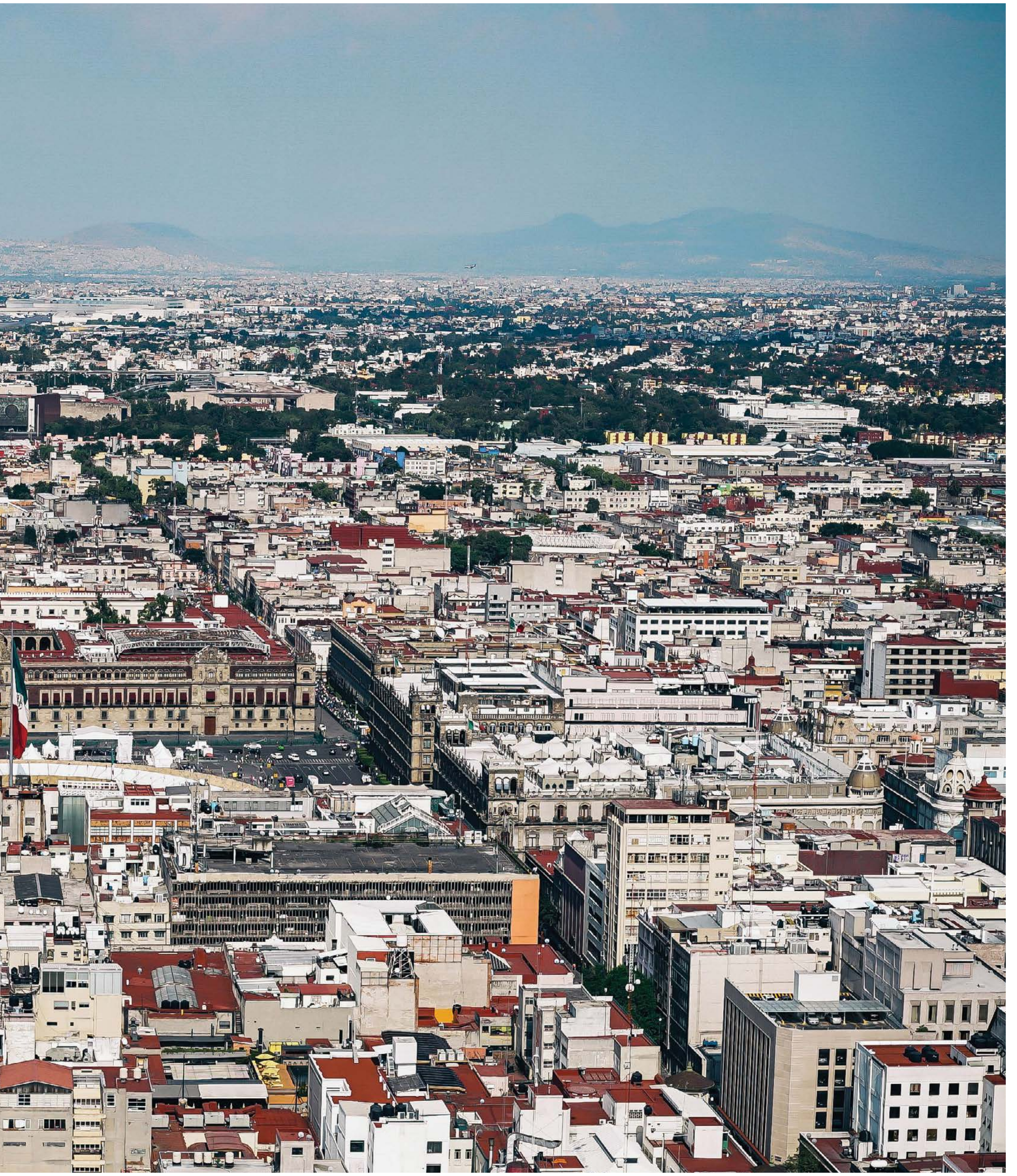
'*Buildings in Mexico City can resemble Cubist drawings, featuring slanted windows, wavy cornices, and doors that no longer align with their frames*' (Kimmelman, 2017), says Kimmelman, a reporter for *The New York Times*, in his report on the city. This surreal scene may be difficult to imagine, but its cause is land subsidence—a serious environmental issue that has persisted in the city for over a decade. Estimates from researchers and government agencies suggest that Mexico City is sinking at an average rate of about 0.5 to 1.0 meters each decade, making its sink rate among the fastest of major cities worldwide. Furthermore, this sinking is widespread, affecting approximately 40% of the city's area, primarily because it was built on a dried-up lakebed (Cabral-Cano et al., 2008; Hernández-Espriú et al., 2014; Cigna and Tapete, 2022).

This dried lakebed consists of a mixture of clay and volcanic soil. The upper layer is stable and composed of porous volcanic soil, which absorbs and transports water without changing based on the water amount. The lower layer consists of highly compressible clay and silt, which can easily compact due to its mineral makeup and physical characteristics. Clay contains very fine mineral particles tightly packed together, giving it high cohesion and susceptibility to shrinking and swelling. Although silt particles are larger than those of clay, they remain smaller than sand, rendering them more vulnerable to compression and consolidation. When a load is applied to a clay or silt layer, the particles are pressed closer together, forcing out the water between them, reducing porosity and increasing the layer's density. Over time, this compaction results in a decrease in the thickness and volume of the layer. Simultaneously, when the moisture content of the clay and silt layers decreases due to evaporation or water extraction, the particles shrink, causing further consolidation of the layer. Conversely, increasing moisture content leads to particle expansion and layer swelling. This indicates that this type of soil is sensitive to changes in water content and weight.

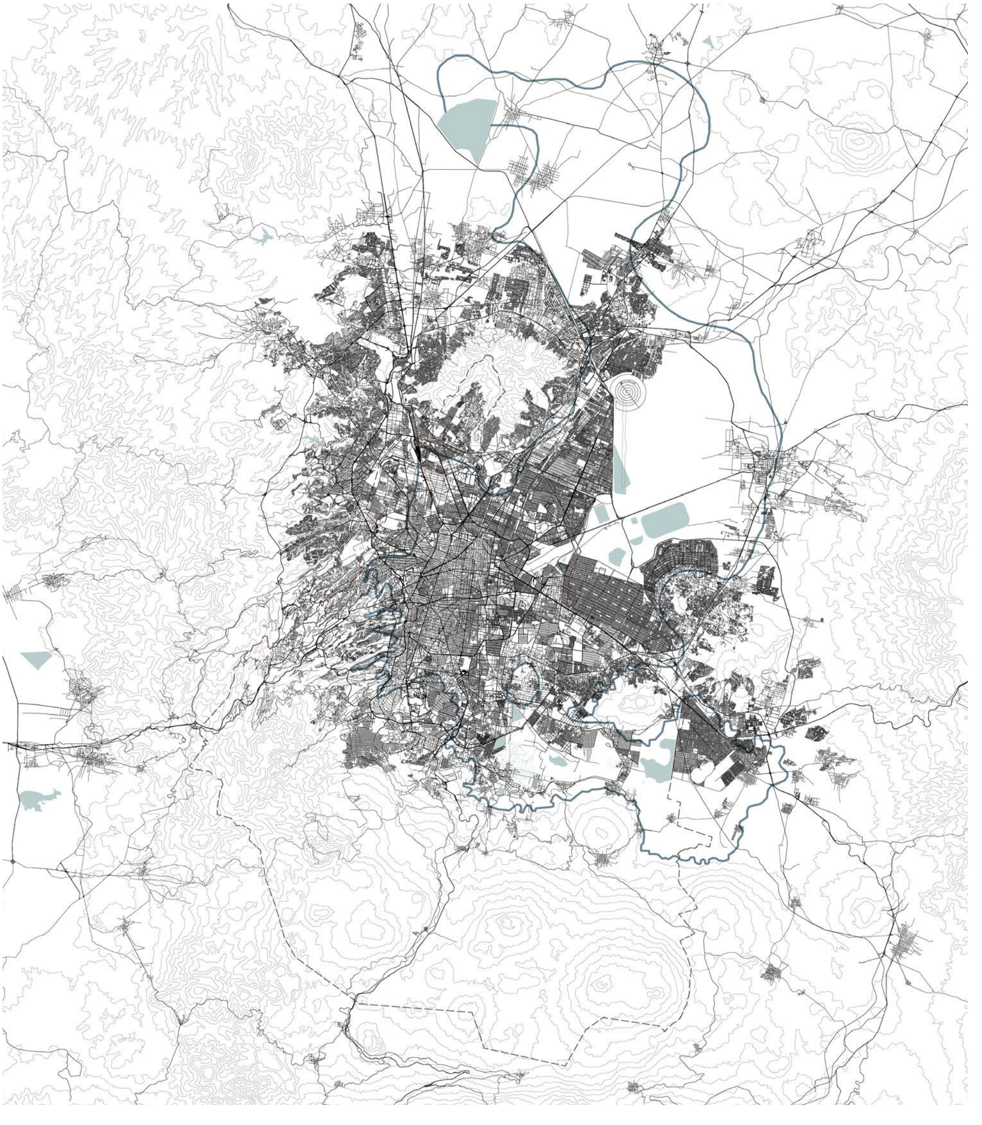
Before reclamation, Texcoco Lake supplied groundwater. The volcanic soil beneath the lake's surface absorbed water and conveyed it to the aquifer. The clay and silt layers remained saturated due to the availability of water and reduced pressure on the surface. After reclamation, rapid population growth and industrial demands dramatically increased water consumption, with people depleting groundwater for decades. Additionally, rainwater cannot penetrate the surface to replenish the aquifer because the land is now covered with concrete and asphalt. This over-extraction and lack of replenishment have caused a significant decline in the groundwater level in Mexico City. The water that once filled the clay and silt layers has been depleted, reducing the pressure that upheld the soil structure. This has resulted in the soil layer collapsing and cracking, thereby contributing to its compression and subsidence (Cabral-Cano et al., 2008; Hernández-Espriú et al., 2014; Cigna and Tapete, 2022). Moreover, the rapid construction and growth of the city have caused escalating and uneven pressure from the above-ground buildings, significantly worsening the subsidence issue in Mexico City.

If all of Mexico City were built on clay, it would sink at least at the same rate. However, the city is constructed on a mixture of clay and volcanic soil, with areas like the city center located on clay while others rest on volcanic fields. The differences in sinking rates across various city sections closely align with the underlying soil structure. For instance, areas with thicker clay and silt layers are more prone to subsidence than those with thicker layers of volcanic soil. In this city, uneven soil subsidence is creating dramatic and hazardous cracks. The subsidence rate distribution map of the Mexico Valley Lake region also shows that different parts of the city are sinking at varying rates, mainly concentrated in the northeast, where it can reach up to 43 cm per year (Chaussard et al., 2021).

Above | Aerial view of Mexico City. Photograph by Ricky Esquivel, 2025.



Mexico City | The map shows Mexico City today, highlighting the 16th Texcoco Lake boundary. Authors' work. Data: Open Street Map, 2023.



N
0
5 km
15 km
30 km
Water
16th lake boundary
City boundary

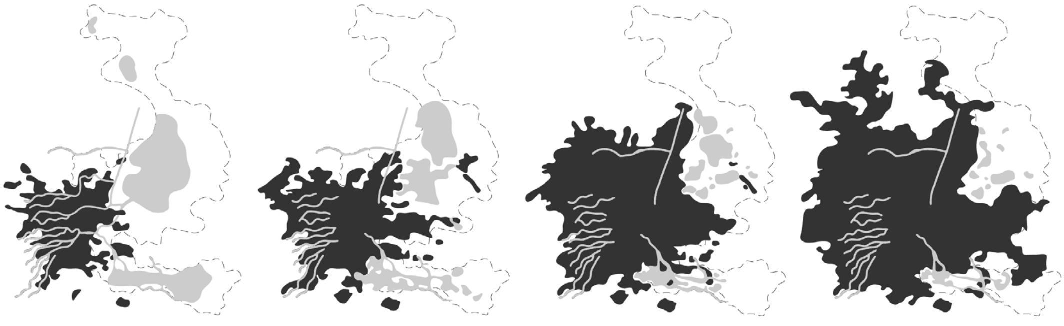
16th Century
Spaniards destroyed Tenochtitlan and filled the chinampas. The entire process spanned centuries.

1824
Mexico achivied independence from Spain and became the main political and economic center of the country.

1929
The Porfirian era began with the centralization of resources and the rapid expansion of cities.

1941
World War II bro
significant chang
to Mexico, hasten
industrialization
and urbanization
to address wartim
shortages.

Reclamation Process | Main events of the Texcoco reclamation process. Authors' work. Data: Sliwa, 2014.



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1959
This period is known as the "Mexican Miracle". Mexico City underwent rapid urbanization and economic growth.

1970
Mexico City's infrastructure development in anticipation of the Olympic Games, rapid population growth, and the expansion of the city's administrative boundaries.

1980
Since Mexico City is experiencing an economic crisis, urban growth has slowed. Meanwhile, the refugees are starting to arrive.

2000
A large influx of refugees is leading to a significant expansion of slum housing areas, yet the infrastructure is not keeping pace.

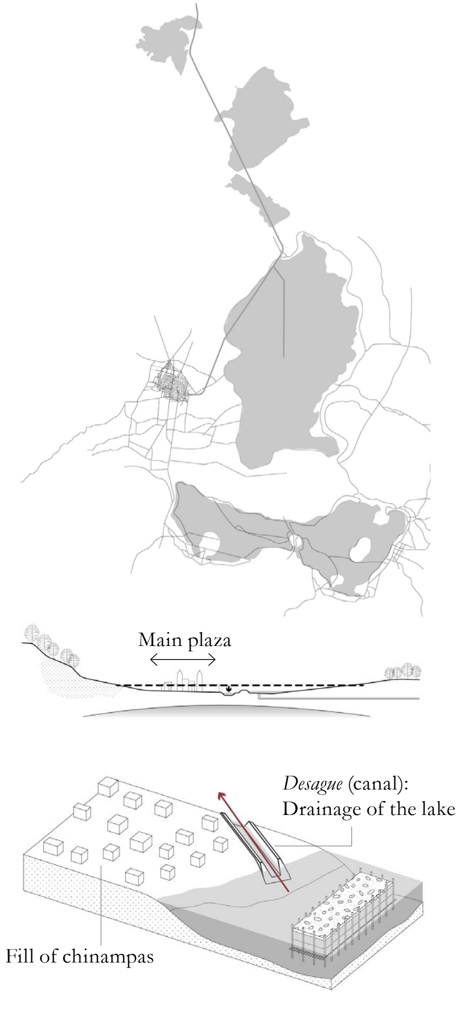
N 0 15 km 45 km 90 km

Original lake borders
Land
Lake
New reclaimed land

Aztec Period

During the Aztec era, the inhabitants of Tenochtitlan constructed chinampas to grow their crops. This circular agricultural method was adapted to the local water system

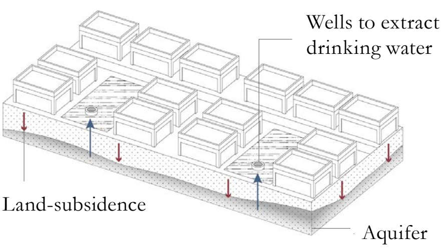
Colonial Period



The colonizers filled the Chinampas and constructed the *desague* to drain the lake.

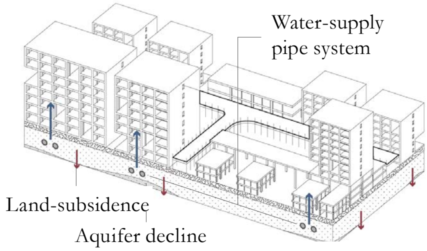
Reclamation Process | The reclamation process and technology on a city-wide scale encompasses four main periods. Authors' work.

Mexican Period



During the Republic period, Mexico City began to expand rapidly. However, land subsidence started, and at that time, people could still extract water from underground aquifers through wells.

Modern Period



In the metropolitan area, severe land subsidence and a declining water table have caused wells to run dry. Residents had to obtain water from distant sources outside of Mexico City via pipelines.

The Street is Full of Water: Flooding

Mexico City has faced frequent flooding in recent years. Data from Mexico's National Water Commission (CONAGUA, 2015) reveals that between 2015 and 2019, the city experienced an average of 55 floods per year, affecting over 5,000 homes and businesses. In 2020, several significant flooding events occurred, including a major incident in September that forced the evacuation of thousands of residents from their homes. This flooding was caused by heavy rainfall that overwhelmed the city's drainage system, leading rivers and canals to overflow.

The probability of flooding in Mexico City has increased from 1% in the 14th century to 11% in the 20th century, with projections indicating that it could rise to 33% in the 21st century (CONAGUA, 2015). A notable increase in flooding likelihood around the year 1900 coincided with the complete drainage of Lake Texcoco, suggesting that land reclamation efforts have heightened the flood risk in Mexico City. Additionally, climate change, which brings about more extreme weather events such as heavy rainfall and storms, implies that the city will continue to confront flood risks in the future, potentially leading to more frequent and severe incidents.

In the Valley of Mexico, also known as the Anahuac Valley, Mexico City is surrounded by mountains and volcanoes. Initially, this valley was home to several lakes, including Lake Texcoco, where the expansive city was established following drainage efforts. Before land reclamation, these lakes received runoff from the surrounding valleys, replenishing them and the aquifers.

However, after reclamation, runoff from the highlands—necessitating proper management, diversion, or channelization—enters the city, causing recurrent flooding. The town has undergone significant urbanization, with numerous buildings and roads covering the original natural soil, preventing or hindering water from penetrating the aquifer. The existing drainage facilities are the primary method for managing collected water, placing immense strain on the infrastructure.

Given the land subsidence in Mexico City, the aging drainage system seems ill-equipped to manage these heavy demands. Subsidence often damages and deforms drainage pipes and facilities. Even when they remain intact, subsidence can lead to tilting and misalignment, significantly diminishing drainage capacity. In some locations, the drainage system cannot function effectively.

Simultaneously, waste accumulation in Mexico City severely affects the drainage system. With the city's rapid development and population growth, the amount of waste continues to escalate, while the capacity to build and maintain waste treatment facilities has not kept pace. As a result, large quantities of garbage accumulate on streets and rivers, washing away with rainwater and clogging the drainage system, leading to blockages and damage to the pipes and facilities. This problem becomes especially severe during heavy rainfall when garbage accumulation and blockages worsen flooding.

Factors such as topography, soil type, rainfall, and urbanization levels influence the distribution of flood risk in Mexico City. Analyzing the flood risk zone map, alongside flood recurrence points from 2016 to 2021, reveals that various flood risks exist across different city areas. The highest risk is concentrated in the northeast corner, where the terrain is lower, urbanization is more extensive, and population density is relatively high.

Chasing a Dewdrop: Water Shortage

According to United Nations Development Programme data, Mexico City is one of the world's most water-stressed cities (UNDP, 2024). Each person uses only 50 liters of water per day, just half of the minimum recommended by the World Health Organization. Approximately 2 million residents lack access to reliable tap water.

Mexico City's rapid development has sharply increased water demand as one of the largest cities globally. However, since the 16th century, when Lake Texcoco was drained, acquiring water from this region has become extremely difficult. Today, 68% of drinking water is sourced from groundwater extraction, while 22% comes from distant reservoirs. Both methods of water acquisition face significant challenges.

Over the past few centuries, the city has constructed numerous wells to meet the water needs of its urban population. The underground aquifers that primarily supply water have been depleted, forcing people to dig deeper wells to access water from deeper aquifers. This situation has resulted in a continuous decline in groundwater levels and water resource issues. Reports indicate that since the 1950s, Mexico City's groundwater resources have been overexploited (Chayssard et al., 2022). By the early 21st century, groundwater extraction occurred at more than twice the rate of groundwater replenishment. The over-exploitation of aquifers reached 297%, with surrounding aquifers also experiencing varying degrees of overexploitation (Deltares, 2015). Although Mexico City has recently started implementing measures to limit groundwater extraction, the long-term overexploitation has caused irreversible effects on the city's water resources.

Another primary water source is reservoirs located hundreds of kilometers away, for which extensive infrastructure has been developed to transport the water. Examples of these systems include the Cutzamala and Lerma water systems. The Cutzamala water system, for example, ranks among the most extensive water supply facilities serving Mexico City. Constructed in the late 1970s, it transports water from the Cutzamala region of Guerrero State to the capital. The system features two main reservoirs and a 225-kilometer-long pipeline, capable of meeting over 20% of Mexico City's demand for tap water (Merlo and Castro-Reguera Mancera, 2019).

The system moves water from an altitude of 1,600 meters to approximately 2,700 meters into the Mexico Valley with an imponent system of pumps and high energy consumption. The Cutzamala water system is considered a vital resource, especially during drought and dry seasons when its capacity to supply water is crucial. However, the costs associated with these large water systems have significantly increased the expense of securing water resources.

At the same time, the city water distribution system suffers from inefficiencies. Pipe damage and leaks caused by settling and poor maintenance result in 40% of drinking water loss due to infrastructure leakage (Hogenboom, 2018), and damaged pipes can also lead to water resource contamination. Additionally, illegal connections to pipelines in certain areas exacerbate the challenges in obtaining clean water sources. The water shortage issue has intensified due to climate change, rising temperatures, and increased water evaporation.

Considering these factors, the distribution of average bi-monthly residential water use across various neighborhoods reveals that the population affected by water shortages is predominantly concentrated in the southern and eastern regions of the city. Residents in these areas are often low-income individuals who cannot afford high water bills, and their communities frequently lack adequate infrastructure.

If we overlay maps showing land subsidence, flooding, and water shortages affecting Mexico City to examine the distribution of these problems throughout the city, we realize that these environmental issues are not evenly distributed. The northeastern part of the city, which is lower in elevation and more developed, is particularly affected. This area largely coincides with land reclaimed from the lake, underscoring the strong connection between these environmental problems and land reclamation. Interestingly, all three environmental issues affect specific blocks in the city center. In contrast, some areas of the city remain unaffected by these problems. This disparity piqued our interest in the living conditions of people in these two regions. Therefore, the following sections will compare this map with a map of income distribution among Mexico City residents. Thus, we have selected two relatively typical communities to analyze how the environmental problems stemming from land reclamation have further intensified social issues in Mexico City.

Struggling in a Fragmented City

Somewhere is Heaven, Somewhere is Hell

The environmental issues in Mexico City pose a significant threat to the well-being of its residents. As highlighted in the first subchapter, the city faces an existential crisis due to the deteriorating infrastructure of its water and sewerage systems. These problems are particularly severe for lower-income and marginalized communities, which are more vulnerable to the adverse effects of environmental degradation.

In addition to these environmental challenges, the city struggles with a range of social issues, such as disease and violence, that disproportionately affect these marginalized groups. The severity of these social issues is worsened by environmental threats, leading to a further decline in living standards within these communities.

To better understand the impact of environmental problems on social issues, we examined the severity of three ecological problems—flooding, water shortage, and subsidence—alongside the city's income levels. Based on this analysis, we chose two communities, Condominios del Bosque and Iztapalapa, with contrasting characteristics to illustrate how environmental threats intensify social issues and contribute to declining living standards.

This subchapter emphasizes the critical role played by environmental factors in worsening social issues and leading to a decline in living standards. By comparing communities with different income levels, we identified the disproportionate impact of environmental threats on marginalized communities.

Diseases: Living with Black Water

Water can be harmful in Mexico City. Even a drop of water from the city taps is incredibly biodiverse, and the bacteria or viruses within it can harm the human body. The diseases they cause can range from triggering mild symptoms like diarrhea to causing more severe illnesses such as meningitis and cancer.

Mexico City's sewage does not always remain where it should. On its extraordinary journey beneath the city streets through waste pipes, sewers, and canals, mishaps often occur, such as blockages, pipe leaks, and floods. The sewage has an unfortunate tendency to return to people, leaking into drinking water, being ingested by pets, or appearing in swimming pools.

In Mexico City, land subsidence has significantly stressed underground water pipes, leading to sewage leaks into drinking water. Long-term subsidence has also caused the city's sewage drains or canals to be higher than the houses' water sources. Whenever heavy rainfall occurs, flooding causes water pollutants to overflow. The contaminated water, reputed to be toxic enough to burn off duck feathers (Hollander, 2014), spreads its stench and disease throughout the city.

Land subsidence causes the water pipes to endure tremendous pressure, making them vulnerable to rupture; meanwhile, rusty pipes and old water tanks made from asbestos can introduce harmful substances into the water. Over time, poor-quality water can corrode the pipes, eventually leading to bursts. The underground pipes in Mexico City's water system have a leakage rate of 12,000 liters per second, accounting for over one-third of the total water flow. Considering the corrosive nature of the contaminated water, how much fecal matter leaks into the water basin or the pipes supplying drinking water remains uncertain.

Leakage does not seem to occur in Condominios del Bosque, which is closer to the Cutzamala water source and benefits from better infrastructure. However, if this water needed to reach Iztapalapa, it would have to be hydro-electrically elevated 1,100 meters and then gravity-fed through more than 150 kilometers of pipes and aquifers. Due to leaks, it loses more than a third of its volume along the way, and three chlorination plants, along with any contaminants, alter the chemical composition it acquires during transit (Soto Montes de Ocaand Bateman, 2006).

In regions where subsidence has been especially severe, like Iztapalapa, the city's sewage drains or canals now sit higher than the houses' water sources, creating a disaster waiting to happen with every storm. When heavy rain arrives, these drainage systems, easily blocked by garbage and sediments, can collapse entirely, causing floods. Sewage containing dangerous substances flows into the streets and over houses, where it could potentially be ingested by anyone traversing the city. For example, during the 2011 'great black flood,' an underground sea of sludge surged to the surface, flooding the homes of 60,000 residents with sewage water. In Iztapalapa, a suburb of Mexico City, wells are contaminated with toxic metals, necessitating costly filtration to produce usable water (Soto Montes de Ocaand Bateman, 2006). Regardless of how the poorest area of Mexico City might afford to invest in water filtration, even after this is accomplished, a water shortage persists, which is supposed to be alleviated by the Cutzamala reservoirs. However, due to water leaks and consumption by affluent neighborhoods to the west, only a trickle reaches its intended destination. Tap water has been noted as sometimes appearing red or yellow, or smelling foul (Hollander, 2014).

Leaks in pipes and floods allow microbes typically found in human and animal waste to flow from the tap and be ingested. The water in Mexico City is an ideal carrier for harmful bacteria, viruses, and parasites, which can lead to gastrointestinal, liver, and respiratory diseases. The city ranks highest in the world for gastrointestinal infections, with about 90% of adults infected with *Helicobacter pylori.* Additionally, over 95% of industrial or agricultural toxic waste is dumped directly into the city's sewer system (Hollander, 2014). These harmful chemicals, including nitrates, toxic metals, organic solvents, agricultural pesticides, herbicides, and radioactive substances, can cause acute and chronic toxicity and lead to mutations and cancer. However, all these issues seem rare in affluent communities like Condominios del Bosque, where residents enjoy abundant, clean water and do not drink tap water. Filtered bottled water has long been neatly arranged in their refrigerators.

Violence: Dry Taps, Hot Conflicts

After exhausting natural water sources, Mexico City developed a new system to transport drinking water over long distances. This infrastructure is a major achievement in engineering, but it falls short in sustainability and social fairness. Rainwater, although abundant, is mostly wasted due to inefficient collection systems, while other water is transported from faraway sources. As a result, the city of nine million people continues to strain fragile aqueducts, and many residents still lack reliable piped water.

In Iztapalapa, one of the city's most densely populated and impoverished districts, wells are contaminated with toxic metals that require costly filtration—methods that still do not guarantee complete purification. The depletion of sources in wealthier western districts and persistent leaks in the distribution network lead to very low water pressure, averaging only 500 grams per square centimeter. For residents of Iztapalapa, dry taps mean unmet basic needs and raise the risk of social unrest. Water shortages have created a vicious cycle of violence: shortages worsen due to speculative urban expansion, while water services in marginalized neighborhoods are on the brink of collapse or becoming increasingly privatized because of limited government budgets, inefficiencies, and corruption. These conditions deepen existing inequalities in access and distribution.

As state institutions weaken, conflicts shift from infrastructural issues to social unrest—manifested through theft, looting, protests, and the rise of local gangs exploiting water distribution for profit. Violent clashes between residents and police, along with repressive government responses, further reduce administrative capacity and worsen shortages—ultimately intensifying the crisis (Kinard, 2023).

Iztapalapa has long been linked to water shortages. Residents have largely stopped expecting water from their household taps. Instead, they rely on water trucks—locally called 'pipas'—which have shifted from emergency aid vehicles to essential parts of daily life (Kimmelman, 2017). However, even these pipas cannot meet the demand. Some fleets make up to 500 trips daily and still fail to quench the city's collective thirst. The limited water each resident receives from the pipas often sparks suspicion, resentment, and violence. Drivers frequently face threats, and acts of aggression against them are common, reflecting growing frustration toward those controlling water access. In some cases, vandalizing water infrastructure becomes a desperate but irrational form of protest. Theft and looting of drinking water happen often, and police patrol Iztapalapa's streets to prevent such acts (Tsui and Chaoul, 2022).

Protests in Iztapalapa—ironically near the city's main water sources—are frequent and often met with repression (Kinard, 2023). These nearby water sources are heavily barricaded, with pipelines diverting flow to wealthier neighborhoods in central Mexico City. The government, unable to solve the structural causes of the crisis, resorts to punitive measures that further undermine public trust and deepen dissatisfaction and unrest.

To make matters worse, organized crime groups have begun exploiting the water crisis. Mexico's long-standing drug cartels are shifting their financial and logistical resources from drug trafficking to illegal control of water supplies—an emerging and profitable extension of their criminal activities. This increases risks for marginalized communities and weakens government authority, linking water scarcity with broader conflicts over governance and territory.

The crisis in Iztapalapa highlights the urgent need for comprehensive reforms in Mexico's water management system. The National Water Commission reports that the country is experiencing its worst drought in thirty years, a situation climate change is expected to worsen. Addressing these issues requires significant investment in infrastructure, technology, and rainwater collection systems to ensure fair and efficient water distribution. Furthermore, solutions must go beyond physical infrastructure to tackle corruption, mismanagement, and political favoritism that distort access to this vital resource. Transparent governance and community participation are essential to rebuild public trust and manage water as a public good rather than a commodity.

In conclusion, the situation in Iztapalapa reveals the deep connections between environmental damage, urban inequality, and social unrest. The city's water crisis is not merely a technical problem but a reflection of broader systemic injustices involving governance, economics, and daily survival. Without decisive and inclusive action, Mexico City's struggle for water may continue to mirror the larger global conflict between progress and sustainability, privilege and deprivation.

Conclusions

The story of Mexico City is etched into a moving landscape—one that has been reclaimed, reshaped, and repeatedly subdued in the name of progress. The transformation of Lake Texcoco and its sister lakes into solid ground was not just an engineering feat but an intervention in the city's ecological and social fabric. What began as an effort to control nature has instead created a lasting tension between the built environment and the land beneath it. The clay of the ancient lakebed, still alive with memory and movement, continues to sink, crack, and flood, serving as a reminder to the city that its foundations rest on fragile and restless terrain.

Across this altered plain, environmental degradation has intertwined with social inequality, creating landscapes marked by unequal suffering. Land subsidence, flooding, water shortages, and pollution—each a sign of the city's long separation from its lakes—disproportionately impact those at its most vulnerable edges. In peripheral neighborhoods and informal quarters, the ground literally shifts beneath people's feet, while water, sometimes absent or invasive, determines the pace of daily survival. Here, environmental danger is closely tied to social vulnerability. The terrain of hazard becomes a terrain of injustice, where the landscape of inequality mirrors the shape of the old lakebed.

These patterns are neither accidental nor recent. They are the cumulative result of centuries of decisions that have favored certain landscapes and communities over others. The physical sinking of the city thus reflects a moral and political decline—an erosion of equity, governance, and trust.

While recent efforts, such as ecological restoration projects and urban design strategies, seek to reconnect the city with its hydrological past, their success depends on recognizing the deep interdependence between land, water, and people. Restoring balance in Mexico City is not just about managing drainage or water supply but about reimagining a relationship with the landscape that sustains us and, at times, opposes us.

Yet amid the concrete sprawl and fractured earth, the memory of the lake endures. It breathes through the mists rising from stormwater channels and through the gentle give of the ground after rain. The city, caught between drought and flood, listens—however faintly—to the heartbeat of the land beneath it. In this dialogue of soil and sky, Mexico City remains both wounded and witness, both ruin and renewal. Texcoco weeps, yes—but its tears are the promise of renewal, a reminder that every landscape, no matter how scarred, holds within it the memory of balance and the potential for healing.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2022–23. Hao Wang, Xinyi Wang, Yiwen Wang, and Huiyuan Zhang wrote the initial paper during the course, with Denise Piccinini and Laura Cipriani supervising the project. Hao Wang, Xinyi Wang, Yiwen Wang, and Huiyuan Zhang also prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the paper. Finally, a native English speaker reviewed the text.

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Land Reclamation Site Data

Location
Panama Canal | Panama
Coordinates
9° 7' 55" N | 79° 41' 13" W
Area
1,432 km2
Length
65.00 km
Time
1821-2024

4 | Unlocking Locks

Mud, Power, Tears, and Engineering in the Panama Canal

Charlotte Delobbe, Ana Paula Duarte de Oliveira Post, Stelina Tsalapati, Svana Rún Hermannsdóttir, Wieke van Ulsen
Laura Cipriani

The Panama Canal is an 80-kilometer waterway that connects the Atlantic and Pacific Oceans across the Isthmus of Panama. France started its excavation and it was later completed by the US, which administered the canal until transferring authority to Panama in 1999. The project arose from the longstanding interest of investors, engineers, and Spanish colonists in creating this shortcut to avoid lengthy routes around South America, establishing Panama as one of the world's most crucial maritime links. The construction phase included land and water reclamation activities at various locations on the Isthmus for multiple purposes, such as building and expanding cities, neighborhoods, water dams, breakwaters, and barriers. The extensive excavations and dredging yielded millions of cubic meters of soil and other materials, which were used to reclaim significant areas that are vital to Panama today. This chapter explores the history of the Panama Canal by examining the environmental, social, and political contradictions involved, offering a critical overview of this modern marvel and ultimately discussing potential future expansions of the canal. Is it time to 'lock' the expansion and work with the current structure?

Introduction

The Panama Canal is one of the world's most remarkable engineering projects. Built in the 19th and 20th centuries, it connects the Atlantic and Pacific Oceans in order to facilitate trade. This article explores various instances of land and water reclamation during and after the construction of the Panama Canal, highlighting both their positive and negative effects on the social and natural environments. Like other land reclamation initiatives that create new land in the sea, the canal serves a similar purpose. Workers excavated materials, soil, and rocks to create a passage for ships and goods. Enormous machinery was essential to meet the economic demands of this new infrastructural waterway. Meanwhile, some of the excavated materials were transported and deposited along the coast to aid in the development of Colón and the expansion of Panamá City. Thus, although we often refer to the Panama Canal using terms like 'construction' and 'expansion,' it is, in fact, a form of water reclamation project. The chapter is organized into four subchapters, each named for a 'Lock,' representing the physical locks of the Panama Canal that raise boats from sea level to a higher elevation (or vice versa). The 'Lock I' subchapter narrates the story of the canal's construction and the efforts to achieve a successful conclusion. A timeline at the end of this section highlights the most significant historical moments, organized to emphasize the French, US, and Panamanian phases of canal ownership. The 'Lock II' subchapter explains how the technical work was conducted and the tools employed. The 'Lock III' discusses the urbanization and perceived benefits accrued during construction, primarily focusing on the cities at the opposite ends of the canal: Colón and Panama City. Finally, the 'Lock IV' subchapter examines potential future expansions of the canal and their environmental implications. Is there a point at which we should 'lock' further expansion and work within the existing structure?

The chapter adopts a multiscale approach to understand the project's various layers and social effects, ranging from the city scale to the country scale and vice versa. The methodology includes a literature review of scientific papers, books, articles, reports, and documents from government sources and websites, which we used to understand the complexities of the canal's construction and development. Additionally, we viewed videos to gather information on the social effects during the construction phase. The chapter also incorporates a 'research through design' method using QGIS (Quantum Geographic Information System) cartography and satellite imagery. We conducted interviews with Manuel Trute, an urbanist from Panama City, and architects David Rodriguez and Orlando Costa from the Panama Canal Authority, and them incorporated into the research methodology.

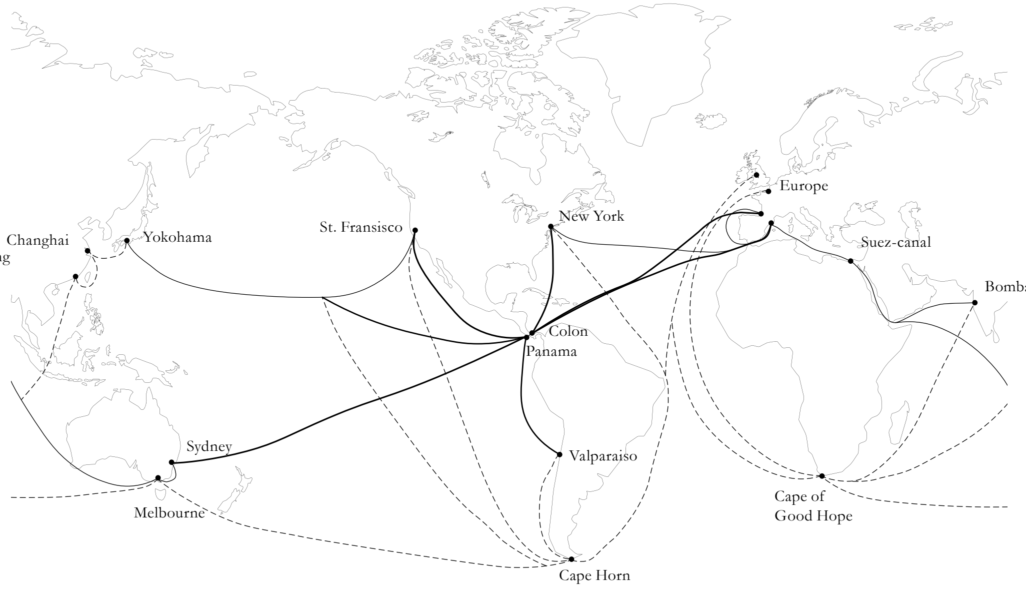
Lock I: The First Attempt at Land Reclamation

The narrow Isthmus of Panama was formed more than 10 million years ago, separating the Atlantic and Pacific Oceans (Buchs et al., 2019; Harmon, 2005). When Spanish colonists, guided by Vasco Núñez de Balboa in the 16th century, arrived in Panama, they recognized the potential to connect these two oceans (A&E Television Networks & History.com, 2015). The Isthmus was a familiar region to them, as they crossed it to transport goods and Peruvian silver to the ports of Colón and Panama City, from where these commodities were shipped to Europe (Keiner, 2020). Following a survey ordered by Charles V, King of Spain, the project was deemed unfeasible at that time (Boardman, 1910). This concept remained dormant for 300 years while Panama gained independence from Spain and became part of Colombia.

In France, a few decades before canal construction began, the economy thrived, and the country experienced significant technological advances, including railroad expansion and the telegraph. The government sought to demonstrate its power and ability to 'achieve great deeds without war.' One such achievement was the French engineers' completion of the Suez Canal under Ferdinand de Lesseps. This engineer also revived the idea of connecting the Atlantic and Pacific Oceans via the Isthmus of Panama. Ferdinand de Lesseps asserted that constructing a canal there would be easier than at Suez, primarily due to the shorter distance (Phillips, 2021). However, initially, de Lesseps and his associates considered an alternative site for the crossing. They proposed crossing Lake Nicaragua in Nicaragua, but this met strong opposition because it served as Central America's most important freshwater source (Campbell, 2016).

Aspiring to be the first engineer to construct a canal across the Isthmus, Ferdinand de Lesseps began designing the project. At the same time, the United States was also searching for a way to connect the oceans (Autoridad del Canal de Panamá, 2021a). The US began constructing a railroad in 1850, completing it in 1851. This railway was necessary for transporting people, materials, and supplies during the French construction of the canal (Bradley and Schwischer, 2014). It was planned to terminate at Colón, where the first land reclamation occurred. The French acquired Isla Manzanillo, near Colón, to establish a railway station. This large swamp was reclaimed using soil extracted from nearby Monkey Hill (Mount Hope). The railway cost $6,564,552.95 in total to construct (Panama Canal Railway Company, n.d.) and commenced operations in 1855 as the first interoceanic connection, proving to be heavily utilized and hence profitable. It transported more than $700 million in gold, but due to poor management, it went bankrupt in 1877 (Panama Vieja Escuela, 2020).

Trade Routes | World map illustrating potential trade routes for ships before and after the completion of the Panama Canal. Authors' work. Data: Compagnie Universelle du Canal Interocéanique de Panama and Erhard, 1886.



Trade routes including canals
Old trade routes

The first plan executed and approved by de Lesseps was for a sea-level canal in Panama. However, this strategy would prove costly for the French, as they realized during construction. Nicholas Joseph Adolphe Godin de Lépinay had already proposed a plan utilizing a set of locks to raise boats to artificial lakes with dams. This plan was initially rejected but was eventually successfully adopted by the US (Bradley and Schwischer, 2014).

With the logistics for construction established, the French began building the canal in 1881, hiring local inhabitants (natives) to clear the forest, as they were familiar with the area. Subsequently, canal excavations started, requiring a labor force from overseas. However, the project encountered multiple delays due to poor working conditions and technical challenges. Harsh labor conditions, coupled with tropical diseases like malaria and yellow fever that were unknown to colonists at the time, resulted in a significant loss of life (approximately 24,000 fatalities). Furthermore, the Compagnie Universelle du Canal Interoceanique de Panama recognized that they needed help to solve technical issues, such as leveling the difference between the two oceans and expanding the Culebra Cut by 400 meters, which involved cutting through a hard basalt hill. These difficulties prompted the French to announce in 1889 their inability to continue with the project as a result of the financial issues that afflicted them (Autoridad del Canal de Panamá, 2021b).

When the French company went bankrupt, the US government offered $40 million to acquire concessions, rights, and equipment for building the Panama Canal. This agreement was finalized in 1903. US authorities were eager to establish a faster route for transporting goods and gold from California to the East Coast. They considered alternatives, including a route crossing the San Juan from the Atlantic to Lake Nicaragua to reach the Pacific Ocean. Although they designed this route, they faced political resistance (Boardman, 1910). In 1903, Panama gained independence from Colombia with US support—most notably from Theodore Roosevelt—under the terms of the Hay-Bunau-Varilla treaty (Phillips, 2021). The United States was granted exclusive rights to operate and control the Canal Zone (consisting of 8 km of land on either side of the canal), while Panama received a payment of $10,000,000 and an annual annuity of $250,000. The Americans resumed the unfinished work in 1904 and aimed to address the issues that led to the French failure (Cho et al., 1998). They implemented strict control measures against tropical diseases through intensive sanitation efforts to prevent further worker fatalities (Lasso, 2021). Acknowledging the excavation challenges faced by the French and the elevation differences between the Atlantic and Pacific Oceans, the Americans developed more effective solutions and techniques to tackle both problems (Cho et al., 1998).

The project was divided into three sections: the Atlantic, Central, and Pacific. Gatun Lake supplied water for the locks and Colon (Autoridad del

Canal de Panamá, 2021b). Because the lake would flood large areas used by the existing railroad lines, a new route was laid outside the inundated zones (BBC News Brasil, 2020). Engineer Gaillard (Gaillard, 1912) partially managed the excavation of the Culebra Cut, whose name was later used for this section of the canal. Heavy tropical rains caused frequent flooding during excavation activities in this area, resulting in continual labor loss. After numerous attempts to regenerate the excavation, they decided to tolerate flooding and instead began dredging in this section. This solution proved to be very successful.

Ultimately, the Americans completed the canal project in 1914 at a cost of $350 million and began profiting from it due to their complete control over operations. The US government maintained strict oversight of the canal and its surrounding area, known as 'La Zona,' ensuring its competitive edge in maritime traffic. As China's global influence expanded and operations declined in the 1970s and 1980s, the Panamanian population increased pressure on the US to return control of the canal to Panama. In 1977, the Torrijos-Carter Treaty was signed to gradually end US control, culminating on the last day of 1999 when Panama regained full authority over the canal (Cho et al., 1998). Since then, the Panamanian government has established the Panama Canal Authority, or 'Autoridad del Canal de Panamá' (ACP), which holds full responsibility for the canal. Ultimately, the country, recognized for one of the most remarkable constructions of the modern era, came to benefit from it.

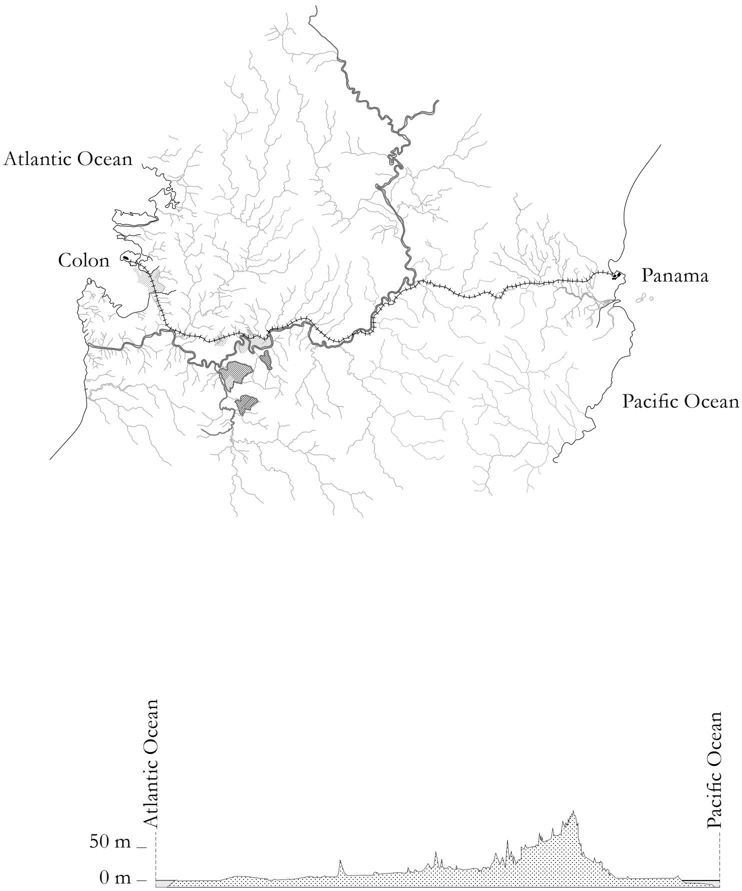
With the continuous advancement of technology and the rise in competition in the trading and shipping industries, new vessels have been designed and built with larger loading capacities to keep pace with the trend. The well-known Panamax vessels, which carry 4,500 TEU (Twenty-foot Equivalent Unit, a unit equivalent to one container 20 feet long), represented the maximum size permitted to pass through the existing locks. Logistics companies began demanding vessels with capacities of 8,000 TEU and beyond. Panama sought to maintain a competitive edge in the global landscape. Therefore, expanding and enlarging the current canal structure became essential (International Finance Corporation, 2016). Despite discussions about the environmental and social impacts of the expansion, in 2006, the ACP held a referendum in which the population voted in favor of the project. An expansion project costing $5.5 billion was approved, and architect Francisco Minguez designed a Master Plan. Unlike the previous locks, the new sets were engineered to reuse 60% of the freshwater consumed during vessel transit (Autoridad del Canal de Panamá, 2021c). This new system was selected alongside several modifications to the canal, such as raising Gatun Lake by 45 cm (to increase the water volume for the locks), constructing new locks at Miraflores and Gatun to accommodate post-Panamax vessels,

Above | The Panama Canal and its terraced landscape excavation on the left. Photograph by Brian J. Tromp, 2022.

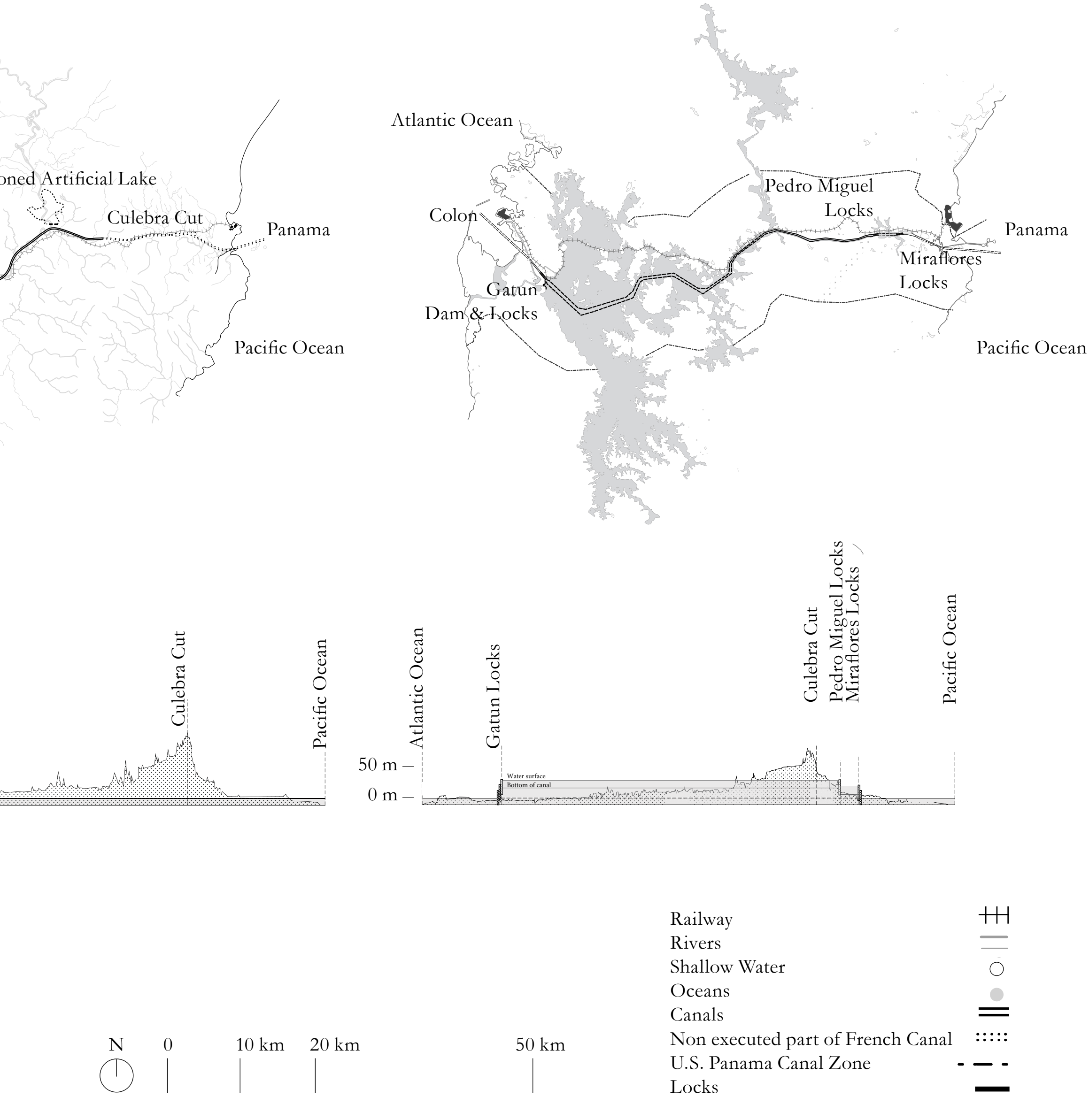

HAFNIA PEGASUS
KØBENHAVN
IMO 9461659

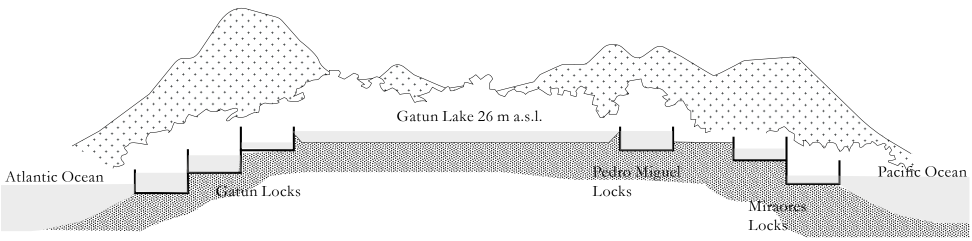
Original Watercourse Isthmus with Railroad | Construction 1850-1855. Authors' work. Data: Compagnie Nouvelle du Canal de Panama, 1890.

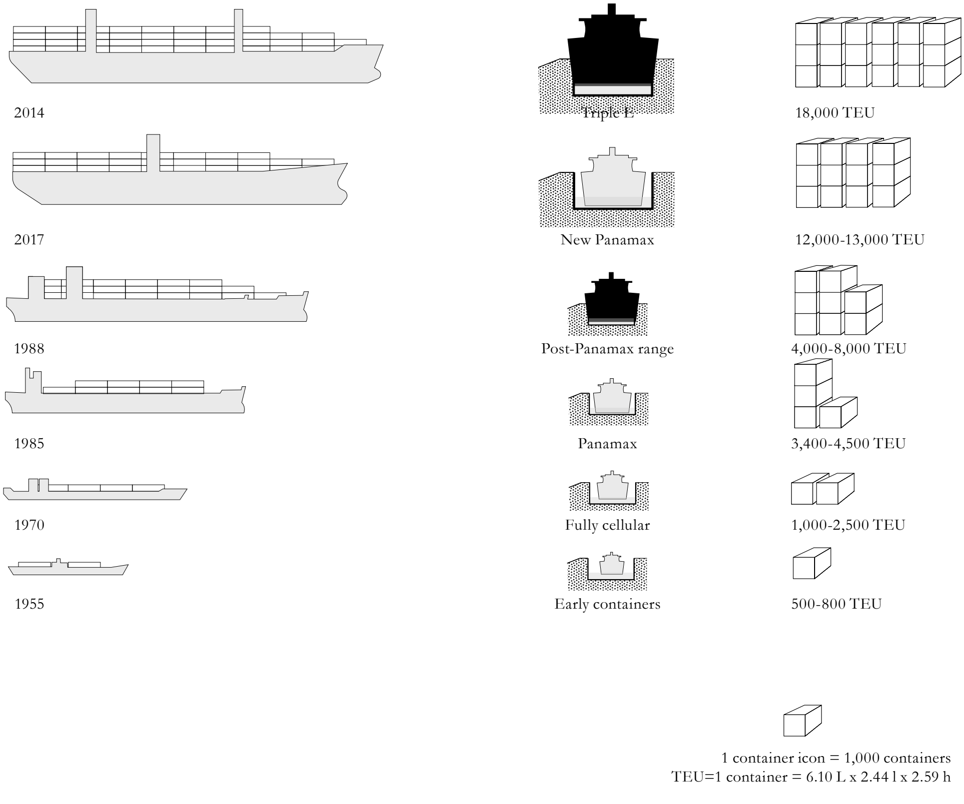
French Sea-Level Canal Plan | Construction 1881-1898. Authors' work. Data: Wyse and Bros, 1886.



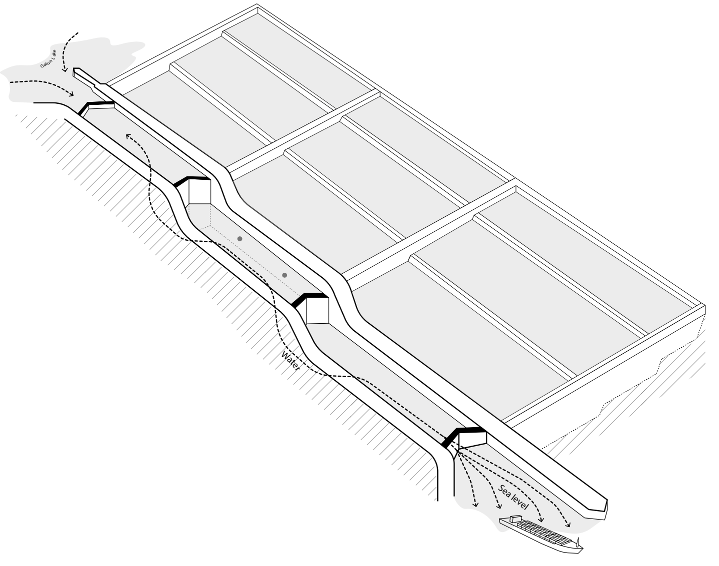
U.S. Canal Plan with Locks | Construction 1881-1898. Authors' work. Data: Hammond, 1911.

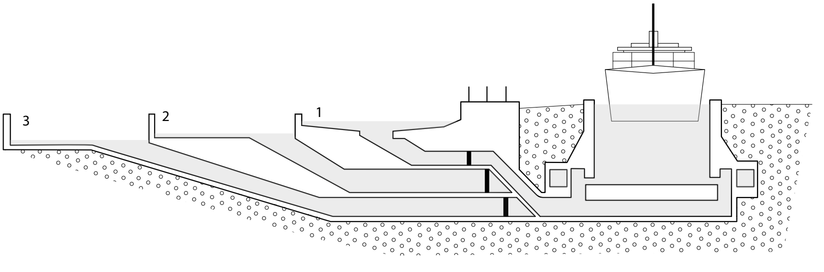






Canals and Vessels | The canal's expansion followed the vessel's growth. Authors' work. Data: Rabelo et al., 2012; Ryszard, 2016.





Water Reuse Basins | Water reutilization basins require 60% less water thancompared to previous locks. Authors' work.

and deepening the Gaillard Cut (Cho et al., 1998). The expansion was completed in 2016, reinforcing the Panama Canal Authority's competitive standing in the global maritime industry.

Lock II: Digging Through Topography

During the construction of the Panama Canal, various techniques were used to overcome the challenging environment. The combination of excavation, dredging, and land reclamation employed different methods and mechanisms. A significant amount of excess soil was generated throughout the excavation process, and despite numerous intended destinations for this soil, millions of cubic yards were carelessly discarded in the jungle. The excavated material also played an essential role in the infrastructure necessary for the canal's operation. Today, the dumping sites are more regulated; however, the Panama Canal still requires ongoing maintenance, with approximately 2.3 million cubic meters of material dredged annually (Herndon, 1977). Understanding the technical work performed, the tools used, the volumes of dredged land, and the current maintenance efforts in the Panama Canal are essential for comprehending the landscape transformations in the region.

Machinery and Equipment

When the French initially attempted to divide the Isthmus, they began by enlisting local Indigenous people to clear the tropical forest near Colón in preparation for excavating the canal. They employed a workforce equipped with essential tools such as machetes and pickaxes. They also used simple steam shovels, while railcars transported the excavated material to designated locations. Additionally, they used dynamite in areas of basalt rock. Their lightweight equipment needed enhancement for heavy work, and the French required an in-depth knowledge of the region, especially when they reached Culebra Cut, a steep mountain of basalt. Ultimately, the French excavated 57 million cubic meters of spoil.

After the French abandoned the project, the Americans took over. They gathered the equipment and machinery previously used by the French, including the steam shovel Marmot, which operated for a short time. They also introduced heavier machinery, such as railway tracks, engines, freight cars, and dump cars. Furthermore, they established telegraph and telephone communication systems. Major companies like General Motors were commissioned to manufacture specific construction machines. By leveraging the Industrial Revolution, machines replaced manual labor, boosting productivity and expediting construction. Ultimately, the US excavated 177 million cubic meters. The spoil was transported by railroad cars to designated dump sites. The excavation was carried out using Bucyrus steam shovels and a railroad crane capable of excavating 920 cubic meters of soil in an 8-hour shift. Lidgerwood, a historic American engineering company, loaded materials into locomotives and wagons. Dirt spreaders and track shifters were also used. One dirt spreader could accomplish the work of 5,000 to 6,000 men working by hand. A track shifter required only 12 operators instead of 600. A swinging boom was also employed to lift railroad tracks and adjust the train route prior to the formation of Gatun Lake.

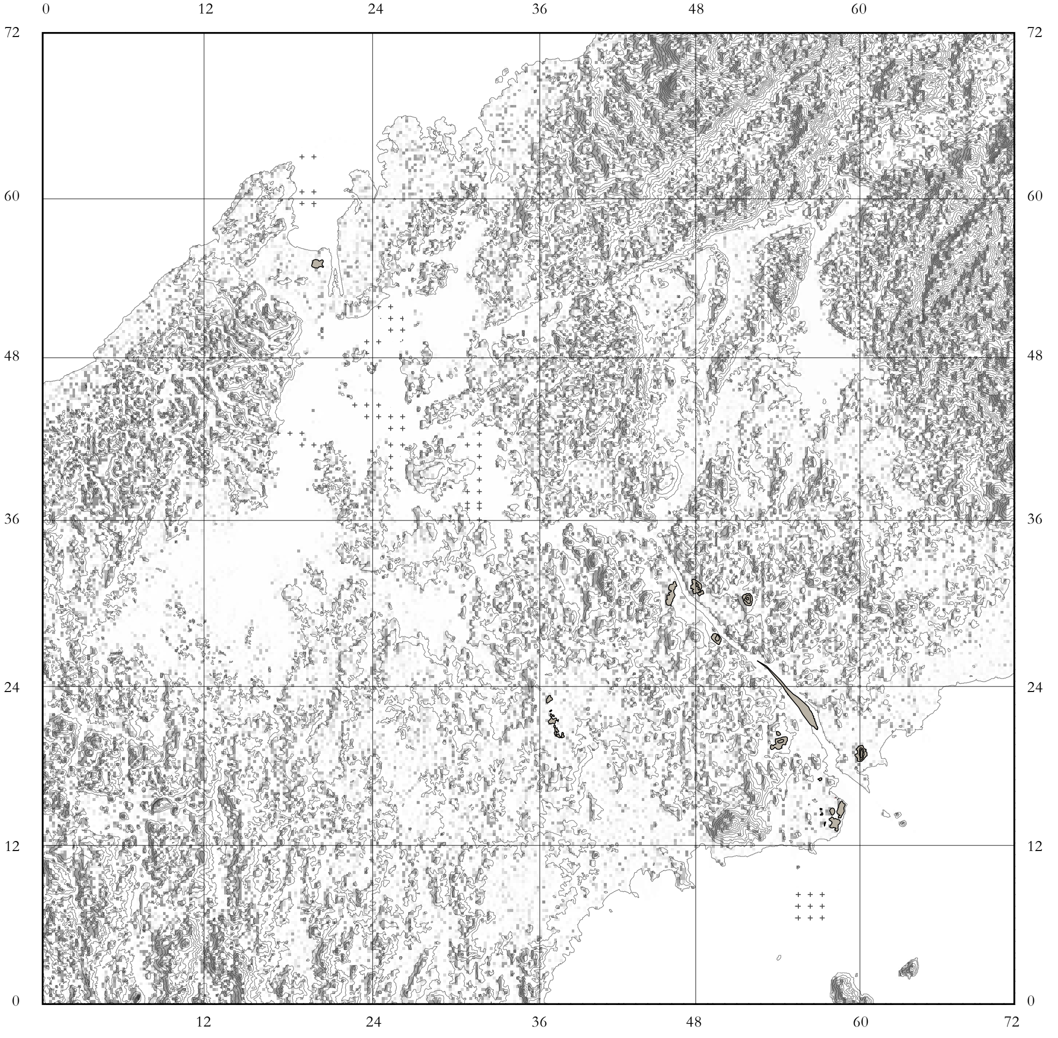
Nineteen million pounds of explosives were utilized, and materials were removed using 4,000 wagons, 160 locomotives, tugboats, and dredgers.

It is evident that techniques and equipment were applied differently for the post-2006 expansion than they had been in earlier construction efforts. The main concern at this time was to ensure the ongoing operations of the Panama Canal while undertaking the expansion. Drilling and safe explosives (which included special trucks and electronic detonation systems) were designed to minimize vibrations in the channel, which was continuously monitored with seismographs. Some of the equipment used for excavations includes: 2 Liebherr 984 excavators; 2 Hitachi ZX-870 excavators; 1 Hitachi 470 excavator; 1 Caterpillar 336 excavator; 20 Volvo A-40 Articulated Dump Trucks; 5 Caterpillar D6 and D8 bulldozers; 2 Volvo G-940 graders; and 2 CAT-988 large-wheel loaders.

Land Reclamation and Use of Excavated Material

The first reclaimed land comprised the Manzanillo swamps near Colón, where a railway station was constructed to facilitate operations during the canal's construction. Materials were extracted from Monkey Hill, which is adjacent to the swamps. Both the French and Americans excavated significant amounts of dirt and rock. The spoil removed by the French was used to create barriers along the canal and to reclaim land in Colón and near Panama City. In Colón, alongside the railway area and facilities for workers, a breakwater was built to ensure smoother access from the Atlantic Ocean. The French excavated over 57 million cubic meters of material before abandoning the project at Culebra Cut, with more than 14 million cubic meters mined solely in that region (ACP, 2006). The total of 177 million cubic meters excavated by the US, approximately 100,000,000 cubic yards of soil and rock, was employed for land reclamation on the Pacific side, sourced from the Culebra Cut. The breakwater, named Causeway, was constructed to prevent silt from obstructing the canal's entrance at Peninsula Amador and to serve as a barrier against waves and sea currents, facilitating vessel navigation. This project also linked the islands of Flamenco, Pericos, Naos, and Culebra, creating a defensive area during the world wars. Later, the Americans

Disposal Areas | Excavation material disposal sites are subject to study. Authors' work. Data: NextGIS, 2023; ACP, 2006.



N 0 5 km 10 km 20 km

Contour lines

Disposal areas contour lines

Disposal areas in water

Right | A barge is dredging in the Culebra Cut (Gaillard Cut) of the Panama Canal. Photograph by David Stanley, 2022.

developed it to accommodate military personnel and their families (ACP, 2006). Approximately 500 hectares of land were reclaimed in the same area to establish Fort Amador and Balboa, a model neighborhood adhering to American standards (Prozzo, 2016). The Miraflores Dam was built from previously excavated material, and was vital for the canal's overall functionality. Its construction was the primary reason for the formation of Lake Gatún. Initially, the French deposited soil in a nearby valley, which accumulated over time and caused issues such as landslides during the rainy season. American engineers later opted to repurpose this soil for the Gatún Dam, which held back water from the Chagres River, creating Gatún Lake. Over time, the soil continued to settle, thereby enhancing the dam's strength (Abdulhafedh, 2014). Completing the massive Gatún Dam was a significant achievement, equally as essential as excavating the Culebra Cut (William T. Taylor, October 1913). Lake Gatún was formed by a creating large earthen dam that spanned a two-mile-wide gap between two hills. When the waters finally reached the top of the dam, Lake Gatún became the largest artificial lake in the world, covering 164 square miles, with a shoreline of 1,100 miles. Gatún Lake now sits 85 feet above the Atlantic Ocean (Tikkanen, n.d.). The Canal's expansion was an ambitious project of Panama's government, supported by the favorable outcome of a national referendum held on October 22, 2006 (Moens and Verplanken, 2011). A comprehensive plan from the contractors was submitted to the ACP to ensure complete control of all operations, particularly regarding the disposition of the excavated material. The ACP's environmental policies clearly delineated the impacts the expansion would have.

The contractors planned the expansion in four phases: first, they would construct locks on the Pacific and Atlantic sides to allow post-Panamax vessels to pass through. Second, they would excavate 6.1 km of the northern approach channel leading to the new Pacific Post-Panamax locks complex. Third, they would dredge the existing navigation channel to accommodate large vessels traversing the Isthmus. Fourth, they would raise the level of Gatún Lake by 45 cm to improve water supply and reduce potential droughts (Moens and Verplanken, 2011).

The companies hired to execute the work focused on dry excavation. As explained by the Jan de Nul Group from Belgium at that time, '*Since the area to be excavated is connected with the existing Canal, the project will be executed using a combination of dry equipment and wet dredging equipment (i.e., Cutter Suction Dredgers and Backhoe Dredgers). The challenge is to optimize the methodology and working sequence to provide the most economical execution method. The wet dredging equipment will be utilized at the end of the project to excavate the remaining link (dykes) between the excavated area and the Panama Canal*' (Moens and Verplanken 2011, p. 5).

The excavation statistics are impressive and can be summarized by area of work. On the Pacific side, Paraiso Hill was leveled from 136 to 27.5 meters high in two phases, resulting in a volume of 15.3 million cubic meters and an additional 26 million cubic meters of unclassified material. The course of the Cocoli River was diverted by 3.5 km, producing 7.4 million cubic meters of material. To separate Miraflores Lake from the new channel, the 2.3 km Borinquen Dam was constructed. The Pacific entrance had to be widened to a minimum of 225 meters and deepened to 15.5 meters, yielding 8.7 million cubic meters of material (Moens and Verplanken, 2011). Gatun Lake was raised by 45 cm, flooding some nearby forest areas. Its northern access was dredged, removing 4.6 million cubic meters of spoil. The Atlantic entrance was deepened to 16.1 meters and widened to a minimum of 225 meters, with 17.1 million cubic meters of dredged material deposited. Access to the new set of locks was deepened to 15.5 meters (Moens and Verplanken, 2011).

The expansion also involved extensive drilling and blasting activities, which were categorized into three types: underwater drilling and blasting, dry drilling and blasting in 9-meter benches, and dry drilling and blasting in 18-meter benches. This planning facilitated the removal of all spoils. As previously noted, these activities did not interfere with the Canal's normal operations, which is one of the project's main achievements.

To manage the material from excavations, dredging, drilling, and blasting, ACP designated the dump sites for the contractors, who were required to submit a detailed plan for prior approval. No adverse environmental impacts were tolerated; therefore, all activities were closely monitored. ACP identified four locations:

- W4, at a hauling distance of 2 km: a capacity of 620,000 m³ for hard rock material.
- W5, at a hauling distance of 4 km: a capacity of 2,800,000 m³ for all types of excavated material.
- Escobar, at a hauling distance of 1 km: a capacity of 2,300,000 m³ for all types of excavated material. (A containment bund was constructed in this area using material from W4 and W5 to prepare it for receiving dredged material, with approximately 1,300,000 cubic meters dredged and reclaimed here.)
- Peña Blanca: a marine disposal area at Gatun Lake designated for dumping material dredged by the Backhoe Dredger *Il Principe*, located 36 km away (Moens and Verplanken, 2011).

Maintenance

The Panama Canal requires ongoing maintenance to preserve its depth in the tropical climate. This includes dredging channels, scheduling lock overhauls, and repairing or replacing machinery (ACP, 2006). Due to heavy rainfall and unstable soils, landslides in the hills adjacent to Gaillard Cut have been a persistent issue since the canal's construction. Preventive and remedial measures have frequently been implemented to keep the channel clear, and a program was developed to stabilize its banks to redirect rainfall that could otherwise undermine its slopes. Since 1970, two significant slides have occurred: the first in 1974 and the second in 1986. In both cases, one-way traffic was enforced in the affected area. Approximately 2.3 million cubic meters of material are dredged annually at both entrances and along 13.6 km of the Gaillard Cut (ACP, 2006). The ACP decides where this material is deposited; it is currently placed in areas alongside the canal.

Lock III: The Urbanization and the So-Called Benefits

Urbanization was one consequence of canal construction, and cities at the opposite ends of the canal, such as Colón and Panama City, experienced the most significant growth. The creation of the Panama Canal required a workforce, primarily because the labor had to be performed by people rather than relying solely on machinery.

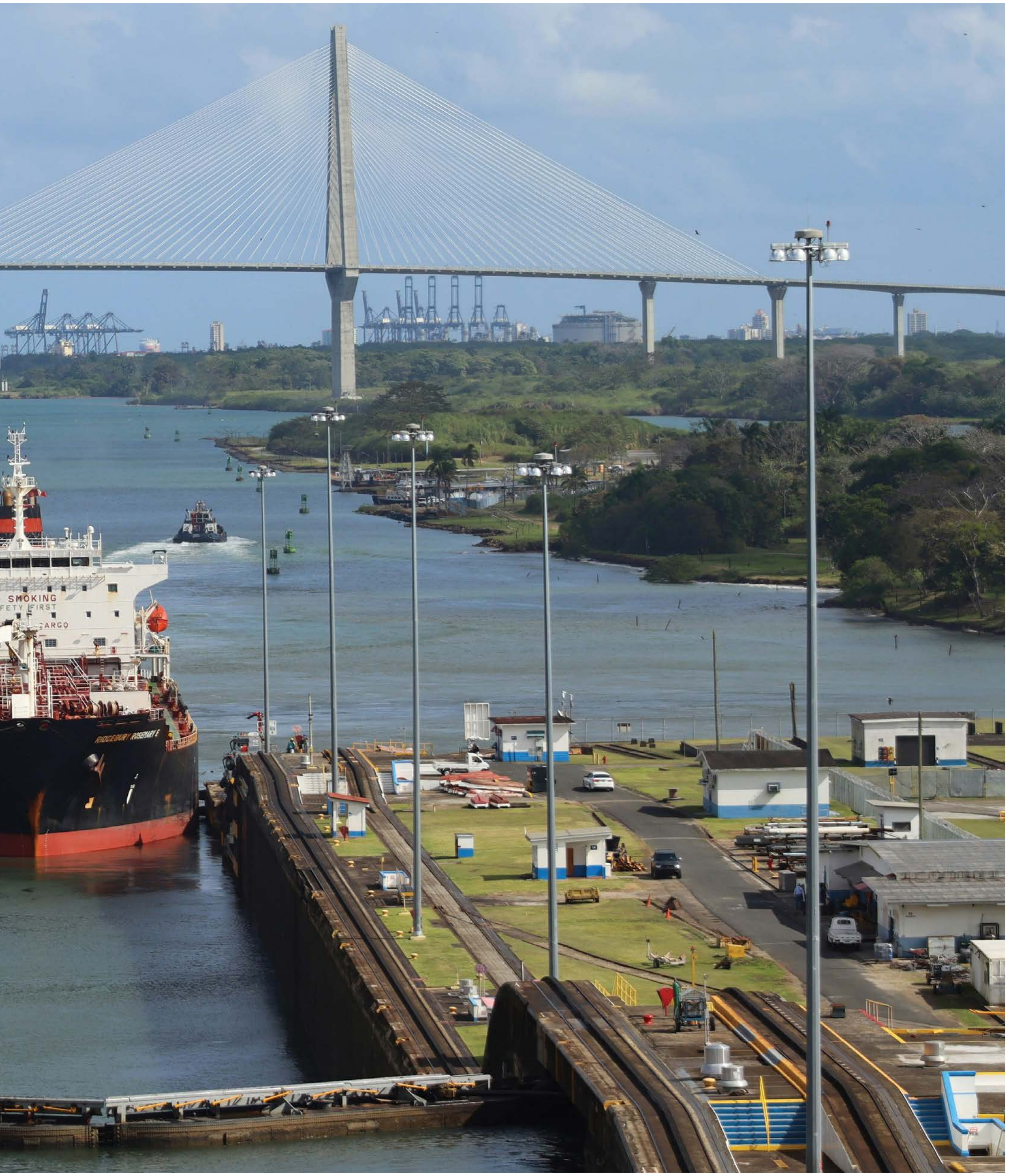
Historically, Panama attracted individuals from various regions around the globe. During the colonial period, enslaved people were brought in from Africa and China. When canal construction commenced, workers from Caribbean islands and neighboring countries left their homes to search for job opportunities in Panama (Hummer, 2003). The Isthmian Canal Commission (ICC), an American organization established in 1914 to oversee canal construction, reported that workers lived in '*dilapidated barracks*' (Lieffers, 2018). Living conditions were poor, and the working environment posed significant dangers. Factors like landslides caused by tropical rains and a lack of knowledge about excavation and spoil disposal led to numerous fatalities (Lieffers, 2018). Additionally, tropical diseases such as malaria, yellow fever, typhus, tuberculosis, and pneumonia spread rapidly, adversely affecting workers. During the French period, nearly 24,000 people died from these conditions (Lieffers, 2018). Journalist Arthur Bullard remarked that the project '*took liberties with nature*' (Lieffers, 2018).

The first actions taken by the Americans upon assuming control of construction were to address the diseases and develop a sanitation plan to improve conditions in Colón and Panama City (Lasso, 2021). They managed an area of 8 km on each side of the canal to oversee its construction. This region was governed by the Hay-Bunau-Varilla Treaty established in 1903 (Lasso, 2021). As construction progressed and more immigrants arrived in Panama seeking work, the primary challenge became relocating people from the villages within 'La Zona.' These areas were densely populated and built around the topography. The US government aimed to urbanize these villages, a goal that required substantial funding. The solution involved moving everyone outside of 'La Zona' (Lasso, 2021). Consequently, areas like Colón and Panama City were called 'pueblos,' indicating some degree of urbanization. The numerous villages within the canal zone were dismissed as 'native villages.' The inhabitants were labeled as 'natives,' implying they were disorganized residents who could be removed since there was no recognizable 'urban landscape'; in other words, there was nothing deemed worthy of preservation (Canal de Panamá, 2021). This was enforced by legislation, enacted by President William H. Taft, that was known as 'Despoblamiento.' Between 1912 and 1916, over 40,000 people were displaced from this area, leaving only military bases scattered in various locations (Lasso, 2019). Some villages were reestablished outside the zone, while others disappeared. Even the names of the relocated villages were changed; for instance, 'Gorgona' was relocated to a coastal area provided by the American government near Panama City and renamed 'Nueva Gorgona,' while 'Emperador' was changed to 'Nuevo Emperador.' New areas that developed because of the canal, such as Balboa, reflected an idealized American city, serving as a model for how all places should be. However, located immediately beside Balboa was La Boca. After the canal's construction, these regions exhibited stark segregation between the wealthy and the impoverished, as well as between black and white individuals. The pristine, urbanized Balboa became a neighborhood for white residents, while La Boca primarily served as the residence for black workers (Lasso, 2019).

Panama City, a modern and rapidly growing area, faces social inequity and a vulnerable landscape today, particularly after the 2016 completion of the canal's expansion (Aledo Tur, 2006). When construction finished, workers found themselves unemployed and living in slum areas or abandoned in the country. Locations like Colón, which experienced significant development during the canal's construction, now exhibit stark contrasts in their urban landscape: luxury hotels and exclusive neighborhoods in the forest, accessible only to a few tourists on one side, and numerous abandoned buildings on the other. This urban divide arose from the lack of employment, prompting people to migrate to the USA or to Panama City (Lasso, 2021; Lasso, 2019).

Mega projects like the Panama Canal raise questions about who truly benefits. Antonio Aledo Tur highlighted this issue as the canal expansion was about to begin. He argues that minorities will never have a voice to prevent major projects or instigate changes. In a top-down approach, the influence of investors and government interests will always prevail (Aledo Tur, 2006).

Above | The Panama Canal and the landscapes around it. Photograph by Alex Pagliuca, 2022.


SMOKING

Lock IV: When Is It Time to Lock?

Most major construction projects spark discussions. The construction of the Panama Canal occurred over various periods in world history, with decision-making concentrated in the hands of a few key individuals (Aledo Tur, 2006). Top-down projects of this scale inevitably generate social and environmental conflicts. The imposition of infrastructure significantly altered the original landscape (Lieffers, 2018). Interoceanic railways, breakwaters at the Atlantic and Pacific Oceans, dams on the Chagres River and at Miraflores, and the creation of Gatun Lake are among the interventions made in the natural landscape. Beyond the impacts of construction, other unforeseen environmental consequences arise from ongoing human activity in and around the canal, which is essential for maintaining the extensive infrastructure, along with dredging and disposal operations. The edges disrupt the soil, leading to ongoing rock erosion into the canal's depths. Dredging boats work to remove this soil runoff, relocating it to higher ground or depositing it in deeper waters, such as the ocean or Gatun Lake. Consequently, these effects are felt both locally and globally.

Significant landscape changes can also be observed in the forested region known as 'La Zona.' This densely vegetated area initially contained several inhabited villages that housed 62,810 residents in 1912, according to Marixa Lasso (Lasso, 2019). The landscape featured low-density vegetation surrounding the villages, which gradually transitioned into the adjacent forest, as illustrated by various photographs presented by Marixa Lasso during a conference about her book 'Erased' in 2021 (Lasso, 2021). Following the 'despoblamiento' triggered by the Taft Act (1912–1916), military bases became the only authorized structures in the 'La Zona' region. With daily human activity curtailed, the vegetation thrived under favorable natural conditions (Lasso, 2021).

The Panama Canal project has documented significant environmental changes (Appleton, 2015). In addition to the pollution generated during construction, regional climate shifts, alterations in land use, saltwater intrusion, and the introduction of invasive species have been noted. Andrea Appleton (Appleton, 2015) observed that some alien species traversed the canal, arriving in Panama concealed in cargo, where they found an inviting environment for proliferation.

Before the expansion began, assessments conducted by both ACP and contractors analyzed all potential impacts. Since then, ACP's policies have increasingly focused on addressing global environmental concerns (Autoridad del Canal de Panamá, 2021d). For instance, vessels continue to grow larger, which is a key reason for widening the canal. However, the shipping industry overlooks these consequences due to two factors:

few ports globally can accommodate super-sized vessels of 18,000 TEU, and the pressure to reduce reliance on fossil fuels is prompting companies to seek more sustainable vessels powered by LNG (Liquid Natural Gas) (ACP, 2006).

'*We at the Panama Canal are committed to sustainability and are laying the groundwork, creating tools, and identifying changes needed to achieve efficiencies that will allow us, as an organization, to reach carbon neutrality. This is a fundamental strategy for the waterway's long-term operation and sustainability*,' remarked Panama Canal administrator Ricaurte Vasquez Morales (ACP, 2021). He added, '*This process will build on our long-standing efforts to minimize our environmental impact, including encouraging customers to utilize cleaner fuels and reduce their carbon footprint* (ACP, 2021).'

For over 100 years, the Panama Canal has witnessed two contrasting approaches to transformative projects: one reflecting human pride in mastering and transforming the landscape at will, while the other, albeit on a smaller scale, tries to balance economic growth with social and environmental commitments. This latter, more recent approach leaves the door open to hope.

Conclusions

The Panama Canal exemplifies the contradictions of progress. Designed to connect two oceans and boost global trade, it serves as a living symbol of intertwined history involving ambition, dominance, and resilience. Its story—spanning centuries of colonial control, imperial ambitions, and national hopes—illustrates that every act of construction also involves displacement, erasure, and change. What became a marvel of engineering also fractured communities and reshaped ecosystems. Thus, the canal is more than just a route for ships; it is a journey through the moral and ecological challenges of modernity.

Its development—through French, American, and Panamanian phases—reflects shifting global capitalist hierarchies. Behind its shining locks and massive dams lie human costs measured in lives lost and voices silenced (Klein, 2021). Thousands of workers, many migrants from the Caribbean and beyond, suffered and died in pursuit of a dream of prosperity that often brought inequality (Aledo Tur, 2006). The 21st-century expansion projects echo these tensions, balancing profit with people, efficiency with ethics. Decisions remain concentrated among powerful players, while affected communities often remain on the margins, both geographically and in discussions.

Environmental impacts of the canal are equally profound. Its construction reshaped landscapes, redirected rivers, flooded forests, and disturbed fragile ecosystems. Ongoing dredging, soil disposal, and deforestation sustain cycles of artificial maintenance that threaten biodiversity. The landscape has become a living document—continually reworked and maintained by human hands—reminding us that such engineering feats are never static. They demand ongoing negotiation and compromise between nature and human intervention.

Today, as global trade expands and ships grow larger, the canal faces questions beyond its physical limits. How much can ecosystems endure under economic pressure? When should humanity recognize the need to 'lock' its ambitions—understanding that unchecked growth leads to destruction, not progress? These questions resonate worldwide where development conflicts with ecological sustainability, reshaping what is possible and acceptable.

Amidst this complexity, there is also a quiet undercurrent of renewal. The canal endures not as a static monument but as a living threshold where land and water, human will and natural force, meet and contend. Its endless tides reveal both scars of history and the promise of change. The waters that once divided now connect; the torn soil fosters new growth. Perhaps the true legacy of the Panama Canal lies not solely in its ability to shorten distances but in its reminder—that every act of creation reshapes the world, and even in the deepest cuts, the earth remembers how to heal.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2022–23. During the course, Charlotte Delobbe, Ana Paula Duarte de Oliveira Post, Stelina Tsalapati, Svana Rún Hermannsdóttir, and Wieke Van Ulsen wrote the initial paper, supervised by Laura Cipriani. Charlotte Delobbe, Ana Paula Duarte de Oliveira Post, Stelina Tsalapati, Svana Rún Hermannsdóttir, and Wieke Van Ulsen prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the chapter. Finally, a native English speaker reviewed the text.

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Land Reclamation Sites Data

Location
Galgeplaat | Eastern Scheldt | Netherlands
Coordinates
51° 34' 6" N | 3° 55' 50" E
Area
0.19 km2
Diameter
0.45 km
Time
2008-2011

Location
Marker Wadden | Ijsselmeer | Netherlands
Coordinates
52° 34' 59" N | 5° 22' 10" E
Area
7.00 km2
Length
4.40 km
Time
2016-2021

5 | The Nature of Design

Can Land Be Reclaimed and Built with Nature?

Xenia Georgiadou, Eva IJzermans, Teresa Lacigová, Sanne Maring,
Hugo Mohr
Laura Cipriani, Denise Piccinini

For centuries, the Dutch have prioritized controlling water flows and reclaiming land as part of their cultural heritage. While their sophisticated engineering methods have received global recognition, they have also led to unintended adverse effects on local ecosystems. Recently, a new approach known as 'Building with Nature' has prompted several land reclamation initiatives in the Netherlands aimed at ecosystem restoration. This chapter will critically assess this design principle by examining the Marker Wadden and Galgeplaat case studies, and will analyze the origins, motivations, core principles, and ecological implications of 'Building with Nature' design.

Although the reviewed projects are portrayed as innovative ecosystem restoration efforts, we will uncover various, more nuanced elements of these narratives: the ecological impacts tend to be limited, and notable debates emerge throughout the project lifecycles, as they demand ongoing human intervention. Design is not merely about building with nature; it involves persistent and often contentious human engagement.

Introduction

The Netherlands has long been shaped by its complex relationship with land and water. Centuries of human effort have molded not only its physical landscape but also its cultural identity. This history dates back to the Middle Ages, when communities began draining peatlands using a network of trenches. This process reclaimed land from what were once called ‘swamp monsters’—the thick, toxic fogs rising from wetlands into nearby villages. These vapors resulted from the decomposition of organic material in waterlogged, oxygen-poor soils, releasing methane and sulfur gases.

Over the centuries, land reclamation became one of the Netherlands’ most transformative practices. By the seventeenth century, advances in engineering and hydrological management enabled the conversion of entire lakes into habitable land. This transformation radically changed the western regions of the country, creating a landscape marked by deep polders and constant negotiations with water. Today, nearly half of the Netherlands lies below sea level, making it especially vulnerable to storm surges and flooding.

To protect these low-lying areas, a complex system of dikes, windmills, and modern pumping stations has been developed. Responsibility for maintaining this extensive network is shared among regional water authorities, municipalities, and national agencies. However, even this advanced infrastructure has faced challenges. Throughout history, the Netherlands has endured devastating floods that have tested its resilience.

One of the most significant was the 1916 flood of the Zuiderzee, a lagoon-like inland sea. A fierce northwesterly storm pushed water into the basin, overwhelming its defenses. Dikes failed, villages flooded, and lives were lost. This tragedy revealed that flood protection needed to extend seaward, beyond near-shore barriers. As a response, a plan was introduced in 1913 to close off the Zuiderzee, creating freshwater reserves and recreational spaces (Stichting Delta Werken, 2004). Construction began in 1920, culminating in the Afsluitdijk, completed in 1932—a massive 2.5-kilometer-wide dam that transformed the saltwater lagoon into a freshwater lake, now known as the IJsselmeer (de Afsluitdijk, 2021). This engineering achievement marked a new chapter in Dutch water management, and the former seabed of sand and exposed clay patches remains visible today (IJsselmeervereniging, 2023).

Another major event was the catastrophic flooding of January 1953 in the southwestern Netherlands (Stichting Delta Werken, 2004). A storm surge breached multiple dikes, flooding 150,000 hectares and submerging entire communities. This disaster underscored the urgent need for comprehensive flood protection. In response, the government established a national committee that designed what would become the Delta Works—a vast network of storm-surge barriers, sluices, and dams built over three decades. These structures significantly enhanced coastal defenses and evolved to support ecological functions, such as allowing fish migration and mixing freshwater with saltwater.

These engineering projects not only protected human settlements but also altered natural systems in unforeseen ways. Recognizing these impacts, Honzo Svasek introduced a new approach in 1979 known as 'Building with Nature' (BwN). This method shifted from traditional 'engineering against nature' to using natural forces as partners in water management, emphasizing sustainability, ecosystem recovery, and the integration of human and natural processes.

This chapter explores how 'Building with Nature' principles are applied in land reclamation, focusing on projects aimed at restoring ecosystems rather than simply expanding human land. Two examples are central: the Marker Wadden and the Galgeplaat. The Marker Wadden comprises five reclaimed islands within the Markermeer, covering about 800 hectares. It serves as a wildlife sanctuary and a pilot project for improving water quality and biodiversity, while also providing public amenities such as a harbor, walking trails, and visitor facilities (Tameling, 2019). In Zeeland, the Galgeplaat features a circular sand nourishment structure built in 2008 to combat erosion of tidal flats and support the local ecosystem.

The first section explains the theoretical foundations of 'Building with Nature'—its origins, principles, and relation to other nature-based engineering approaches—while addressing concerns about 'greenwashing' in sustainability discussions. The subsequent sections analyze the ecological context of the projects before reclamation and assess their environmental impacts. Ultimately, the chapter questions whether 'Building with Nature' truly fulfills its promise of aligning human engineering with natural resilience.

Research for this chapter employed a variety of methods. Semi-structured interviews provided recent, context-specific insights, allowing participants to share perspectives beyond predefined questions (Punch, 2014). Interviewees included an environmental activist scrutinizing the materials used in the Marker Wadden and a civil engineering professor critical of its construction approaches. These insights, combined with documentary and scientific sources, contributed to the development of a comprehensive understanding of the case studies.

A Growing Design Approach

What is 'Building with Nature'? Where does this term originate? How does the 'Building with Nature' concept apply to land reclamation?

In 1979, Honzo Svasek officially developed the water management approach known as 'Building with Nature.' In practice, the reclamation of land formed by sediment deposits, often inadvertently caused by human activities, has occurred for much longer. Land reclamation driven by natural processes has repeatedly occurred throughout history, including by means of strategic water management, such as allowing enemy canals to dry up or constructing barriers to prevent significant silt accumulation in major channels (Branagan, 2020). In addition to these 'accidental' land reclamation efforts based on nature's responses to complex engineering, water managers and coastal designers adopted a 'powered by nature' approach even before Svasek coined the term. Martens (2017) notes that 'Building with Nature' draws from the 'Ecological Engineering' (EE) approach, which encourages scientists to engage with nature to actively generate social and ecological benefits—a practice that began in the 1830s (Anderson, 2002). Despite these similarities, a unique aspect of 'Building with Nature' is its focus on the 'local situation,' whereas 'Ecological Engineering' was applied and implemented in various locations (Davis and Cornwell, 2013).

Martens (2017) asserts that lessons learned from 'Ecological Engineering' indicate that the success of 'Building with Nature' originates from the emergence of sustainable awareness movements in the 1970s, which prompted developers to move away from the limited perspective that saw water systems as merely supporting industrialization. While the underlying principles remain similar, the 'Building with Nature' approach rests on three main pillars, enhancing the 'Ecological Engineering' methodology. These pillars are Nature, Humans, and Engineering. Martens (2017, p.16) offers two definitions for the Nature pillar: hydro-morphological processes (the Abiotic environment) and ecological processes (the Biotic environment). Both formal and informal governance elements define the Human pillar. Lastly, the Engineering pillar includes the human interventions that impact the natural system.

Until 2008, Svasek's approach remained largely theoretical. After presenting this theoretical framework, Ecoshape tested it from 2008 to 2012 for two Dutch dredging companies: Royal Boskalis Westminster and Van Oord (de Vriend and van Koningsveld, 2012). The testing included several pilot schemes covering land reclamation projects, which involved various soil types. Through extensive testing, a five-step guideline was established in 2010 to support the conclusions of the 'Building with Nature' approach. Although viewed as an extension of 'Building with Nature,' the guidelines that remain relevant today are referred to as *The Guidelines for Eco-Dynamic Development and Design* (EDD) (van Koningsveld and van Raalten, 2011). In 2012, de Vriend and van Koningsveld (2012, p. 36) outlined the five steps. The first step is understanding the system (ecosystem service, value, and interests). The second step involves identifying realistic alternatives that utilize and provide ecosystem services. The third step evaluates the qualities of each alternative and selects an integral solution. Step four focuses on fine-tuning the selected solution, considering practical restrictions and governance. Finally, the fifth step prepares the solution for implementation in the following phase.

In parallel with 'Building with Nature,' the World Association for Waterborne Transport Infrastructure (PIANC – formerly the Permanent International Association of Navigation Congresses) developed a new design approach for projects called 'Working with Nature' (WwN) in 2008. PIANC explains that although this design approach is similar to 'Building with Nature,' 'Ecological Engineering' (EE), and other related methods, WwN is genuinely sustainable (PIANC, 2008) in a way that suggests 'Building with Nature' may not be. They assert that 'true' sustainability can be found in their approach, as the primary goal of WwN projects focuses on ecological objectives, such as restoring damaged habitats (Aiken et al., 2021). While this assertion seems valid, companies utilizing the 'Building with Nature' approach appear to pursue similar goals, as demonstrated by the design projects of the Marker Wadden and Galgeplaat.

Engineering With Nature (EWN) is a method developed by the U.S. Army Corps of Engineers (USACE, n.d.), which defines its approach as follows: '*Engineering with Nature is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration*' (USACE, n.d.). This definition closely resembles those provided for 'Building with Nature.' Unlike PIANC's strategy, we found no mention of 'Building with Nature' on USACE's web pages or in the literature we reviewed about them.

Recently, a Dutch consulting and design firm, Witteveen + Bos, summarized all nature-based solution terminology in one article—including PIANC's 'Working with Nature,' USACE's 'Engineering with Nature,' 'Ecological Engineering,' and 'Building with Nature'—analyzing the definitions like the ones used by Chiu (Chiu et al., 2019). According to this review, 'Building with Nature' is the most inclusive approach, encompassing the following keywords: Nature/Environment, Economical/Cost-efficient, Engineering/Technical, Social, Sustainable/Resilience, and Adaptable/Flexible. The only keyword noted as missing in this article is restoration.

Overall, the philosophy behind 'Building with Nature' is that coastal development happens for human or economic reasons. However, it should be implemented with consideration for nature and sustainability. Other companies and articles do not support PIANC's claim that only 'Working with Nature' is a sustainable approach. More clearly stated, based on Witteveen + Bos's findings, PIANC's approach also seems to lack sustainability, and its exclusive focus on restoration is unsubstantiated. The USACE approach appears to be quite similar to 'Building with Nature.'

Examining the concept of 'Building with Nature' in land reclamation by exploring its origins, and investigating in more depth the underlying philosophy aids in evaluating the approach. What is 'Building with Nature'? To define the strategy in a structured manner, we will refer to Ecoshape's statement: '*Building with Nature is a design approach to develop Nature-based Solutions for water-related infrastructure, such as flood defenses, sustainable port development, and ecosystem restoration. It leverages the forces of nature to benefit the economy, society, and the environment. Through the BwN approach, we can create sustainable infrastructure and contribute to sustainable development goals*' (Ecoshape, 2022). Despite 'Building with Nature' being a much more extensive design approach, this paper will focus exclusively on ecosystem restoration. After exploring the purpose of the 'Building with Nature' approach and the various definitions provided by scientists, this paper will try to understand how it harnesses the forces of nature to benefit society and the environment. Finally, the research will encompass the development of sustainable infrastructure that contributes to sustainable development goals.

In this chapter, 'Building with Nature' refers to a design approach for developing sustainable solutions to restore ecosystems, enhancing the forces of nature to benefit society and the environment. We will test this definition by evaluating two 'Building with Nature' land reclamation projects in the Netherlands to determine whether it fulfills its promises.

Forcing Nature's Hand

The Dutch have a long history of managing ecosystems for their benefit, and have often seen nature as something to control. This viewpoint has led to unforeseen consequences, particularly in two areas of the Netherlands undergoing significant changes and requiring new solutions. This chapter will detail these two projects, the Marker Wadden and the Galgeplaat, and explore the materials and principles of 'Building with Nature' that were utilized in their development.

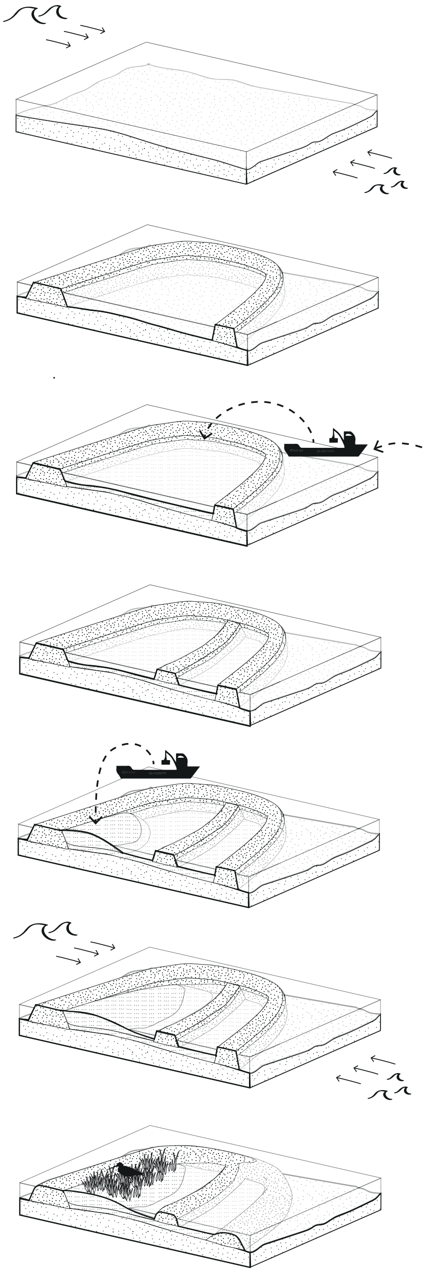
The Marker Wadden

The story of Marker Wadden began with the construction of the Afsluitdijk. The government planned to utilize the enclosed lake area for five land reclamation projects, including the Markerwaard Polder (Omroep Flevoland, 2020a). The initial step in this endeavor was to create the Markermeer by building the Houtribdijk dike in 1976 to define the boundary of the land reclamation project. The development of the new polder was halted due to significant negative impacts on the bird population and the risk of drying out the mainland (Rijkswaterstaat, n.d. a). The Markermeer was established to remain in place, although the construction of various dams and dikes has profoundly altered the water body, disrupting the natural water flows that once existed in the area.

From a hydraulic perspective, the Markermeer can be described as a weak dynamic system, as the lake is nearly closed. Water flows in and out from various sources, primarily influenced by wind and soil configuration (Royal HaskoningDHV, 2014). The lake's bottom reaches 2 to 4 meters, causing water to flow significantly more slowly at the bottom than on the surface where the wind acts. This current generates an undertow that carries silt to the lake's bottom. Even with a dominant wind blowing from the south/southwest direction (Bestemmingsplan Markerwadden, 2013), variations in direction and speed create complex water flows (Royal HaskoningDHV, 2014). These water flows, in turn, impact sedimentation, with the highest levels occurring in the lake's central area.

Furthermore, the complex and constantly changing flows result in murky water, as turbulent conditions lead to high sedimentation levels (Verdonschot, 2020). Due to excessive sedimentation, the water quality was so poor that it caused the ecosystem to collapse. The thick layer of silt, the absence of natural shorelines, and natural shallow areas led to the death of fish, plants, and shellfish. Consequently, bird populations dependent on these dwindling species have also declined, with some species seeing reductions of up to 75% (Natuurmonumenten n.d.).

The Marker Wadden was designed and developed to restore the value of the local ecosystem and enhance the water and soil quality of the Markermeer. The Rijksoverheid, Natuurmonumenten, and the Province of Flevoland funded the Marker Wadden project, which Royal Boskalis constructed. In 2016, the construction of the first five islands began, with two additional islands scheduled for completion by 2023 (Natuurmonumenten, n.d.), covering an area of 1,300 hectares (Havermans, 2021). The design considers various wind directions and water currents (Vista, 2021). At the specific location of the Marker Wadden, water strikes the Houtribdijk and flows back into the lake, leading to turbulent waters of low ecological quality. The Marker Wadden implements the 'Building with Nature' principle, with the islands built to integrate these natural flows and utilize them for environmental purposes. Moreover, the project is distinctive for using sand and minimal hard materials for its foundations, while silt and clay are dredged to form islands on a silt and clay base (Boer, 2022).



Natural water flows before the project

Construction of an outer sand dike

Dredging silt into the sand outline

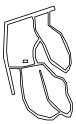
Construction of the inner dike

Dredging silt into the inner part

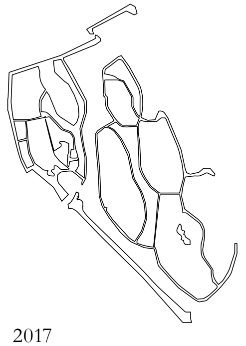
Silt is redistributed by water flows

Drying of the upper layer and development of the ecosystem

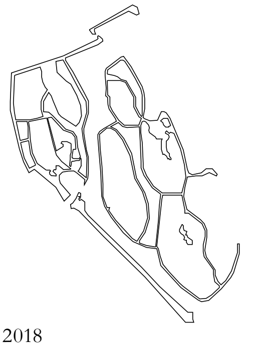
Developing Marker Wadden | Above, schemes of development. Right, the development of the Marker Wadden. Authors' work. Data: Topotijdreis, 2022.



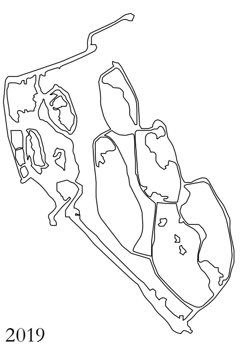
2016



2017

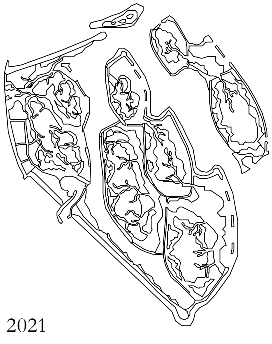


2018

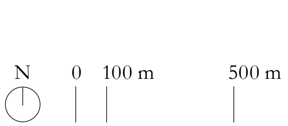


2019

2020



2021



Left and Right | Observation towers at Marker Wadden. Photographs by Laura Cipriani, 2022

The dominant southwest wind mainly affects the 'arms' of the island group. This effect is alleviated by constructing a sandy shore and a ridge of dunes 4 to 5 meters high (Veenstra, 2016). Behind this shore, calmer waters allow silt to settle. The other islands are situated on the leeward side of these 'arms' and are formed with sand dams. A sand dam outlines the island and is filled with dredged clay and silt. This method creates height variations and waterways across the island, as larger clay particles settle near the pumps and lighter ones land further away. The subsequent construction phase allows the top layer in a small section of the island's outline to dry out. Birds can then use this crust, which becomes the foundation for various plants (Vista, 2021). The resulting landscape features height variations that support diverse habitats for plants and fish. The waves that recede from the Houtribdijk generate a dynamic water system as they flow into the area from the north. This intricate engineering can be traced back to the dams built using dredged material. The objective is for the existing water and wind flows to keep shaping the island and the various ecosystems designed to flourish there. This system can even show water level differences of 20 to 30 centimeters, which is why they are also called '*windwadden*' (wind mudflats) (Veenstra, 2016). Finally, the existing and newly constructed sand dams provide different pathways for foot traffic, highlighting another crucial function of the Marker Wadden: tourism (Vista, 2021).

Overall, settling on a plan is theoretically challenging. However, the construction of the Marker Wadden has ignited controversy, particularly regarding its location and the materials used. Activist Annemieke van Straaten embarked on a journey to uncover the origins of all the materials used in the Marker Wadden. After conversing with her, she shared her ongoing efforts with a team of journalists. By requesting all documents related to the construction of the Marker Wadden from the government through the 'Wet Openbaar Bestuur' (WOB), she gained detailed insights into the materials employed. She discovered that the sources of these materials differed from what was initially claimed, as did their classification (van Straaten, 2022). They uncovered four hundred cubic meters of granulite, containing a harmful binder known as polyacrylamide, a carcinogenic substance used (Stegenga, 2020). This material proved to be a thousand times more toxic than the safe levels for fish.

Additionally, the documents revealed that materials from sources other than the Markermeer were utilized, despite Natuurmonumenten and Rijkswaterstaat claiming otherwise. These revelations sparked significant outrage, initially prompting Natuurmonumenten to deny that materials from different sources had been used or were anything other than Class A silt. As if this were not alarming enough, Annemieke faced intimidation from certain parties, urging her to let the matter rest and refrain from further investigation. Nonetheless, Annemieke and her team persisted, and ultimately, the contractor and project owners admitted that a small test of this specific granulite had taken place in 2019. However, the test results indicated that the material was unsuitable for construction. They were classified as negligible, with 34.5 million cubic meters of dredged materials (Stegenga, 2020).

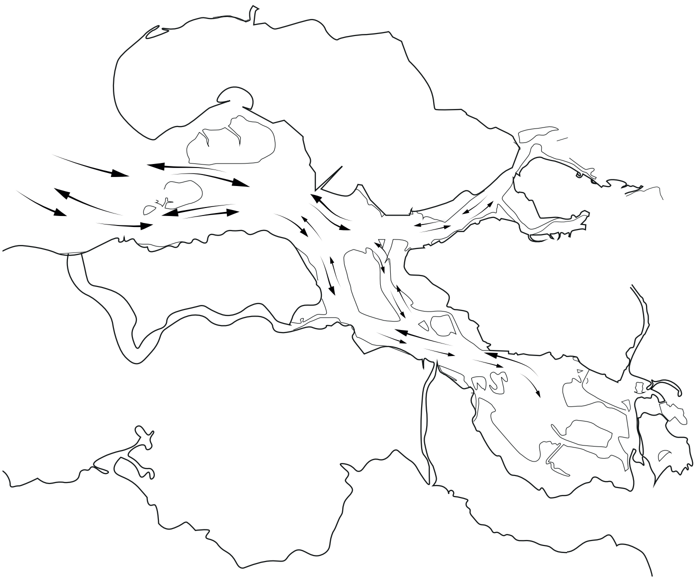
Regarding the silt used, an independent analysis by Royal Haskoning revealed that it was collected from various locations, not just the Markermeer. Furthermore, it became clear that Class B silt had been utilized, even though Boskalis stated they only used Class A silt. In total, 25,300 cubic meters of lower-quality silt were used (Kooiman, 2022), with 4.2% of the materials sourced from places other than the Markermeer (Royal Haskoning DHV, 2022). Unfortunately, the revelations did not end there. Annemieke discovered that not all ships importing dredged materials were inspected, leaving the possibility of contaminated silt being used. This issue also partially invalidates the Royal Haskoning analysis.

She also found more ships registered to transport contaminated silt to the area. While Natuurmonumenten claims that those contaminated materials were ultimately not used, she could not find any official documents confirming that the shipments were rejected, which might suggest they were indeed utilized (van Straaten, 2022). In subchapter three, it will be revealed whether, despite these serious accusations, the Marker Wadden has had a positive impact on the area.

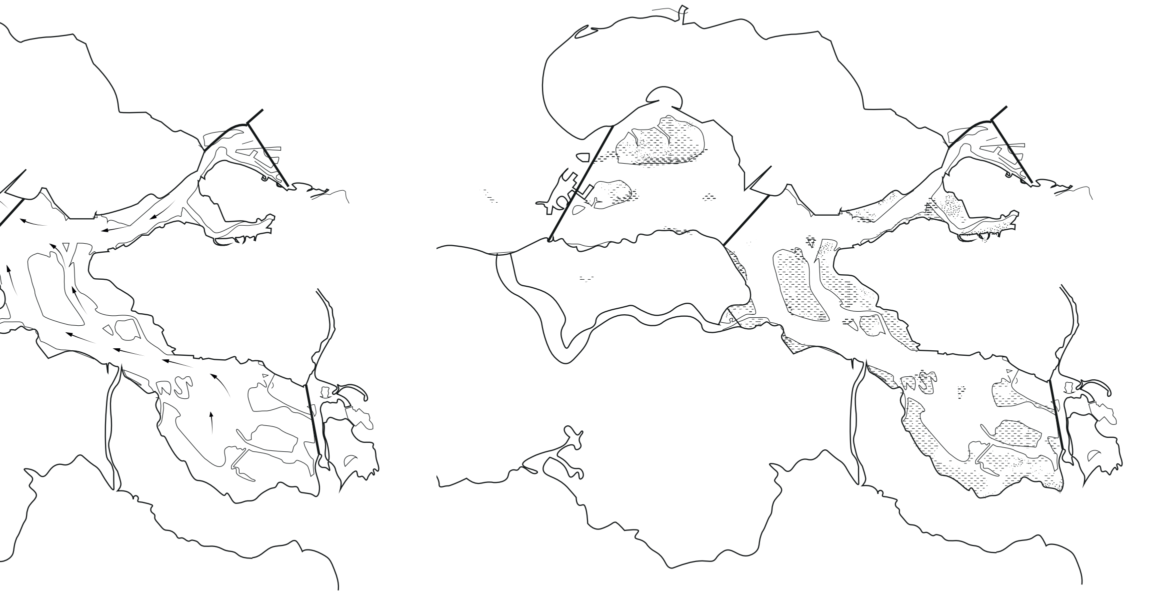
The Galgeplaat

The story of the Galgeplaat began with the construction of several storm surge barriers after the storm of 1953, particularly the Eastern Scheldt Storm Surge Barrier. This development resulted in a significant engineered flood protection barrier in the Eastern Scheldt. Completed in 1986, the barrier protected Zeeland from future flooding. The Eastern Scheldt served as an estuary with saline water and tidal influences from the North Sea. The combination of salt and freshwater provided a high level of nutrients, making it a valuable ecological area populated by mussels, oysters, seals, and seagrass (Wijsman, Engelverts and van den Brink, 2010). However, the completion of the Oesterdam in 1986 disrupted the estuarine dynamics of the Eastern Scheldt. The Eastern Scheldt is a tidal basin of four geomorphological types: ditches, salt marshes, muddy tidal flats, and sand flats. Water from the North Sea flows into the basin during high tide, and during low tide, approximately the same volume of water flows out, maintaining a balance (Kohsiek et al., 1987). During high tide, the North Sea water brings sediment into the bay, with some settling in the ditches and around the edges of the tidal flats. The sediment that does not settle flows back into the sea at low tide. The tidal flats and

Left | Sediment traps in coastal engineering at the Marker Wadden islands. Photograph by Laura Cipriani, 2022.
Right | Coastal interventions at Marker Wadden. Photograph by Laura Cipriani, 2022.



Water flows in the Eastern Scheldt | Starting from the left, in the first image, water flows in the Eastern Scheldt before the flood protection dikes. In the second image, water flows in the Eastern Scheldt after the flood protection dikes. The third image shows average sedimentation and erosion in the Eastern Scheldt. Authors' work. Data: Van Zanten and Adrianse, 2008.

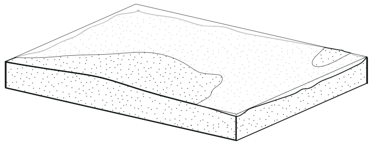


> 5 cm/year sedimentation
2 - 5 cm/year sedimentation
1 - 2 cm/year sedimentation
1 - 2 cm/year erosion
2 - 5 cm/year erosion
> 5 cm/year erosion

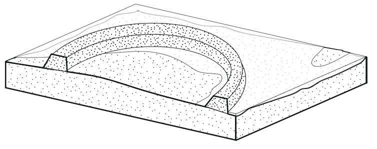
N

0 1 km 5 km 10 km

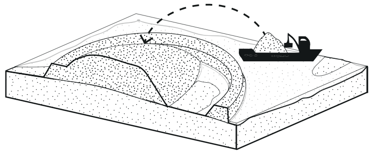
Inflowing and outflowing water
Water flow direction with southwest wind
Wind direction



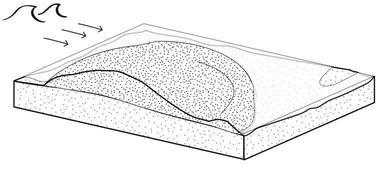
Tidal flat prior to project



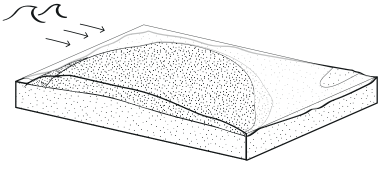
Construction of sand circle



Dredging sand into the circle



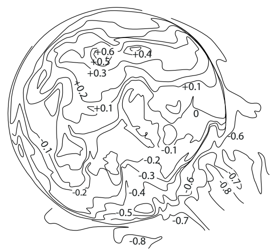
Water redistributes the sand



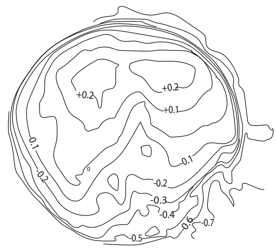
Height differences gradually fade away

Developing Galgeplaat Wadden | Above, schemes of development. Right, the Galgeplaat Wadden development. Authors' work. Data: Van der Werf, Reinders and van Rooijen, 2013.

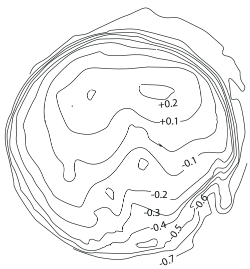
2008
Before construction



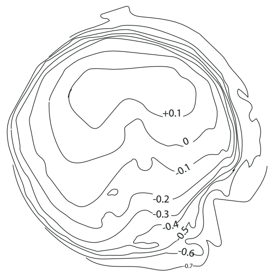
2008
After construction



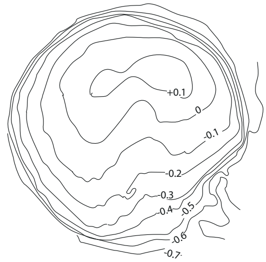
2009



2010



2011



2012

salt marshes also face erosion from the waves crashing against them. This cycle of sedimentation and erosion created a delicate yet balanced system that safeguarded the geomorphology and ecological values of the Eastern Scheldt (Holzhauer and van der Werf, 2009).

Despite the storm barrier's protective function for the community, it has significantly affected the bay's ecology. The engineers behind the barrier acknowledged the ecological significance of the Eastern Scheldt. They chose to facilitate the exchange of water, sediment, and wildlife by opening the barrier underwater during safe times (Rijkswaterstaat, n.d. a). However, this barrier continues to influence the inflow and outflow of water in the bay as the current speed behind the barrier decreases. This speed is crucial for sediment settling rates; lower speeds diminish sediment concentration in the water because the sediment settles more rapidly to the bottom of the Scheldt. As a result, less sediment reaches the tidal, sand, and salt marshes (Holzhauer, van der Werf, Dijkstra and Morelissen, 2010). Another contributing factor is the depth and width of the ditches in the Scheldt. Due to the reduced velocity, the water lacks the necessary force to transport sediment through these ditches and deliver material to the flats (Deltares, 2010). Consequently, sediments are effectively 'lost' to the sea without new sediment deposits. This has caused the sinking of the tidal flats. Typically, these flats would dry out for specific periods, but this is becoming less likely (de Ronde et al., 2013). This situation has led to the decline of natural habitats for many species.

These 'sinking' flats indicate that a change was necessary to preserve the quality of the natural area. Various parties collaborated to address these issues while developing the Galgeplaat: Deltares, the Institute for Marine Resources and Ecosystem Studies, the Royal Netherlands Institute for Sea Research, and Rijkswaterstaat, which commissioned the project (EcoShape, n.d.). The Galgeplaat project is part of a broader research initiative exploring different options to combat 'sand hunger' in the Eastern Scheldt (Holzhauer and van der Werf, 2009). Construction began in 2008, including a sand barrier and the nourishment itself. The barrier was built using a bulldozer, forming a circular wall with the sediments already on the flat (EcoShape, n.d.). The circular wall has a diameter of 450 m and stands approximately 1 m above sea level. An outlet was created towards the southeast of the circular wall to allow water to flow away. A settlement area was excavated before the outlet to prevent sediments from leaving with the outflowing water, which could affect the area's commercial mussel beds (Holzhauer and van der Werf, 2009). Commercial mussel beds are also a vital aspect of the restorative project, as they are threatened by the changing ecosystem (van Zanten and Adriaanse, 2008).

The second phase of the project specifically focused on sand nourishment. This phase applied the 'Building with Nature' design principle by strategically using the tidal power of the Eastern Scheldt. During the rising tide, 130,000 m² of sand was pumped into the circle to achieve an average height of 0.65 meters. When the tide fell, bulldozers spread the pumped sand throughout the circle (van der Werf et al., 2015). The sand was sourced from two maintenance areas where sand removal was necessary. These areas included the Witte Tonnen Vlije and the Brabantse Vaarwater, located near the Galgeplaat flat, allowing the sand to have a local second life (Holzhauer and van der Werf, 2009). After construction, there was no further human interference with the system. The project was based on the concept that tidal waves would gradually redistribute the sand from the circle to nourish the flat once again.

Hand in Hand with Mother Nature?

Land reclamation can serve various purposes, including ecological ones. Projects designed according to the 'Building with Nature' principle aim to enhance ecological value by harmoniously integrating reclamation designs with natural processes. This subchapter will evaluate the environmental conditions before and after the projects were constructed, determining whether the 'Building with Nature' principle meets its promises.

Marker Wadden

The Marker Wadden was established to improve water and soil quality while helping to reintroduce flora and fauna in the Markermeer lake heavily affected by reclamation (Marker Wadden, 2022). Species living on the old seabed were also at risk; they were suffocating due to the mud accumulated at the bottom of the lake. Additionally, little light reached the lower depths because of the murkiness of the water. All these factors strained the resilience of local biodiversity to its limit (Natuurmonumenten, n.d.). One of the main objectives of the reclamation project is to provide a valuable habitat for flora and fauna. The ecological productivity of the Marker Wadden landscape can theoretically be enhanced (Marker Wadden, 2022). Roel Posthoorn, the principal project director, stated: '*To restore nature in this beautiful place and create a new horizon, we aim to restore the ecological balance in Markermeer Lake*' (Natuurmonumenten, n.d.). The project plans to succeed by stimulating the area's biodiversity by adding features characteristic of natural lakes, such as gradual land-water transitions, variations in water depth, and sheltered regions among the islands where fine sediments can settle, thus enhancing water transparency. These goals theoretically signify a positive development toward a healthier ecosystem. In practice, it is becoming evident that an increasing number of birds and fish are growing accustomed to the area (Rijkswaterstraat, n.d. c). The mud and sediment began to accumulate and consolidate, resulting in more transparent water at the surface of the Marker Wadden islands (Klooster, n.d.).

Since plankton has been observed in the area, various birds, insects, and fish have been attracted to the region due to these changes. Many species have even begun to settle in the Marker Wadden. Based on this information, one could reason that the primary goal of the intervention is likely to be achieved while also noting that the area must continue to maintain this trajectory for further development (Klooster, n.d.). Although the current situation shows a positive trend, it remains uncertain whether Marker Wadden's goals will be met in the long term. Monitoring of the project indicates that the initial aim of improving water quality has yet to be fully realized (van der Winden et al., 2019). Additionally, concerns have arisen regarding the types of flora and fauna that are establishing themselves.

Furthermore, only common fish species, such as bream, perch, and roach, are finding food, while other fish have nearly vanished (Tien, Van Rijssel and Vrooman, 2021). It should be noted that the newly created biotopes have only recently been established, and the construction of two additional islands is still in progress. This could negatively affect the ecological features of the area due to the ongoing construction work on the islands (van der Winden et al., 2019). The recreational function of the islands is also evolving. One of the islands has been open to the public since 2018, and there are expectations that the number of visitors will rise to 300,000 per year (BLOC, 2022), raising the question of who these islands were built for. Human presence on the islands will likely disrupt the original idea of creating a nature sanctuary.

Nevertheless, the implications of human activity are yet to be fully understood. While visiting the Marker Wadden for a week in October 2020, the activist Annemieke van Straaten also developed an alternative perspective. She observed that humans had introduced most plant species, and there were cases of botulism, a type of water contamination that led to dead birds scattered across the island. Rijkswaterstaat also informed visitors about this, as it can pose dangers to humans in certain situations (Omroep Flevoland, 2020b). Additionally, she found several areas where oil was floating on the water, which she believes is directly tied to the contaminated silt used in the projects (van Straaten 2022). However, neither scientific research nor observational evidence support this claim.

The construction and its impact on the ecology of Marker Wadden are part of a broader debate. One of the scheme's most notable critics is Professor Emeritus Bart Schultz from the UNESCO-IHE Institute for Water Education. He argues that the Marker Wadden will not resolve the silt issue as intended. He explains that the silt problem in Markermeer is merely a natural result of the lake's soil type and should not be considered a problem. The soil features a thick, 4-meter layer of clay with silt on the surface. Dredging this silt will merely destabilize the newly exposed clay layer, causing it to erode, and replace the removed silt with fresh silt. He contends that if the Afsluitdijk and Houtribdijk had not been constructed, the bottom of the Zuiderzee would have similarly accumulated large amounts of silt. This suggests that 'poor water quality' is a natural state inherent to the region (Schultz, 2022).

Additionally, he raises another critical point, noting that natural forces will lead to the islands subsiding back into the water, requiring complex ongoing engineering (Schultz, 2022). This subsidence occurs for two reasons. First, the sandy foundation on which the islands sit needs to be stronger to bear their weight. Second, both silt and clay are added to soil filled with similar materials. The soil layer contains 80% water; consequently, dredging onto it will cause natural subsidence due to the weight of the newly constructed islands. These issues have already required maintenance and the addition of more sand to the islands (Mulder, 2020). Natuurmonumenten acknowledges that the islands were built with the expectation of regular maintenance as part of the project (Boer, 2022). However, the 'Building with Nature' approach must be in harmony with the idea that nature should be able to sustain itself.

Natuurmonumenten and Professor Schultz disagree on the extent and duration of subsidence. In some areas, the islands have already sunk by several decimeters. Professor Schultz estimates this process will continue over the coming decades, resulting in significant unforeseen costs. Sand is regularly added to the main structures (van Straaten, 2022). Conversely, Natuurmonumenten believes maintenance is necessary but not to the extent projected by Professor Schultz. They also assert that they can continually replenish sand, silt, and clay without harming the local ecology. However, since the construction work is currently cited as a primary reason for the site's slow ecological development, the question of whether the goals of Marker Wadden will ever be achieved remains.

Galgeplaat

The tidal flats in Zeeland are recognized for their significant ecological value, hosting numerous species of fauna and flora. Despite its environmental importance, the Galgeplaat is experiencing the repercussions of sand hunger in the Eastern Scheldt. This prompted Rijkswaterstaat to initiate a pilot project involving sand nourishment to enhance the tidal flat based on the 'Building with Nature' principle.

Given that the Galgeplaat is in an area with very calm hydrodynamic conditions, this design needs adequate natural hydropower. The sand nourishment is also protected from the current by a constructed sand barrier. Consequently, there has been minimal sand redistribution by the natural water currents (Holzhauer, van der Werf, Dijkstra and Morelissen,

Right | Artificial dunes on the Marker Wadden.
Photograph by Laura Cipriani, 2022.

2010). The overall impact on the larger area is minor when viewed on a broader scale. Galgeplaat covers 950 hectares, of which the area where the sand nourishment is applied is merely a small part, only 20 hectares in size (Van der Werf et al., 2015).

Some changes can be observed in the smaller area, specifically at the center of the sand nourishment itself. Over the years, the water has evened out the height differences created during construction. This has resulted in a more uniform distribution of sand within the circular area. As mentioned in the previous subchapter, the height difference between the north and south was previously measured at around 1 meter. By 2012, four years after completion, the difference had decreased to about half a meter. Outside the circular area, sediments have settled around the northern side of the barrier.

In terms of ecology, during the sand nourishment process, two types of species were present on Galgeplaat: permanent residents and transient visitors. The permanent residents include mussels, Japanese oysters, clams, snails, worms, and various types of seaweed (Nolte, Grashof and Bolman, 2024). Seals, curlews, oystercatchers, and other birds represent the transient species (Holzhauer, van der Werf, Dijkstra and Morelissen, 2010) that visit the tidal flat to forage or rest. For most species, the intervention did not disrupt their habitat. However, many organisms did not survive the supplementation process at the exact location of the nourishment. This was an anticipated outcome of the intervention. Additionally, due to the relatively small scale of the intervention, both flora and fauna returned to the nourishment site within two years (Westdorp, 2011). Throughout and after the nourishment, the state of the species in Galgeplaat was monitored for two years by Rijkswaterstaat and investigations were carried out by Deltares.

As mentioned, mussel farmers cultivate mussels on the Galgeplaat and divide them into plots (Holzhauer and van der Werf, 2009). These plots were categorized and monitored during the sand nourishment to assess the potential effects on the mussels. After two years of monitoring, the nourishment did not affect the mussels (Holzhauer, van der Werf, Dijkstra and Morelissen, 2010). Even small-scale nourishments can still support economic activities on the tidal flats.

In the long term, Rijkswaterstaat aims to use sand nourishment to preserve shallow water habitats for many species. However, in 2013, Deltares concluded that a structural solution could not be found for the Eastern Scheldt (de Ronde et al., 2013). The only options would be to remove the storm surge barrier or import 400-600 million cubic meters of sand for nourishment, both of which they consider unrealistic. Instead, they propose a flexible approach, using sand nourishments to restore the tidal flats temporarily. The sand would need to be sourced locally to save costs and sprayed onto the flats to a height of 1.0 to 1.5 meters. They assert that with this intervention, the tidal flats in the Eastern Scheldt should be able to sustain themselves until 2060. While this appears to be a feasible solution, the downside is that permanent life will be temporarily eliminated on every tidal flat (Vroege Vogels, 2019). This implies that large-scale interventions pose risks to the soil species and, consequently, to those who forage on them. As a result, Deltares revised their advice to advocate for a more step-by-step approach, indicating that not all flats should be addressed simultaneously. This way, transient species can still find refuge in undisturbed or restored tidal flats.

One aspect that the report needs to clarify is the method for implementing these nourishment efforts. The pilot project on the Galgeplaat is a small-scale intervention and cannot be compared to the large-scale nourishment of an entire tidal flat, which would require the subsequent reintroduction of the species that inhabit these habitats. Whether these species can achieve this independently or if human intervention is necessary remains unaddressed, but this is a significant question. Human interventions are essential for upholding the 'Building with Nature' principle. Ultimately, using sand nourishment is an ongoing process. If the tidal flats can sustain themselves until 2060, a second nourishment will then be necessary. Since the root cause of the problem—the loss of water velocity—has not been addressed, issues related to sand hunger and the reduction of flat surfaces will persist. Therefore, sand nourishment remains a temporary solution to the problem.

Conclusions

The 'Building with Nature' approach promotes a fundamental rethinking of how we intervene in the landscape. Both Marker Wadden and Galgeplaat demonstrate that ecological restoration and infrastructure design can be combined—but they also reveal the conflicts inherent in such a combination. While each project emphasizes working with natural processes, both still depend heavily on human control, planning, and technological intervention. This paradox lies at the core of the Dutch relationship with water: a continuous cycle of domination and coexistence.

In the Netherlands, where land and sea have been engaged in centuries of negotiation, 'Building with Nature' acts as both a continuation and a critique of tradition. It builds on earlier engineering innovations used in reclamation projects while reimagining their purpose. No longer solely focused on protection or expansion, modern interventions aim to restore and sustain ecosystems. However, as the cases discussed here show, this shift is neither complete nor universally accepted. The rhetoric of 'working with nature' can conceal the ongoing influence of human-centered logics—

design choices driven by human expectations of control, predictability, and measurable results.

At Marker Wadden, this tension manifests in scale and ambition. The project proves that ecological recovery and increased biodiversity are possible, but it relies on extensive dredging, modeling, and design supervision. Building 'natural' islands with heavy machinery raises questions about the authenticity of the created environment. Is this truly restoring ecological function, or creating a new type of engineered wilderness? As Tameling (2019) suggests, Marker Wadden blurs the line between artifice and nature, creating a hybrid landscape where technology becomes a tool for ecological imagination.

Meanwhile, the Galgeplaat project exemplifies a more gentle approach—one that respects natural rhythms and changes over time. Its success depends less on construction and more on allowing hydrodynamic forces to do their work. Even here, the process is guided by design: sediment volumes are calculated, monitoring systems are set up, and adaptive management plans are implemented. In both projects, 'Building with Nature' functions like choreography—a guided performance of natural processes rather than their spontaneous development.

This hybridity shows that 'Building with Nature' is not only an ecological method; it is also an epistemological stance. It redefines knowledge creation as participatory and iterative, relying on feedback between human and nonhuman actors. The landscape itself becomes a co-designer, producing data, responses, and adjustments that evolve the project over time. Such reciprocity transforms design from a one-time act into an ongoing conversation with matter, energy, and life.

From a philosophical perspective, 'Building with Nature' aligns with what scholars like Latour (2004) and Ingold (2011) describe as a posthuman or relational ontology—an understanding of the world where agency is shared among humans, technologies, and natural processes. In this framework, landscapes are not static backgrounds but dynamic assemblages continuously co-created by different actors. In this sense, the Dutch practice of land making takes on new ethical depth: it becomes less about mastery and more about coexistence.

However, this shift presents political and ethical challenges. As Fletcher (2017) warns, the language of 'Building with Nature' can be misused to justify projects that primarily serve economic or infrastructural goals while claiming to promote sustainability. When ecological restoration is framed as a means to support human interests—such as tourism, branding, or national pride—it risks reinforcing the very instrumental thinking it seeks to move beyond. The challenge, therefore, is to ensure that 'Building with Nature' remains genuinely ecological in both purpose and outcome, rooted in the intrinsic value of nonhuman life rather than its usefulness to human systems. Practically, the success of 'Building with Nature' depends on long-term governance, adaptive monitoring, and community involvement. Projects like Marker Wadden and Galgeplaat demonstrate that ecological resilience isn't achieved through design alone; it requires ongoing care and oversight. Maintaining sediment balance, water quality, and biodiversity must be embedded in policies that acknowledge the temporary nature of ecosystems. As van Slobbe et al. (2013) note, 'Building with Nature' functions best when seen as a continuous process rather than a fixed project—a practice of learning through experience, where uncertainty is a natural part of coexistence.

On a cultural level, 'Building with Nature' redefines the Dutch story of land reclamation. Traditionally, the Netherlands has celebrated its ability to 'make land' through human ingenuity—a story of conquering water. 'Building with Nature' shifts this narrative to one of dialogue: creating land with water, not against it. This shift has important implications for environmental identity and ethics. It encourages a more humble outlook, recognizing that landscapes are not just objects to be perfected but active participants in an ongoing ecological story.

Ultimately, 'Building with Nature' blurs the boundaries between engineering, ecology, and design. It suggests that resilience in the Anthropocene doesn't come from fighting nature but from reconnecting with it. The Dutch experience offers valuable insights for other delta regions facing rising seas and ecological decline. But the lessons extend beyond technical skills. 'Building with Nature' teaches us that sustainability isn't a fixed goal but an ongoing relational practice—an ongoing negotiation between human aims and the earth's own agency.

In summary, 'Building with Nature' marks a major shift in how societies perceive and engage with their environments. By transforming construction into ecological participation, it fosters a more thoughtful, ethical, and adaptable way of engagement. The challenge ahead is to further develop this approach—not just as a design method but as a cultural mindset that recognizes interdependence as essential to both ecological and social resilience.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2021–22. During the course, Xenia Georgiadou, Eva IJzermans, Teresa Lacigová, Sanne Maring, and Hugo Mohr wrote the initial paper, supervised by Laura Cipriani and Denise Piccinini. Xenia Georgiadou, Eva IJzermans, Teresa Lacigová, Sanne

Maring, and Hugo Mohr prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the chapter. Finally, a native English speaker reviewed the text.

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Land Reclamation Sites Data

Location
Othodo-Gbame | Lagos | Nigeria
Coordinates
6° 27' 50" N | 3° 30' 48" E
Area
0.56 km2
Length
0.80 km
Time
2000-2022

Location
Makoko | Lagos | Nigeria
Coordinates
6° 30' 2" N | 3° 23' 19" E
Area
0.91 km2
Length
0.80 km
Time
1980-2020

Location
Eko Atlantic City | Lagos | Nigeria
Coordinates
6° 24' 26" N | 3° 25' 15" E
Area
7,92 km2
Length
5.70 km
Time
2008-2019

6 | Who Owns the Land?

Formal and Informal Land Reclamation in Lagos

Xiaoqian Cheng, Jingwei Guo, Antong Huang, Chenye Yang
Laura Cipriani

Lagos is the largest coastal city in Nigeria and one of Africa's largest metropolises. Urbanization and population growth have led to a land crisis, prompting the city to pursue land reclamation. Since the colonization of Lagos, the gap between the rich and the poor has widened, which is evident in its division into upper- and lower-class areas. Poor management of the slums has resulted in congestion and unhealthy housing conditions, further aggravating the city's segregation. The city features two types of land reclamation: formal and informal. The upper classes drive formal land reclamation by using sand to create housing for the affluent. In contrast, informal land reclamation occurs spontaneously among the lower classes, who use waste as a reclamation material. On this basis, this chapter explores the narratives of (in)formal land reclamation in Makoko, Otodo-Gbame, and Eko Atlantic City in Lagos. It asserts that social conflict, fundamental human rights, and economic and ecological issues must be integrated into future decisions, while at the same time recognizing informal land reclamation as a vital component of the urban landscape.

Introduction

In the 21st century, urbanization is recognized as one of the most significant trends worldwide. Over half of the global population now resides in urban areas, with projections estimating that this figure will reach 60% by 2030 (PRB, 2007). Furthermore, 90% of population growth is expected in urban regions, particularly in Africa and Asia (United Nations, 2018). Urbanization is rapidly advancing in many developing nations in these continents due to government policies supporting this phenomenon and increased migration from impoverished areas. For instance, Lagos, Nigeria, has witnessed its population grow 100-fold, expanding its area to 1 million square kilometers in just over 50 years, making it one of the largest cities in the world (Agbola and Agunbiade, 2009).

However, the swift pace of urbanization also presents challenges, including inadequate urban infrastructure and overwhelmed management systems. This rapid transformation strains resources, resulting in congested roads, difficult-to-manage pollution, and rising population numbers. In these struggling cities, an increasing number of slums emerge, with an increasing percentage of residents living in substandard housing, lacking security in land and housing, and facing heightened inequality and discrimination. Lagos, characterized by its numerous slums, grapples with vast wealth disparities and social stratification, which contribute to social isolation within its development.

In this troubling urbanization process, the neglect and deprivation of residents' rights are pressing issues. Do cities exist solely for the privileged and affluent? Can those who labor and contribute to the city's growth and economy yet still endure harsh conditions in urban slums find a place within the city's fabric?

The Birth of Segregation

Class segregation in Lagos's urban development can be traced back to the colonial period, which marked the beginning of modern urbanization in the city. In the 15th century, Lagos was a small fishing village inhabited by the indigenous Yoruba tribe, whose members engaged in traditional fishing and hunting activities (Adeshokan, 2020).

Beginning in the early 16th century, Portuguese colonizers started trading with the inland kingdoms of the region, and in 1851, Lagos officially became a British colony. Urban development and construction during the colonial era were distinctly chauvinistic and aimed at safeguarding European rights. As a result, the indigenous population was pushed into cramped and narrow housing.

To increase the livable area, the colonial government reclaimed eroded and barren swamp and creek regions and constructed new roads to connect various parts of the island. Additionally, the government sought to improve residents' infrastructure and public facilities. However, these efforts were primarily concentrated in areas where Europeans lived, such as Marina on the southeastern side of Lagos Island, which became a European settlement (Fernelius, 2020). The colonial administration built a network of roads, commercial areas, warehouses, administrative zones, religious sites, and other housing developments. It also established specialized engineering and health departments responsible for urban planning and maintenance.

In contrast, the indigenous population living near Marina, in Isale Eko on the northwestern side of Lagos Island, was left to fend for themselves. Their roads were narrow and muddy, trash was scattered everywhere, and the houses were old and dilapidated, lacking modern infrastructure. Following the British annexation of Lagos, more impoverished individuals migrated to the city for opportunities. However, the development of urban services and building technologies failed to meet demand while adhering to traditional Nigerian architecture, exacerbating living conditions.

The urban construction approach during the colonial period was justified at that time in the name of public interest, decreasing the living space of local ethnic groups while preserving the luxurious lifestyle of Europeans and reinforcing social control over the colony. Thus, early social class divisions were established, profoundly affecting the development of Lagos city and embedding the harmful effects of wealth polarization within Lagos's social fabric.

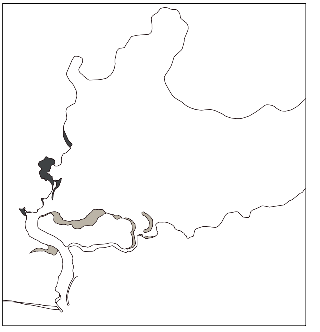
After Lagos gained independence, warlords began fighting among themselves. Consequently, the middle class and the impoverished became targets of plundering and exploitation, leading to increased social stratification and a widening wealth gap within Lagos. The independence movement resulted in segregation reminiscent of the colonial period, seen most notably in the violent expulsion of slum dwellers.

As early as the colonial period, the British government had considered slum clearance plans essential social services due to hygiene and urban image concerns. However, after Lagos attained independence, similar slum clearance efforts continued and became more violent. The government directly commanded the military or police to demolish informal settlements without implementing resettlement or compensation measures, even causing casualties in the process.

This method of slum clearance gradually evolved into a new strategy allowing developers and the government to profit, removing the poor from urban areas with significant potential for redevelopment and subsequently initiating new real estate projects to build and sell high-rise

Right | Makoko is often called the 'Venice of Africa' because canals serve as the main infrastructure. Photograph by Hugo Kempeneer, 2017.

1931-1964

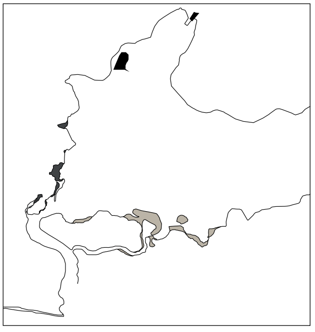


1964-1984

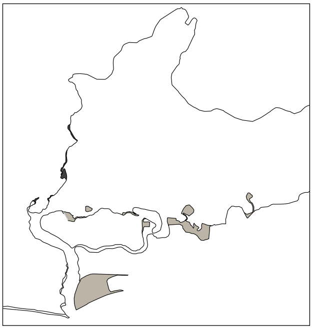
Stage 1 | The government started filling lagoons from the mainland and Lagos Island.

Stage 2 | Informal reclamation near the mainland and formal reclamation on Lagos Island both increased.

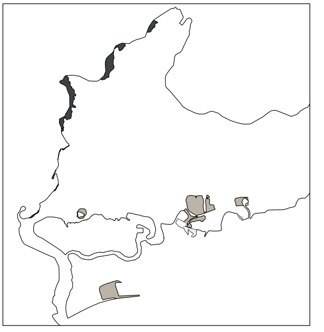
Land Reclamation Timeline | Authors' work.



1984-2001



2001-2015



2015-2022

Stage 3 | Lagos Island continued to grow through formal reclamation.

Stage 4 | Developers began constructing Eko Atlantic City and reclaimed additional land along the Lagos Lagoon waterfront.

Stage 5 | Significant new reclamation projects were initiated.

N

Land
Water
New reclaimed land
Informal reclaimed land
Formal reclaimed land
Transition land

buildings and commercial complexes. Some informal settlements near the coast, such as Otodo-Gbame and Iluburin, have faced violent evictions recently. New real estate developments have taken over the land where impoverished individuals had lived for decades, building on their ruins. This approach continues to displace low-income individuals from the city, further worsening their living conditions.

Topographic inequalities, erosion, and flooding are also linked to spatial segregation. Lagos is a low-lying city with an average elevation of just 1.5 meters above sea level. Much of its flat topography is at or below sea level and continues to sink at a rate of 87 millimeters per year, placing the city's peripheries at significant risk (Ikuemonisan and Ozebo, 2020). To make matters worse, Lagos's low coastline is eroding, and storm surges are intensifying flooding as sea levels rise and sand mining along the coast continues (Ajibade and McBean, 2014). The frequent flooding in Lagos has devastated homes and public infrastructure, particularly affecting the coastal slum communities that suffer the most damage, harming local aquatic ecosystems, threatening fish productivity, and increasing the vulnerability of slum residents. All of these factors have further intensified the city's segregation.

Formal and Informal Land Reclamation

The history of land reclamation is closely tied to the city's landscape. Agiri and Barnes note that '*coastal lands from the Benin River to Badagry were sandy and unfit for large-scale agriculture (...). Swamps extended deep into the hinterland, filled with dense mangroves and high brush (...)*' (Ogbebor, 2015). The land's nature dictated that land reclamation activities would accompany urban expansion.

The coastal lands from the Benin River to Badagry primarily had sandy soil, which was unsuitable for large-scale agriculture. Nevertheless, palm products were abundant, and yams could be cultivated in certain nearby coastal soils. Swamp areas stretched deep into the hinterland and were densely covered with mangroves and tall bushes. Water transportation was crucial for movement, enabling relatively easy contact among people.

Following the British colonization of Lagos in 1861, a significant number of Africans migrated to the city, and the pressure of the growing population on social infrastructure accelerated the extensive land use policies implemented by colonial authorities, such as the draining and reuse of swamps that continued to increase Lagos's size. Non-Yoruba migrants to Lagos, primarily Igbo, Izon, Edo, and Hausa, settled in newly established towns like Oko Awo, Yaba, and Ebute Metta. Thus, formal land reclamation projects in Lagos began approximately a century ago under the colonial government's direction.

However, the class segregation and entrenchment initiated by colonialism have always surrounded Lagos and externalized the division of urban space, significantly affecting land reclamation practices. After the Nigerian Civil War ended in 1970, Lagos experienced renewed urban sprawl, for which an increase in both formal and informal land reclamation projects often acted as a catalyst (Chilaka, n.d.). The locations of these projects prompted the emergence of various institutions, whether residential or industrial. Many land-hungry '*Lagosians*' (Adebayo, 2017), including aspiring landowners, flocked to these new towns or suburbs, seeking to purchase reclaimed land for their dream homes or to establish rental accommodations (BBC, 2020)—the latter being highly sought after in the metropolis. However, controversy and discontent were prevalent. For example, when the federal government sought to reclaim the former Makoko slums in the early 1990s and transform them into modern residential areas, evictees recounted the brutal cleansing of Makoko by the then-military government, hatred, rape, loss of valuables, bloodshed, and in extreme cases, the death of loved ones (Amnesty International, 2006). The eviction of informal reclamation areas (maritime slums) by the government and developers for personal gain led to significant changes in urban reclamation, resulting in a new type of land reclamation—the shift from informal to formal. Today, in the 21st century, the urban coastline of Lagos is still lined with many informal reclaimed marine areas formed spontaneously by slum communities, and violent evictions have not ceased.

Formal and informal land reclamation define the practice of land reclamation in Lagos. The term 'formal' refers to projects that have received official approval and planning; conversely, 'informal' covers various forms of land appropriation and construction by individuals, often comprising spontaneous actions driven by necessity and lacking compliance with a formal planning process. This section summarizes and compares three types of reclamation projects in Lagos—Makoko, Otodo-Gbame, and Eko Atlantic City—focusing on their areas, designs, reclamation methods, and urban challenges.

The Informal Land: Makoko

Makoko, an informal settlement across the Third Mainland Bridge on the mainland coast of Lagos, is the largest floating slum community in the world. It spans an area of about 91 hectares, extending 0.8 km into the water, and is home to over 100,000 people (Agbola and Agunbiade, 2009). A third of the community is built on stilts above the lagoon, reclaimed by the community, while the remainder is constructed on solid ground. For this reason, it has been humorously if ironically referred to as the 'Venice of Africa,' despite its living conditions differing greatly from those in Italy.

Initial Settlement
The section of Makoko built on land has been established.

Expansion into Water
Due to the shortage of living space, Makoko began to expand into the water and create spontaneous land reclamation.

Period 1
Initial Settlement

Period 2
Disorderly Growth

1980

1990

19th Century
Makoko started as a fishing settlement, with families migrating there from the Benin Republic in the 19th century. Since 1962, the population of Makoko has increased dramatically.

Land Reclamation Process in Makoko | Authors' work. Data: Google Earth, 2023.

Formation of Community Structure
Makoko's borders continued to grow increasingly dense, leading to the formation of its community structure.

Eviction
Makoko's borders have diminished following a violent eviction.

Integration into the Urban Fabric
Makoko continues to expand and mature, becoming more integrated into the urban environment.

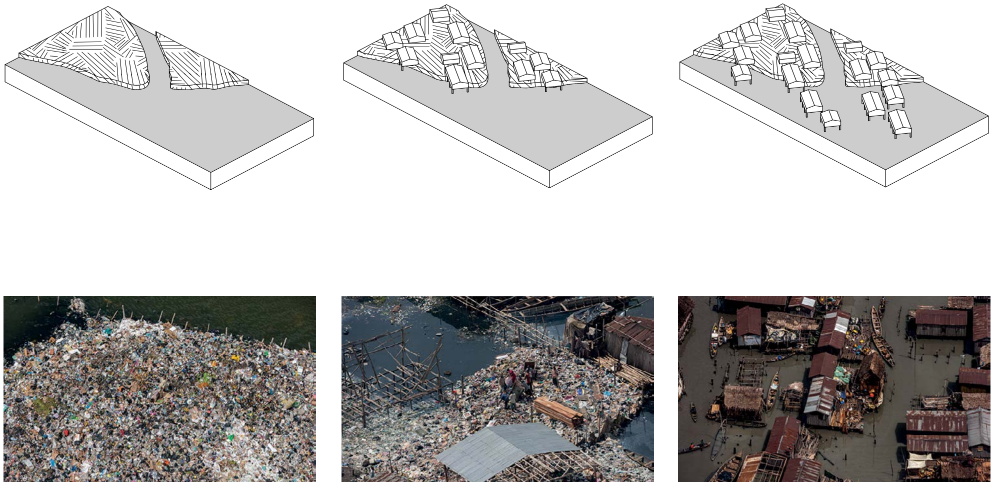
Period 3
Community Maturation

2000

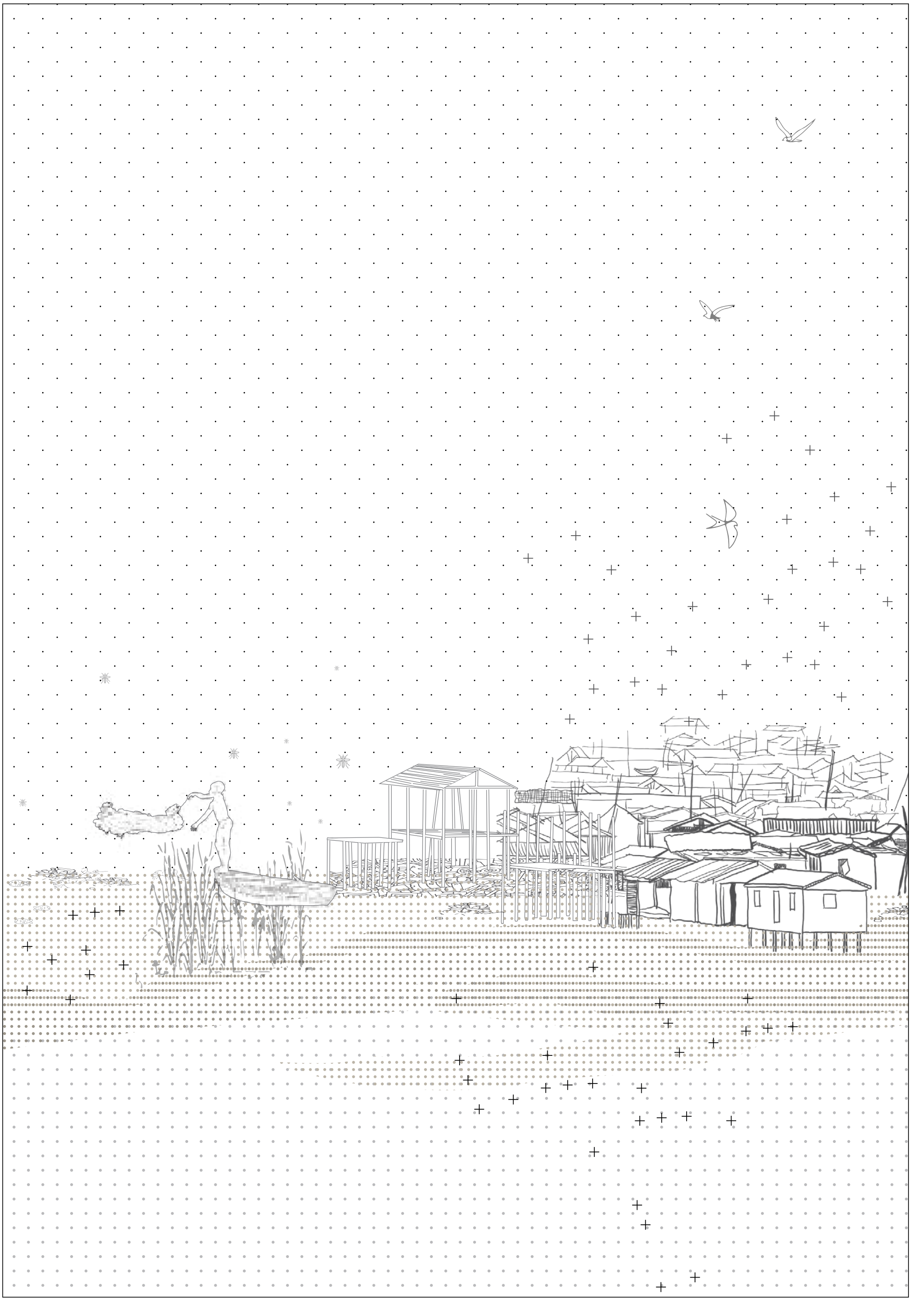
2010

2020

2012
Under the leadership of Babatunde Fashola, the Lagos State government ordered the demolition of the stilts on the Iwaya/ Makoko waterfront, resulting in dozens of stilts being taken down within 72 hours of notifying the residents.



Reclamation Method in Makoko | Authors' work.



Left | Tree trunks in the waters of the lagoon in front of Makoko. The wood is transported into the lagoon surrounding Lagos via nearby rivers, where workers cut it into planks. Photograph by Hugo Kempeneer, 2017.
Right | The informal settlement of Makoko in Lagos, Nigeria, features houses built on wooden stilts. Photograph by Hugo Kempeneer, 2017.

Due to urban development in Lagos, increasing numbers of impoverished individuals have migrated to the city in search of opportunities but they are unable to afford urban housing and basic survival. The imbalance created by rapid growth, the widening gap between the rich and the poor, and limited housing availability have all resulted in a land shortage. Consequently, living in informal settlements or slums has become a solution for these individuals. Makoko, as a relatively low-cost community, concentrates a portion of the city's poor; however, it cannot serve as a permanent solution. As the population grows, Makoko's original settlement can no longer adequately provide housing. Given its position as a waterfront community, it is natural for residents to reclaim land and expand their living space into the lagoon. The expansion of reclaimed land and the influx of impoverished persons have reinforced one another, leading to an increased strain on land in the area and resulting in a highly densely populated community that continues to face a lack of living space and inadequate infrastructure. It is important to note that this type of land reclamation is purely spontaneous, lacking government approval or organization, and the land created is informal and unrecognized by authorities.

Makoko began as a fishing community in the early 19th century, with land reclamation emerging from the initial settlement through uncontrolled growth and expansion into the water. By the 1990s, the layout of Makoko's current community had been established. A desperate need for housing drove this phase of land reclamation, representing the first attempt by low-income individuals to create their own living space. As such, it was formally irregular and lacked any community structure. Historical maps show that the land and houses were scattered over the water with considerable distances between them. Some homes were built on reclaimed land, while others were shanties constructed on stilts.

From the 2000s onwards, Makoko's development took on a new form, gradually evolving into a true community. While it continues to expand in size, this growth is significantly slower than in previous periods (Gilbert and Shi, 2023). It has been accompanied by an increase in community density and the formation of a community structure. One manifestation of this shift is the spontaneous planning of several major and minor waterways. Makoko's primary mode of transport is by boat. Unlike the previously wide waterways, the community now has designated channels for passage amidst its high density. Another manifestation is the interconnected structure of the neighborhoods. Various houses are linked together, with residents constructing platforms that increase the space available for each family through this communal effort. Additionally, Makoko has developed its own infrastructure systems, such as power and water systems, that meet the minimum living requirements of residents (Bowlsby, 2019).

As Makoko's growth became increasingly visible, the government began to restrict its expansion through forced evictions. However, Makoko persisted due to its resilience and the urgent housing needs of countless individuals, and it continues to grow. There is no doubt that Makoko has become a genuine community.

The method of reclamation used in Makoko relies on waste-based materials and human-powered techniques. The original reclamation site was a shallow wetland along the lagoon, which provided suitable conditions for reclamation. First, inhabitants would create an initial layer using piles of garbage, then cover the waste with sawdust to mask the odor, and finally top it with sand to stabilize the newly formed land. Residents would then build homes in this newly created area. The buildings in Makoko primarily come in two forms: wooden houses and brick houses. Construction materials typically include thatch, bamboo, sacks, plastic, rubber, and zinc. Due to the rapid pace of development, residents at the community's edge also resort to constructing temporary houses on stilts directly over the water, which are then filled with earth to enhance stability. As a result, these structures transition from temporary to permanent as Makoko gradually expands outward.

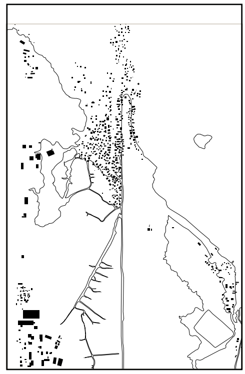
In Lagos, it is more common to use sand and machinery for land reclamation, which is more efficient and creates land that is more resilient to various risks. In contrast, the reclamation method used in Makoko is less efficient and more vulnerable. The land and structures are simple in design and do not meet modern standards. However, the Makoko community consists of individuals who lack financial resources and technology, giving rise to this inexpensive, easy-to-build, and viable method. Furthermore, it is noteworthy that this approach to using waste as raw material has the advantages of being recyclable, renewable, and sustainable.

Informal to Formal: Otodo-Gbame

Otodo-Gbame is a typical waterfront settlement in Lagos (Sawyer, 2014). In Egen, the name translates to 'a house built in a swamp.' The community is located on the Lekki peninsula and boasts a 200-year history that traces back to the arrival of its ancestors from Badagary, a neighboring region in Nigeria. These ancestors were the area's original settlers, drawn by rich fishing opportunities. As a result, the first settlements were built entirely on the water.

Conflict regarding the land has been ongoing since 2014. On September 11, 2014, residents from nearby informal settlements on land owned by Lekki's traditional king, Oba Elegushi, attacked the community. At that time, that community comprised around 10,000 homes. At its peak, it accommodated over 30,000 residents living at the edge of the Lagos Lagoon, extending inward from Lekki (Adebayo, 2017); modern developments have

2000
Some informal settlements began to form along the mangrove wetlands at the lagoon's edge.



2006
The wetlands are disappearing, formal houses are starting to appear from the southern lake side, and informal settlements are spreading to the lake.

Period 1
Informal Settlement

Period 2
Transformation from Informal to Formal

1800 — 2000 — 2002 — 2004 — 2006 — 2012 — 2014

Ancestors Settled

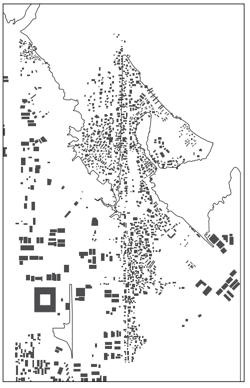
Mandatory Eviction

1800-2011
Otodo Gbame has a 200-year history, with roots stretching back to when residents' ancestors arrived from Badagary. The original settlement was built entirely over the water.

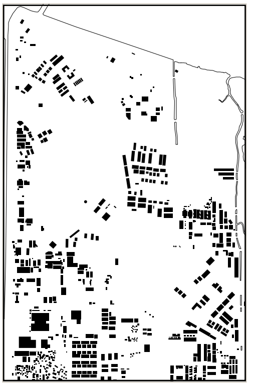
2011
Residents of the Otto and Otumara communities received a "Notice of Abatement of Nuisance" from the Environmental Sanitation Agency to keep their environment "free from filth, refuse or waste."

2016 | 11-09
Forced Eviction Number 1: The police began setting fire to Otodo's houses. About a third of the community was destroyed without prior notice. Most of the buildings on land have been demolished, while many structures on the water remain intact.

Reclamation Method in Otodo-Gbame | Authors' work.



2016
Illegal residences occupy formal land. Informal settlements and formal projects grew simultaneously.



2022
Complete transformation into formal land. The informal settlements are fully cleared, the land is filled with sand, leaving behind only formal projects.

Period 3
Informal Reclamation

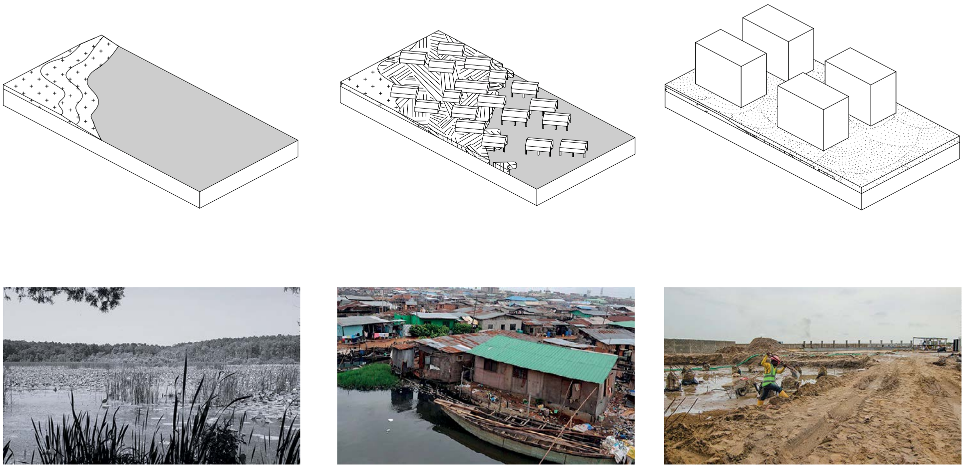
2016 2018 2020 2022

Reconstruction After Eviction

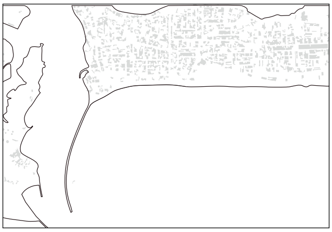
2017 | 03-17
Forced Eviction Number 2: Without any prior notice, Otodo-Gbame residents were forcibly evicted again. The forced evictions left many of the 4,700 residents homeless. Residents protested, and police raided at least 12 of them.

2017 | 04-09
Forced Eviction Number 3: The police started shooting and demolishing buildings; the community was largely destroyed. People continued to sleep in canoes.

Now
The land is jointly owned by the Lagos State government and a private company, developed by the Elegushi family. Consequently, the Elegushi family will profit from the development of the former site of Otodo Gbame.



Reclamation Method in Otodo-Gbame | Authors' work.



Before 2008
The beginning of the reclamation project and the Great Wall of Lagos.

2008-2011 Reclamation Area
Period 1
The reclamation process is completed for 25 percent.

2011-2014 Reclamat
Period 2
The reclamation proc
for 40 percent.

2005 2007 2009 2011

Initial Reason: Climate Threat

2005
In 2005, the coastal city of Victoria Island in Lagos faced the imminent threat of being overwhelmed by ocean surges from the Atlantic Ocean.

2008
In 2008, physical work began on Eko Atlantic City.

2009
The initial rocks for the Great Wall of Lagos were laid, and the core of the seawall was in progress.

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Land Reclamation Process of Eko Atlantic City |
Timeline of the reclamation from 2005 to 2017. Authors' work. Data: Google Earth, 2005-2017.

ion Area

ess is completed

2014-2017 Reclamation Area
Period 3
The project process is completed for 65 percent.

2013

2015

2017

2019

International Influence

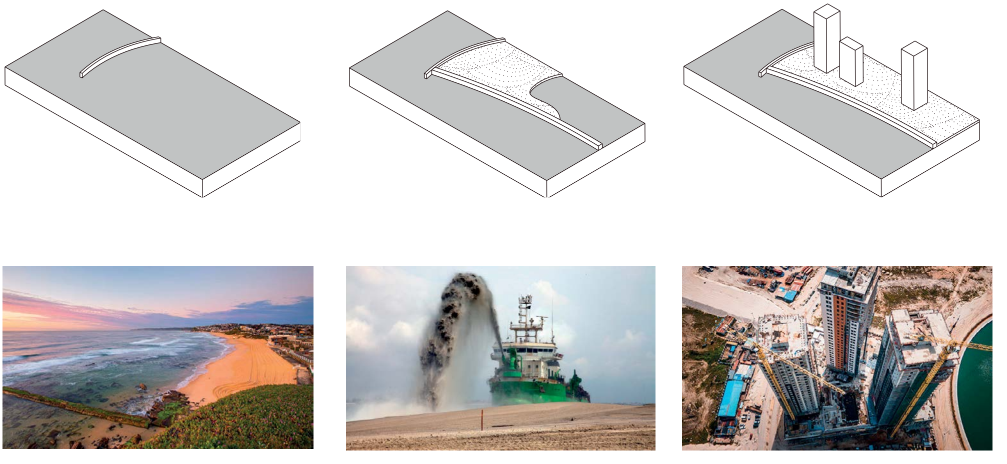
2013
Bill Clinton attended the dedication ceremony of the Eko Atlantic City project, which spans five million square meters.

2016
The Kuramo slums were once again demolished by the government.

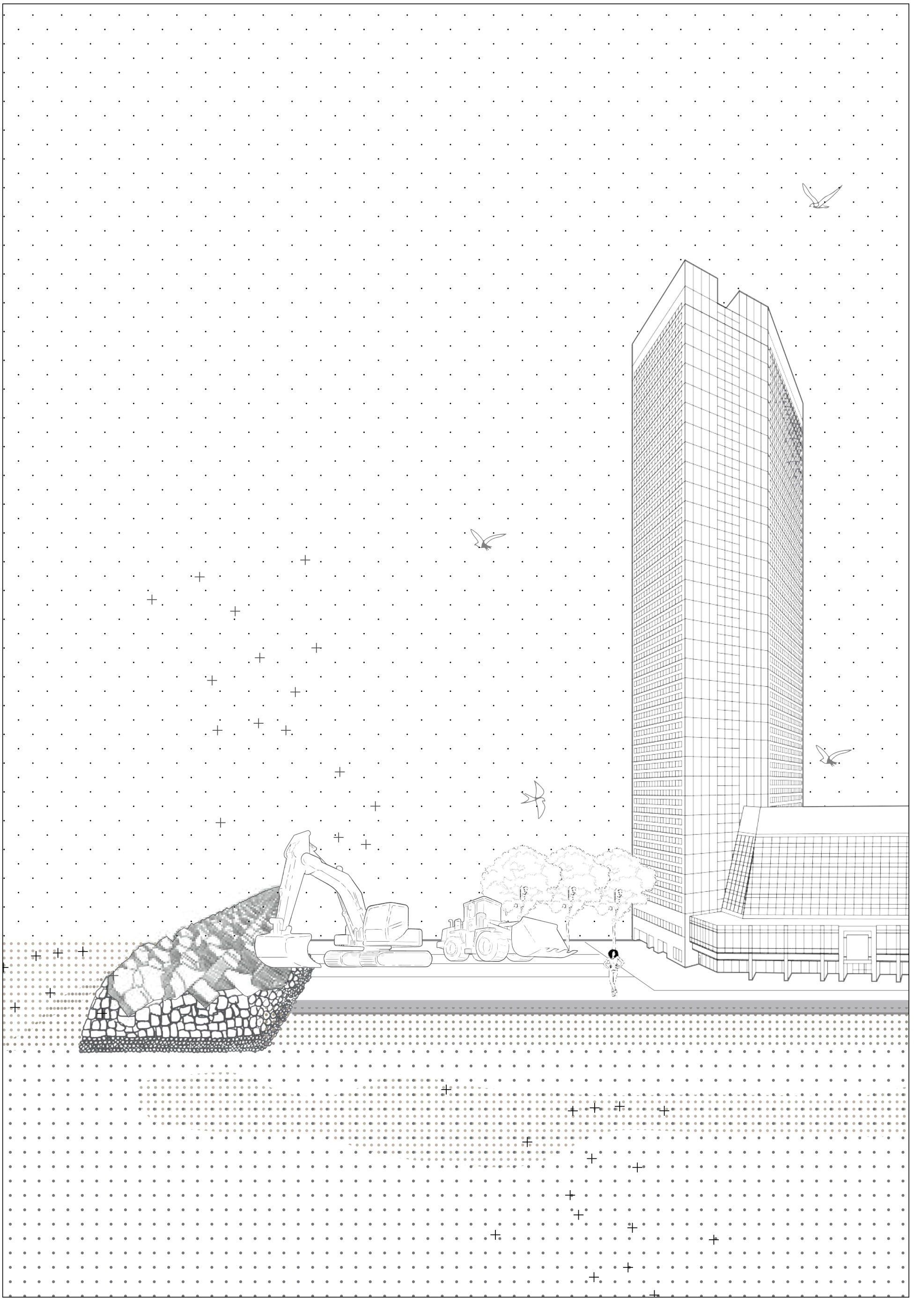
Termination

2019
All reclamation projects for the Lagos lagoon have been canceled.

2
ean surges impacted ramo. The government nolished the Kuramo ns. Residents of informal lements were evicted.



Reclamation Method in Eko Atlantic City | Authors' work. Data: Eko Atlantic City website.



rapidly proliferated in all directions. However, this assault led to a conflict between the residents of Otodo-Gbame and Elegushi's men, culminating in a fire that claimed three lives and destroyed 400 homes.

This was followed by a mass eviction. On October 9, 2016, the Governor, the Honorable Akinwunmi Ambode, issued a seven-day notice for the *'immediate demolition of all shanties around the creeks and on the waterways'* (Ebuzor, 2016). After being evicted on November 9, 2016, some residents rebuilt their huts in Otodo-Gbame. On March 17, 2017, the Lagos State Task Force returned to Otodo-Gbame with the Gendarmerie and demolished all the remaining structures and homes. The estimated 4,698 residents left homeless after the final clearance subsequently resettled in informal settlements throughout the city (Amnesty International Nigeria, 2018).

Otodo-Gbame's natural environment is a lagoon wetland. Lagoons provide habitats for various aquatic organisms, including numerous fish species, which offer income and food for the surrounding communities. The lagoon is relatively shallow, accommodating no oceangoing vessels, only smaller barges and boats. The Ogun and Osun Rivers flow into the lagoon, creating diverse sediments supporting mangrove swamps and creating muddy and sandy foreshores.

In the early 2000s, people filled the area with sand. Some houses are built on the beach, while others are constructed on the newly sand-filled water along the lagoon. Most homes are timber-panel structures topped with tin roofs (Etomi, 2012). Additionally, there are concrete block houses, a church, two schools, and two clinics. However, residential homes have been converted from plank structures to cinder block structures to protect against eviction (Adama, 2020).

Otodo-Gbame is distinctive in that it is situated on the Lekki peninsula. Developers and private homeowners have rapidly constructed compounds and apartment buildings on the sandy marshes between the Lagos Lagoon and the Atlantic Ocean. Real estate companies fill the lagoon with sand to expand the available land (Adebayo, 2017).

Formal Reclamation: Eko Atlantic City

Eko Atlantic City is a planned community in Lagos State, Nigeria, designed to be built on land reclaimed from the Atlantic Ocean. Situated next to Victoria Island, it covers over 10 million square meters and is expected to accommodate at least 400,000 residents upon completion (Van Bentum et al., 2012). The primary objective of this initiative is to address the issue of coastal erosion affecting Lagos. Victoria Island has long been affected by wave erosion; in 2005, a tsunami directly hit the coastal road, Ahmadu Bello Way. To counter this threat, the developer proposed constructing a seawall to protect Victoria Island from the Atlantic Ocean's effects while reclaiming land to develop housing and ease Lagos's housing shortage (Fernelius, 2020).

Eko Atlantic City will meet the demands of finance, commerce, housing, and tourism accommodations, featuring infrastructure that meets modern and environmental standards (Fernelius, 2020). The developer and the government aim to establish this project as a new landmark in Nigeria, showcasing the country's strength and ambition (Fernelius, 2020). The city plans to utilize cutting-edge technology to create a vibrant urban area reminiscent of modern Dubai (Fernelius, 2020).

However, the project has faced criticism from nearby residents who argue that the ongoing construction has caused coastal erosion and increased flooding (Fernelius, 2020). In August 2012, rising waters from the Atlantic Ocean flooded the area, sweeping 16 individuals into the sea, leading to several fatalities and submerging regions such as Kuramo Beach and parts of Victoria Island.

China Communications Construction Company Limited oversees the reclamation efforts for Eko Atlantic City, under the supervision of the Nigerian firm HaskoningDHV. The reclamation process primarily involves two main tasks: sand filling and the creation of sea defenses.

Sand dredgers extract sand from the Atlantic seabed near Lagos, which is then transported and spread in the reclamation area. Meanwhile, the construction of the 8.5-kilometer-long and 12.5-meter-wide sea defenses require various aggregate materials, geotextile fabric, and precast concrete elements. Each component is made from reinforced concrete, weighs 5 tons, and is assembled on-site. In total, 100,000 components will be meticulously arranged in a predetermined grid using GPS technology. The extensive sea defense structure comprises 12 distinct layers of rock and concrete, and a Danish company is conducting physical tests using a scale model (Emordi, 2024). The reclamation employs traditional sand and stone materials and modern scientific techniques.

Comparing Formal vs. Informal Land Reclamation

The three cases—Makoto, Otodo-Gbame, and Eko Atlantic City—allow us to compare formal and informal land reclamation practices. First, regarding land area and population carrying capacity, formal land tends to be more extensive and extends farther toward the water than informal land due to more favorable technical and financial conditions. Its population carrying capacity is greater due to its larger area, the greater availability of essential resources, and its higher productivity. Conversely, informal land is not subject to modern urban standards; the poverty of its inhabitants results in a significantly higher population density compared to formal land. This creates a paradox in Lagos's urban planning: while formal land accumulates considerable wealth and fewer affluent individuals, informal land is overpopulated with most of the city's poor residents.

Second, the developmental characteristics of the three land types can be observed in terms of urban fabric. As a mature informal community, Makoko has evolved into an urban space with a clear road network and community structure, characterized by very high density yet maintaining order. Otodo-Gbame, however, has transitioned from informal to formal and is gradually becoming fully formalized despite still being immature; thus, informal and formal land can coexist in the same area. The informal segment shares some similarities with Makoko, which remains in a phase of unstructured development, suggesting that Makoko's development process may reflect the universal principle of organic growth of informal land. The formal aspects of Otodo-Gbame exhibit the same qualities as those of Eko Atlantic City, where the land benefits from a rational design and planning process, resulting in attributes such as integrity and regularity.

Third, a distinct difference exists between formal and informal reclaimed lands in terms of the methods and materials they use for reclamation purposes. Fragile structures jeopardize the physical safety of informal land residents. In contrast, in Lagos, when informal land is converted into formal land through forceful eviction, formal projects typically utilize land composed of waste generated by impoverished individuals, which is then covered with sand to create a more stable surface. This represents a troubling aspect of the investment process for Lagos investors: achieving cost savings through the eviction of residents from informal communities. Overall, when comparing the three projects, we find that Makoko, which remains an informal settlement, grapples with more immediate challenges, including infrastructure deficiencies, community vulnerability, and a housing shortage. This comparison also highlights the paradoxes and irrationalities inherent in urban planning and development, which are precisely the issues that Lagos needs to reconsider and address.

The Necessity of Desegregation

The disparity between formal and informal land in Lagos can lead to even greater segregation if the government persists in neglecting the city's informal land and its associated issues, conducts inappropriate and violent evictions, and promotes investment in formal projects that encroach upon informal land.

First, pollution and livelihood challenges arise from chronic mismanagement of informal lands and violent evictions therefrom. Informal land development, conducted entirely by the impoverished living in slums, is constrained by a lack of knowledge and technology. Such lands' infrastructure systems are entirely inadequate, further worsening the region's unhealthy conditions. The community lacks a proper sewerage and disposal system. As a result, residents dump garbage and wastewater into the water, directly contributing to water pollution (Cortes and Arrocha, 2021). Water pollution primarily affects the health of residents who depend on the lake for their water supply. Moreover, most residents living on informal land earn their livelihoods from fishing, and ongoing water pollution will degrade water quality and negatively impact the fishing industry, thereby threatening residents' livelihoods. Additionally, violent evictions destroy the equipment and shelters of those who rely on fishing, forcing them away from the waterfront and leading to lost income.

Second, urban homelessness results from the government's inappropriate methods of evicting low-income individuals and seizing their informal lands without providing adequate housing. With 70% of the urban population living in informal settlements (Badmas et al., 2019), it is predictable that continued violent evictions will leave many people homeless and living on the streets. These individuals often inhabit flimsy wooden, plastic, or cardboard structures or canoes with makeshift roofs, devoid of any guarantee of safety. At the same time, the increasing homeless population poses a destabilizing threat to the city's security.

Third, human rights and social equity concerns are among the most pressing challenges to the governing authorities. The poor conditions on informal land and the threat of violent evictions lead to human rights violations for low-income individuals. Their rights to survival, development, housing, and even education and freedom of religious belief are not protected. Informal land has fostered many crumbling yet simple and effective homes within a small area, providing shelter for the city's many impoverished residents. Nevertheless, it continues to face threats from the government and investors. Numerous formal developments are underway, claiming to address the city's housing crises and depicting Lagos as a global metropolis while concealing the struggles of the city's underclass with grandiose rhetoric. However, despite the influx of investments, not a single cent benefits these poor individuals. This contradiction has led to the human rights and social equality issues that Lagos must confront.

The Value of Informal Land

Informal land holds unique technical and social values that deserve recognition. Regarding technical value, land reclamation and housing construction technologies present significant potential. First, in terms of land reclamation, informal land typically employs waste as reclamation material, augmented by sawdust deodorization and a layer of sand.

This method embodies sustainability, recyclability, and regeneration. It mitigates the disadvantages of landfills and introduces innovative waste disposal solutions, ultimately reducing resource waste.

Second, concerning housing construction, while homes on informal land may face specific stability issues, they offer benefits like low cost and recyclability. The majority of materials used consist of waste or by-products from other industries. Additionally, these structures are easy to build and disassemble. As waterfront houses, this adaptability allows them to align quickly with the rapid pace of urban development. Consequently, these informal land construction practices can be further utilized and enhanced during future renovation or renewal efforts.

From a social value perspective, informal land can temporarily address housing challenges and mitigate urban housing conflicts. It provides an affordable and accessible solution to the housing needs of low-income individuals, promoting social stability and economic vibrancy.

On this foundation, communities that emerge on informal land possess considerable potential for growth and development. As informal settlements, these communities boast a structure and organic planning that encompasses housing, transportation, commerce, education, health care, faith, and other functions that evolve into a self-sufficient and dynamic system, even if it lacks formal scientific design. Residents have developed their means of surviving and thriving within the city. They integrate steadily into urban life, doing so in their own ways and at their own rhythms. In this manner, they are becoming an integral part of the city, fulfilling specific urban needs and functions.

The Future of Formal and Informal Land Use in Lagos

One can anticipate three potential hypotheses about the future of informal and formal land treatment: 'Keep demolishing,' 'Stop intervening,' and 'Regeneration and collaborative compromise.'

'Keep demolishing' entails the government and developers continuing their hardline approach by conducting forced evictions and demolitions to convert informal lands into formal lands like Eko Atlantic City. This 'solution' disregards human rights and social justice, cleansing the city's so-called dark side at a substantial cost and mirroring previous solutions adopted by Lagos. It arises from a top-down perspective that fails to recognize the rights of the lower classes in the city. The immediate and predictable outcome of activities in this vein was the loss of housing for tens of thousands of lower-class individuals, with even more significant negative consequences.

'Stop intervening' refers to the government and developers ceasing their involvement in informal land, thereby transferring development rights to the community residents. This enables those residents to construct their settlement in their own way and at their own pace, with a degree of freedom and autonomy. This hypothesis grants considerable liberty to informal lands and their inhabitants. However, these individuals need the capacity and conditions to effectively plan their land and spaces. Consequently, more developing informal lands are expected to follow the patterns established by Makoko, ultimately evolving into full-fledged slum communities. Such communities provide land that meets the basic subsistence needs of many impoverished individuals whom the government cannot resettle. However, they can also have a continuous negative impact and function as an urban hazard.

We propose a third hypothesis, 'Regeneration and collaborative compromise,' as a middle ground; we consider it a relatively reasonable approach. Its essence lies in an urban regeneration plan that balances preservation and demolition alongside collaboration and compromise among various stakeholders. During the regeneration process, government entities, investors, and societal groups provide financial and technical support from the top down. Simultaneously, residents express their demands, offer suggestions, and engage from the bottom up. Different demographic groups pursue their own paths, while various and interconnected issues—such as social conflict, human rights, economy, and ecology—are incorporated into the decision-making process. Ultimately, we expect a new model of urban renewal with universal applicability to emerge, which can then be applied to the transformation of additional informal lands. This suggestion presents a more favorable solution for informal lands, enhancing both the quality of life and the environment while reducing the threat of eviction and respecting the social foundation of these areas. For the city, it also represents a compromise that considers all socioeconomic classes and various types of land. It offers a more effective and viable logic that neither overlooks nor ignores contradictions nor attempts to resolve all issues at once.

The topic of community renewal invites a thoughtful exploration of various strategies aimed at enhancing both livability and sustainability. When considering practical suggestions for renewal, several key areas emerge:

First, the improvement of transportation infrastructure plays a pivotal role. By widening waterways and enhancing transportation functions, communities can build upon existing road networks to create a well-integrated transport system. This is essential for accessibility, ensuring that all residents can navigate their environment with ease.

Next, the restructuring of community layouts warrants attention. This involves a deliberate effort to clarify and streamline building clusters and neighborhood arrangements. By treating them as living entities, we can

Above | The informal settlement of Makoko in Lagos. Photograph by Hugo Kempeneer, 2017.
Right | Trash, plastic, metal, and wood are the primary construction materials used in the silt houses of Makoko. Photograph by Hugo Kempeneer, 2017.

approach planning modularly, fostering rational living conditions that accommodate a growing population within limited spaces.

Moreover, addressing housing needs is crucial. Renewing building forms and ensuring structural stability is necessary for accommodating new residents. Two innovative construction approaches—raising existing buildings and designing flexible floating structures—can meet contemporary demands while enhancing the adaptability of housing solutions.

Infrastructure development must be another focus of this discussion. Taking a scientific planning approach to the current infrastructure, which includes reinforcing power supply stability and transforming inefficient water extraction methods, paves the way for a cleaner and more efficient water system. Separating clean and dirty water is vital for safeguarding public health.

Waste management practices need significant improvement. Sustainable land reclamation methods can be learned from innovative reclamation techniques applicable to informal lands, thereby preventing water pollution and enhancing land stability through mechanical assistance.

Public spaces, too, deserve our attention as they are foundational to community life. By increasing public spaces, we can enrich residents' quality of life and foster a vibrant public sphere. Meanwhile, constructing ecologically sensitive floating islands serves a dual purpose: enhancing water quality near informal lands and mitigating negative impacts through targeted environmental strategies. This aligns with broader sustainability goals while also improving quality of life.

Lastly, developing ecological fisheries signifies a pivotal shift towards the 'ecologization' of livelihood practices within informal lands. By transforming outdated fishing methods into more sustainable practices, we can ensure that local economies thrive while promoting an ecological balance.

In conclusion, the government should initially approach informal land dialectically, addressing both its advantages and disadvantages, acknowledging it as an integral part of the city, and upholding the human rights of settlement residents. The subsequent step is to develop a new urban regeneration and planning model that combines top-down and bottom-up perspectives and tools; fosters collaboration among various stakeholders; and integrates a wider range of topics into the decision-making process. A vibrant urban landscape will result.

Conclusions

The story of Lagos, as described in this chapter, unfolds both as a record of rapid change and as a reflection of persistent inequality. By examining the city's land reclamation practices, this study reveals how Lagos's urban problems are not just technical or administrative but are deeply rooted in historical and spatial injustices. The city's growth—its increasing population, expanding urban landscape, and ongoing land demands—shows a recurring pattern of exclusion that began during the colonial era and continues today. What initially started as a spatial divide between colonizer and colonized has transformed into a structural gap between privilege and hardship, expressed through the city's physical materials: the sand, concrete, and refuse that make up Lagos's physical and social layers.

The cases of Makoko, Otodo-Gbame, and Eko Atlantic City demonstrate these layered contradictions. Makoko, with its maze of waterways and stilted houses, symbolizes resilience and creative adaptation—a community built directly from the city's debris, turning waste into land and transforming instability into endurance. Otodo-Gbame, on the other hand, highlights the violent clash between informal vitality and formal development: a landscape once filled with families and livelihoods, now erased and repurposed for profit. Eko Atlantic City, rising on engineered terrain, represents the pinnacle of formal land reclamation—an intentionally planned district that shields itself from both the ocean's tide and the tide of poverty. Each example shows how land reclamation, often promoted as a technical solution for housing shortages and coastal erosion, has become a stage where Lagos exposes its deepest social divides.

However, within this uneven landscape, there exists a paradoxical vitality. Informal settlements—though marginalized and insecure—embody forms of urban life often absent in the formal city: solidarity, adaptability, and ecological harmony. The use of recycled materials, communal homebuilding, and micro-economies on these fragile lands demonstrates an alternative approach to sustainability. Meanwhile, the formal city advances with polished plans and shiny façades but relies on the unseen labor, waste, and creativity of those living on its margins. Therefore, Lagos's land reclamation efforts are not just about reclaiming land; they challenge ideas of meaning, belonging, and visibility within the urban landscape.

Moving forward, Lagos's future must focus on regeneration through collaborative compromise. This approach recognizes that destruction cannot endlessly precede creation—and that the city's renewal depends on embracing, rather than erasing, its informal roots. It calls for dialogue between the top-down planning and the bottom-up insights of residents; between the needs of environmental resilience and the urgency of human rights. Only through this dialectical process can Lagos transform its fractured geography into a just and resilient urban ecosystem.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2022–23. During the course, Xiaoqian Cheng, Jingwei Guo, Antong Huang, and Chenye Yang wrote the initial paper, supervised by Laura Cipriani. Xiaoqian Cheng, Jingwei Guo, Antong Huang, and Chenye Yang prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the paper. Finally, a native English speaker reviewed the text.

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Land Reclamation Sites Data

Location
Thulusdhoo | Maldives
Coordinates
4° 13' 1" N | 73° 32' 30" E
Area
0.33 km2
Length
1.58 km
Width
0.68 km
Time
2014-2016

Location
Hulhumalé | Maldives
Coordinates
4° 12' 60" N | 73° 32' 24" E
Area
4.32 km2
Length
2.40 km
Width
1.00 km
Time
1997-2015

7 | Chasing Land in a Sinking World

Dredging in the Maldives

Pleun de Braake, Wout de Joode, Linde Karnebeek, Nils Wolff, Junhui Zhang
Laura Cipriani, Denise Piccinini

The Maldives, the world's lowest-lying country, is made up of many islands, each with its own community and lively culture. However, adapting to rising sea levels poses significant challenges for the archipelago. Some islands have undergone land reclamation fueled by increased tourism, population growth, and the looming threat of rising tides, although each island faces unique issues regarding climate change, political circumstances, ecological concerns, and social dynamics. This chapter analyzes the ecological and social ramifications of these efforts by comparing the Hulhumalé and Thulusdhoo projects. Due to the swift effects of climate change and rising sea levels, several reclaimed islands—like Thulusdhoo, famous for its stunning beaches and tropical sun—are at risk of flooding and may eventually succumb to the ocean. In contrast, the Hulhumalé reclamation initiative, situated close to the capital and aimed at boosting tourism and economic growth, disrupted natural processes and damaged essential reef formations. This chapter explores the social and ecological challenges tied to these two reclamation initiatives and posits that land reclamation represents a continual struggle rather than a promising opportunity in light of the rapidly rising sea levels.

Introduction

The Maldives, situated in the Indian Ocean to the southwest of India, is a small nation known for its very low-lying terrain. It consists of twenty-seven atolls, which contain over a thousand islands. These atolls are structured as ring-shaped reefs that keep many islands above sea level (Mörner, Tooley and Possnert, 2004). The average land elevation is merely one and a half meters, presenting considerable future challenges for the Maldives. The looming threat of rising sea levels from climate change concerns many residents, but these concerns often go unaddressed. As numerous social issues arise, passing this problem on to future generations is no longer an option. In response, the government is investing in land reclamation projects to combat the loss of territory due to the encroaching sea, essentially seeking to secure land in a world that is gradually sinking.

This opening subchapter introduces the Maldives, outlining the climate change challenges it faces, the different types of islands, and the land reclamation methods used. It also emphasizes the social and ecological issues related to these reclamation efforts.

The subsequent subchapter, 'Journey to the Unknown,' lays the groundwork for understanding the implications of land reclamation in the Maldives. The subchapter that follows, 'From Paradise to Paradox,' focuses on land reclamation projects on the Maldivian islands of Thulusdhoo and Hulhumalé, offering a comprehensive analysis of how similar adaptation strategies affect islands with differing social and ecological contexts. Thulusdhoo Island represents the stunning beauty of the Maldivian landscape and is a popular tourist destination due to its proximity to the densely populated capital, Malé. This advantageous position has led to significant land reclamation to boost tourism, yet these changes have adversely affected the island's surrounding ecosystems. In contrast, Hulhumalé is an entirely artificial island created next to Malé. It features an airport and more space for residents. While the newly reclaimed areas provide a safer option for Maldivians, social and economic challenges arise as many people move to Malé.

The Consequences of Climate Change for the Maldives

The Intergovernmental Panel on Climate Change (IPCC) projects a sea level rise (SLR) of one hundred centimeters by 2100 if human behaviors remain largely unchanged (IPCC, 2021). This increase poses significant threats to coastal areas and island nations, particularly the Maldives. Shifting weather patterns, including frequent storms and intense rainfall, exacerbate the situation. Combined with rising sea levels, these conditions could result in catastrophes and extreme weather events afflicting the archipelago.

The Maldives' distinctive topography makes it especially susceptible to rising sea levels. Current data shows that a one-meter rise in sea level could submerge eighty-five percent of the nation's land despite the flat reef accretion of two to six millimeters annually (Storlazzi et al., 2018). The advancing sea levels would render the islands unlivable, and increased coastal flooding significantly affects them already. Such flooding disrupts daily life and infrastructure, leading to the salinization of fresh groundwater, creating a water scarcity that forces locals to rely on rainwater collection to maintain a sufficient supply throughout the year (Jaleel et al., 2020). The Maldives has experienced several devastating events linked to climate change, including the extreme heat occurrences in 1998 and 2016 related to an 'El Niño event,' which resulted in widespread coral bleaching (Pisapia et al., 2017). As El Niño events persist, other extreme weather patterns will likely become more common in the future.

Land reclamation is a notable strategy for adapting to rising sea levels in the Maldives. Duvat (2020) conducted a comprehensive study revealing a human-driven expansion of over twenty-three square kilometers from 2006 to 2016. Over 12% of the monitored islands exhibited growth rates surpassing 50% during this timeframe. If land reclamation continues at this pace until 2100, projections indicate that artificial land area in the Maldives will exceed that of natural land by the mid-21st century (Duvat, 2020). The overall decrease in the land area would be significantly mitigated if prior reclamation rates were maintained. Ultimately, there may come a point when no natural land in the Maldives remains habitable.

The following sections will discuss several effects of land reclamation on the Maldives' beautiful nature and rich heritage. It is crucial to note that many aspects of these scenarios are uncertain and can only be predicted with considerable variability. For instance, the potential fluctuations in the natural reef flat accretion rate remain undetermined, depending on whether decision-makers focus on climate change adaptation or mitigation. Local government strategies recently initiated include efforts to reduce CO2 emissions as part of mitigation (Bank, 2015), while land reclamation primarily serves as an adaptation measure. However, since 2017, the Maldives' president, Thoriq Ibrahim, has reduced the urgency of local initiatives to lower CO2 emissions, favoring economic growth instead (Vidal, 2022).

Land Reclamation in the Maldives

Although climate change affects the Maldives dramatically, the Maldivian government is actively engaged in land reclamation efforts. This initiative supports the government's objectives of tackling climate change while enhancing decentralization and connectivity to shorten island travel times (Buitendijk, 2022).

Island types in the Maldives | Distribution of inhabited and resort islands in the Maldives. Authors' work. Data: Google Maps, 2023.


Thiladhunmathee Uthuruburi
Haa Alifu Atoll | Dhidhdhoo
Thiladhunmathee Dhekunuburi
Haa Dhaalu Atoll | Kulhudhuffushi
Miladhunmadulku Uthuruburi
Shaviyani Atoll | Funadhoo
Miladhunmadulku Dhekunuburi
Noonu Atoll | Manadhoo
Maalhosmadulu Uthuruburi
Raa Atoll | Un'goofaaru
Faadhippolhu
Lhaviyani Atoll | Naifaru
Maalhosmadulu Dhekunuburi
Baa Atoll | Eydhafushi
Malé Atholhu
Kaafu Atoll | Malè
Ariatholhu Uthuruburi
Alifu Alifu Atoll | Rasdhoo
Ariatholhu Dhekunuburi
Alifu Dhaalu Atoll | Mahibadhoo
Felidhuatholhu
Vaavu Atoll | Felidhoo
Nilandheatholhu Uthurumuri
Faafu Atoll | Magoodhoo
Mulakatholhu
Meemu Atoll | Muli
Nilandheatholhu Dhekunuburi
Dhaalu Atoll | Kudahuvadhoo
Kolhumadulu
Thaa Atoll | Veymandoo
Hadhdhunmathi
Laamu Atoll | Fonadhoo
Huvadhuatholhu Uthuruburi
Gaafu Alifu Atoll | Vilin'gili
Huvadhuatholhu Dhekunuburi
Gaafu Dhaalu Atoll | Thinadhoo
Foamulah
Gnaviyani Atoll | Foahmulah
Adduatholhu
Seenu Atoll | Hithadhoo
N
0 10 km 50 km 100 km
Inhabited island
Atoll administrative boundary
Resort island

Right | View of one of the Maldives atoll islands from an airplane. Photograph by whosaynow, 2022.

Typically, land reclamation is achieved in the Maldives by dredging sand from the seabed within the atolls' lagoons. The sand and water are transported via pipelines to the designated reclamation area. First, dikes are built to define the boundaries of the reclamation site. Next, the area is filled with the sand-water mixture. The water is then drained away, and the sand is leveled using shovels. This process ultimately creates a new artificial landmass. Once reclamation is complete, shore protection is installed using rock formations, and, in some areas, geotextile tubes, which are long bags made of geotextile fabric and filled with sand. These tubes have shown effectiveness in various climate adaptation initiatives, such as dam construction (Buitendijk, 2022).

It is well established that land reclamation can adversely affect the environment (Bank, 2015). Modifying the seabed through dredging can disrupt the physical environment by altering current speeds and wave patterns. Additionally, suspended sediments can reduce light availability for seagrass, coral reefs, and other marine organisms, negatively influencing their growth and survival (Mostafa, 2012). Buitendijk (2022) suggests that numerous opportunities exist to create more sustainable land reclamation methods, such as relocating coral reefs. However, the sustainability of these reclamation efforts in combating climate change can be debated. The subsequent subchapters will explore specific ecological effects of land reclamation in the Maldives.

Different Island Types

The Maldives, whose economy heavily relies on tourism, is tackling ocean-related threats while utilizing its distinctive tourism assets, including tropical beaches and crystal-clear waters. The sun, sea, sand, and remarkable landscapes have consistently given the Maldives a competitive edge in tourism.

When the first, 280-bed resort opened its doors in 1972, only 1,000 tourists visited the Maldives. In 1983, a tourism master plan was introduced to develop the sector further. Following this, the government established the one-resort, one-island (OROI) policy (Zuhuree, 2021). Tourist-related industries such as lodging, dining, and recreation were restricted to selected uninhabited islands designated solely for tourism, while accommodation on inhabited islands was banned.

The OROI policy has resulted in two distinctly different island types in the Maldives: inhabited and resort islands. Inhabited islands, mainly located on the atolls, are generally larger than resort islands and have densely packed buildings alongside developed road systems, as well as more complex facilities such as schools, harbors, hospitals, and airports. In contrast, the resort islands are primarily found within the lagoons of the atolls, boasting more deliberately organized and uniform housing layouts.

These two island patterns create the iconic landscapes of the Maldives, showcasing charming resort islands where tourists enjoy secluded sandy beaches and luxurious holiday accommodations. However, there are also densely populated residential islands. Both types of communities require substantial land area. Recent decades have seen a focus on artificial land reclamation, leading to an increase in resort islands to meet tourism demand. This decision has also enlarged residential islands within the atolls to accommodate greater infrastructure, including airports and desalination plants, enhancing the convenience for the tourism sector (Duvat, 2020).

Journey to the Unknown

In recent decades, the Maldives has carried out numerous land reclamation initiatives across key atolls. These initiatives include building additional airports, harbors, and housing, and developing more resort islands to support the tourism industry's growth (Duvat, 2020). Nevertheless, the negative consequences of these unchecked land reclamation efforts have become increasingly apparent. This subchapter investigates specific ecological challenges linked to or triggered by land reclamation and addresses social issues in the Maldives, particularly concerning migration.

The social implications of land reclamation in the Maldives are significant. One major consequence is the inadequate social infrastructure on newly developed islands, which leaves residents without essential services (Bank, 2015). Furthermore, the forced displacement of local communities due to reclamation raises substantial concerns, as many individuals and families have been compelled to abandon their homes and neighborhoods (Storlazzi, 2018). This situation has intensified competition for land ownership between local residents and outside investors. Additionally, migration prompted by the establishment of new islands has further marginalized local populations, threatening their cultural identity, which is already under strain. These social consequences highlight the urgent need to carefully consider the repercussions of land reclamation in the Maldives.

Coral reef destruction is a critical ecological concern, as it disrupts the fragile marine ecosystem (Duvat and Magnan, 2019). Moreover, land reclamation can worsen beach erosion, pollution, and coastal flooding, degrading valuable coastal habitats. Finally, the loss of biodiversity from the destruction of natural habitats on land and in the sea is a significant worry, as numerous marine organisms have lost their original homes.

In the following sections, this essay will discuss the challenges faced by the Maldives from the viewpoint of the social and ecological repercussions of land reclamation.

Social Challenges

When the government lifted restrictions on tourist establishments on inhabited islands in 2010, guesthouses emerged as a new market segment (Zuhuree, 2021). Unlike the more exclusive resorts, guesthouses promote inclusivity and provide increased job opportunities through outsourced services.

In 2019, the Maldives welcomed over 1.7 million tourists, marking a record high that tripled the nation's population (Zuhuree, 2021). While this growth in the tourism sector brings significant economic advantages, it also presents considerable challenges.

If we consider tourists as 'temporary residents' of the islands, the bed capacity data from the 'Settlements and Tourist Distribution Map' illustrates their spread across the Maldives' atolls, which aligns with the distribution of resort islands.

As tourism increases on developed resort islands and those with local populations, limited public resources such as beaches, coral reefs, and freshwater are increasingly utilized. These resources seem nearly free compared to those available in resorts, amplifying the opportunity to build additional accommodation to meet demand. For example, Maafushi Island in Kaafu Atoll had over 50 registered guesthouses and 1,445 beds by 2020, nearly quadruple the bed capacity of most resorts in the country (Zuhuree, 2021). This implies that islands dependent on tourism can only compete for resources against resort islands by expanding infrastructure for airports, ports, and other facilities, rather than enhancing housing for local families.

This situation disadvantages local residents, who are more vulnerable to resource competition from tourists. The lack of economic opportunities on underdeveloped islands reveals a pressing need for locals to achieve greater financial independence and resilience to climate change (Muller, 2022). Consequently, those looking to improve their lives often find it necessary to migrate to urban areas, particularly the capital city of Malé and the newly developed city of Hulhumalé (Avas, 2022).

Land reclamation and urbanization have dislocated local communities, especially those in low-lying regions or small islands. Many individuals are compelled to relocate to Malé or other urban areas to access improved social and technical infrastructure. This significant wave of internal migration has resulted in city overcrowding, straining infrastructure and services.

Ecological Challenges

Land reclamation in the Maldives triggers both human and non-human migrations. Known for its rich underwater and terrestrial ecosystems, the Maldives is home to over 2,000 fish species, and the distinctive structure of atolls fosters unique habitats (Otte, 2023). Coral reefs serve as crucial marine habitats and the foundational structure for each island. On land, mangrove forests, which complement coral reefs, are habitats for numerous fish, amphibians, and insects.

Although these extraordinary ecosystems support the Maldivian tourism and fishing industries, they face severe threats from human activities. Artificial land reclamation significantly alters these ecosystems, particularly through dredging, which adversely affects local plant and animal life. The extraction and placement of sand result in sedimentation and noise pollution, directly affecting various species. The movement of land disrupts algae meadows, corals, and mangrove forests, disturbing the habitats and livelihoods of organisms such as fish, birds, and reptiles. This noise can also prompt migrations of animals in and out of aquatic environments.

Moreover, land reclamation brings about several indirect effects. Changes in land use—stemming from increased tourist activities like diving and reef fishing, along with economic expansions such as air and sea traffic, industrial fisheries, and pollution—heighten stress on local ecosystems.

The 'Ecological Pressures on Islands' map depicts human effects on the coral reefs surrounding Maldivian islands. Duvet and Magnan (2019) found that pressures in each atoll rose between the years 2006 and 2016, primarily due to harbor-basin dredging and sand mining for land reclamation. In 2016, coral reefs near the densely populated northern and southern Kaafu atolls and the Alifu atolls faced the greatest human pressures.

From Paradise to Paradox

The following sections explore island-specific conflicts related to land reclamation projects in Thulusdhoo and Hulhumalé. Thulusdhoo, a tourism-oriented island, is undergoing a significant reclamation effort aimed at increasing visitor numbers. This case highlights the ecological impacts of land reclamation in Thulusdhoo, demonstrating practices that enhance tourism. The newly created artificial land is primarily intended to accommodate resort areas and features the typical characteristics of tourism islands.

In contrast, the reclamation in Hulhumalé is mainly designed to create more living space for residents and is seen as an expansion of the capital city, Malé, with its residential planning. This focus on residential development has led to a substantial influx of migrants to Hulhumalé. This case study investigates the social effects of this reclamation, addressing the challenges and opportunities arising from the growing population and the need for infrastructure and services. It analyzes how reclamation projects

Human pressure on the island´s reef

No to limited pressure

Moderate pressure

High to very high pressure

Share of total atoll

Less than 20%

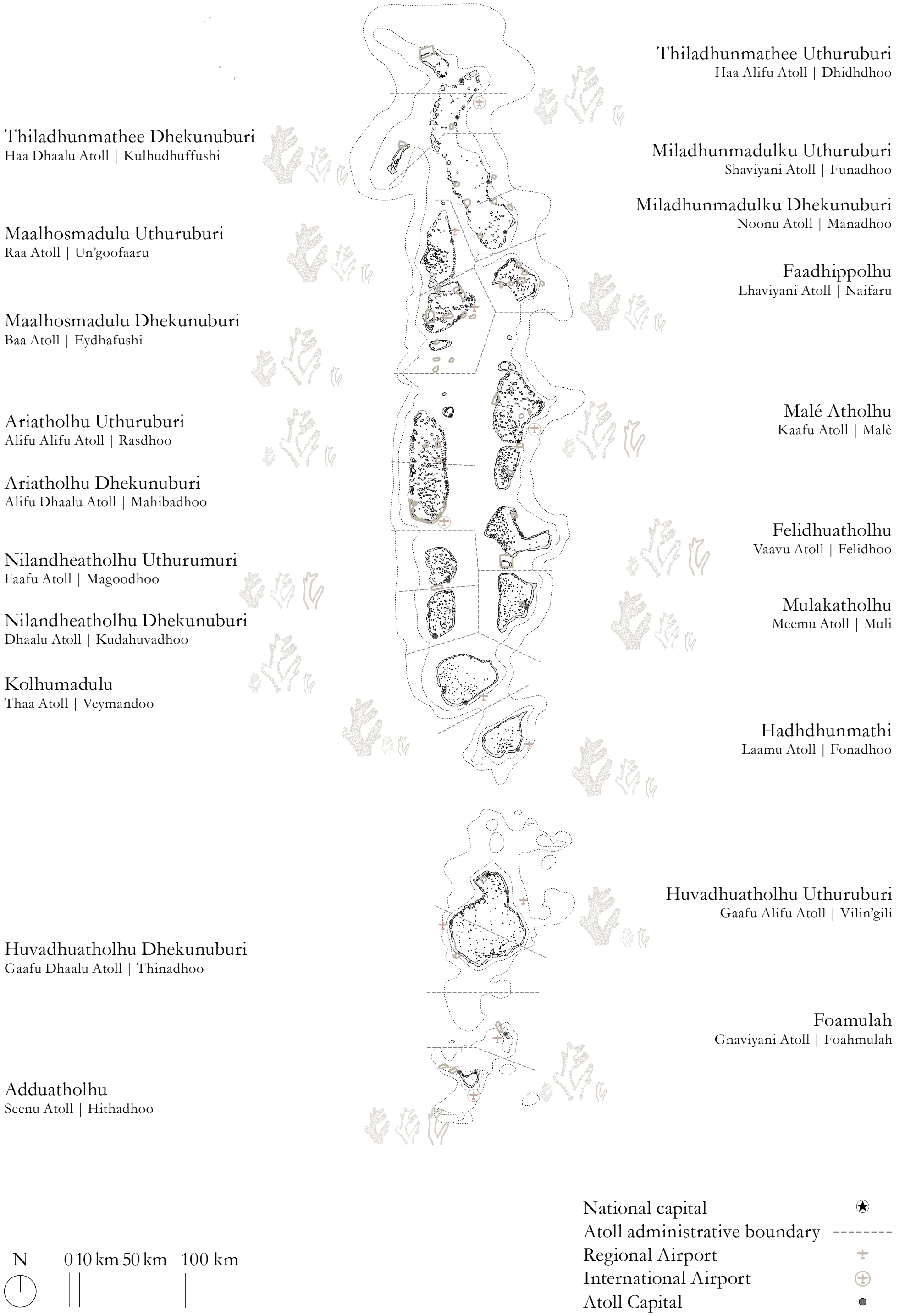
20% to 50%

more than 50%

Marine protected areas

Original Name
English Transcription | Capital

Ecological pressures | Ecological pressure on the islands of the Maldives. Authors' work. Data: Duvat and Magnan, 2019.


Thiladhunmathee Uthuruburi
Haa Alifu Atoll | Dhidhdhoo
Thiladhunmathee Dhekunuburi
Haa Dhaalu Atoll | Kulhudhuffushi
Miladhunmadulku Uthuruburi
Shaviyani Atoll | Funadhoo
Miladhunmadulku Dhekunuburi
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Ariatholhu Dhekunuburi
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Huvadhuatholhu Dhekunuburi
Gaafu Dhaalu Atoll | Thinadhoo
Foamulah
Gnaviyani Atoll | Foahmulah
Adduatholhu
Seenu Atoll | Hithadhoo
N
0 10 km 50 km 100 km
National capital
Atoll administrative boundary
Regional Airport
International Airport
Atoll Capital

like those in Hulhumalé drive rapid urbanization and migration in the Maldives. As the capital expands, it attracts more individuals seeking jobs and services, resulting in infrastructure strain and increased migration from the atoll islands, in turn triggering consequences for the Maldivian economy and demographics.

Beautiful Islands Spark Controversy: The Thulusdhoo Case

In 2004, a tsunami struck the Maldives, leading to extensive damage (ADRC, 2005). Following this disaster, the Dutch civil engineering firm Boskalis was called upon to reconstruct various islands (Minivan News, 2014). This effort initiated land reclamation projects in the Maldives, notably on Thulusdhoo, the capital of the Kaafu atoll, situated 30 kilometers northwest of Malé, the national capital. By 2014, the area of Thulusdhoo Island had nearly doubled due to these efforts (Naish, 2014).

Most land reclamation initiatives in the Maldives primarily target the creation of large resort facilities for tourists. However, Thulusdhoo, originally a residential island, transitioned towards developing a tourist hotspot featuring pristine beaches and sunny weather. This change, along with several challenges, has resulted in many residents migrating from Thulusdhoo to Malé. This trend is prevalent throughout the Maldives. While the population is presently dispersed across various atolls, Malé will inevitably surpass the combined population of the other atolls in the future.

Zarah, the owner of a local surf camp, points out that land reclamation disrupts natural processes, leading to erosion and a decrease in native flora and fauna (NPO, 2023). '*Tourists come here for the beauty of the scenery. To provide that, we destroy the scenery. It is ironic, but precisely what is happening*' (NPO, 2023). This statement highlights the effect of the reclamation of Thulusdhoo's west coast. As human activities alter the natural landscape through land reclamation, the environment faces the risk of disappearing. For Thulusdhoo, this disruption also affects the island's surrounding ecological systems.

In their natural state, the Maldive islands would shift with ocean currents prior to any land reclamation. On one side, sand would typically erode, while on the opposite side, it would accumulate. For Thulusdhoo, this means that sand erodes from the eastern ocean side, while it gathers on the western lagoon side. Over time, these shifts affect the whole island, causing inhabitants near the eroding shore to migrate. The housing on these more natural islands is quite basic, allowing people to move easily to other locations. Along with the drifting sand, the reef structure and the countless organisms living among the coral also shift. It is essential to understand that human migration is merely one facet of these challenges—much is also occurring underwater and above the surface.

After Thulusdhoo's size doubled due to the reclamation efforts (Naish, 2014), these natural systems were disrupted. The island's position has now stabilized, and it no longer shifts. Despite the continuing erosion of the beach on the ocean side, sand is unable to accumulate on the lagoon side. Additionally, reef migration has been hindered. While the resort accommodates guests on the lagoon side, the erosion on the ocean side is clear, with numerous tree roots exposed. Ultimately, this situation threatens the homes of Maldivians, including Zarah, who can observe this destruction unfolding just meters from her home.

New Reclamation Projects: The Hulhumalé Case

Land reclamation poses ecological concerns, as seen on Thulusdhoo; but many islands also grapple with social issues. A prominent reclamation endeavor in the Maldives, the Hulhumalé project, illustrates how centralization, migration, and various social challenges generate significant problems.

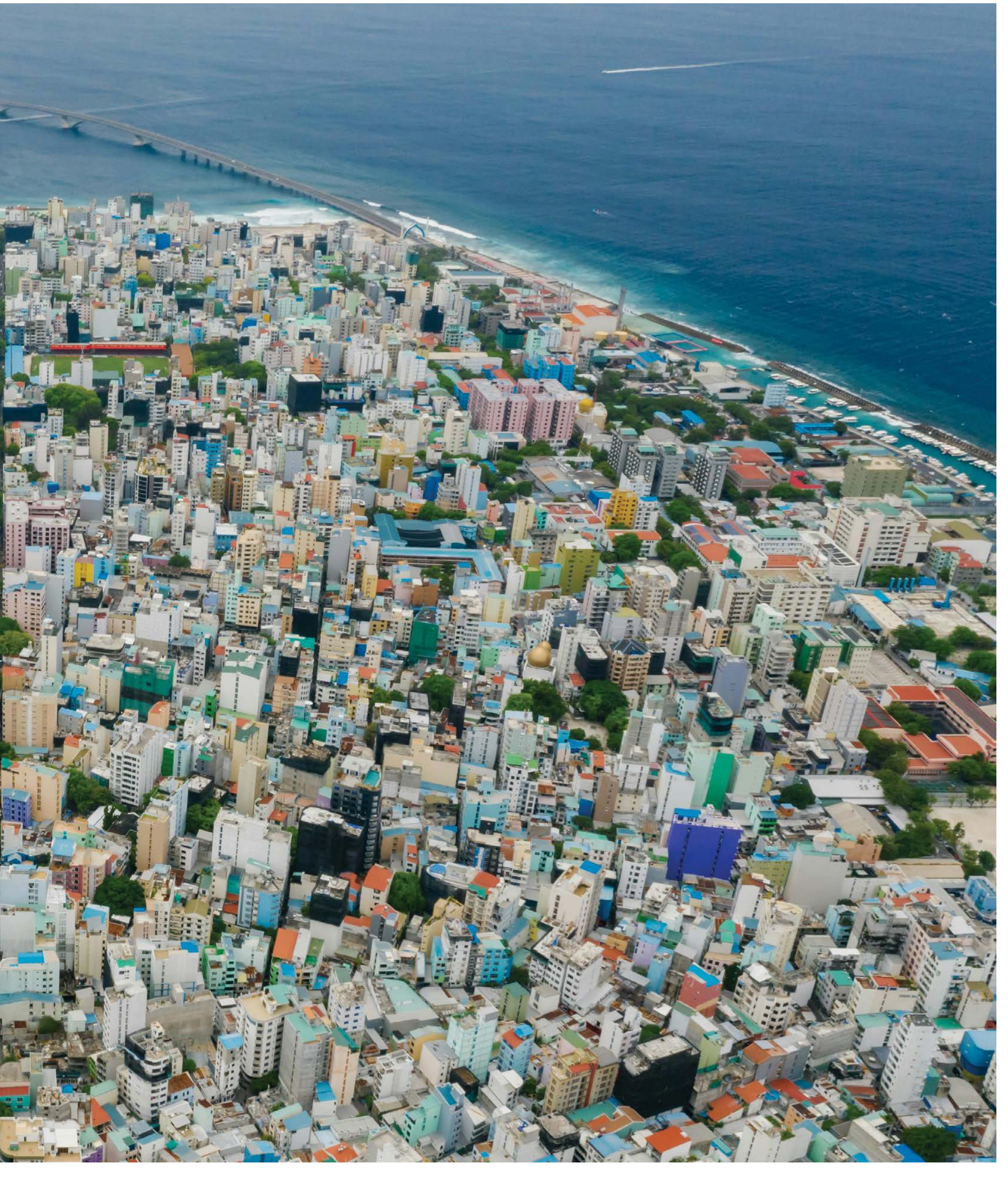
Hulhumalé is ideally situated just a brief boat ride from the capital, Malé, and about 30 kilometers from Thulusdhoo. Its development was a response to the pressing issues of population density and land shortages in the Maldives, particularly in Malé (Turak, 2017).

Hulhumalé's land was reclaimed from existing coral reefs. The initial reclamation effort, covering 188 hectares, began in 1997 and was completed in 2002, allowing the first 1,000 residents to move there in 2004. Additional reclamation started in 2010, which required dredging six million cubic meters of sand from the GhulhiFalhu Lagoon's seabed. Typically, nearby seabeds are dredged to minimize transportation expenses. The 244 hectares of land reclamation was finalized in 2015, supporting over 50,000 residents by the end of 2019. The island plans to house 240,000 individuals by around 2025, indicating rapid growth within a short timeframe (Miller, 2020).

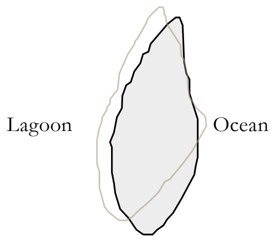
The development of Hulhumalé Island provided essential land for growth, yet it also caused various social and environmental issues. Land reclamation damaged coral reefs and marine ecosystems, adversely affecting the local environment (Pisapia et al., 2017). Furthermore, the reliance on desalination for fresh water raised energy consumption and carbon emissions, aggravating climate change.

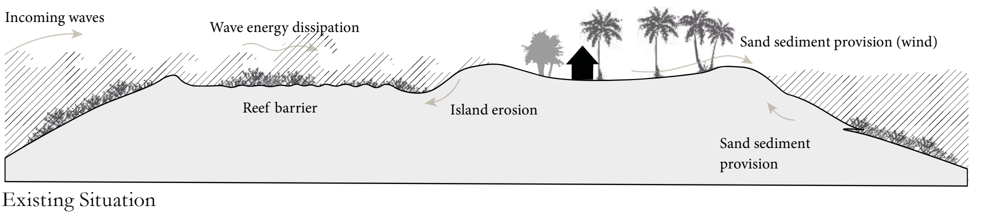
However, the principal factor motivating migration from the atoll islands to both the capital and Hulhulmalé is not climate change but the pursuit of better educational and job prospects, improved healthcare, and perceived social advantages (Speelman, Nicholls and Dyke, 2016). Migration pressures influence living conditions and housing costs in the Malé islands, including Hulhulmalé. Despite the households in Malé averaging double the income of those on the atolls, Maldivians spend a

Above | Aerial view of Malé, with Hulhumalé island in front. Photograph by Mikhail Nilov, 2019.

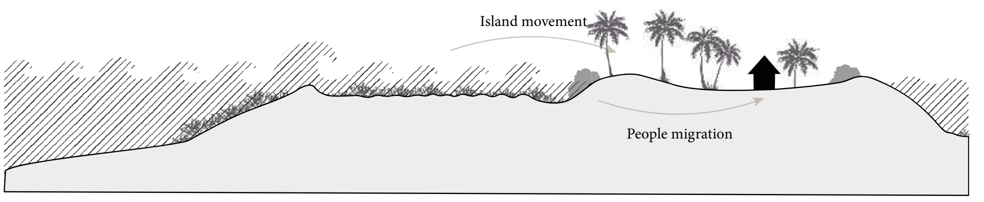


Shifting Islands | Sections illustrating the movement of the islands and alterations in their natural flow. Authors' work.

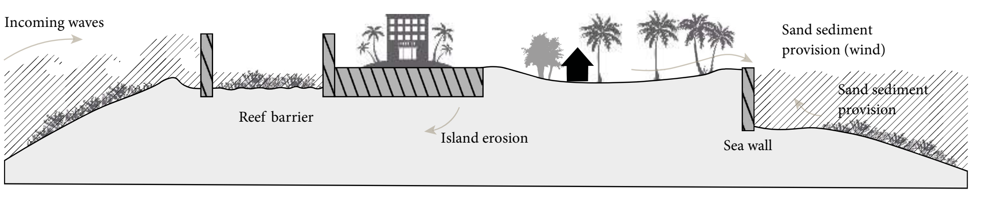




Existing Situation



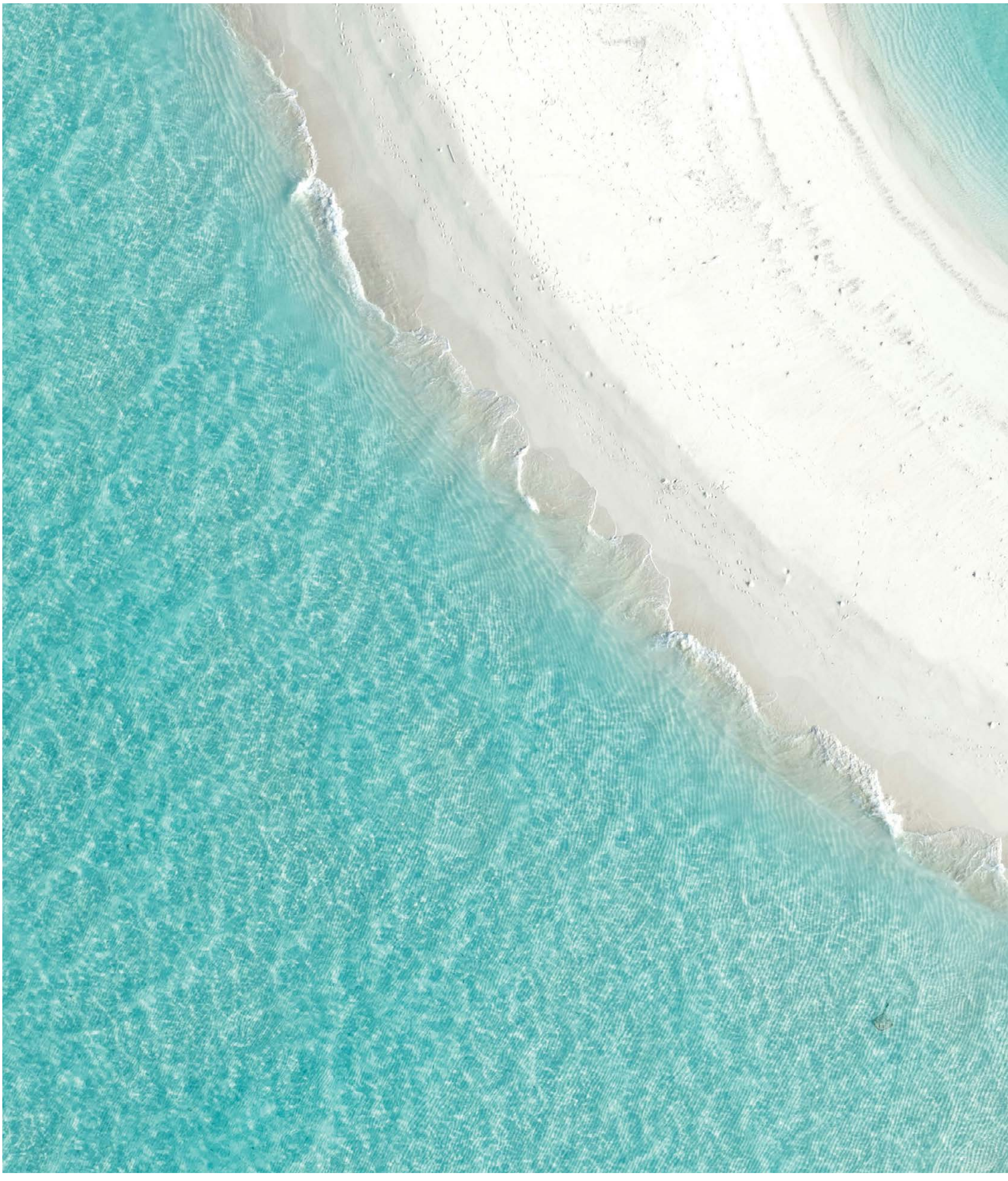
Future Natural Situation



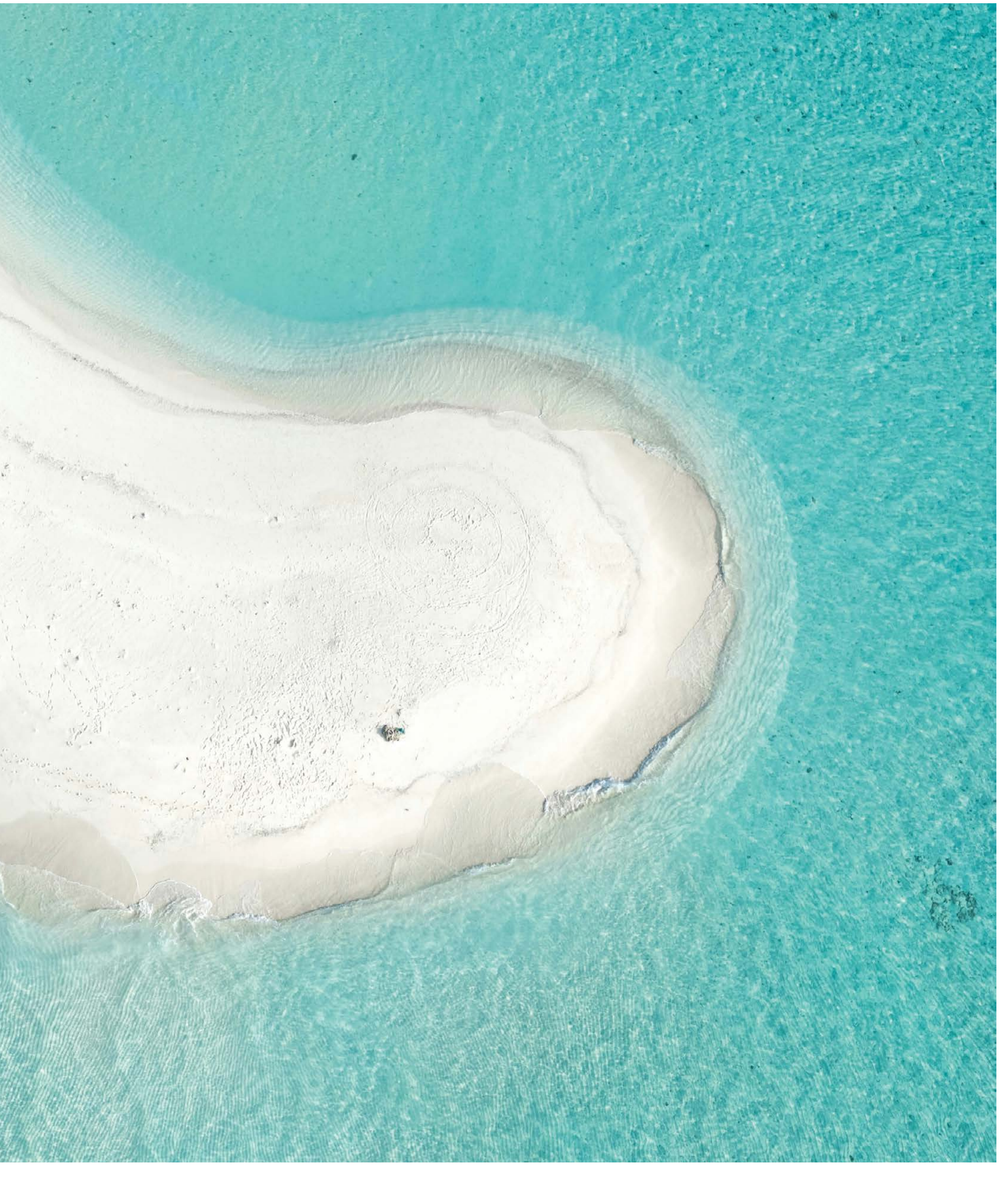
Future Reclaimed Situation

Current island borders

Island borders after ocean erosion



Right | The movement of sand on islands. Photograph by Hamdhulla Shakeeb, 2024.



considerably more significant portion of their earnings on housing within the capital.

While urbanization and land reclamation may appear detrimental, some positive outcomes are evident. For instance, in 2019, significantly fewer households in the capital faced hardships from disasters. Floods and severe rainfall damage notably reduced on Malé. This is attributed to 'fortification reclamation,' which fortifies reclaimed land against water hazards such as floods and heavy rain. Interestingly, survey results indicate that Maldivian planning authorities have prioritized individual motorized transport over public transit or bicycle lanes (National Bureau of Statistics, 2019), an unexpected choice given the country's vulnerability to climate change. Consequently, nearly every household owns a motorized vehicle, while only 7% of households in Malé possess a bicycle in 2019 (National Bureau of Statistics, 2019).

Unlike land reclamation projects on other atolls, the development of Hulhulmalé profoundly influences human migration patterns across the Maldives, primarily due to its large scale and its close location to the capital, Malé. This reclamation project has intensified the demographic shift between Malé and the atoll islands. According to the 2022 census, most working-age individuals reside in Malé, whereas children and the elderly primarily live in the atolls (Maldives Bureau of Statistics, 2022). Furthermore, the emphasis on tourism within the atolls alters gender demographics: women, who often find employment in the service sector, are more frequently counted in the atolls than in Malé (Maldives Bureau of Statistics, 2022). This migration to the capital raises significant concerns for the older Maldivian generation due to the sociocultural changes it is likely to provoke (Yahya, Parameswaran and Sebastian, 2005). Additionally, the resettlement of thousands of individuals could severely affect the social and cultural traditions of Maldivians who have a strong connection to their ancestral atolls, potentially leading to a loss of cultural heritage and a decline in traditional lifestyles (Yahya, Parameswaran and Sebastian, 2005).

The Hulhulmalé land reclamation project has offered Malé vital space to grow and develop in line with international urbanization trends. However, this expansion presents various environmental and social issues. The necessary dredging and landfill activities have harmed the country's marine ecosystems, including coral reefs. Moreover, the influx of migrants from the atolls has escalated real estate demand in the capital, putting pressure on infrastructure and services such as healthcare and education. These challenges significantly affect the Maldives' economic and demographic landscape as it strives for sustainable development. Land reclamation is not merely a straightforward remedy to the challenge of rising sea levels; it is a complex issue that introduces multiple difficulties. Tourism, climate change, and land reclamation are also creating a migration flow that risks undermining the nation's rich, ancient culture.

Conclusions

The history of the Maldives centers on the tension between stability and change. As the lowest-lying country in the world, its future depends on the rhythms of the Indian Ocean and rising tides. Climate forecasts warn that a one-meter rise in sea level could flood nearly eighty-five percent of its land, placing the nation at the front lines of climate change. In response, the Maldives has undertaken an ambitious yet paradoxical effort of land reclamation—an act of survival that both reshapes and threatens the ecosystems supporting it. Between 2006 and 2016, human-driven expansion created over twenty-three square kilometers of new land, blurring the line between natural and artificial islands. This chapter has examined the dualities within this transformation: resilience and vulnerability, progress and loss.

In Thulusdhoo, where coral reefs once moved freely with the currents, reclamation projects have immobilized the island's shifting sands, silencing the natural dialogue between erosion and renewal. The process, meant to preserve the island's appeal to tourists, has disrupted its fragile ecosystem balance. Corals, mangroves, and delicate beaches that once shifted with the tides are now scarred by sediment and erosion. Such contradictions reveal how adaptation can also be an act of erasure—one that breaks the ancient bond between people, sea, and land.

In contrast, Hulhumalé embodies the Maldives' modern ambition—a city built on the sea, symbolizing engineered hope. Designed as a refuge from overcrowding and rising tides, it reflects the country's desire to concentrate population and opportunity in a single fortified urban center. Yet beneath its paved roads and organized housing blocks lie quieter displacements: the migration of families from distant atolls, the fading resonance of ancestral ties, and the homogenization of once-diverse island cultures. The coral beds dredged to form Hulhumalé's foundations remind us that each reclaimed hectare carries an ecological cost, one that cannot be easily measured in GDP or square meters of new land.

Together, Thulusdhoo and Hulhumalé reflect the interconnected ecological and social paths of a nation facing an existential dilemma. Land reclamation offers stability in an unpredictable world, but it also sustains cycles of displacement and environmental harm. As tourism and urban growth reshape the Maldivian archipelago, the line between inhabited, touristic, and artificial islands becomes blurred. What remains is a landscape increasingly shaped by human activity, with natural rhythms disrupted by the machinery of survival. In this transformation, the Maldives risks becoming an archipelago full of paradoxes—where adapting to climate change involves sacrificing natural heritage and social continuity.

Beneath the surface of this change lies a deeper question about coexistence between human progress and the natural world. The Maldives is at a point where the pursuit of permanence conflicts with the ocean's natural fluidity. Land reclamation, though presented as adaptation, highlights the paradox of resisting change in a landscape characterized by motion. Each new island built on dredged coral and displaced sediment becomes both a symbol of resilience and a sign of loss. The reclaimed land of Hulhumalé and the eroding shores of Thulusdhoo together show a country negotiating its survival through acts of redefinition—turning the sea into soil and the temporary into the tangible. But the rhythm of the tides reminds us that the ocean can never be fully subdued. The Maldivian experience thus encourages a reevaluation of how societies live with uncertainty: not as something to be conquered, but as a shared horizon where culture, ecology, and memory come together to shape tomorrow's islands.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2022–23. During the course, Pleun de Braake, Wout de Joode, Linde Karnebeek, Nils Wolff, and Junhui Zhang wrote the initial paper, supervised by Denise Piccinini and Laura Cipriani. Pleun de Braake, Wout de Joode, Linde Karnebeek, Nils Wolff, and Junhui Zhang prepared the drawings.

Laura Cipriani finalized the publication text by rewriting sections, editing the chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a plagiarism check on the paper. Finally, a native English speaker reviewed the text.

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Land Reclamation Site Data

Location
Kuttanad | Kerala | India
Coordinates
9° 20' 17" N | 76° 24' 41" E
Area
24.00 km2
Length
7.75 km
Time
1880-1945

8 | The Rise and Fall of Kuttanad

How the Sea Reclaims the Rice Bowl Kerala

Venne van den Boomen, Lotte Bongers, Kim Handelé, Hilde Huijboom
Laura Cipriani, Denise Piccinini

Kuttanad is a reclaimed wetland on the west coast of Kerala, India, near the Arabian Sea. It is renowned for its rice paddy cultivation on the Kayal Nilams, which are lands reclaimed from the Vembanad backwaters that comprise Kerala's lagoon lakes, commonly known as 'Kayals.' The wetland and the Kayal Nilams are located below sea level, making them some of the lowest points in India. Due to its unique geography and productive rice farming, the region has earned the title 'The Rice Bowl of Kerala.'

The local inhabitants have coexisted with the water for many decades; however, in recent years, they have been displaced from their homes by the growing threat of rising waters. Longstanding issues threaten the inhabitants and the local ecosystem as the sea gradually reclaims the land.

This chapter maps and assesses historical land reclamation and human interventions while exploring the factors contributing to the current and future threats to the land, its ecosystem, and its people. Once viewed as an opportunity, land reclamation has evolved into a struggle against water and has become a trap, with Kuttanad's worst floods in the past two decades occurring recently.

Introduction

The residents of Kuttanad have lived near flowing water for centuries. Flooding is integral to their lives, occurring annually alongside heavy monsoons. Recently, many families who have called this area home for generations have left their houses behind. They can no longer endure the water that they once claimed as theirs. Significant changes occurred in Kuttanad in 2018 when two major floods struck the region in July and August. An alarming 90% of the surface area was submerged throughout Kerala, with Kuttanad being the most severely affected zone (Vishnu et al., 2022). Nearly 75% of the houses in Kuttanad required reconstruction, and since 2018, floods have regularly devastated the area, making it increasingly difficult for residents to rebuild their homes (Sooryalekshmi, 2019). Once seen as an attractive destination for farmers and a symbol of prosperity, the region is now transforming into a series of 'ghost villages.' Over 6,000 families and 30,000 residents have relocated for safer living conditions in the past two years. '*After the massive floods of 2018, my family chose to leave*' (Shaji, 2021), says Eruthiyel, who had spent his entire life in Kerala. He reflects on his beautiful former home and its peaceful atmosphere: '*We have endured at least half a dozen floods yearly for over a decade, and things have worsened since the 2018 floods. Now, everything stays submerged for extended periods. How can you prepare meals in a kitchen full of water? Nights are filled with fear as water can invade anytime without warning. Whenever it rains, the outer bunds of the paddy fields are breached, jeopardizing many lives*' (Shaji, 2021). Eruthiyel managed to leave the area, but for less fortunate individuals like Vinodini Raju and her family, abandoning their flooded home, built with bank loans, is not an option. Since 2018, flooding has become a recurring issue; residents sleep with one eye open. Income from farming has decreased, and on top of that, tourism revenue stagnated after COVID-19 lockdowns halted both domestic and foreign travel. With little to no effort being made by the government to restore Kuttanad's ecology and make it flood-resistant, more families are being forced to migrate (Shaji, 2021). The people of Kuttanad are turning into refugees, losing their land.

The Kuttanad wetland is located in the state of Kerala, India, where four rivers—the Pampa, Achenkovil, Manimala, and Meenachil—flow before emptying into the backwaters of Vembanad Lake, which are also known as Kayals. This deltaic formation is called the 'Holland of Kerala' due to its distinctive low position within the landscape. The land sits 0.2 to 2.6 meters below Mean Sea Level (MSL). Rice paddy fields are cultivated on Kayal Nilams, the local term for reclaimed lands. This low-lying area, characterized by backwaters, canals, and water networks, is the only place in India where farming takes place below sea level. The entire Kuttanad region spans 874 square kilometers and encompasses three districts of

Kerala, consisting of 4,400 hectares of reclaimed land. The Kayal Nilams are highly productive, thanks to silt-rich soil deposits from the Western Ghats, a north-south mountain range along the western coast of India. These nutrient-rich sediment deposits are used in land reclamation, which began in the 19th century, creating an optimal environment for rice paddy cultivation (Chandran and Purkayastha, 2018).

The fishing industry and agriculture are vital economic resources for the local population. The region's location is ideal, as the backwaters connect to the Arabian Sea, allowing fishers to take advantage of changing tides and seasonal salinity. This area also functions as a nursery for coastal fish and shellfish.

In this chapter, we explore the rise and fall of Kuttanad. The story of Kuttanad can be divided into four key periods: Land as Nature, Land as an Opportunity, Land as a Battle, and Land as a Trap. The first subchapter, 'Land as Nature,' addresses the prehistoric development of Kuttanad. During this time, nature shaped the land. The second subchapter, 'Land as an Opportunity,' focuses on the changes made to the landscape during various phases of land reclamation. The 'Land as a Battle' subchapter highlights the emergence of challenges and the struggle of human interventions against natural forces. The final subchapter, 'Land as a Trap,' explores the obstacles Kuttanad faces today and the difficulties ahead.

Land as Nature

Before humanity entered the area and began reclaiming the vast Vembanad backwaters, the coast experienced several changes in sea level, which shaped it into its current form. Clarifying the ancient history of Kuttanad before human intervention is challenging due to a lack of reliable historical records and materials. Nevertheless, it is possible to estimate past events to some extent by analyzing soil structures, local place names, and folk legends. For instance, it is believed that Kuttanad was once forested (Sreejith, 2013). One of the etymologies of Kuttanad, Chutta Nadu, translates to 'burnt land.' This implies that a fire once ravaged a larger forest within Kuttanad, and geological evidence such as burnt wood, charcoal, and other organic fossils found in the soil supports this idea. However, the absence of specific evidence makes it difficult to determine when this fire occurred. Due to this lack of substantial evidence, only a general outline of the area's development can be sketched by examining reports on soil buildup.

Vembanad Lake connects to the Arabian Sea through a northern channel near Kochi. In the 19th century, a significant change occurred within the water system when people began reclaiming land for cultivation.

Land as Nature
1880-1850

Land as Opportunity
1850-1945

1800
A shallow, fertile area is created at the mouth of the lagoon.

1834
Lake reclamation as *padasekharams*.

1880
First phase of land reclamation.

1888
Second phase of land reclamation.

1903
Prohib
reclam

1912
Phase
reclam

Land Reclamation Timeline | Authors' work.

pition on land
nation.

three of land
nation.

Land as a Battle
1945-1967

1940
The advent of the electric pump.

1945
'Grow More Food' campaign.

1949
Indian independence.

1955
Spillway at Thottapally is built with the regulator at Thanneermukkon (government construction).

1958
Construction of the Alleppey Changanaeherry Road.

Land as a Trap
1967-Now

1967
Western and Eastern parts of the Thanneermukkon bund.

1970
End of the feudal system.

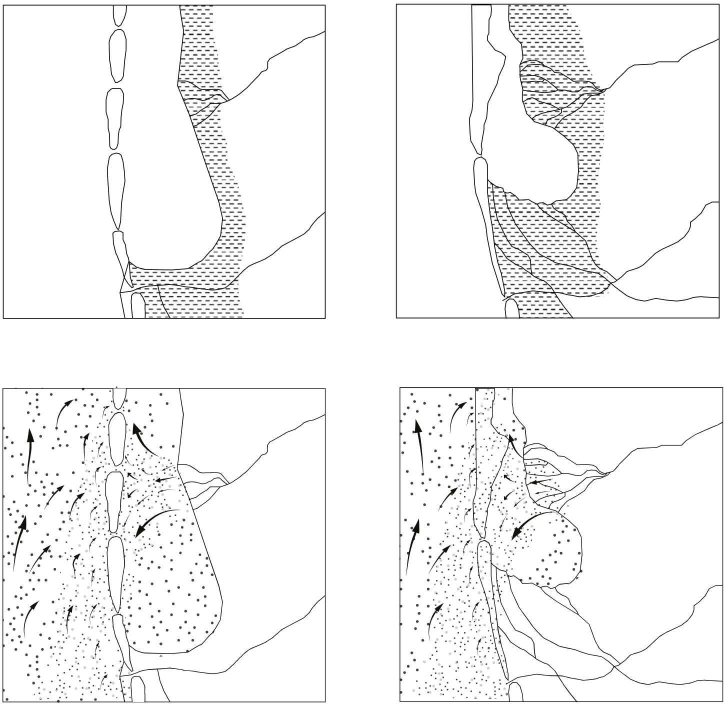
1983
Decline of paddy fields starts.

2000
One-third of reclaimed land is gone.

2018
Major flood. Over 350 people have been killed by the flood.

2019
COVID 19

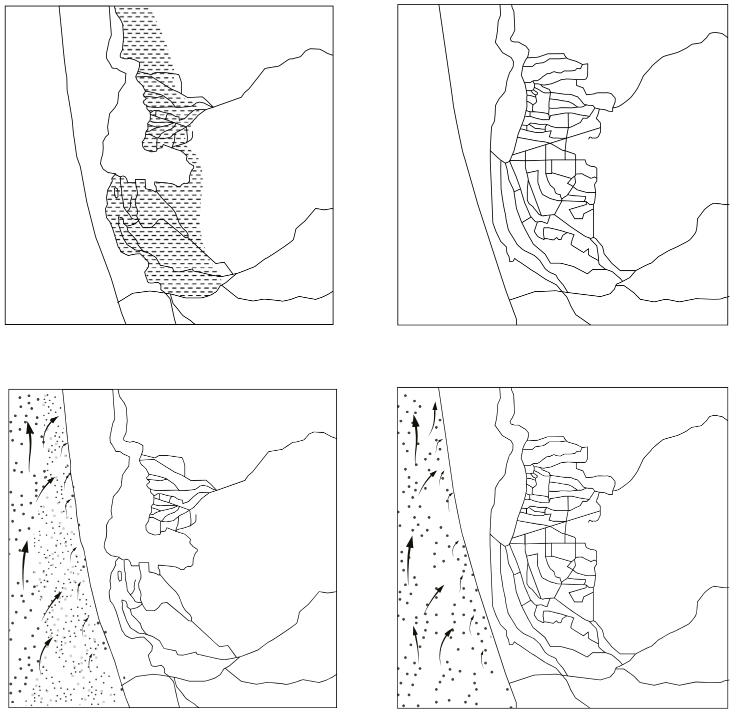
Above | Backwaters of Alleppey, Kerala. Photograph by Miguel Baixauli, 2020.



Early-Middle Holocene

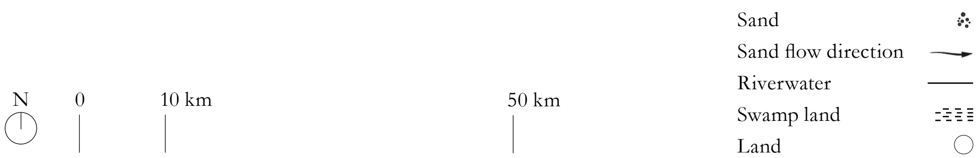
Late Holocene

Geomorphology Map with Sand Flows | Authors' work. Data: Vishnu Mohan et al., 2022.



1917

Today


N
0
10 km
50 km
Sand
Sand flow direction
Riverwater
Swamp land
Land

The fluvial waterways were canalized, and the once swampy landscape transformed into a network of ditches (Padmakumar, 2013). Before the reclamation of Kuttanad, the region, which featured large bodies of water and a connection to the sea, provided a vital source of livelihood for a considerable portion of the local community. Fishing has been an essential source of income for the area's population for centuries. Many residents, particularly lower-caste landless laborers and fishers, relied on Vembanad Lake and its surrounding waterways. Today, the fishable area has significantly reduced due to the reclamation of the Kayal lands.

Land as an Opportunity

At first, making new land was seen as an opportunity. The reclamation period consists of three distinct phases. Initially, the Pulayas and Parayas (lower-caste groups of Kerala) spearheaded the effort, realizing that rice was the most productive crop in the drained Kayals. The second phase saw a reclamation ban enacted by the Presidency of Madras, which aimed at mitigating the adverse impact on the nearby port of Cochin. This ban was eventually lifted during the third and final reclamation phase, as new technologies emerged. These advances reduced labor intensity and enhanced cultivation rates, significantly benefiting many farmers despite their effects on marine, soil, and land ecosystems.

Land reclamation in Kerala involves both natural and artificial land reclamation. Natural processes drive natural reclamation: some polders in the reclaimed wetlands formed naturally due to sediment deposition from the four rivers flowing into the Vembanad backwaters, particularly prevalent during the dry season. In contrast, artificial land reclamation results from human activity, primarily in response to food shortages during the colonial period, which created ideal conditions for paddy cultivation.

The First Reclamation Phase (1880–1888)

Land reclamation was undertaken by the Pulayas and the Parayas. These individuals had no access to land and consequently began to exploit it on their own. They discovered that rice cultivation flourished in the drained Kayals (Kuriakose, 2014, Mateer, 1883). This was attributed to the low elevation of the land, which sat nine meters below sea level (Alex George, 1987). The land reclamation required skilled craftsmanship and involved considerable physical effort. Due to limited financial resources and a lack of knowledge about dredging technologies, the work had to be done entirely by hand.

The first step in this reclamation process was to set boundaries by placing bamboo poles (M S Swaminathan Research Foundation et al., 2012). The imprint left behind marked the established boundary.

The second step involved constructing fences, which was the most skilled task. Long and heavy coconut poles were driven into the lakebed to create two rows of stakes. When these were covered with woven coconut leaf plates, an impermeable wall was formed that could then be filled with sand, twigs, sedges, and organic debris. The fence was topped with clay extracted from the deeper parts of the lakes. This clay excavation was known as 'Katta Kuth.' At this point, the land was ready to be dewatered.

The third step in the reclamation process involved dewatering, which was accomplished using water wheels. Kerala farmers are renowned for using these wheels. They extract water by manually driving the wheel. The size of the water wheels varies depending on the area size and the volume of water to be removed. Consequently, the number of individuals required to operate the water wheel was determined by size. These wheels could range from 4 to 18 leaves, with an average wheel pedaled by 12 to 14 men. The wheels pump water into external canals and surrounding bodies of water. Due to the higher water levels outside the reclaimed land's boundaries, the bunds required consistent protection and repairs. This maintenance is also applied to the inner irrigation canals (M S Swaminathan Research Foundation et al., 2012). Cultivation could begin once the land was sufficiently dried, primarily yielding rice.

The Second Reclamation Phase (1903–1912)

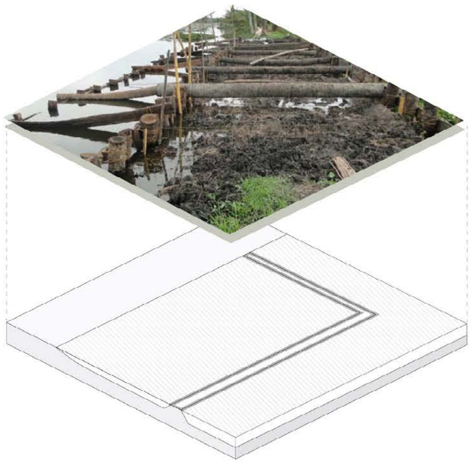
The Presidency of Madras halted the reclamation activities due to their potentially adverse effects on the nearby port of Cochin. At that time, 1,764.14 hectares of land had been reclaimed. The upper caste owned the reclaimed land, which was divided into seven smaller plots to improve management and increase productivity. In 1912, the King of Travancore lifted the ban on reclamation, providing tax breaks and permitting loans (Pillai and Panicker, 1965). This marked the beginning of the third phase of reclamation.

The Third Reclamation Phase (after 1912)

New technologies were introduced in the land reclamation process, with electric pumps becoming the latest method for dewatering. These pumps, known as 'petti and para,' were powered by internal combustion engines or electric motors. This innovation made the process less labor-intensive, benefiting the hardworking farmers. By 1945, 4,406.68 hectares of land had been reclaimed.

The reclaimed land was primarily used for rice cultivation, particularly in Kuttanad, where the region's geography and environment favored this type of farming. Kuttanad produced nearly 37% of the state's rice output, explaining the region's nickname: '*The Rice Bowl of Kerala*' (M S

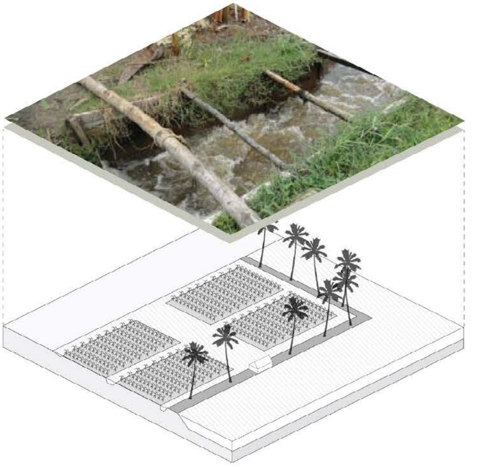
Creating the boundary



Fencing

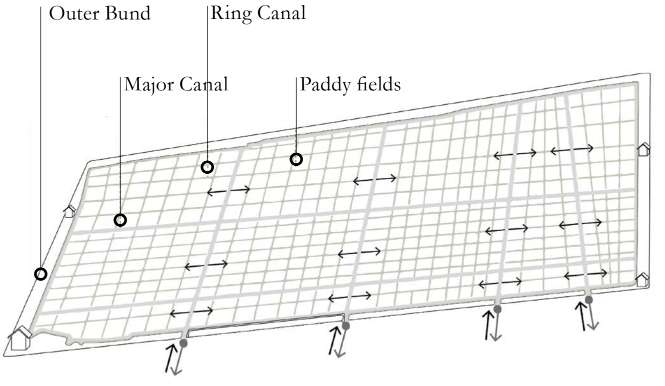
Land Reclamation Process | Authors' work. Data: M S Swaminathan Research Foundation, Government of Kerala, Food and Agriculture Organization of the United Nations (FAO), 2012.

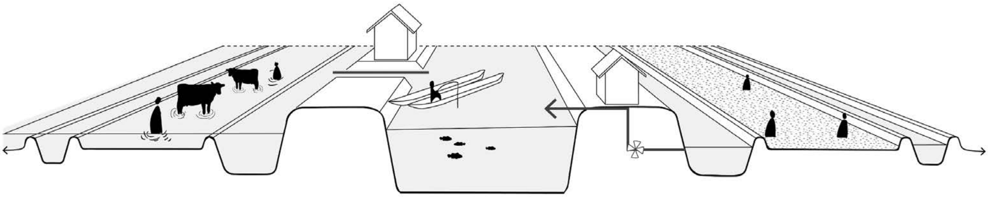
Digging, filling, and dewatering



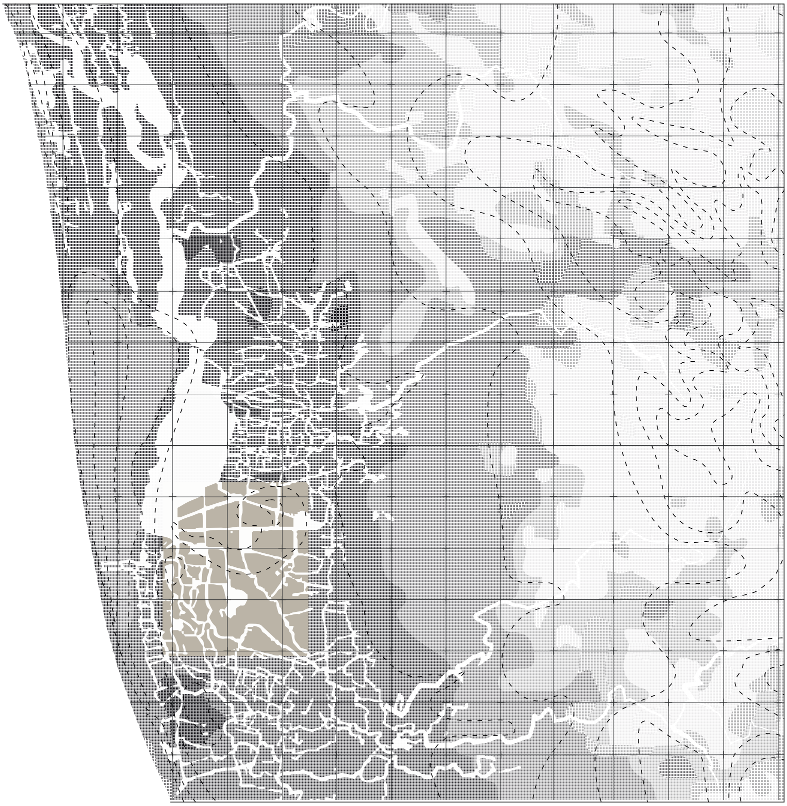
Stabilizing the bund and farming

Above | Backwaters of Alleppey, Kerala. Photograph by Rimjhim Agrawal, 2023.





Watersystem | The watersystem and its features. Authors' work. Data: Ali, 2020.
Elevations | Authors' work. Data: Kerala topographic map, 2024.



N

0 1 km 5 km 10 km

100 - 200 m
50 - 100 m
5 - 50 m
5 - 0 m
> 0 m
Reclaimed land
Water body

Swaminathan Research Foundation et al., 2012).

Coconut is the second most important crop grown in the area. It is planted on the narrow embankments of the reclaimed land. In 'garden lands,' fruit trees such as mango and jackfruit are planted, with roots and tubers like yams and taros placed between them (M S Swaminathan Research Foundation et al., 2012). The rice and coconut systems are surrounded by water sources, including estuaries, floodplains, kayals, ponds, and canal networks. In addition to rice production, a significant quantity of fish can be caught here, totaling 7,000 tons yearly. The annual yield of giant freshwater prawns, one of the region's most renowned species, reaches 100 tons. The Karimeen species, Kerala's state fish and sometimes known as the Pearl Spot, has an annual yield of 2,000 tons, while black clams account for 30,000–40,000 tons annually (M S Swaminathan Research Foundation et al., 2012).

Other noteworthy products obtained from these lands included clay and shrubs. Clay is essential for land building, brick making, and medical applications. Deep-mined clay was used to treat wounds and cuts. The shrubs were utilized for mat weaving (M S Swaminathan Research Foundation et al., 2012).

Land as a Battle

After constructing their living environment, the people finally had a place to live, farm, and sustain themselves. After several generations, they recognized the land's potential and gradually transformed their situation into a challenge against the water. Once the land was reclaimed, the farmers of Kuttanad were able to cultivate crops once a year. This was due to periodic flooding of saltwater from the sea, which made the backwater area saline or brackish, particularly before the monsoon season. In April, the influx of seawater rendered crop cultivation impossible for the month (Jayan, 2010). During this period, no crops could grow.

During the 1950s and 1960s, the rate of cultivation could not satisfy the rising demands of the growing population. In 1960, during the Green Revolution, Kuttanad was chosen as one of the regions to address this significant food scarcity. It became part of the Integrated Agricultural Development Program (IADP), which aimed to boost cultivation rates. This resulted in various interventions. Large quantities of chemical fertilizers and pesticides became available, primarily intended to increase rice production. The Green Revolution proved successful, leading to a steady rise in food production. By the 1970s, India transitioned from importing rice to becoming an exporter (Vallikappen, 2020). Kerala initially boasted a rich diversity of traditional rice varieties that thrived in different seasons. However, the push to increase rice production led to the disappearance of indigenous rice varieties, which were supplanted by high-yield types. The government supported the promotion of high-yield seeds, chemical fertilizers, and pesticides through substantial subsidies (Vallikappen, 2020). Nevertheless, they should have considered the environmental impact of these interventions, which resulted in excessive weed growth and an increase in pests and diseases in the water (Padmakumar, 2006).

In addition to large-scale rice production, coconut was Kuttanad's second main crop, and the region's participation in the IADP further enhanced coconut cultivation. To prepare the fruit for sale, the husk of the coconut is soaked in water for six months, leading to the decomposition of coir and the release of significant amounts of organic pollutants into the water (MWS, 2022). Along with the excessive use of pesticides to boost cultivation rates, large-scale human interventions affected the area. Before these constructions, high sea levels and monsoon rains devastated farmers' livelihoods. Consequently, the Thottappally spillway was built in 1955 to protect and improve agricultural production; it was designed to channel surplus water from the Pampa River basin into the region. Additionally, the spillway serves as a barrier to block saltwater from the Arabian Sea. Although farmers welcomed this intervention, it negatively affected the fishing in the region, leading to dissatisfaction among fishermen. An agreement was established regarding the opening and closing periods of the spillway, which remains open from June to December, to prevent saline water intrusion from the Arabian Sea (Kamranuddin, Reddy, Prathap 2021).

The water system is also affected during the monsoon season when significant rainwater enters the area. Over 90% of floodwaters reach Kuttanad and are discharged directly into the sea through the spillway. However, the issue of water accumulation due to rising sea levels needs to be addressed in a reconsideration of the spillway's design. During the monsoon season, the sandbar on the seaward side of the spillway was not accounted for, resulting in the actual capacity being less than one-third of the expected capacity at the time of its construction in 1955, thereby hindering its functionality in support of its intended purpose.

The Thottappally spillway appeared to be insufficient at preventing saltwater intrusions. A more extensive intervention was needed, leading to the construction of the Thanneermukkom bund in 1974 (Kolathayar, Krishnan and Sitharam, 2021). This structure, measuring 1.252 kilometers in length, is located in a narrow section of Vembanad Lake and is designed to stop saltwater from encroaching. This would create a freshwater reservoir, allowing an annual cultivation rate of two to three crops (Kolathayar, Krishnan and Sitharam, 2021). Additionally, the bund

Right | Floodwaters in Kuttanad, Kerala, India. Kuttanad is located below sea level and frequently experiences flooding during heavy rains. Photograph by Gannu03, 2024.

was built to mitigate floods and reduce salinity levels in 55,874 hectares of paddy fields in Kuttanad (Kolathayar, Krishnan and Sitharam, 2021). However, this was merely a prediction, as poor management of the bund resulted in significant environmental (and subsequent social) damage in Kuttanad. The construction caused substantial alterations to the ecosystem and led to considerable environmental degradation due to design flaws (Jayan, 2010). The ecological impacts of reduced saline water in this area resulted in weed proliferation, the accumulation of aquatic pollutants, and decreased fish production. Water hyacinth proliferated rapidly as salinity levels dropped, creating challenges for paddy cultivation, fisheries, and the survival of other estuarine organisms (Kolathayar, Krishnan and Sitharam, 2021). The stagnant waters contributed to the buildup of aquatic pollutants, leading to the death of various fish species. The reduction in salinity threatened specific fish and prawn species that rely on an estuarine environment to complete their life cycles (Kolathayar, Krishnan and Sitharam, 2021). Fish production sharply decreased due to the disruption of the lake's physical and biological habitats, with approximately 75% of fishing households reporting a decline. As noted earlier, nearly all commercially important fish species have become extinct or are present in very low numbers (Padmakumar et al., 2019).

In terms of economic and social effects, the disappearance of saline water inundations has resulted in poverty and health issues for local residents. The region's inhabitants primarily consist of fishermen, coir workers, farmers, and small communities working for larger companies (Kolathayar, Krishnan and Sitharam, 2021). Industrial, human, and agricultural waste has stagnated in the water, as it is no longer flushed away by the sea. This polluted water is also used daily by locals, leading to numerous health problems. The rampant growth of water hyacinth has worsened the pollution issue, as the accumulation of this plant has a toxic effect on humans (Kolathayar, Krishnan and Sitharam, 2021).

Many interventions aimed at boosting cultivation rates have backfired, leading to increased water pollution and ultimately making the land less productive. Not only did efforts to enhance crop cultivation pollute the seas, but modern development and globalization also introduced additional factors contributing to water pollution. One such factor is the construction of the Alappuzha-Changanassery (AC) Road. This 24-kilometer road runs east to west through the heart of Kuttanad. Built in 1958 by filling in paddy fields, the road connects the towns of Alappuzha and Changanassery as part of the government's infrastructure development plans for the region. Before the road's construction, ferry transport was the primary means of travel. The AC Road has provided significant socio-economic benefits by linking the two cities, thus improving transportation (Vallikappen, 2020). The road runs alongside the Alappuzha-Changanassery canal, which was created to drain floodwaters from the rivers and upper Kuttanad. However, the canal was designed without accounting for the volume of floodwater during each monsoon season, rendering it insufficient to handle all excess water. Furthermore, the AC Road obstructs water flow into the canals, causing the road to become submerged during the flooding season (Vallikappen, 2020). In addition to flooding, water stagnation contributes to pollution.

Another contributor to water pollution as a result of globalization is tourism. The beauty of Kuttanad's wetlands has attracted a significant number of tourists since the 1990s, leading to a boom in backwater tourism. Approximately 1.1 million tourists are expected to visit Kuttanad and its surrounding areas each year. The tourism industry provides income for nearly 85,000 households in the region. New hotels and resorts are being built to accommodate the growing number of tourists, resulting in increased encroachment on the lakebed and water-covered areas. Additionally, mangroves and trees, which are vital for retaining water in wetlands, have been cleared to make way for tourism-related developments. Crucially, these resorts often lack adequate wastewater management systems, resulting in the direct discharge of raw sewage and solid waste into the backwaters (MWS, 2022).

Rice cultivation in Kerala has been steadily declining, with decreases in both productivity and profitability. Due to flooding during the monsoon season, double rice cropping is not always feasible, discouraging farmers from pursuing rice farming. An effective alternative is integrating rice and shrimp farming (Jayan, 2010). Because the land is often submerged, rice plants can grow up to two meters tall. As they mature, the plants bend over, and only the upper parts are harvested—the remaining stalks decay in the water, providing nourishment for the prawns. Prawn farming has lowered production costs, allowing for immediate seeding of rice. This rice-shrimp/prawn farming practice has increased farmers' net income (Halwart, 1998).

Land as a Trap

No one was prepared for a major flood during the southwest's monsoon season in August 2018, when the adverse effects of human interventions harmed the inhabitants of Kuttanad and its paddy fields. The region experienced its worst floods in the past two decades, with water levels rising by approximately 1.5 meters. Over 521 km² of fields were inundated. Within three days, the flooded area decreased to 395 km². The subsequent runoff took more than 40 days to reach 260 km², mainly due to poor maintenance and degradation of the land's waterways, which diminished the land's infiltration and drainage capabilities. The flood's impact on Kerala was devastating, resulting in at least 504 deaths and affecting an estimated 23 million people. Many houses were destroyed, leaving more than 200,000 individuals homeless (Sooryalekshmi, 2019).

Three significant factors contributed to the flooding: the unusual rainfall averaging twenty-four percent above normal, the opening of dam floodgates in the highlands, and the sea's high tide. From June 1 to August 19, 2018, Kerala received 2,346.6 mm of rainfall, causing reservoirs to reach full capacity by early August. The extensive rainfall continued, with 13 of the 14 districts in Kerala recording their highest historical rainfall (Sooryalekshmi, 2019). James Wilson, an adviser on water issues for the Kerala state government, informed the BBC: '*It is a calamity that has occurred after 100 years, and no one had predicted this amount of rain. That is why there was no preparation for this level of disaster*' (Ali, 2020). The rising water levels compelled the opening of all of Kerala's dams to release the water. The water surged from the rivers, elevating the water level in Vembanad Kayal and directing it toward the Kuttanad region. Within hours, multiple areas were flooded, and water began to flow into the low-lying regions of Kuttanad. Infrastructure obstructed water flow toward the sea, worsening the flood on land (Vallikappen, 2020). Although high rainfall and the accompanying river discharge were the primary causes of the catastrophic flooding in Kuttanad, the effect of the ocean was also critical. The elevated sea level at the Thottappally spillway blocked the discharge of floodwater. Oceanic factors such as winds, waves, and sea level likely intensified the complications arising from heavy rainfall and increased river discharge (Modi et al., 2021).

Access to safe drinking water and proper sanitation are vital health necessities; indigenous residents typically rely on groundwater for their drinking supply. During the flood, groundwater became contaminated by mixing with floodwater. Moreover, the lack of sanitation worsened contamination levels. This situation led to the spread of various waterborne diseases, posing a health hazard to the residents (Kurian and Mathews, 2021). Numerous cases of chickenpox, typhoid, hepatitis A, dengue, leptospirosis, and malaria were reported.

The heavy rains and floods also significantly affected local residents' finances. In 2020, the widespread collapse of bunds hindered farmers from benefiting from paddy farming. Pandemic-induced lockdowns then exacerbated the situation. The virus spread rapidly through the densely populated areas, affecting paddy rice farmers in various ways. For instance, labor costs increased while the price of rice decreased. Beyond the economic impact, social ramifications also emerged. Eighty-nine percent of rice farmers come from outside Kerala. Because of the lockdown, migration decreased, and workers returned to their homes in northern India, leading to a significant labor shortage. Furthermore, mobility restrictions made it increasingly difficult to transport rice outside Kerala. The effects on farmers are still being felt today. For example, migrants remain in their hometowns, forcing farmers to forfeit much of their rice production. However, those who lease paddy lands still need to pay the landowners, complicating the system as the profits from rice production do not always cover the rent. This is one reason why farmers have been compelled to leave the area (Menon and Schmidt-Vogt, 2022).

No solutions exist for heavy rainfall during the monsoon season; this issue must be addressed over time, and also in light of climate change. Floods are expected to occur more frequently in Kuttanad. The potential for disasters such as storms, hurricanes, earthquakes, and tsunamis exists and will continue if not dealt with. These disasters have exposed humanity's vulnerability to nature. Given the current circumstances and possible future scenarios, the Kuttanad region may face a bleak future (Kamranuddin, Reddy and Prathap, 2021). The Kerala government estimates that over 6,000 families and 30,000 residents have been forced to migrate in the last two years. Where there was once hope and residents fought against challenges, they are now left without options, and the land has become a trap.

Conclusions

The story of Kuttanad highlights the delicate balance between human ambition and the natural environment. For centuries, the wetlands thrived under nature's care, providing abundant fish, fertile soils, and a wide variety of plants and animals across six distinct ecological zones. When left undisturbed, the flow of the rivers, the tides of Vembanad Lake, and the cycles of monsoon rain dictated the rhythm of life, shaping both land and livelihoods. However, human intervention disrupted this fragile balance. Land reclamation, initially seen as an opportunity, shifted the region's economy from fishing to rice farming, bringing quick prosperity but also long-term problems.

The phases of reclamation reveal both human ingenuity and unintended damage. In the first phase, the Pulayas and Parayas showed remarkable skill and persistence, discovering rice farming as an effective way to support themselves on the drained Kayals. The second phase introduced external control under the Presidency of Madras, temporarily halting reclamation due to concerns about Cochin's port. Finally, the third phase adopted modern technologies, reducing labor needs and increasing productivity. These efforts, while praised for their immediate agricultural benefits, caused significant ecological costs, changing the hydrology, soil makeup, and aquatic life of the backwaters.

The introduction of chemical fertilizers, pesticides, and waste from coconut husks, combined with large-scale constructions such as the Thottappally spillway and the Thanneermukkom bund, disturbed the natural water circulation. While these measures aimed to prevent seawater intrusion and boost crop yields, they unintentionally trapped pollutants, degraded soils, and reduced fish populations. Additional pressures from road construction and tourism expansion worsened these issues by blocking water flow, eroding mangroves, and introducing raw sewage into the backwaters. What initially seemed like progress gradually turned into a struggle against the very landscape it sought to control.

The devastating floods of August 2018 exposed this struggle. Water levels rose over 1.5 meters, flooding large areas of reclaimed land. Poorly maintained waterways and disrupted hydrological systems caused floodwaters to linger for more than forty days, resulting in loss of life, displacement, and destruction. Over 504 lives were lost, 23 million people were affected, and hundreds of thousands lost their homes. The flood revealed the limits of human efforts to control the land instead of working with it.

Today, Kuttanad faces a crossroads. Rice yields are declining, fish populations are shrinking, and polluted water threatens public health. Families who have called this land home for generations face the harsh reality of migration, leaving behind a landscape shaped by both memory and hope. The once-valued opportunities of reclamation have become ongoing challenges, with resilience continually tested by both natural forces and human activity.

Still, even in the face of loss, the wetlands whisper reminders of their enduring presence. If people can reconnect with the natural rhythm of this land between water and soil, hope can grow again for these landscapes and communities.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2021–22. During the course, Venne van den Boomen, Lotte Bongers, Kim Handelé, and Hilde Huijboom wrote the initial paper, supervised by Laura Cipriani and Denise Piccinini. Venne van den Boomen, Lotte Bongers, Kim Handelé, and Hilde Huijboom prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the chapter. Finally, a native English speaker reviewed the text.

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Land Reclamation Site Data

Location
Central and Wan Chai | Hong Kong | China
Coordinates
22° 16’ 59” N | 114° 10’ 4” E
Area
0.75 km2
Length
4,1 km
Time
1993-2019

9 | The Author(s)

Increasing Public Engagement in Hong Kong's Land Reclamation Activities

Linghao Gu, Kelin Mu, Junjian Yu
Laura Cipriani

Hong Kong has a longstanding practice of land reclamation for urban expansion, driven by its mountainous geography and limited flat coastal areas. This process has resulted in various adverse consequences, including ecological harm, increased urban density, and the erasure of natural landscapes, which have gradually fueled public dissatisfaction. In 2003, citizens prompted a judicial review of the reclamation efforts in Central and Wan Chai. This event marked a significant shift, empowering the public to meaningfully influence reclamation projects. It fundamentally altered the previously dominant top-down decision-making approach and significantly affected the later Lantau Tomorrow Vision. This chapter examines Hong Kong's reclamation history and contrasts it with present public debates regarding land reclamation in light of spatial limitations. We analyze the Lantau Tomorrow Vision as a case study to scrutinize public engagement in its planning process. This chapter assesses the extent to which public opinion is integrated into reclamation initiatives from a local viewpoint. Finally, it offers recommendations for future reclamation efforts to improve public involvement in the spatial development of newly reclaimed areas.

Introduction

Hong Kong, situated on China's southern coast, boasts a significant history as a key trading center in the Pearl River basin. Its natural deep-water harbor provided a unique opportunity for rapid modern development; however, the city's hilly terrain and limited flat land presented challenges for urban growth. Reclamation emerged as a quick solution, with 80 hectares of land reclaimed before 1945. Since then, reclamation projects have expanded to address residential, industrial, and infrastructural needs, featuring iconic developments such as the new Hong Kong International Airport and Central, built in the 1990s. Reclamation planning became a significant public focus in 2018 when the Lantau Island of Tomorrow project proposed to create an artificial island in the waters of East Lantau to alleviate the housing shortage in Hong Kong. This plan sparked controversy and ignited the Great Hong Kong Land Debate, leading to substantial public engagement in reclamation planning.

This chapter explores the subject of public participation in Hong Kong's reclamation plans. It is divided into three subchapters, each focusing on different aspects of the issue. The first subchapter, 'The Author: The Dominant Administrative Power,' examines the history of reclamation in Hong Kong and how public participation has influenced past projects, including the ramifications of public power on the planning and execution of reclamation initiatives. In the second subchapter, 'The Authors: The Growing Public Engagement,' we assess the four revised options for the Lantau Island of Tomorrow project, and outline the shifts in public attitudes and the effects of the various options. This subchapter also analyzes the effect of reclamation on various groups, including ecological and indigenous communities, as well as the residents of Hong Kong Island and Kowloon. The third subchapter, 'The Future: Embracing the Voices of the People and Nature,' discusses the future of Lantau Island, reclamation in Hong Kong, and urban planning there, considering local culture, public participation processes and models, and potential local development sites and parcels of land. Ultimately, the chapter highlights the importance of public participation in the decision-making process for reclamation plans in Hong Kong and advocates for the development of genuine public and natural assets for the city.

This research draws upon a substantial body of theoretical literature and news reports to provide a comprehensive understanding of land reclamation projects in Hong Kong from multiple perspectives. The theoretical literature establishes an objective and detailed factual foundation for this chapter. The favorable public opinion climate in Hong Kong has created a platform for various social and political groups with differing views to express their opinions freely. Furthermore, numerous insightful tracking reports offer diverse perspectives that we can reference. Additionally, we included observational documentaries as a source of information, as written records of individual oral histories are unavailable. These sources serve as valuable supplements to personal experiences, such as the recollections of local citizens, allowing us to examine the impact of reclamation projects on individuals through the lens of public engagement.

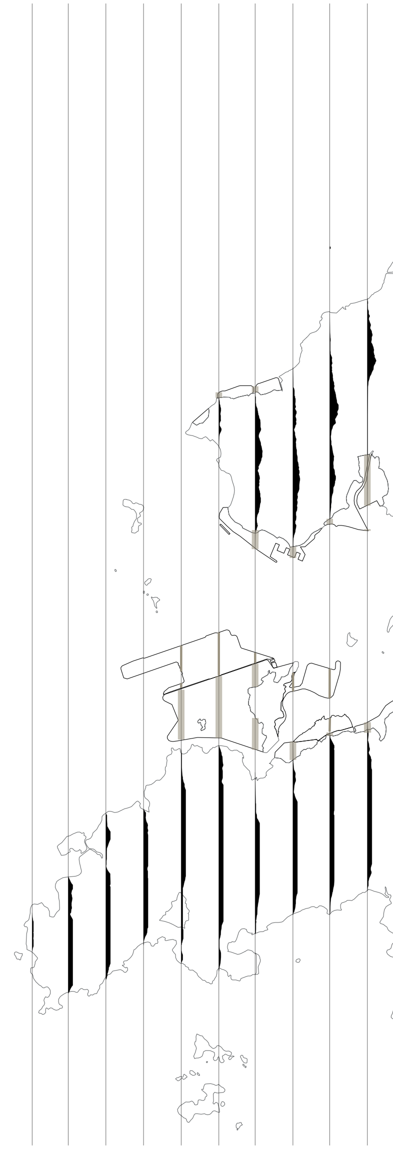
The Author: The Dominant Administrative Power

Top-Down Reclamation Trajectory

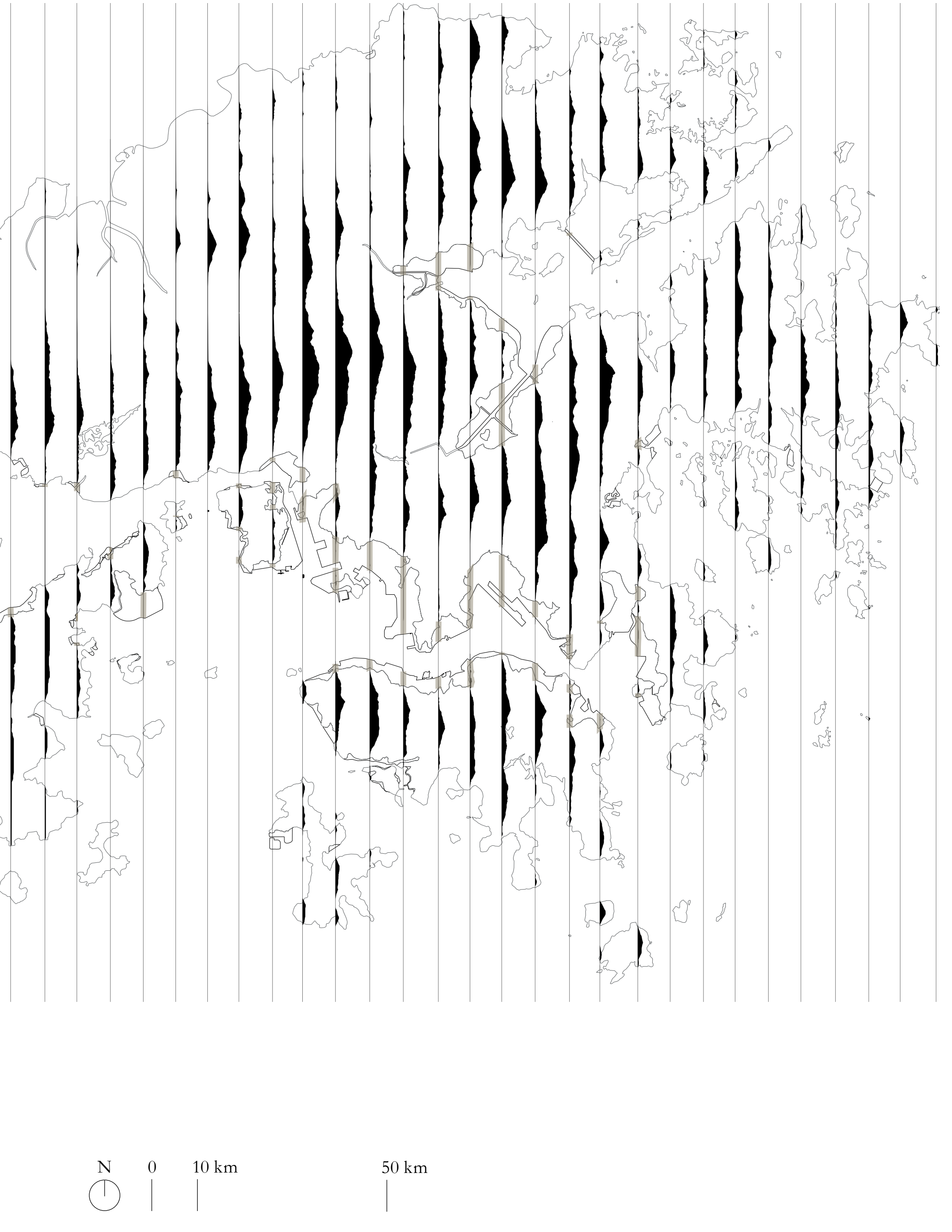
Since 1842, Hong Kong has continually reclaimed land from its coastal areas to tackle challenges caused by population growth and urban development, given the limited potential for further development of existing land. By 2022, around 70 square kilometers of reclaimed land, accounting for 7% of Hong Kong's total area, supported 27% of the population and hosted 70% of business activities (Lam, 2019). Traditionally, most reclamation efforts in Hong Kong have been government-led, with minimal involvement from the public and NGOs (Xue and Sun, 2022). In this context, this subchapter narrates the history of top-down land reclamation in Hong Kong, with a specific focus on the Central and Wanchai projects. It shows how public participation in these projects has broadened, enhancing the public's influence over their living environment and somewhat changing the course of reclamation initiatives since then.

The initial informal reclamation in Hong Kong took place in 1842, in only the second year after the city's establishment, driven by the need for urban development spurred by economic growth. Developers opted to dump large amounts of sand and gravel generated from construction directly into Victoria Harbour in order to minimize transportation costs. This practice not only reduced expenses but also expanded the buildable area, marking the inception of land reclamation in Hong Kong. The first formal reclamation project, initiated through the 1852 Reclamation Scheme, aimed to create land mainly for government offices and harbor facilities. Following this early phase and continuing until the Second World War, reclamation activities persisted in Hong Kong. However, there was notable opposition from the private sector, as exemplified by the Bowring Reclamation Plan of 1850, which remained unimplemented due to significant resistance (Wong, 2020). It was abandoned because it clashed with the interests of influential business groups and individuals, neglecting grassroots concerns.

The ongoing top-down land reclamation movement is closely tied to Hong Kong's urban development history. Prior to the 1997 handover, reclamation projects were executed directly or indirectly by the British



Hong Kong Topographic Sections | Profiles in black represent the original area, while the light brown highlights the reclaimed areas. Authors' work. Data: ESRI, 2023.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Mapping of Reclaimed Areas 1840-2023 | Data: Vivian, 2020; ESRI, 2023.


1840-1860
1861-1880
1881-1900
1901-1920
1921-1940
1941-1960
1961-1980
1981-2000
2001-2020
N
0
10 km
50 km

Hong Kong government's Governor. The Governor selected Legislative Council members to endorse these projects, facilitating implementation by aligning with the views of the wealthy elite and securing financial backing (Zhou, 2016). This strategy allowed the government to advance reclamation without considering public sentiment. Consequently, even as dissenting voices emerged, these projects largely proceeded unchanged. However, towards the end of British rule, the Central and Wanchai reclamation projects in Victoria Harbour attracted considerable attention and community involvement. This led to the launch of several public initiatives, including the 'Protect Victoria Harbour' campaign. With 170,000 signatures, the Society for the Protection of the Harbour (SPH) was founded in 1995 to defend Victoria Harbour against land reclamation and urban development, while advocating for responsible urban planning. In June 1995, the society submitted the Protection of the Harbour Ordinance, which came into effect in June 1997, prohibiting unrestricted government development in the harbor (Society for Protection of the Harbour, 2021).

Since Hong Kong's handover in 1997, land reclamation projects have become more cautious and inclusive, aided by a stronger multi-agency monitoring system and a more favorable public opinion landscape. The establishment of the Society for the Protection of the Harbour and the Protection of the Harbour Ordinance has provided the public with a legal and effective platform from which to engage in discussions about reclamation, even allowing them to shape the project's direction. This has created a richer dialogue, making the process more inclusive of various social groups. Viewing public participation from this angle, the history of land reclamation in Hong Kong illustrates the gradual rise of grassroots engagement, which has enhanced the public's influence over the environment and landscape they live in.

Turning Point: Central and Wan Chai Reclamation

The Central and Wan Chai Reclamation project, initiated by the Hong Kong government in the 1990s, aimed to create land for various purposes. This reclamation included three separate development zones, interspersed with parks, and unfolded over five phases: three for the Central district (1993–2011) and two for Wan Chai (1997–2019) (CEDD, 2019). Over 26 years of urban transformation, the Central and Wan Chai area has become Hong Kong's economic and political hub, offering numerous job opportunities, promoting international business, and creating venues for public life and recreation. However, the ecological repercussions of the reclamation of Victoria Harbour persist. These repercussions manifest as marine pollution from disrupted marine mud, seabed, and shoreline habitats; loss of biodiversity due to the presence of rigid barges and dikes

(EPD, 2014); and deterioration of water quality from urban sewage (EPD, 2007). These problems are also influenced by ocean currents and affect the wider environment in the region.

The ecological effects of land reclamation projects in Hong Kong, along with the neglect of public input, have been persistent concerns. In his 1997 article 'Overview of Reclamation in Hong Kong,' Otto Poon, Senior Vice-President of the Hong Kong Institution of Engineers, pointed out the disadvantages of such projects, including the irreversible loss of natural habitats, impacts on historical significance and landscape, and the need for the government to focus on urban wasteland development rather than hasty sea reclamation. He further urged authorities to engage in extensive public consultation from a landscape viewpoint (Poon, 1997). Nevertheless, the contentious Wanchai II (2003) and Central III (2004) reclamation projects highlighted the disconnect between the government's top-down methods and public sentiment. Initially, the Wanchai II project aimed for significant reclamation from east of the Hong Kong Convention and Exhibition Centre Extension to the Causeway Bay Typhoon Shelter shoreline, but it was modified in response to public protests and a judicial review request from the Society for the Protection of the Harbour to the Hong Kong High Court in 2003. Ultimately, construction began in 2009, resulting in a nearly 40% reduction of the Wanchai II project's reclaimed area. Although judicial reviews and legal actions had little effect on the Central III project, its development history illustrates the substantial role of public engagement in reclamation efforts projects.

Public opposition to land reclamation in Hong Kong stems from environmental issues like marine pollution and soil subsidence (Koo, Lai and Zen, 2018). The Environmental Protection Department's 2001 Environmental Assessment Report for the Central Reclamation Phase III site revealed that 57.4% of marine mud samples were severely polluted with heavy metals including cadmium, chromium, copper, nickel, lead, zinc, and mercury. The primary approach used for reclamation was low-cost, non-separated mud dredging (Greenpeace East Asia, 2003). Greenpeace criticized the use of silt curtains as a budget-friendly option, arguing it would merely transfer toxic contaminants to other waters. Conversely, the government's Advisory Council on the Environment claimed that the reclamation would not lead to irreversible damage to the marine environment (Chong, 2003). However, this assertion may overlook the long-term ecological deterioration of Victoria Harbour, which has suffered significantly from human activities, resulting in a meagre natural habitat and the absence of critical species. Moreover, fishermen have reported a 50% decline in their catches since reclamation started in Central. The government also faces allegations of disposing of toxic dredging materials near artificial reefs set up to safeguard marine life, including the Chinese white dolphins.

Above | City buildings along the reclaimed coastline in Hong Kong. Photograph by Jimmy Chan, 2018.

The Protection of the Harbour Ordinance (PHO) has greatly enhanced the influence of the public and NGOs in reclamation projects. This Hong Kong law aims to protect and preserve the harbor by generally banning reclamation activities (HKeL, 2018). Introduced by the Society for the Protection of the Harbour in 1996 and presented by Legislative Councilor Christine Loh, the ordinance was approved on June 27, 1997. Initially focused on the Central Hong Kong harbor area, the ordinance was later expanded in 1999 by the Secretary for Planning, Environment, and Lands to cover all of Victoria Harbour, as defined in Schedule 3 of the Interpretation and General Clauses Ordinance (Cap. 1) (HEC, 2017). In 2003, the Society for the Protection of the Harbour sought a 'stay of execution' order and a judicial review of the reclamation works. Despite this, the government moved forward with the Central Reclamation Phase III project because the court did not grant approval by the deadline (HPLB, 2007). On September 1, 2004, the Town Planning Board rejected the draft from the Court of Final Appeal related to the Wan Chai North Outline Zoning Plan. As a result, the Wan Chai Reclamation Phase II was reviewed, and the project was relaunched in 2009 after passing assessments from the government and various community organizations (HPLB, 2006).

The Protection of the Harbour Ordinance (PHO) recognizes the public's right to engage in reclamation projects. It states that the harbor is public property meant to benefit the community. Additionally, the government is required to take public interests into account when planning the harbor landscape. In 2003, High Court Judge Ms. Chu outlined three criteria that must be satisfied to override the presumption against reclamation specified in Section 3.1 of the Ordinance: 1) a compelling, overriding, and current necessity; 2) the lack of a viable alternative; and 3) minimum impairment. Since then, these criteria have frequently been referenced by the government and other stakeholders to either support or oppose proposed reclamation initiatives. These clear guidelines have significantly increased the public's role in landscape protection and decision-making. A series of follow-up waterfront urban design studies have placed public participation at the forefront, ensuring that community feedback is incorporated into the monitoring, optimizing, and revising of the urban landscape (Pland, 2011; Pland and AECOM, 2019).

Voices Heard

Public participation in land reclamation activities has changed over the centuries. This subchapter outlined the evolution of land reclamation in Hong Kong since 1842, detailing the government's involvement in top-down projects and the growing public influence on these initiatives. Organizations focused on public interests, such as the Society for the

Protection of the Harbour, and legislation empowering them, such as the Protection of the Harbour Ordinance, have amplified the public's voice in these matters.

The increasing public concern for coastal ecology and landscapes is expected to foster a more thoughtful approach to justifying future reclamation plans by the Hong Kong government. This shift is exemplified by recent retractions of reclamation plans due to social pushback, including opposition from environmental groups and citizens (Wang et al., 2014). Therefore, one can conclude that such resistance has prompted a reevaluation of the justifications for reclamation projects. Consequently, upcoming reclamation initiatives are likely to undergo more rigorous scrutiny and assessment to ensure that they are truly justified.

The Authors: The Growing Public Engagement

From East Lantau Metropolis to the Lantau Tomorrow Vision

The housing crisis in Hong Kong is often described as an '*unending crisis*,' a '*modern tragedy*,' and a '*chronic failure*' (Goodstadt, 2014). A persistent shortage of housing and land has long plagued the region. Land reclamation emerged as a viable solution to this issue, implemented through a centralized decision-making process. The Central and Wan Chai Reclamation project marked a significant shift, as citizens began to express their views on reclamation, gaining substantial influence in the conversation. This subchapter will explore the 'Lantau Tomorrow Vision,' which highlights the increasing public engagement and the interplay between government and citizens in reclamation debates.

Since its inception in 2005, the 'Lantau Tomorrow Vision' (LTV) has been subject to modifications driven by public involvement. In this section, we will examine the project's overall progression, how the dynamic between the government and the public has evolved, and how each has affected the other. To assess the various challenges encountered during this process, we will utilize Harold Thomas's four phases of policy formulation: 1) appraisal, 2) dialogue, 3) formulation, and 4) consolidation (Thomas, 2001).

Lantau Island holds a uniquely strategic position within Hong Kong, supported by a comprehensive transportation network that links it to the world through air, road, and rail, while also enabling seamless connection to the established business district of Central. Between 2005 and 2014, the government kept detailed planning proposals and data confidential. On October 27, 2016, it unveiled its 'Hong Kong 2030+' initiative, which identified the East Lantau Metropolis (ELM) as a key growth area for the territory. The plan includes reclaiming 1,000 hectares of land for the construction of between 400,000 and 700,000 housing units, with a projected budget of HKD 226.9 billion. This marked the ELM's inaugural mention in the government's land planning and urban development consultation documents. The government also specified concerns regarding the ecological impacts, environmental issues, maritime traffic channels, and fishing resources involved in developing the ELM. The 2018 LTV proposed a significant reclamation initiative in the eastern waters of Lantau Island, near Kau Yi Chau and Hei Ling Chau. This project aims to build an artificial island of approximately 1,700 hectares that is intended to serve as a third core business district. It is projected to house 260,000 to 400,000 households, with public housing comprising about 70%, catering to a population between 700,000 and 1.1 million. The estimated construction costs have risen to HKD 624 billion, representing half of the city's fiscal reserves, and the supply of housing and employment figures have also doubled, leading to controversy and environmental concerns. By December 2022, the estimated cost for the new artificial island reclamation project was adjusted to HKD 500 billion, while anticipated land sale revenue fell from HKD 925 billion to HKD 750 billion. Although housing supply and employment doubled, they did not return to the levels experienced during the ELM period. The government justified the increased cost with claims that additional research was needed for accurate projections. However, they could not specify the expected revenue from land sales, prompting a request for an appropriation to determine a clearer cost assessment by 2025.

Problems in the Process

Throughout the entire process, the government devoted an excessive amount of time to appraisals, leading to a chaotic environment that lacked adequate dialogue. Meanwhile, the formulation phase progressed, with the dialogue and consultation processes nearly being merged (Poon, 2020). This oversight should have been recognized during the formulation and announcement of the Tomorrow Vision Plan, and it resulted in public outrage and forced the government to revert the plan back to the formulation stage, culminating in the revised proposal rollout in 2022.

During the 2018–22 revision of the plan, the government continued to evade public dialogue despite increasing opposition. The new proposal seeks to address public concerns regarding the expanded land reclamation area, the budget for the LTV project, and its environmental impacts. However, methods of open and peaceful dialogue proved inadequate throughout the formulation process. Although a task force was established to liaise between the public and the government, the public felt compelled to resort to radical measures and adopt an uncompromising stance to capture and hold the government's attention. Only the loudest voices were acknowledged by the authorities, leaving quieter voices struggling to express their needs.

The government's stringent governance strategy provides minimal reassurance to the public. Despite a comprehensive evaluation process, variations in data, disregard or distortion of available resources, uncertain cost forecasts (Legco, 2022), unpredictable proposal timelines, and the government's indifference to public consultation outcomes have all contributed to rising skepticism. This situation challenges Hong Kong's governance model, which is perceived as a blend of representative democracy and centralized control (Fung, 2020). Growing public doubt and frustration call for a transition to a more open, transparent, and productive dialogue framework.

The following sections will amplify the unheard perspectives on landscape transformation. The various voices demonstrate the facets of the struggle for the public's right to express concerns about land reclamation.

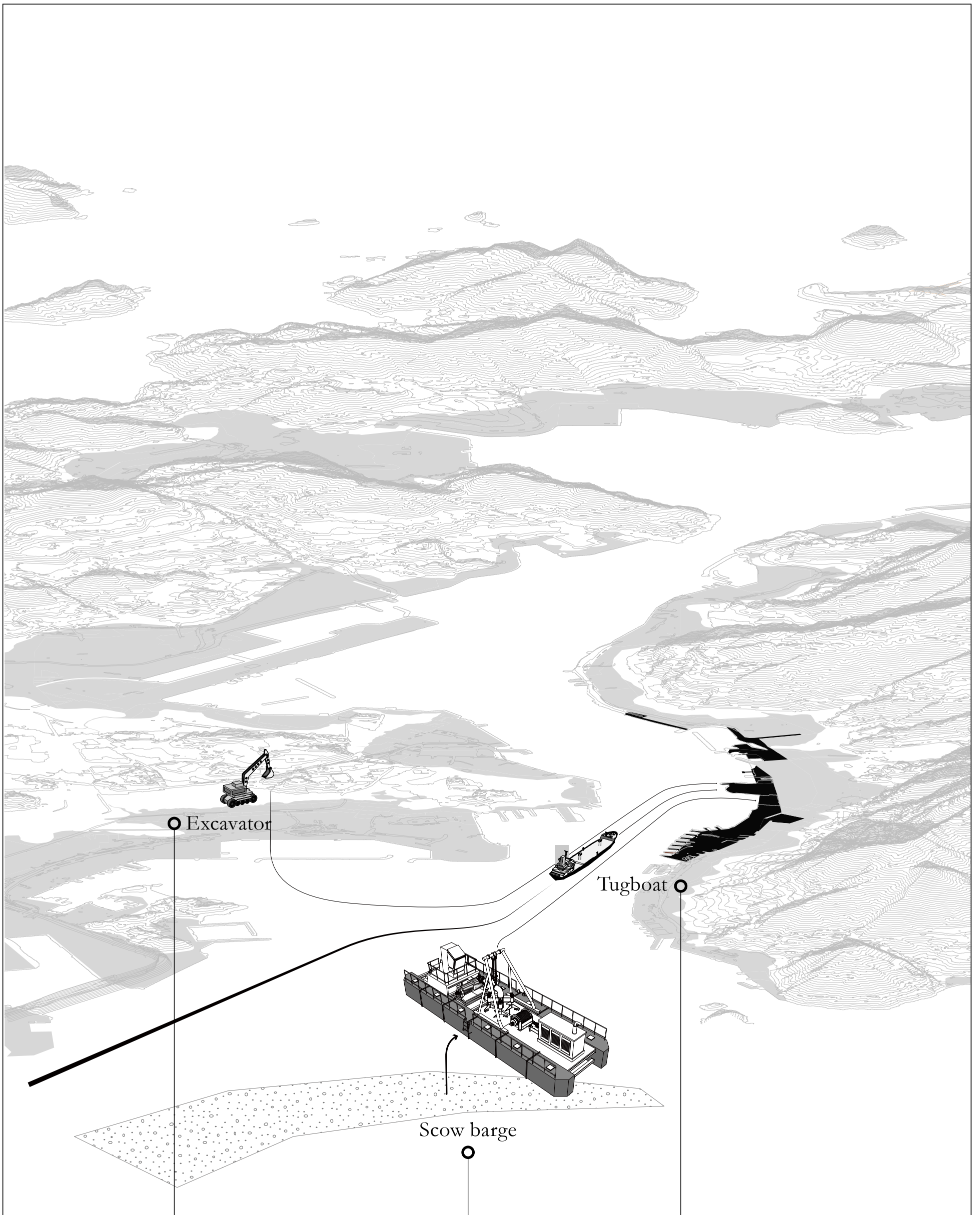
Unheard Authors Behind the Vision: Fighting for Nature

Environmentalists have raised awareness effectively regarding the environmental hazards posed by the Lantau Island and LTV projects, including rising sea levels and potential harm to dolphins. This effort involves not just prominent environmental organizations like Greenpeace, Conservancy Association, Green Power, and the World Wildlife Fund (Yeung, 2021), but also a new coalition called the 'Save Lantau Alliance,' formed by former Hong Kong Chief Executive Leung Chun-Ying in 2014 after the announcement of the ELM project. The alliance has been advocating for eliminating ELM and LTV and compiling environmental reports based on quantitative data to show that the government may have underestimated the costs and damage to the ecosystem resulting from land reclamation (Savage Lantau Alliance, 2018). These organizations have also coordinated protest activities alongside land justice groups. Despite the government's efforts to raise public awareness, the interests of the business sector have consistently been seen as the more critical focus when devising policies in Hong Kong. Without significant commercial concerns, environmentalists are unlikely to participate in policy networks or advocacy alliances (Fung, 2020).

Local Species: Silent Victims

Lantau Island is the largest outlying island in Hong Kong, characterized by its mountainous terrain and almost entirely natural coastline. It provides a diverse range of habitats, including primary woodland, shrubland, grassland, rivers, streams, and freshwater marshes, all rich in biodiversity. Despite LTV's focus on ecological considerations, such as implementing new reclamation methods, establishing a marine park,

Sources of Reclamation Material | Authors' work.



Construction waste and public filler 60%

Extracted marina sand 20%

Imported manufactured sand 20%

and selecting less ecologically sensitive waters, the LTV represents the country's most significant reclamation efforts that will inevitably harm the aquatic environment, alter ocean currents, impact the migration and reproduction of fish, and destroy the habitat ecology of marine and adjacent terrestrial species. The number of recorded Chinese white dolphin sightings around North Lantau has decreased by 40% since the initiation of the Hong Kong-Zhuhai-Macao Bridge project (AFCD, 2021). Furthermore, due to reclamation and mud piling in the Pui O buffalo habitat, the wetland's water level has fallen, shrinking the buffalo habitat and leading to repeated instances of human-cow interactions. The destruction of benthic coral communities will be another detrimental impact of the reclamation project. Moreover, the reclaimed hard barges—flat-bottomed vessels for reclamation purposes—will be incapable of retaining sediment or slowing currents, rendering them unsuitable for habitats and vulnerable to future sea level rise. The ecological destruction of biological habitats caused by reclamation is nearly impossible to reverse. Given humans' limited understanding of complex biological communities, many more species will vanish before we become aware of their existence. Such loss will remain unknown and irretrievable. As more individuals recognize the value and significance of ecology, the government must shift its development paradigm to a balanced approach that integrates social, economic, and ecological progress; otherwise, the voices of living organisms will continue to be passive and silent, even though they are the affected area's original inhabitants.

Lantau Indigenous: Disappearing Hometown

Hong Kong possesses a rich history and a diverse population, influenced by its unique geography and colonial past. The British colonizers categorized the Chinese population into three primary ethnic groups based on language: Punti, Hakka, and Tanka. Today, the indigenous population is divided into four main ethnic groups: Guanbao, Hakka, Tanka, and Hoklo. These communities primarily rely on fishing and shipping for their livelihood. Fishing has been a crucial industry for Hong Kong since ancient times, with over 5,000 fishermen and farmers recorded in 1841 when the British arrived. Before the city's urbanization began, the indigenous people of Hong Kong mainly depended on fishing. As Hong Kong expanded and developed, many immigrants flocked to the area, leading the indigenous population to adapt to urban life. However, residents of outlying islands like Peng Chau still maintain their traditional way of life, which revolves around fishing (Wong, 2022). In the 1960s and 1970s, many fishermen continued to live on boats along the north coast of Peng Chau. The fishing industry enabled them to maintain their traditional practices and preserve the cultural ambiance of Peng Chau. Currently, fishing in Hong Kong is primarily concentrated in the waters from Peng Chau to Hei Ling Chau. Nevertheless, land reclamation projects such as LTV pose a threat to the livelihood and cultural heritage of indigenous people who depend on fishing for their income and way of life.

City Dweller: Urgent Housing Needs

Hong Kong is known for its low livability due to the overcrowding of public housing, with approximately 209,700 people residing in 92,700 units (Census and Statistics Department, 2018). Although the government promotes policies like ELM and LTV to address housing needs, only a portion of grassroots citizens support these initiatives (Hong Kong Economics Journal, 2018). In July 2019, 14 political and social groups established the Land Justice League to oppose the ELM, arguing that it will deplete Hong Kong's fiscal reserves. Instead, they advocate for alternative short-term solutions such as brownfield sites, which are less expensive and more environmentally friendly, and the development of the Fanling golf course, which currently caters only to the affluent (Yam, 2018). Urban residents are the most vocal and mainstream group in Hong Kong. Their well-being is a top priority for current urban development and aligns with mainstream trends in modern urban development. They have protested against the government's plans, feeling that their voices have been overlooked and that private developers have been favored over public consultations (Yeung, 2021). Their voices seem weak in light of significant wealth gaps, government decision-making processes, and a focus on economic development (Fung, 2020). Thus, instead of protesting, city dwellers need to seek more peaceful and orderly methods that are more likely to ensure that their voices are heard during the appraisal stages.

The Landscape Underlying Different Authors

As a collective, the public in Hong Kong has successfully influenced the government's formulation and implementation of top-down policies regarding land reclamation. However, in the current chaotic situation, only those who shout the loudest can be heard, while many voices remain silent due to the absence of peaceful dialogue.

Beyond the confrontation between the public and the government, public participation also encompasses complex components representing different demands and interests. Just as the government, as a powerful author, opposes the previously disenfranchised public, similar dynamics exist within the public, where weaker voices may sacrifice their interests to benefit the louder voices, even if they are the most directly affected.

Public groups embody various lifestyles that reflect the interaction between humans and nature. These differing lifestyles create a variety

Right | Land reclamation activities at the Hong Kong Shipyard. Photograph by Shreyaan Vashishtha, 2025.

of landscapes. In public protests, the degree of vocalization by other groups regarding their interests symbolizes their right to express views on different types of landscapes. Therefore, it is essential to explore in detail what various categories of the public may gain or lose in the chaotic struggle between the public and the government over land reclamation. Through this examination, we can come to realize that the battle for the public's right to voice concerns about land reclamation is, in some sense, a defense or enhancement of a particular group's lifestyle and environment, behind which lies the transformation and evolution of the landscape.

Biological species and indigenous peoples adapt to or make limited modifications to the natural environment in which they reside. However, throughout the history of Hong Kong Island's development, those in power have prioritized economic and urban advancement. Through land reclamation, they have erased the natural and local cultural memories associated with the densely populated city and its unrestrained expansion. A dense city has supplanted the historical character of Hong Kong Island, and Lantau Island now faces a critical choice. Fortunately, public awareness and authorship have been awakened, and the public is currently challenging the government's authority with its power.

The public participation process of the LTV project reflects, to some extent, the current condition of the landscape. The government's authority in unified planning and the generation of homogeneous landscapes is being contested against the backdrop of its substantial possession of social resources and discourse power. The public craves a lifestyle that authentically belongs to them, one guided by their voices, which is evident in various landscapes.

Compared to the past, modern Hong Kong residents are more cognizant of the value and significance of natural ecosystems and yearn for an exceptional urban living environment. The older generation in Hong Kong has sacrificed their memories for the city's development. Now, the burden of this development has shifted to sacrificing the indigenous rural landscape of Lantau Island, which may lack natural channels for its inhabitants' voices to be heard. Everything comes at a cost, but have past sacrifices made Hong Kong perfect today? New problems have arisen, and now the price is being paid by sacrificing the lives and landscapes of other areas.

What is the goal of development? Is it economic prosperity, status, and a lively city? Is it beautiful nature and serene countryside? The answer can be both yes and no because we believe that the endpoint of development is for every 'author' to obtain what they need while ensuring respect for every 'author's' survival, rights, and memories. Today, we can develop the bustling Eastern Lantau metropolitan area at the expense of nature and the Lantau fishermen, but who will bear the cost tomorrow? Who will experience a lasting victory?

Public struggle aims to safeguard individual rights and lives, and it is rooted in various types of landscapes. Preserving these landscapes symbolizes the rights of the communities they represent. By maintaining these landscapes, we promote social diversity, equity, and justice while honoring collective memories.

The Future: Embracing the Voices of the People and Nature

Respect for the Indigenous

The transformation of Hong Kong from a fishing village to a major global city is frequently idealized. This change has prompted the expansion of the import/export sector, a strong real estate market, and a thriving financial industry. However, the roots of Hong Kong, including its once-vibrant fishing trade, have largely been forgotten. It is essential for urban planning and development to focus on the well-being and lifestyles of residents, including the accessibility of commercial spaces and shops. During the 1960s and 1970s, Hong Kong experienced significant urban growth and population increases, but the skills and knowledge of local fishermen were seen as outdated, and their residences were viewed as eyesores within the cityscape.

Hong Kong's mixed economy was extensive and mutually reinforcing, with fishing and agriculture establishing the cultural bedrock for its inhabitants' livelihoods (Yip, 2022). However, as the fishing industry declined and government support diminished, the livelihoods of fishermen became increasingly at risk. Reclamation efforts and the accumulation of marine waste have reduced the area available for fishing communities, leading to increased pollution and hazards in the harbor.

To preserve the cultural heritage of a city, it is vital to acknowledge and reinvigorate the lives and traditions of its native communities. Hong Kong's fishing sector and its related water culture deserve recognition and revitalization rather than disregard and neglect. Although residents often take pride in the city's evolution from a fishing port to a financial hub, they frequently overlook the rich history of the old fishing villages and the contemporary lives of fishermen. The large vessels and dredgers employed in reclamation projects have further obscured the memories of past generations by replacing their cultural landmarks with landfills and waste.

Possible Future Public Engagement Model

In Hong Kong, the governance model merges representative democracy with a centralized system, fostering an economy aimed at growth. However, the policy formulation process has consistently lacked dialogue, relegating public involvement to later stages, like 'consultation.' While the LTV has made several adjustments informed by historical context and public input, the overall process remains dialogue-deficient. The public only became aware of their rights and agency during the Central–Wan Chai Reclamation Project. This awareness led to protests that prompted the government to revisit the formulation phase. Increasing public participation is becoming crucial in reclamation project decisions, and it is essential to incorporate the perspectives of diverse public groups, especially local communities, into development planning.

The Hong Kong government has taken steps to boost public engagement, such as through consultations, stakeholder participation, and outreach initiatives. However, the key to improving this engagement lies in enhancing transparency and accountability within the decision-making process. This involves making the process more accessible, providing greater opportunities for public input and feedback, and integrating various forms of local knowledge during the planning stage. M. Striker (2011) emphasizes that local authorities should initiate dialogue with residents at the start of the planning process and ensure that the resulting plans genuinely reflect this dialogue, rather than developing plans in secrecy and facing delays or modifications due to public pressure and discontent.

It is vital to balance the interests of affluent and vulnerable groups, reconcile ecology with culture, and recognize the importance of social and economic development in the planning process. Additionally, a strong government is essential, featuring representatives possessing effective leadership and communication skills (Striker, 2011), instead of relying on an overly rigid planning approach that may not engage the public effectively.

Public participation should not be treated as an isolated aspect of the planning process for communities and NGOs; it should be viewed as a fundamental element of governance and the sole avenue through which Hong Kong can attain democracy. The government must articulate the rationale behind its decisions and explain why specific recommendations were not implemented.

Hajer and Zonneveld propose creating a 'more socialized planning process' that involves stakeholder engagement from the beginning. They also advocate for a 'planning system that leverages knowledge from various stakeholders and seeks to incorporate diverse interests and viewpoints into policy design at an institutional level' (Hajer and Zonneveld, 2000, p. 352). This is the path to follow for achieving aware and constructive participation.

In the 21st century, the government needs to emphasize economic, environmental, cultural, and social development. The fundamental idea is to make development—a fusion of social, financial, and ecological factors—a collective responsibility (Ng and Hills, 2000, p. 27).

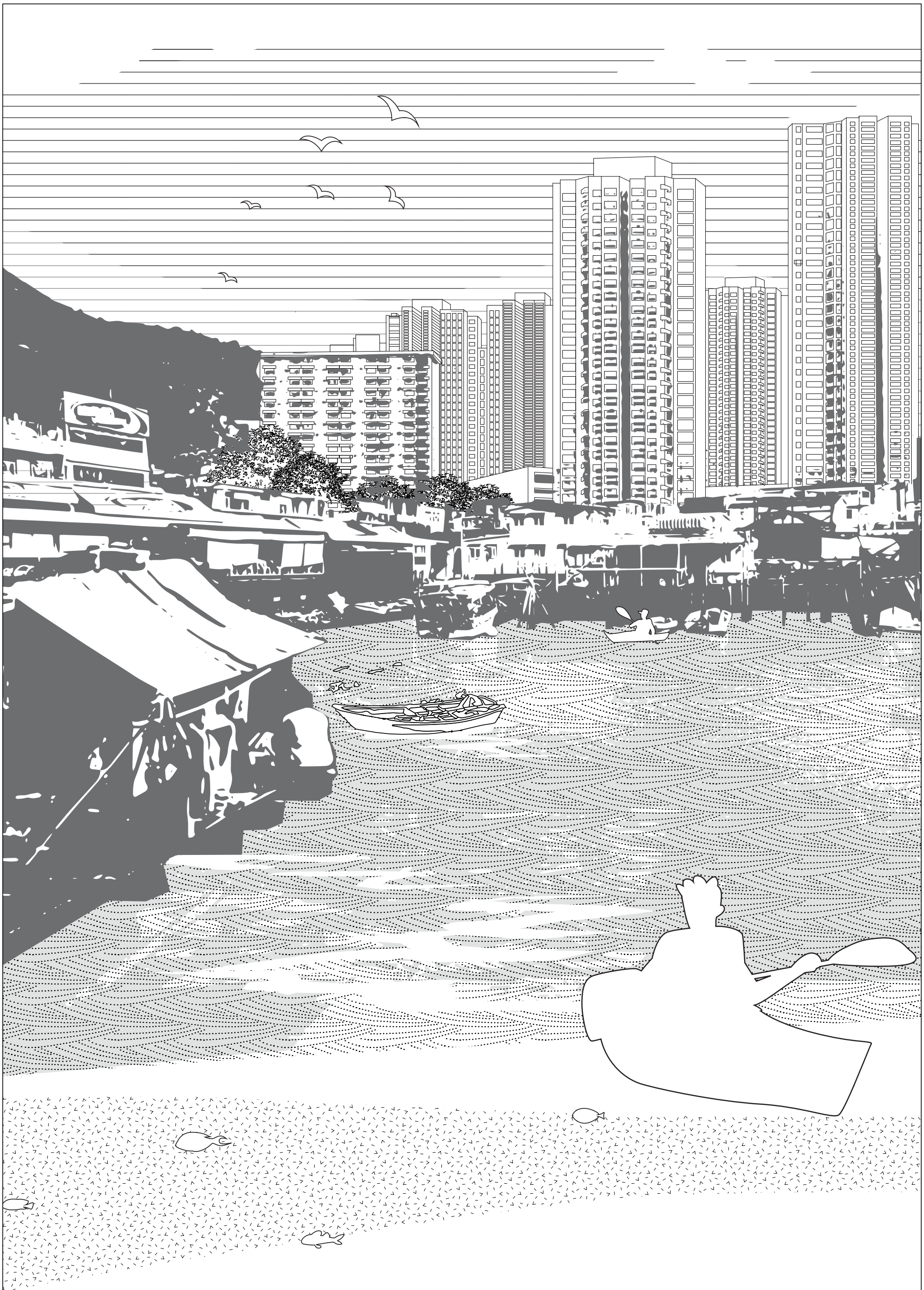
The history of land reclamation in Hong Kong has undergone phases of rapid growth and periods of slowdown. Nevertheless, it continues to depend on reclamation projects to provide land for the new urban developments driven by market demand (Lai, Lu and Lorne, 2014). Buildable land serves as a critical spatial asset for Hong Kong's economic progress and is intricately linked to the city's sustainable development. To achieve sustainability objectives, it is essential to have a thorough and careful understanding of the ecological conditions of the affected waters during future land reclamation efforts. This includes effective pre-assessments and simulations, real-time monitoring during construction, and transparent data sharing. Such measures ensure that new land can be developed while minimizing adverse environmental impacts.

Public awareness of the ecological consequences and damage to the living environment and landscape associated with reclamation projects in Hong Kong is widespread, as discussed in the previous sections. As a result, environmental authorities, non-governmental organizations (NGOs), and legal restrictions are currently challenging the viability of reclamation. In response to this opposition, the government has gradually moved the focal point of urban development inland towards the northwest (Wu, Wang and Gou, 2023, p. 2565). The effects of land reclamation projects on the urban landscape and the ecological environment beneath the sea are considerable and cannot be ignored. For instance, the area of Victoria Harbour has reduced by about 40% due to years of reclamation, leading to increased wave intensity and speed in the basin, which hampers the natural restoration of the harbor environment (Luo, 1997). Land reclamation in Hong Kong is anticipated to continue, as it is a vital strategy for converting inland areas into construction land (Shih, 2018). While these projects offer economic advantages, they also pose significant environmental challenges that require mitigation. Therefore, establishing a comprehensive and responsible framework for future land reclamation initiatives is crucial for facilitating sustainable development with reduced adverse environmental impacts.

A thorough pre-assessment and simulation is a key step toward sustainable land reclamation. This evaluation is essential for guiding engineers and decision-makers regarding the ecological and geological aspects of the sea, where most reclamation efforts take place. Relevant scholars should engage in this dialogue actively, offering insights on necessary development constraints. Their findings can inform engineers and government officials, allowing them to make suitable adjustments in development plans.

Real-time monitoring during the construction phase is another essential component of sustainable land reclamation. Any human engineering work

Vision of Future Landscape | Authors' work.



beneath the sea will influence water conditions, making timely feedback and documentation critical for all involved in monitoring the project's advancement. Such feedback can enable swift modifications to avoid actions that could severely affect marine ecology. Although these aspects have been noted in past reclamation initiatives, issues have emerged due to delays in data collection, tardiness in releasing pertinent reports, a lack of detailed explanations of specific categories, and insufficient data availability.

Consequently, the government must prioritize the release of transparent and timely data to overcome these challenges. This focus will allow the public to track the project's progress, promote increased community engagement, and provide constructive feedback that reflects public sentiment, thereby enhancing the project's strategic vision and viability. Transparent and timely data dissemination is vital for achieving sustainable land reclamation, as it grants all stakeholders access to essential information for informed decision-making, ensuring responsible development throughout the project.

Conclusions

The 180-year history of land reclamation in Hong Kong reflects not only the city's physical growth but also the increasing awareness of its people and a gradual awakening of civic voice. From the earliest colonial reclamations to the disputed visions of Lantau Tomorrow, the story of Hong Kong's shores has shifted from unilateral governance to shared authorship. This change, though uneven and filled with tension, signifies a key shift: from a government acting in isolation to one that can no longer ignore the voices rising from its harbors and hills.

However, this dialogue between the government and the public remains fragile. The long-standing top-down approach to policymaking—effective in implementation but lacking empathy—struggles to address the demands of a society increasingly aware of ecological, social, and cultural issues. As public awareness grows, the old method of merely 'informing' citizens is no longer enough; what's needed is an open dialogue that begins before decisions are made, not after. Sustainable and fair development requires not only economic wisdom — an understanding that the city's prosperity depends on the well-being of its people, its cultural memory, and the delicate ecosystems that support it.

The diverse communities featured in this study—from Lantau fishermen and indigenous families to urban residents and environmental activists—represent the many voices shaping Hong Kong's landscape. Their voices, though varied in prominence, form a collective testimony: progress is not just about the land gained, but about the inclusivity and sensitivity with which development occurs. The marginalization of fishing communities, whose livelihoods and traditions have long defined Hong Kong's coastal identity, highlights the moral cost of unchecked reclamation. To preserve the city's essence, urban planning must respect its roots by revitalizing the lives and knowledge of native communities and viewing the landscape as both a living archive and a right worth protecting.

Meanwhile, ecological concerns have become a strong counterbalance to economic pursuits. The destruction of marine habitats, the disappearance of local species, and the erasure of cultural coastlines demand a more responsible and environmentally aware approach to reclamation. The government therefore holds a dual responsibility: to promote sustainable practices and to protect the cultural and natural heritage intertwined with Hong Kong's identity.

Looking ahead, the way forward is through a governance model that is socially inclusive, transparent, and participatory—one that recognizes every citizen, community, and even nature itself as legitimate storytellers of the city's future. Policy development should start with dialogue, not orders, combining the diverse insights and hopes of stakeholders. Only through fair processes can citizens share authority with the government in shaping their environment, maintaining shared memory, and creating landscapes that reflect the diversity of their society.

Ultimately, reclamation in Hong Kong is no longer just about engineering land from the sea; it is about rethinking how people coexist with their environment—how the voices of humans and nonhumans alike can live together in harmony. The city's future depends on whether it can learn to listen: to its citizens, its history, and its tides. Because we are all—government, community, and nature—co-authors of the same changing shore.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2022–23. During the course, Linghao Gu, Kelin Mu, and Junjian Yu wrote the initial paper, supervised by Laura Cipriani. Linghao Gu, Kelin Mu, and Junjian Yu prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the chapter. Finally, a native English speaker reviewed the text.

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Land Reclamation Site Data

Location
Changxing Island | Dalian | China
Coordinates
31° 24’ 30’’ N | 121° 41’ 28’’ E
Area
13.30 km2
Length
10.00 km
Time
2003-2007

10 | Ghost Town Reclamation

The Story of a Small Island Village in Dalian

Fazhong Bai, Ailin Han, Wanning Liang, Chang Sun
Laura Cipriani, Denise Piccinini

To address their nation's industrial land shortage, the Chinese government began utilizing open ocean space along the coast to expand development areas, signaling the start of China's fourth reclamation boom. In addition to government-planned reclamation projects, illegal individual initiatives have been undertaken for private profit, with Dalian Changxing Island serving as a typical example. This chapter will explore the Dalian case, discussing land reclamation's social, environmental, and political-economic consequences. The impact of this reclamation on the livelihoods of coastal communities, especially fishermen, has been significant, as they lost the fishing work that supported their daily lives and were compelled to relocate from their homeland. Over time, large-scale artificial reclamation projects gradually replaced the original natural coastal zones. The local government briefly benefited from the reclamation, attracting sizable international shipbuilding companies to establish factories there. Following the global financial crisis in 2009, most companies on Changxing Island shut down. Once the workers left, the island transformed into a 'ghost town,' leading to numerous factories and residential buildings being abandoned. Surprisingly, this neglected land has not been forgotten. The fishermen who once lived here seem to have discovered a new way to survive. They returned to the area they once called home and launched a new fishing venture, revitalizing the 'ghost town' with renewed hope.

Introduction

In recent years, China's social and economic landscape has changed rapidly. The coastal provinces and cities have experienced significant economic growth, with the marine economy increasingly dominating this development. Urbanization and industrialization in coastal areas have accelerated, leading to a rise in various marine economic activities. A mismatch between supply and demand has forced local governments to focus on coastal regions, transforming reclamation projects from isolated efforts into broader regional developments. Previously centered around salt production, beach farming, and sea farming, these projects have now shifted towards industrial and construction uses of marine resources.

Throughout its history, China has relied on land reclamation as a vital strategy to address land resource constraints in coastal regions. Since the establishment of the People's Republic of China, the pace and scale of land reclamation have significantly increased. Four major reclamation 'trends' can be identified in China's history. The first occurred in the 1950s, when the government organized extensive sea reclamation for salt production, which notably accelerated the siltation of coastal beaches. The second phase, spanning the mid-1960s to the 1970s, involved large-scale beach reclamation to expand agricultural land, leading to the disappearance of vast near-shore beaches and a nearly 50% reduction in the total area of natural coastal beaches and wetlands. The third phase, from the mid-to-late 1980s to the early 1990s, witnessed another round of large-scale reclamation for aquaculture development. This resulted in severe eutrophication of near-shore waters due to extensive artificial aquaculture, exacerbating ecological and environmental issues in marine areas. Since the late 1990s, a fourth phase of reclamation has emerged, primarily concentrating on engineering projects, including port construction, ship repair, and airport development, and industrial purposes such as steel production, oil storage, and coastal residential development. While providing significant social and economic benefits, the chaotic, excessive, and uncompensated reclamation has also inflicted grave negative impacts on the aquatic environment and resources in coastal regions, particularly affecting hydrodynamic changes in near-shore waters, damaging marine ecosystems and fishery resources, destroying wetland landscapes, and degrading water quality.

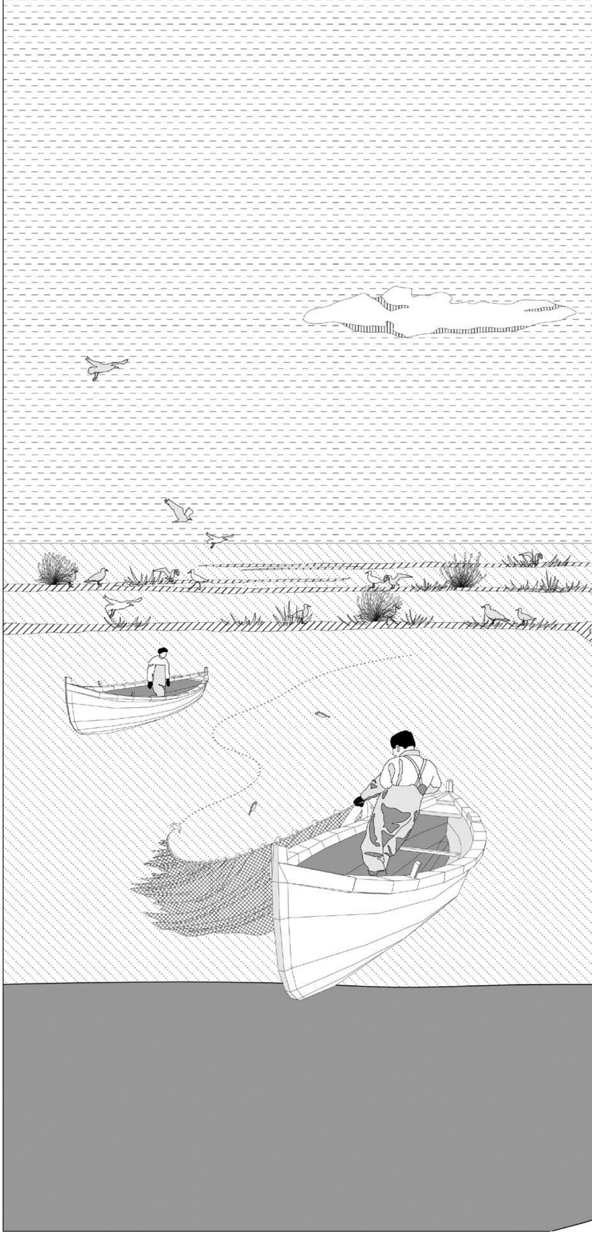
This chapter outlines the entire developmental history of Changxing Island, from its inception to its decline, reflecting on the failure of the Chinese government's extensive, blind reclamation efforts. The first subchapter presents an overview of what Changxing Island looked like before its development. The second subchapter examines the overall development process, detailing the opportunities, conditions, strategies, and situations involved. The third subchapter recounts the irreversible crisis that Changxing Island faced due to the economic downturn and the issues left in the wake of its decline, considering both natural and human factors. A concluding summary highlights the experiences and lessons learned by the local government from the Changxing Island case.

To evaluate the impact of land reclamation on the region, we gathered information about the geography, economy, residents' lives, and natural ecology both before and after the reclamation process. Due to national regulations in China, certain geographical details are classified and confidential, which means our data may not be comprehensive. We collected data regarding two locations: Bohai Bay and Changxing Island. We compiled relevant information through literature reviews, news articles, and online forums. Using data visualization techniques, we analyzed the economic changes and ecological impacts in the local area before and after reclamation. Furthermore, we examined videos shared on social media to gain insights into residents' and visitors' perspectives. This additional material enabled us to understand how people's lives were affected and how different social groups viewed the reclamation efforts. We tracked the geographical features of the site over time using ArcGIS historical satellite maps and OpenStreetMap as our basis. By comparing government plans from the era of reclamation with the actual satellite maps, we were able to analyze the execution of local plans and how different areas shown on those maps were utilized in reality.

Changxing: An Untouched Island

The History of Changxing Island

In ancient times, China's myths and legends described a captivating fairyland, thought to be hidden in remote mountains or the vast ocean. The spread of Taoism greatly enhanced the allure of these fairyland stories. It is within this rich tapestry that Changxing Island was revealed. Ancient texts portray the island as a realm where exotic flowers bloom, unusual animals wander, and countless gods and goddesses descend from the skies, representing the fairyland many dreamed of visiting. During the Southern Song Dynasty, a group searching for an immortal island stumbled upon Changxing Island. While it was not the fabled island of immortality, its extraordinary natural beauty and plentiful resources made it an ideal location for settlement. As a result, they chose to establish their home on the island. Since then, generations have thrived there, giving rise to the community known today as Changxing Island. Over time, the original settlers attracted others to join them. After centuries of development, Changxing Island has gradually evolved into the site of a



A Fishing Village | Dalian started as a fishing village. Fishing practices on the island can be categorized into two methods: traditional fishing and deep-sea fishing. Authors' work.

picturesque seaside town, with an increasing number of residents building homes and nurturing a vibrant community.

Changxing Island boasts one of the highest forest coverage rates among urban areas in the province. The town's forested area has expanded to an impressive 157,000 mu (where one Chinese mu equals nearly 666.67 m2), leading to a forest coverage of 42.6% (Anonymous, 2020). This extensive greenery makes Changxing Island lush and verdant. Additionally, the island has successfully transformed its villages and units into landscaped, garden-style environments. Since 1997, the town has organized a competition aimed at promoting these activities. Every road, river, and town on the island has undergone afforestation, resulting in the introduction of lush greenery throughout. Institutions, schools, and businesses have enthusiastically contributed by planting evergreen trees, establishing flower beds, and enhancing the overall landscape.

As a coastal area, Changxing Island relies primarily on fishing, salt pans, and mariculture for the survival of its inhabitants. Many local fishermen begin their journey at sea around the ages of 14 or 15, guided by their elders, and they often continue fishing for most of their lives. To them, the life of a fisherman is simple, free, joyful, and devoid of worry, with no concept of 'pressure' concerning them. They often express that if fishing were not enjoyable, they wouldn't dedicate so much time to it. Each afternoon, they mend their nets, gather with friends for tea and conversation, and eagerly anticipate the next day's catch. Tomorrow holds the promise of yet another ordinary, yet happy, day.

Fishing practices on the island can be categorized into two methods: traditional fishing and deep-sea fishing. Traditional fishing entails fishermen wading into the sea along the beach, where they set up simple nets with bamboo poles. After some time, small fish may swim into the nets, perhaps accompanied by a larger fish or two. This method is generally for personal consumption or small-scale sales. In contrast, fishermen also venture out in boats to catch deep-sea fish to sell to businesses. Deep-sea fishing typically requires three to four days at sea for a fruitful harvest, with five or six fishermen collaborating on the boat. This approach demands more labor than traditional fishing, as they must face harsh weather conditions and be ready for the unpredictability of their return journey.

In addition to fishing, the practice of mariculture on Changxing Island has been ongoing for many years, providing residents with a stable livelihood. The island's unique geographical position, surrounded by the Bohai Sea, offers high-quality ocean waters that create an ideal environment for cultivating and breeding various deep-sea fish. Bohai Bay's seawater exchange capacity and natural self-purification exceed those found in other seas, supplying rich nutrients that make this area especially well-suited for mariculture. Almost all residents of Changxing

Island maintain their own mariculture areas and possess extensive experience in this field.

Beyond fishing, the residents of Changxing Island also benefit from a reliable source of income derived from the salt flats. The island is surrounded by numerous salt fields, with the land segmented into several quadrangular sections, each dark and covered with salt. These salt flats primarily serve as evaporation sites for salt production, which are predominantly found in coastal areas. On Changxing Island, residents utilize seawater as the raw material, channeling it into salt ponds on the flat coastal mudflats. As the seawater evaporates under the sun's warmth, it leaves behind white crystalline particles. This natural process provides residents with additional income. The salt produced on Changxing Island is evaporated using only sunlight and wind, with no additives involved in the drying process, resulting in a completely handmade and organic product.

For a long time, the residents of Changxing Island have exemplified a harmonious way of life through their rich traditions of fishing, mariculture, and salt production. This way of life reflects their deep connection to the land and sea, ensuring the sustainability of their vibrant community for generations to come.

The Reclamation of Changxing Island

Development Opportunities

Dalian, a key city in northeastern China known for its strategic coastal location, includes within its purview Changxing Island, an emerging hub characterized by significant economic potential and rich natural resources. Dalian's urban development began on the coastal plain and has gradually expanded over time, resulting in a clustered pattern of growth. The city has transformed from a commercial port into an industrial town and eventually into a comprehensive modern city. Its internal spatial structure has been consistently adjusted to align with its functional roles and the goals of urban planning. Environmental factors play a significant role in shaping the city's spatial framework, providing both opportunities for development and constraints. At the same time, political factors primarily influence the evolution of Dalian's urban spatial structure, while economic factors are becoming increasingly important, and social factors have a relatively lesser impact (Liu, Dupre and Jin, 2021).

Thanks to its unique geographical position, Dalian has served as one of northern China's maritime transportation hubs since ancient times, often being referred to as the 'Gateway to Beijing and Tianjin.' After the establishment of the People's Republic of China, Dalian's advantageous location enabled it to become a key port in Northeast China, and later, an open coastal city and sub-provincial city. This evolution significantly contributed to the transformation of its urban spatial structure. Additionally, the development of Dalian's external trade areas—from the early foreign trade processing zone to more recent high-tech and bonded zones—has also driven the city's rapid growth.

Changxing Island is situated to the west of Wafangdian City in Dalian, within the central area of the Liaodong Peninsula. It is encircled by the Bohai Sea and is linked to the mainland by a single bridge. Covering an area of 252.5 square kilometers, it is the largest island located north of the Yangtze River. The island stretches 30 kilometers from east to west and 11 kilometers from north to south, boasting a coastline of 91.6 kilometers, a marine area of 100 square kilometers, and 1,500 hectares of mud flats. Its topography presents rolling hills, with the elevations rising towards the west and the central and eastern regions being lower. Changxing Island experiences a warm, temperate, humid continental monsoon climate, known for its mild, moist weather and four distinct seasons.

The island's proximity to the Bohai Sea grants it a strategic geographical advantage for developing a marine economy and accessing international markets. It connects to the mainland via a bridge to the east, located 358 meters from the shoreline and 29.6 kilometers from the entrances and exits of Guantuan on the Shenhai Expressway. Changxing Island is situated 120 kilometers south of Zhoushuizi International Airport in Dalian and 312.6 kilometers north of Shenyang, the capital of the province. Directly across the sea to the west are Qinhuangdao and Beidaihe. Additionally, it lies 339 nautical miles from the port of Incheon in South Korea and 646 nautical miles from the port of Nagasaki in Japan.

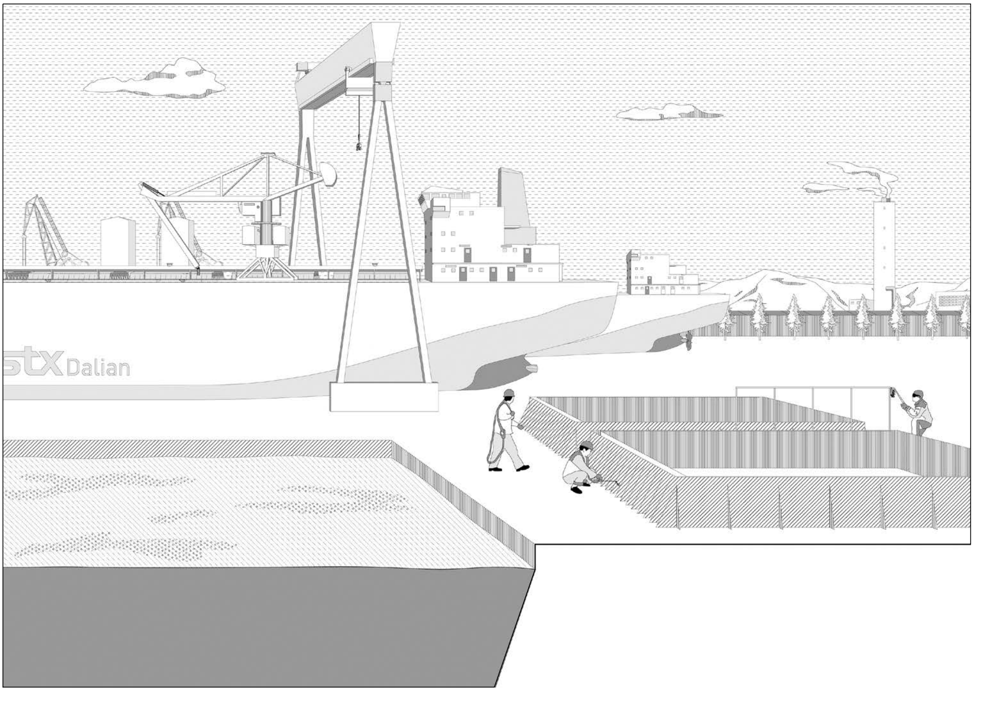
Before 2005, Changxing Island was a typical township in northern Dalian, primarily engaged in salt production and agriculture. However, the island's promising resources for port development—featuring around 30 kilometers of coastline, including approximately 5 kilometers of near-shore, 20-meter-deep water—rendered it ideal for constructing deep-water berths and extensive integrated port facilities. Moreover, Changxing Island is rich in limestone, with over 52% CaO and proven reserves of 600 million cubic meters, spread across more than 70 square kilometers of mineable land. It also possesses 200 million cubic meters of titanium shale, along with abundant resources such as diamonds, quartz sand, and sea amphibole (Liaoning Provincial Department of Natural Resources, 2022). This rich array of natural resources paved the way for the growth of the building materials industry and limestone aggregate operations, ensuring a steady cargo supply for the port. In addition to urban development areas, Changxing Island primarily comprises arable land, forests, and grasslands, while the surrounding islands feature predominantly woodlands and grasslands. This underscores the importance of preserving the existing natural hills as planners strive to create green spaces for residents. The numerous salt fields and mudflats surrounding the island also offer ample land for the town's expansion.

As a result, in 2005, the regional government of Liaoning Province launched the 'five points and one line' development strategy, actively promoting the coastal economy and establishing the Changxing Island Lingang Industrial Zone, which benefits from provincial development policies (Business News, 2014). That same year, a pivotal decision was made to plan and develop Changxing Island with the whole province's support, aiming to gradually transform it into a vital area for Liaoning's coastal and open economy (Weihui, 2014b). The story of Changxing Island will be transformed forever.

Blind Reclamation

Beginning in 2005, the Liaoning government focused on attracting foreign investment firms, broadening the international investment potential of Changxing Island, and elevating its status as a global port (Business News, 2014). In 2006, STX Group chairman Kang Deok-su and his team toured Changxing Island to assess the shipyard's development (Weihui Ma, 2014). At that time, Changxing Island had fewer advantages than other locations. Importantly, STX's initial project aimed to occupy 5.5 million square meters, whereas the reclaimed land on Changxing Island measured less than 2 million square meters. To convince STX to set up operations there, the Dalian government invested over 80 million yuan in the Changxing Island Port Industrial Zone and organized workers to level coastal hills and reclaim land. An additional investment of 120 million yuan was subsequently allocated to prepare over 800 stone and earth cubes to level the operational area. Ultimately, in September 2006, an investment agreement was finalized with STX Group from Korea (Weihui, 2014b). This experience led the local government to appreciate the advantages of land reclamation for attracting investment. To draw the PetroChina refining project, Changxing Island transformed its landscape by reclaiming over 7.2 million square meters of land, with total project investments exceeding 1.55 billion yuan.

The local government aimed to increase industrial land on Changxing Island to attract more businesses, thereby boosting the economic development of the Changxing Island Industrial Zone and enlarging the port area. Despite China's large size, its per capita land availability remains constrained due to a substantial population. Demolishing old structures for new ones effectively conserves land and improves productivity, aligning with the intended demolition goals and mirroring the shifting dynamics in urban planning. While new land was being created, long-term



Blind Reclamation | In this stage, the city expanded as the government invested in the Changxing Island Port Industrial Zone and organized workers to level coastal hills and reclaim land. Authors' work.

residents often had to move. In addition to sand-blowing and reclamation efforts, agricultural land was repurposed for industrial use.

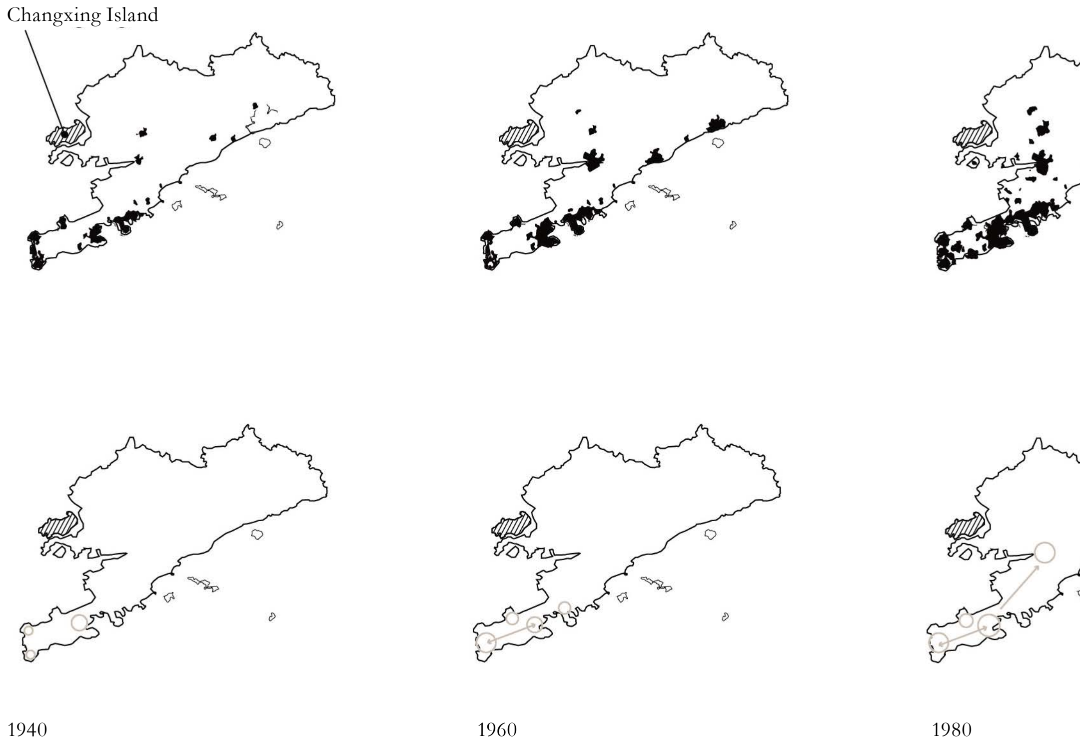
In 2005, the Dalian Changxing Island Lingang Industrial Zone Management Committee managed to relocate 50 square kilometers in just 100 days, affecting over 7,000 individuals and more than 60,000 mu of agricultural land, including over 40,000 mu of uncultivated fields (Sina Finance, 2007). The Dalian government's urgent attempts to foster development and create available space led to the seizure of many farmlands and residential areas without the central government's approval, as these areas had been privately owned. Again, in 2006, the Changxing Island Administrative Committee took a significant amount of land, relocating 194 hectares in the village of Santang within four days, affecting 912 households and over 4,000 mu of farmland. Subsequently, this committee confiscated land from over 1,000 households in Shiyao Village, more than 400 households in Huzhong Tun, and the homes and fields of over 400 families in various other villages. Overall, the expropriation of farmland surpassed 15,000 mu (Sina Finance, 2007).

The reclamation method used on Changxing Island is unique, primarily involving sand-blowing reclamation. Unlike traditional dredging, this technique gathers sand around the reclamation site through blowing. A dredger's pump moves sand and water from the sea floor outside the designated area into the target zone, allowing seawater to escape while keeping the sand within the defined circle. The blowing method is flexible; during the initial stages, it is directed towards the center of the circle where there is no land, and in the later stages, it shifts focus to the edge of the area, using a line of sandbags or steel plates to delineate a specific portion of the sea surface. A pile-driving machine on a specialized ship then anchors this edge by driving piles into the ground. After land formation, the soil is compacted and loosened with a heavy rammer.

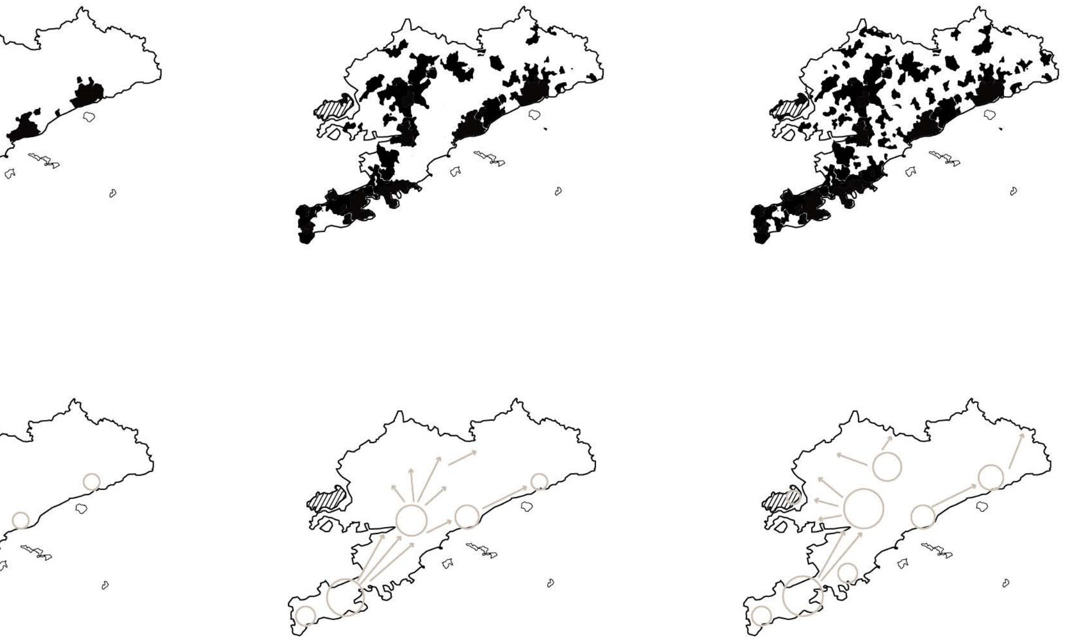
While the Dalian government has invested heavily in the development of Changxing Island, the swift establishment of infrastructure has led to significant economic advantages, dramatically boosting local productivity in a brief period. Nevertheless, the local government's narrow focus has resulted in neglecting the development's ecological and residential repercussions, fostering an overdependence on foreign companies and creating a façade of success amid ongoing difficulties.

A Temporary Prosperity

As the leading investment project in Dalian and the flagship initiative for developing Dalian Changxing Island, STX Shipbuilding's arrival and subsequent bankruptcy mark two significant milestones in the island's progress. Unlike the traditional shipyard setup, STX Shipbuilding came to Dalian during the 2008 global financial crisis. At that point, orders for new



City Expansion Process | Dalian has been the most important port in the Bohai Bay since the early 20th century. Before 1960, the city was relatively small. The city expansion process accelerated significantly starting in the 1980s, progressing from the southwest to the northeastern area. Changxing Island was not urbanized prior to 2000. As of 2021, the urbanization rate of Dalian is 67%. Authors' work.



2000

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vessels had drastically declined, many were abandoned, and reports of new launches dwindled. Confronted with a cash shortage, STX Shipbuilding had to hasten its expansion to generate short-term profits.

The STX Dalian project benefited from collaboration with the Chinese government. STX Shipbuilding utilized nearly all of the reclaimed land on Changxing Island II. The STX Dalian project on Changxing Island was officially launched on March 30, 2007, and began operations on January 17, 2009 (Anonymous, 2009). Typically, building a shipyard takes at least three years. In contrast, STX Shipbuilding launched its first ship in under two years and completed two ships in 18 months—an impressive industry achievement.

The STX Dalian project successfully attracted many local individuals into employment, helping to mitigate the job issues faced by residents who lost their land due to major redevelopment. The initiative focused on hiring from the Changxing Island area first, then from nearby regions. During that period, 67.5% of the Group's workforce was situated in Liaoning, with more than 10,000 were receiving ongoing training. This initiative greatly enhanced competition for talent, expanded job opportunities, and fostered economic growth in Changxing Island and its surroundings.

In February 2009, Clarkson, a global shipping authority, revealed that STX Shipbuilding had overtaken Hyundai, Daewoo, and Samsung Shipbuilding in Korea, becoming the world's fourth-largest shipbuilder by December 2008, according to the order book of each shipyard (Business News, 2014). Kang Deok-su noted that while the global financial crisis heavily affected the shipbuilding industry, STX Shipbuilding remained optimistic about navigating this difficult period (International Ship Network, 2009). The company had several initiatives planned for the Dalian market, with aspirations for its Dalian base to be the most prestigious shipyard worldwide, featuring top-notch production technologies and capacities.

Despite this ambitious outlook, conditions were still unstable. Ultimately, STX Shipbuilding could not endure the negative pricing climate, leading to losses of up to 22 billion US dollars while waiting for economic recovery. After a decade of rapid growth, it filed for bankruptcy in April 2013, causing its shares to sharply decline in value (Weihui Ma, 2014b). The company began a significant restructuring effort in mid-April. The company's operation, located on Changxing Island in Dalian for only four or five years, teetered on the edge of collapse due to broader challenges in the global shipbuilding sector. On October 14, 2014, Kang Deok-su was sentenced to prison for allegedly embezzling 2.6 trillion won (about 14.95 billion yuan) through negligence. The Seoul Central District Court found that Kang Deok-su's embezzlement and wrongdoing caused considerable harm to the South Korean economy, branding him as the mastermind of these offenses. According to South Korean prosecutors, he was liable for providing improper assistance to STX Group over a long period, leading to missed restructuring opportunities, significant losses, and severe mismanagement (International Ship Network, 2014).

The Tragedy of GDP Heroism: The Existing Condition of the Changxing Island

A Stagnant Development

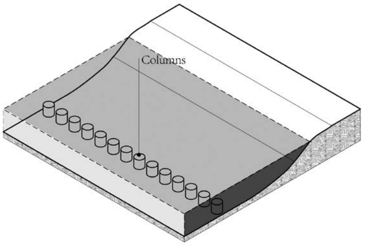
The bankruptcy of STX (Dalian) Enterprises, a key importer, severely impacted the Changxing Island planning project, leading to a dramatic population decline and the collapse of many real estate developments. This effect was initially observable in businesses that provide support services to STX Dalian Enterprises. The once-thriving workforce of Changxing Island has decreased, with tens of thousands of employees who previously commuted on over 300 shuttle buses each day now reduced to a mere handful. Many of those buses now sit idle in the lot next to STX Seaview Gardens, the leading residential complex for workers, their paint peeling and windows broken.

As the ancients said, '*Small streams run dry when the mainstream is low*' (Business News, 2014). The new project on Changxing Island has struggled to come to fruition. The Santai Industrial Zone, designed to be the island's service area, has wholly failed. Although the broad roads in the Santai Industrial Zone are equipped with traffic lights and streetlights, the vast wasteland lining both sides of the road indicates that few projects have been attracted to the area in recent years.

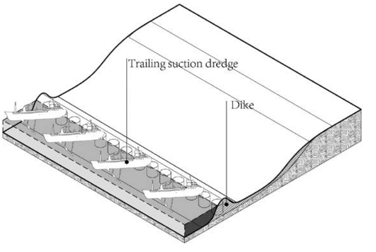
The plan initially anticipated 500,000 residents moving to Changxing Island (Business News, 2014). The Santai Industrial Zone invested billions in foundational projects, including relocation, land reclamation, and improved regional connections. A 2008 Changxing Island real estate market survey indicated that over 20 projects were underway or available for sale (Business News, 2014). At that time, the average price per square meter for the main apartment types, typically 70 to 80 square meters, was around 3,000 yuan. By 2011, this average soared to about 5,500 yuan per square meter, with more than 60 real estate projects emerging on the island. However, after the second half of 2012, the average price dropped to 4,000 yuan per square meter, leading to an almost total halt in transactions for both new and used homes. The once-bustling real estate market on Changxing Island is now lifeless (Business News, 2014).

Today, Changxing Island has taken on the feel of a 'ghost town.' Many previously vibrant restaurants, supermarkets, cinemas, and other services near the established residential area are now largely closed, their windows plastered with 'For Rent' and 'For Sale' signs. The real estate market

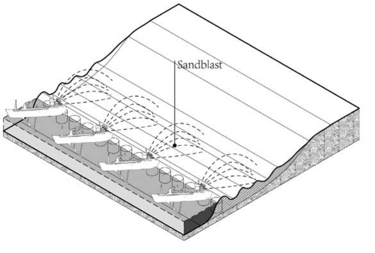
Step 1 | Secure the piles to the seabed to stabilize the foundation



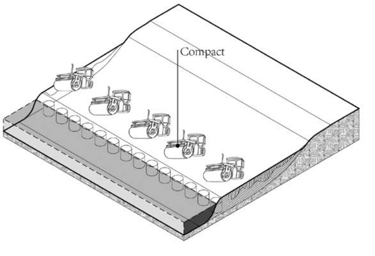
Step 2 | Build a sand wall around the piling area to form an enclosed region



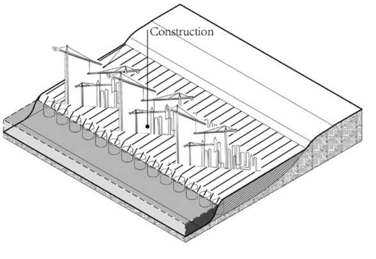
Step 3 | Filling the sand into the enclosed area to create new land



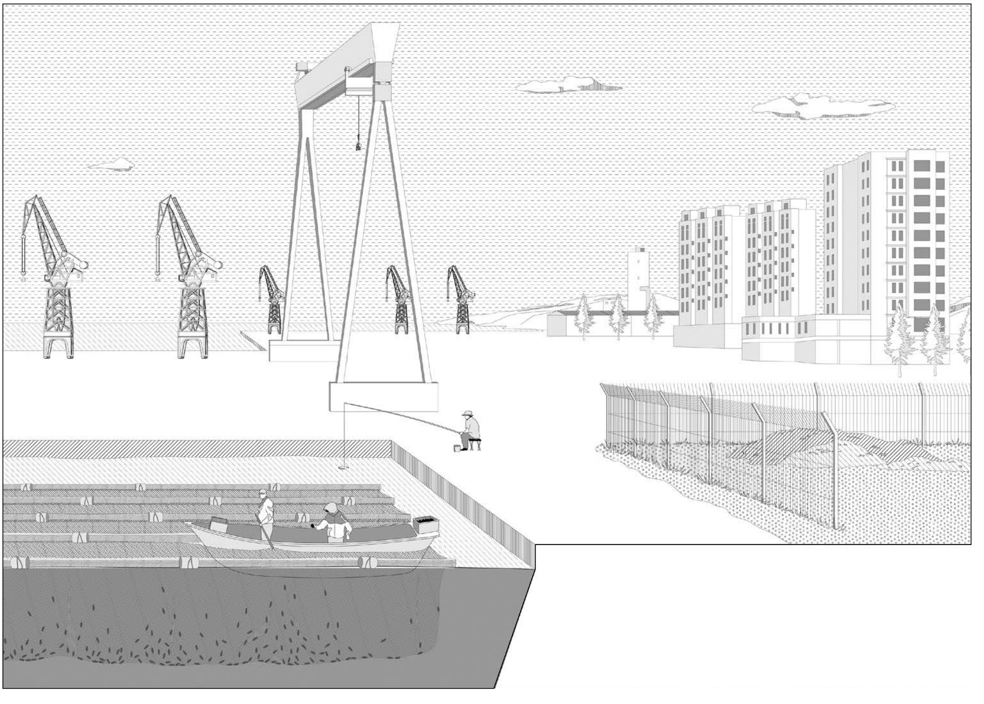
Step 4 | Compress the new land and build a granite wall to prevent the land from wave erosion



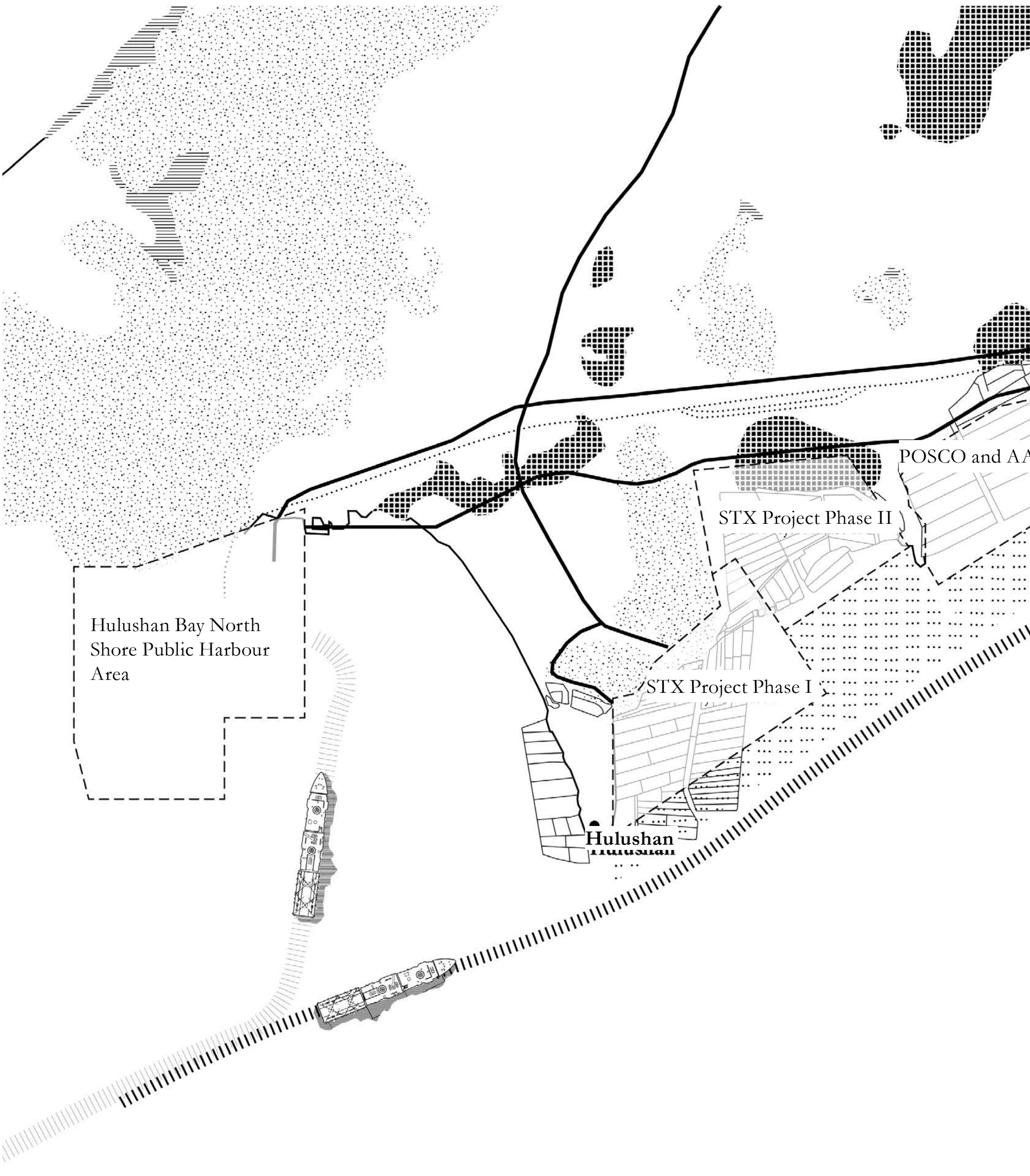
Step 5 | Re-vegetation and construction on the new land



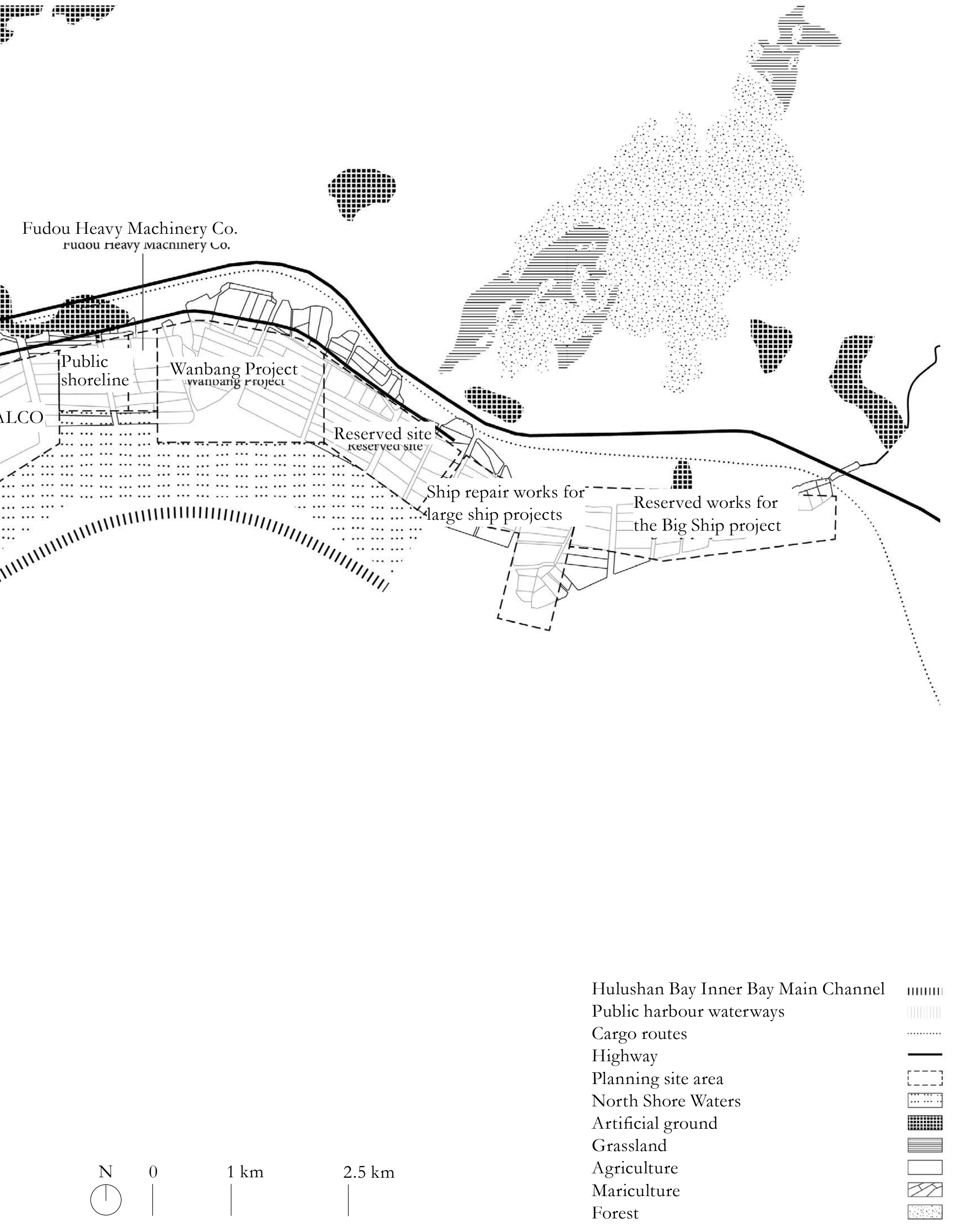
Reclamation Process | The reclamation technique is based on a method known as sand-blowing reclamation. The reclamation process involves five steps: piling, diking, filling, compressing, and building. Authors' work.



The Decline of Nature | The expansion of port terminals and coastal industries has severely harmed the ecological environment of Changxing Island's coastal zone. Authors' work.



Reclaimed Areas | Main reclaimed areas in Dalian.
Authors' work.


Fudou Heavy Machinery Co.
Fudou Heavy Machinery Co.
Public shoreline
Wanbang Project
Wanbang Project
ALCO
Reserved site
Reserved site
Ship repair works for large ship projects
Reserved works for the Big Ship project
Hulushan Bay Inner Bay Main Channel
Public harbour waterways
Cargo routes
Highway
Planning site area
North Shore Waters
Artificial ground
Grassland
Agriculture
Mariculture
Forest
N
0
1 km
2.5 km

remains stalled at several unfinished sites, where scaffolding and tower cranes stand idle. The exteriors of towering buildings show windows yet to be installed, revealing dark, vacant openings. Thousands of homes are unoccupied, adding to the 70 million unsold residences built nationwide for the middle-class population (Business News, 2014).

The Decline of Nature

The expansion of port terminals and coastal industries has severely harmed the ecological environment of Changxing Island's coastal zone. By 2020, the island's natural shoreline had reduced to 48.0 km, representing a 45% decrease since 2005 (Ai et al., 2021). This loss of natural shoreline significantly affected the health of the ecosystem. The reclamation has severely altered the benthic habitat of the mudflat wetlands.

Moreover, the migratory birds that rely on these benthic organisms have also been significantly affected. Changxing Island is the only known wintering ground for gray cranes in Liaoning Province, many of which migrate from New Zealand and Australia, covering over 10,000 kilometers almost non-stop. Many of these cranes have lost 30-40% of their weight by the time they arrive at Bohai Bay (Weihui, 2014a). If they regain their energy in this area, they can proceed northward and complete their breeding cycle.

Sea reclamation fundamentally changed the bay's natural characteristics. The semi-enclosed configuration of Hulushan Bay, bordered by land on three sides and open to the sea on one, could have a better water exchange capacity. The bay's shape has transitioned from that of a gourd to a more elongated form. The area of open water has diminished from 69.01 km² in 2005 to 43.47 km² in 2015, reflecting a 37% decline over the past decade (Weihui, 2014a). This reduction has diminished tidal forces and the capacity for water exchange, leading to significant harm to the ecological functions that support marine life, including spawning and feeding. Marine environments offer vital ecosystem services, such as food production, climate regulation, and water purification. Research by Shanshan Wu et al. and the Liaoning Provincial Fishery Statistical Yearbook indicates that the average ecosystem service value per unit area in the Bohai Sea is 10,542 Euros/(ha) (Wu et al., 2008). By integrating the GDP of Dalian Changxing Island with the actual area occupied by harbor industries, we can assess the social benefits derived from sea area development. Between 2014 and 2016, the marginal compensation for sea usage was negative, suggesting that marine resources and environmental capacity were overstrained, leading to declining social benefits as sea utilization expanded. After 2016, the marine resources and environment near Dalian Changxing Island were over-exploited, with the marginal effect plummeting to a concerning -479,000 Euros per hectare (Business

News, 2014). These alarming statistics reflect not only economic repercussions but also ecological devastation afflicting the coastal zone of Changxing Island: destruction of coastal wetlands, declining seawater quality, overfishing, loss and fragmentation of biological habitats, and rising instances of marine disasters.

The Dilemma Faced by Locals

Prior to the development of Changxing Island, the local population numbered around 30,000, supplemented by approximately 9,000 migrant working population. The establishment of the industrial zone triggered a remarkable surge in population, which soared to nearly 100,000 by 2011(Wang, 2014). During this period of rapid growth, the number of local residents nearly matched that of foreign residents. Unfortunately, this peak was fleeting, lasting just two years. After 2013, the population began to decline sharply as unemployed workers left the island in search of opportunities elsewhere. This exodus led to widespread displacement, and an aging demographic has rendered further economic growth on the island unfeasible. Despite earnest attempts to enhance living standards and create employment opportunities, these efforts have proven to be short-lived.

With fluctuations in employment levels, a segment of the population will inevitably remain unemployed, which can lead to social instability. The transition to unemployment has had a profound impact on the lives of local villagers residing on the island.

During the initial development phase of Changxing Island, many residents were compelled to leave their homes. After the expropriation of land and the relocation of over 2,000 villagers, the industrial zone still faces the task of securing essential land requisition and demolition approvals (Wang, 2014). Although villagers received compensation payments after losing their land, they simultaneously lost their primary source of income. Their once reliable agricultural revenue has given way to an unstable financial situation.

Originally, the Changxing Island area amalgamated agriculture and industry, resulting in a workforce in which some industrial workers were relatively skilled, while those engaged primarily in agriculture and aquaculture tended to be older and less skilled. Due to their age and skill limitations, older individuals lost their income following necessary home purchases and other resettlement measures. They now rely on compensation and subsistence allowances to maintain their livelihoods.

To gain deeper insights into workers' perspectives, we analyzed videos shared on social media. We discovered three distinct groups of laborers: local workers, migrant workers, and mariculture farmers.

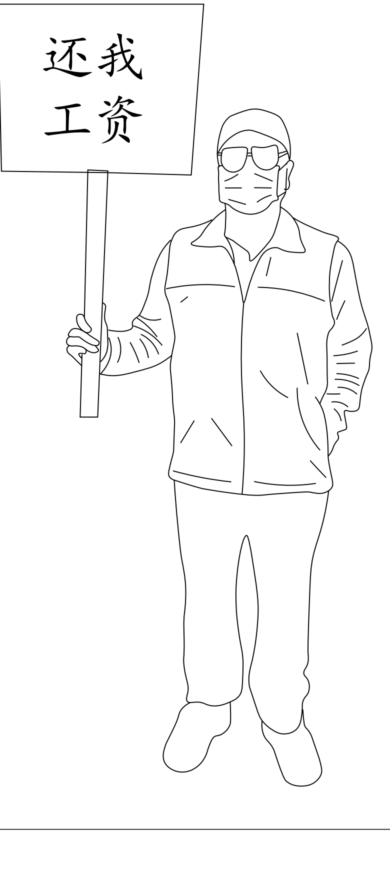
Many of the first group, local workers, depend solely on land compensation payments for their survival, leading to declining living

The whole village was demolished. We used the demolition funds to relocate to the downtown.

Relocated Units

A few months ago, they told us to take unpaid leave. Until today, we still haven't received last year's salary.

Local Workers



I spent all my savings but still cannot cover the insurance.

I can't find a new job that will allow me to pay my mortgage.

Migrant Workers

We do not want the reclamation. It will not only affect our livelihoods, but also damage the marine ecology.

Mariculture Farmers

standards, especially for middle-aged individuals. Consequently, a significant number have chosen to leave the island, seeking employment opportunities in Dalian City. Others have found factory jobs, yet their lives remain fraught with challenges (Weihui Ma, 2014b). This group has moved past its productivity peak but still bears the responsibility of supporting both aging parents and young children. These families' standards of living remain stagnant due to the burdens of educational and medical expenses. Additionally, urbanization in the central area has driven up the cost of living. Following the shipbuilder's bankruptcy, they lost their source of income once again, with unpaid wages exacerbating their difficulties.

The second group is made up of migrant workers. Like many of his friends, Qiao Ao has been employed at the factory for four years. '*Our orders have been falling from the beginning of this year,' he remarked. 'doing as much overtime these days as I used to when business was good, so I don't make as much money as I used to'* (Vaswani, 2015). Migrant workers constitute at least two-thirds of the workforce in the industry. In earlier years, they witnessed Changxing Island transform from a modest fishing village into a state-level economic and technological development zone, with wages that surpassed those in Dalian City. Remarkably, 85% of shipyard workers have taken out loans to purchase commercial housing, and some have depleted their entire family savings. They were taken by surprise when the shipyard abruptly closed, leaving the island without an income source and mired in mortgage debt.

Lastly, we identified mariculture farmers as the final category of workers. The aggressive reclamation of land has not only caused a decline in marine species and degraded coastal ecosystems, but also negatively affected a largely overlooked group: sea fishermen. Over the past decade, villagers residing along the shoreline have relied on the mudflats for their livelihoods. Spanning from Hulushan Mountain to the northeast, a designated 60-kilometer stretch of shoreline supports fishing and marine farming activities for shrimp, crabs, fish, sea cucumbers, shellfish, and various other marine products. However, as reclamation from the sea intensified, those living near the water increasingly struggled to sustain their livelihoods (Wu, 2011).

In Hulushan Bay, the development of a deep-water port has directly affected the villagers who operate seafood farms in the area. They have been given minimal compensation and left to navigate these challenges alone. The fishing and mariculture breeding operations of other fishermen nearby have also been hindered. The establishment of sand-blowing facilities and industrial zones has diminished the outputs of shellfish, sea cucumbers, shrimp, and fish in coastal farming, leading to significant financial losses for farmers. Both mariculture farmers and fishermen are suffering, and consumers are beginning to feel the effects, with rising seafood prices and shrinking sizes of marine products (District Management Committee, 2009).

Unexpectedly, signs of recovery are emerging. Since 2016, satellite imagery reveals that villagers have begun reclaiming the coast (ESRI World Imagery Wayback, 2022). With tidal flats converting into industrial ports, purse seine fishing has become increasingly untenable, prompting mariculture farmers to adapt by shifting to offshore farming. Sea cucumber-farming cages have been established in the waters surrounding the abandoned port, gradually expanding over the years as villagers assert their land titles against the encroaching shipyards.

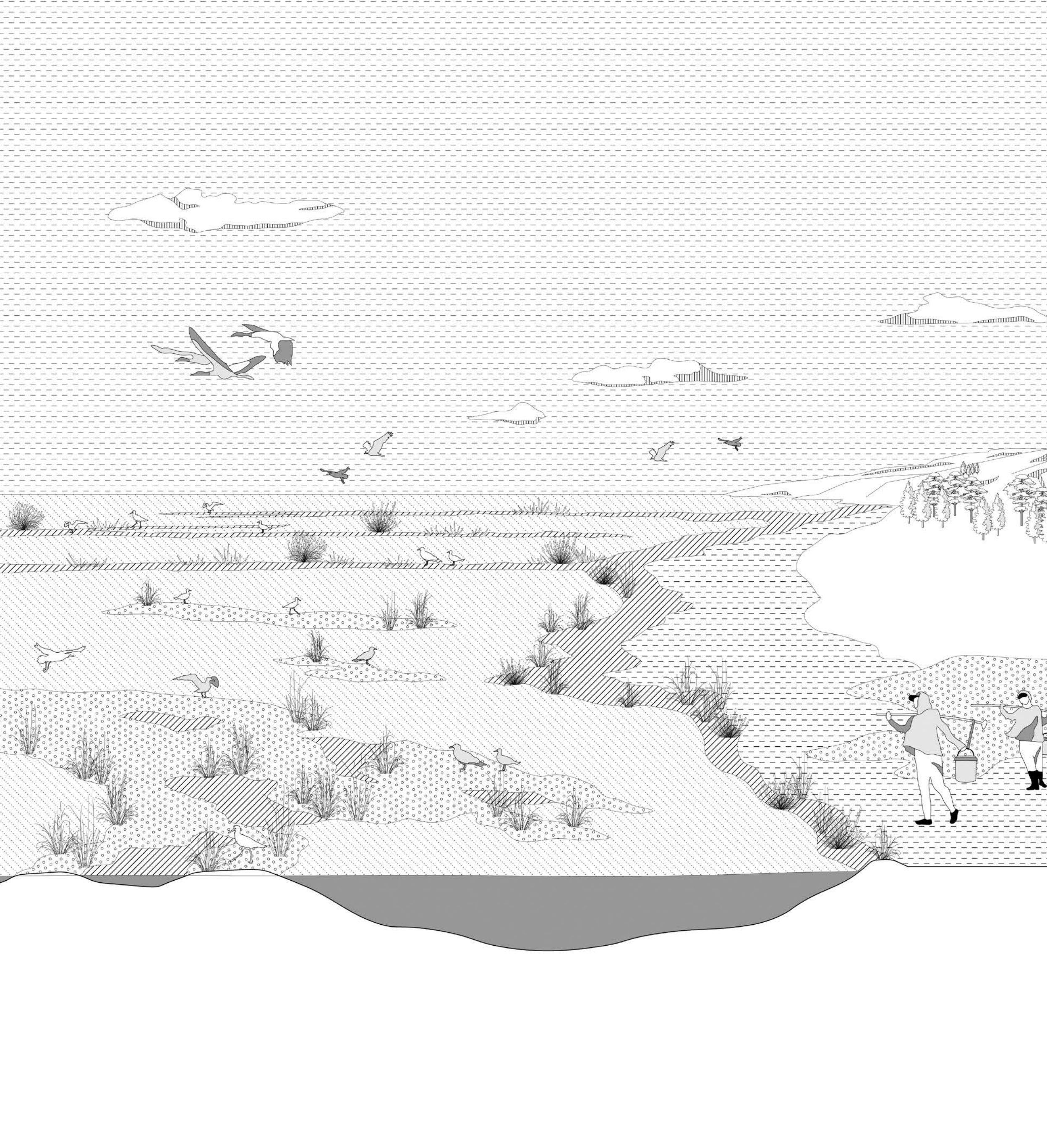
Despite the challenges faced, the resilience of the local population offers a glimmer of hope for a sustainable future on Changxing Island.

The Future of Changxing Island

The future development of Changxing Island requires careful reconsideration, as its natural environment has suffered significant damage from extensive marine polder and industrial land reclamation. While development on the island is stagnant, this pause may offer an opportunity for nature to recover. To ensure the future sustainability of this coastal industrial zone, the local government must prioritize addressing the historical consequences of reclamation while promoting the stringent protection of marine resources and effectively restoring and utilizing the existing land. Conducting an ecological assessment of the reclamation project and proposing viable restoration measures is essential for mitigating the impacts on marine hydrodynamics and biodiversity. Additionally, maximizing control over the reclamation area, improving the efficiency of shoreline resource usage, and implementing necessary ecological restoration will enhance wetland ecological functions.

Restoring the damaged coastline, increasing public access, and improving the environmental aesthetics of the new shoreline are also critical. Furthermore, creating a naturalized, ecologically balanced coast is vital. Changxing Island's authorities must enforce a stringent marine ecological protection system, prohibiting any development that fails to meet established standards.

It is crucial to strengthen the management and protection of coastal wetlands and enhance the enforcement and supervision of marine protected areas. Conducting special inspections will help to address illegal development and utilization activities effectively. Remediating and restoring coastal wetlands should involve reclaiming land from the sea, returning agricultural practices to coastal zones, and revitalizing wetland



The Future of Changxing Island | After the global financial crisis in 2009, the island became a 'ghost town,' resulting in many factories and residential buildings being abandoned. Surprisingly, the fishermen returned to the area and started new fishing ventures. Authors' work.

ecosystems. This process must also include the gradual recovery of the ecological functions of damaged coastal wetlands.

A comprehensive enhancement of regulatory capacity involves improving investigative and monitoring systems, establishing active surveillance measures, and regularly assessing the ecological changes in coastal wetlands and natural shorelines. Moreover, various levels of environmental impact will arise during the construction of reclamation projects, including in the design and construction of dikes, from sand extraction, and potential pollution from sediment and oil. After project completion, the resulting sewage and waste may pose significant marine pollution risks, representing a considerable future challenge.

Reclamation projects are among the most critical initiatives for developing marine space resources and addressing current land resource limitations. However, these projects can profoundly affect the marine ecological environment. Humanity must acknowledge the environmental damage and water pollution that result from reclamation efforts and strive to minimize harm through (enforced) regulations and other legislative tools. This includes reducing suspended sediment production, ensuring ecological restoration and compensation, and regulating biological resources.

We must align social and economic objectives with ecological and environmental goals, making sustainable development a collective priority for humanity both to embrace and to pursue diligently.

Conclusions

The story of Changxing Island unfolds as both a warning and a reflection—a mirror of China's broader struggle with rapid modernization. What began as an ambitious effort toward progress, reclaiming sea and land in pursuit of prosperity, has instead become a lesson in the imbalance between human goals and the natural environment.

Economically, the reclamation projects were meant to be engines of quick growth—aimed at guiding Changxing Island into a new era of maritime success and global competitiveness. However, this expected prosperity proved fragile. The 2008 worldwide financial crisis disrupted the stability of foreign-invested companies like STX, whose bankruptcy shattered the economic foundation that had briefly elevated the island as investments dried up. A cycle of halted development, business failures, and declining capital followed. The physical signs of progress—factories, ports, and new residential areas—were left half-finished, caught between ambition and abandonment.

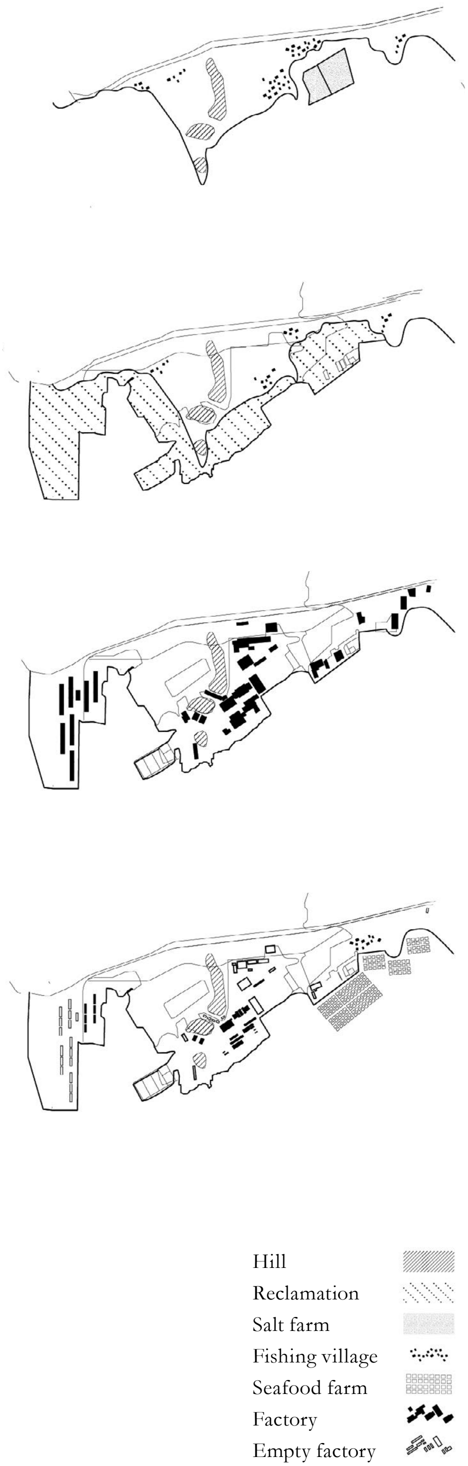
Socially, this economic instability caused long-lasting hardship for the

1955 Fishing villages

2003-2007 Blind reclamation

2007-2011 Temporary prosperity

2022 Stagnant development



The Evolution of Dalian | The development of Dalian from 1955 to 2022. Authors' work.

residents. During the early reclamation years, farmers were displaced from their ancestral lands, losing both their income and their sense of identity. The compensation they received couldn't replace the stability once provided by farming and fishing. Many were resettled but not truly reintegrated, forced to seek uncertain jobs in Dalian's city center or elsewhere. The shutdown of major companies triggered more unemployment, leaving behind communities of empty buildings and idle workers—creating a phenomenon that turned lively new towns into 'ghost cities.' For migrant workers who had invested their savings and hopes in the island's industrial boom, the industry's collapse meant not only losing wages but also losing trust in the promise of modernity.

Ecologically, the effects have been equally significant. Reclamation and industrial expansion have changed the coastline and harmed the marine environment. The destruction of coastal wetlands and the loss of natural shoreline have upset the delicate balance of marine ecosystems. Hulushan Bay, once known for its semi-enclosed tidal rhythm, has lost 37% of its open water in just ten years, greatly reducing its ability for water exchange and ecological renewal (Ai et al., 2021). The decline in fish populations, habitat fragmentation, and worsening seawater quality have further lowered the region's ecological resilience. What was once a self-sustaining coastal ecosystem is now a fragile area of environmental imbalance.

Despite these challenges, awareness is rising. The lessons from Changxing Island have prompted reflection among policymakers, scholars, and citizens alike. Growing concern for ecological health and human well-being is starting to change attitudes toward coastal development (Hao, 2019). National initiatives, such as the 'who pollutes, who controls' policy, now emphasize corporate responsibility and environmental accountability (District Management Committee, 2020). Heavy industries on the island are gradually adopting more sustainable practices, while urban planners and designers are rethinking development strategies to prioritize coexistence over exploitation. Some local projects—such as collaborations between architects and fishermen—show a new direction—one that combines traditional livelihoods with ecological tourism and cultural preservation (Hao, 2019).

The case of Changxing Island highlights the importance of assessing the true costs of reclamation before starting. Ecological compensation should be part of industrial planning, recognizing that each hectare of reclaimed sea results in the loss of priceless natural resources. Restoration efforts—such as building artificial reefs, replenishing fish stocks, and restoring wetlands—can help repair what has been damaged, although they can never fully replace what was lost.

Overall, Changxing Island's story emphasizes the urgent need to balance economic goals with ecological protection and social fairness. The ocean isn't just a frontier to conquer but a living system vital for human survival. Managing the coast responsibly means understanding that prosperity and preservation must go hand in hand—that real progress is measured not just by growth but by resilience.

Ultimately, the island challenges us to rethink what it means to build, live, and belong. Sustainable development cannot be forced upon nature; it must evolve through a dialogue with it—one that respects the natural rhythms of land, water, and community. Changxing's story isn't finished, and perhaps that's its hope: that from the silence of its failed prosperity, a more balanced vision of coexistence can emerge—where human progress moves not against, but with, the tide.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2021–22. During the course, Fazhong Bai, Ailin Han, Wanning Liang, and Chang Sun wrote the initial paper, supervised by Laura Cipriani and Denise Piccinini. Fazhong Bai, Ailin Han, Wanning Liang, and Chang Sun prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, and editing the entire chapter. Sari Naito and Fazhong Bai conducted a bibliography check on the paper. Finally, a native English speaker reviewed the text.

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Land Reclamation Site Data

Location
Baseco | Manila | Philippines
Coordinates
14° 35' 29'' N | 120° 57' 29'' E
Area
0.40 km2
Length
1.70 km
Time
1989-2009

11 | The Struggles of Squatters

Formal and Informal Forces Acting to Reclaim the Baseco Compound in Manila

Liyun Chang, Anna Gorokhova, Yi Lu, Chuhan Zhang
Laura Cipriani, Denise Piccinini

Baseco is a 52-hectare artificial island that provides informal housing for 60,000 migrants, who represent one of the most vulnerable segments of society in Manila Bay, the Philippines. The island illustrates the various social, political, economic, environmental, and demographic forces that have contributed to the rise of informal settlements and aggressive land reclamation, driven by the government in response to the growing demand for housing among the increasing migrant population. Formal and informal dynamics play a role in the expansion of Baseco, affecting the urban framework of squatter settlements, their inhabitants, and the land itself. Unlike other forms of top-down planning with formal functions, this neighborhood has a strong sense of spontaneity, disorder, and irregular patterns that define the space and lifestyle; it has aptly been described as '*organized complexity endowed with inner unpredictability*' (Cutino and Di Pinto, 2018, p. 491). This chapter explores the underlying processes involved in the development of Baseco through reclaimed land and informal settlements, as well as the effects and challenges stemming from these processes. To understand the core social, political, economic, ecological, and demographic dynamics, we examine the evolution of Baseco's informal settlements and land reclamation activities.

Introduction

The rising trend of rural-to-urban migration is a global phenomenon that cannot be ignored. In 2018, 55.24% of the world's population lived in urban areas, and this percentage continues to rise (UN, 2018). By 2050, it is anticipated that over 68% of the global population will live in urban environments (UN, 2018), giving rise to new social, political, economic, and ecological challenges that affect social structures and the landscapes people inhabit. This shift from rural to urban areas has occurred over the last century as industrialization and mechanization have changed the nature of human labor. The effects of such migration are visible in transforming landscapes and urban development, both of which have undergone significant structural changes as population distribution increasingly favors urban areas. As the rural population decreases, so does the countryside's capacity to provide adequate employment, healthcare, and educational opportunities, all of which have become less accessible in rural regions. Consequently, more individuals are compelled to migrate, intensifying the demands on services in larger urban centers and worsening urban inequalities. As cities expand, urban poverty rises, fueled by income inequality and the uneven distribution of wealth and opportunities. The shift from an agricultural to an industrial focus leaves rural migrant workers with limited prospects, placing them at a higher risk of falling into urban poverty.

The Philippines exemplify a rapidly growing economy facing significant rural-to-urban migration, resulting in urban sprawl without adequate housing resources. Metro Manila, located on Luzon Island, is the National Capital Region. Its population exceeded 14.4 million in 2022, making it one of the largest high-density urban agglomerations in the world. This region serves as the Philippines' primary economic hub, producing more than half the country's economic output. Over the past 50 years, as the city has expanded and developed more financial opportunities, it has transitioned from rural to urban, drawing more suburban residents to leave their homes searching for a better life. Since the 1970s, Metro Manila's population has surged by over 50% (Macrotrends, 2025).

Due to unexpected population growth and local authorities' inadequate response to the worsening housing crisis, the spread of informal settlements in the area has become notably more pronounced. Rural migrants are increasingly likely to become part of the urban poor living in these informal settlements due to economic conditions. Urban poverty has become a critical issue in Metro Manila, contributing to income inequality.

Land reclamation has emerged as a communal response to urban expansion. The government has opted to create new land in the sea to fulfill the demand for commercial space near the urban center. The Manila 'reclamation spree' project has been initiated in Manila Bay, drastically transforming the region. However, as coastal zones are pushed back, the area confronts rising environmental challenges. Furthermore, the new land reclamation projects have faced criticism for gentrifying the city and exacerbating the growth of the urban poor population.

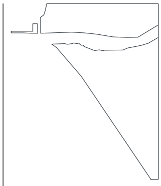
Baseco Compound, located in Manila, reflects the growth of the urban poor community and the subsequent transformations in the landscape, influenced by formal and informal social, political, economic, environmental, and demographic forces. The primary reason for choosing Baseco Compound in Manila Bay is to examine one of the most vulnerable segments of modern society, the urban poor, as well as informal settlement development, the tremendous effect of natural disasters, and landscape changes within these social conditions. Baseco is among the largest long-term informal settlements in Manila Bay, accommodating over 60,000 urban poor residents.

The chapter examines the Baseco compound's reclamation process by analyzing the formal and informal forces involved. It adopts social, political, economic, ecological, and demographic perspectives to identify the causes of landscape changes and the growth of informal settlements.

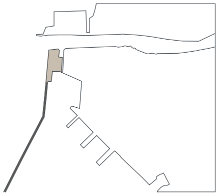
The chapter discusses Baseco's development over three time periods. The first subchapter, 'Initial Forces,' explains how the Baseco area was designated as one of the port expansion planning sites during the prosperous port trading period. The second subchapter, 'The Emergence of an Informal Settlement,' investigates the processes and reasons behind the compound's population growth. It details the external factors driving migration to Baseco, as well as the consequences of such migration. The subsequent subchapters focus on the 'mainland reclamation' stage, examining reclamation and informal settlement topics influenced by formal and informal factors. Subchapter 3 centers on the reclamation process and methods; subchapter 4 addresses the development of informal settlements and explores how slum patterns evolve under natural and social influences; and subchapter 5 identifies the multifaceted problems caused by reclamation and discusses how official and unofficial communities respond to these outcomes.

The methods we used to analyze the reclamation processes in the Baseco compound include literature reviews, mapping analysis, and data collection. The study encompasses multiple scales: regional, city, site, and finer-detail scales. These methods facilitate a comprehensive understanding of the area and the on-site impacts of informal and formal forces, including history, population density, ecological systems, culture, commerce, economics, and social factors.

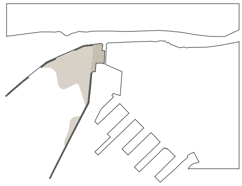
We gathered regional information to understand the site's larger-scale dynamics. This process involved reviewing background materials such as



Before
Original shore.



1903
The breakwater was built.



20th Century
The land was declared to be a residential area.

1898

1903-1908
Two hundred acres of land were reclaimed to expand port facilities, including a breakwater and piers.

1946

Mid 1950s
The engineering island served as the dockyard for NASSCO (National Shipyard and Steel Corporation).

1957

1961

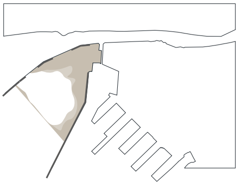
1964
NASSCO was acquired by the Romualdez family, relatives of Imelda Marcos, and subsequently renamed BASECO (Bataan Shipyard and Engineering Company).

1965

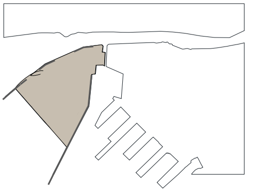
1977
With the construction of Bay City, poor urban families were displaced by Marcos' clearing operations.

1986

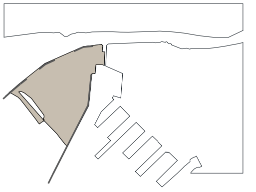
Land Reclamation Timeline | Authors' work. Data: Google Earth, 1989-2020.



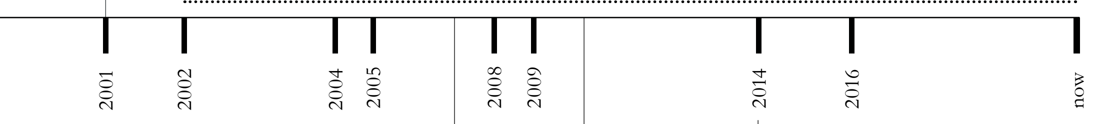
2001
The land was declared to be a residential area.



2004
Waste materials from Pier 18 were transported to fill the land.



2008
The new beach has been reclaimed.



2007
The President, in collaboration with Habitat for Humanity and the city of Manila, handed over 1,000 units of newly constructed homes to the residents of Baseco who were victims of three significant fires.

2010
Severe flooding.

2014-2016
As part of its upgrade efforts, the city has established public amenities such as schools, a barangay hall, a health center, markets, basketball courts, playgrounds, and shipping facilities throughout the main commercial district.

data, maps, articles, historical notes, and scientific papers. The research provided insights into city expansion and its complexities.

Initial Forces

The Baseco compound is located next to Manila South Harbor, one of the largest harbors in the Philippines. It has a barangay identity, meaning it is a small administrative district. The compound's formation came from the government-driven construction of the harbor, demonstrating that it was initiated with formal authority.

The harbor's history can be traced back nearly 500 years. Manila Bay is a natural harbor where the first commercial route between the Americas and Asia, the Urdaneta Route, was established in 1565, and the Spanish capital, Intramuros, was founded in 1571. The well-known tale of the Manila galleons refers to the Spanish treasure ships that transported valuable goods such as spices, silk, and porcelain from Manila to Mexico from the 16th to the 19th centuries.

When the Commonwealth government took over from the Spanish regime in 1899, Manila became open to foreign trade and adopted a more accessible and liberal economic system. Overseas commerce grew steadily, with the United States emerging as a significant trading partner. The original port on the north shore of the Pasig River required expansion to accommodate the increasing traffic. Consequently, the Americans envisioned constructing port facilities along Manila Bay to provide berthing space for ocean-going vessels (Migu, 2009).

Before World War II, the Americans used land reclamation techniques to expand port construction along Manila Bay by more than 200 acres, costing $4 million from the local tax revenues of the Philippine Commission (Barrows, 1914).

Initially, they employed a floating crane to lift large boulders to construct the massive southern breakwater from the mouth of the Pasig River. The sea behind the breakwater deepened, and the excavated mud was pumped to fill the land (Barrows, 1914). Eventually, the new port was constructed with four finger piers and a rim pier for ocean-going vessels. One of these piers was considered at that time to be 'one of the finest in the world and the longest in the Far East' (Migu, 2009).

Although the American administration initially intended the port facilities for commercial use, the breakwater later became the foundation of the Baseco Compound. This linear structure significantly changed water and sediment flow distribution by altering the effects of the Pasig River and high tide: terrestrial sand, mud, and fragments accumulated along the breakwater, forming a small delta on the shallow seabed.

In 1957, shipbuilding became the favored industry under President Carlos P. Garcia's 'Filipino First' policy, which supported Philippine industries after the country gained independence. Engineering Island, situated at the beginning of the breakwater and formerly part of the port, served as the dockyard for the National Shipyard and Steel Corporation (NASSCO). The employees of NASSCO became the island's first residents (Murphy, 2012).

After being acquired by the Romualdez family in 1964, the island was renamed BASECO (Bataan Shipyard and Engineering Company). The population grew with the arrival of workers' families, and it is noted that 15 to 20 families lived in Baseco during the 1970s (Murphy, 2012). When new families arrived in the late 1970s, they constructed their houses on low-lying land composed of a mixture of river silt, mud dredged from the South Harbor, rubble from old buildings, garbage, and small white shells (Murphy, 2012). Although the shipyard went bankrupt in the 1990s, the name Baseco endured, and a steady influx of migrants to the BASECO Compound has been recorded since then (Mercado, 2016).

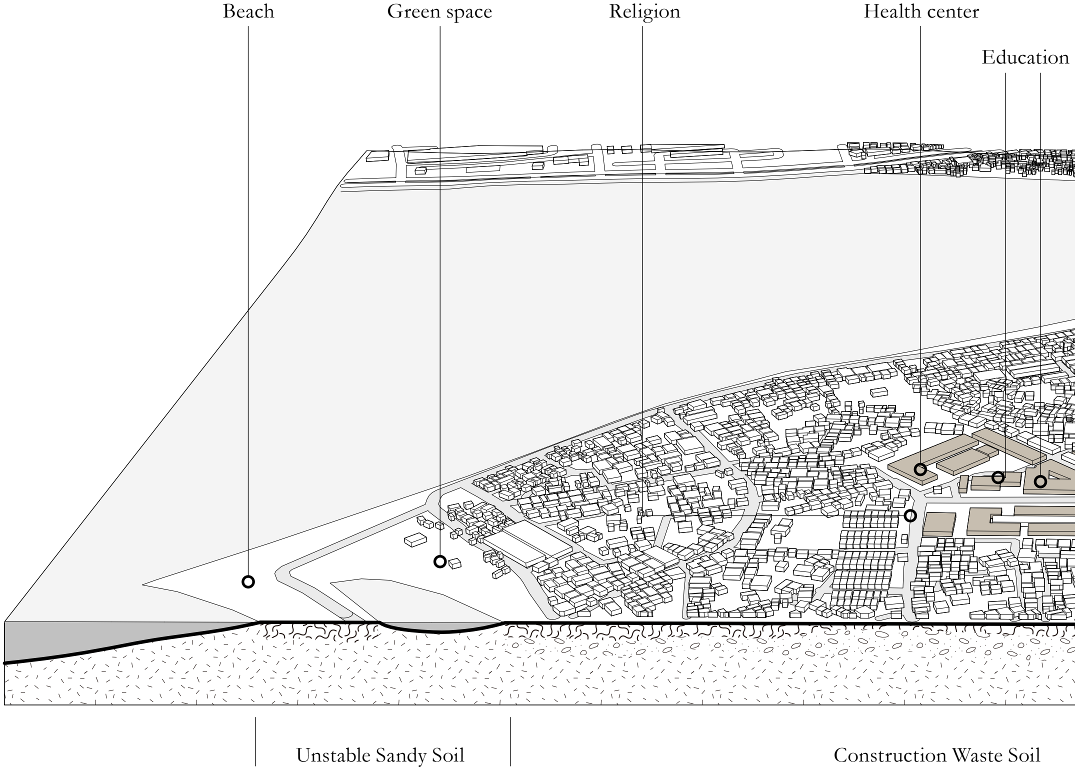
The Emergence of an Informal Settlement

Baseco Compound exemplifies the growth of informal settlements in Manila. Several factors led to a significant population increase in Baseco from the 1980s to the early 2000s, during which the number of settlers quadrupled. To understand this process, it is crucial to consider general population trends and issues that affect neighboring Southeast Asian countries, though perhaps to a lesser extent.

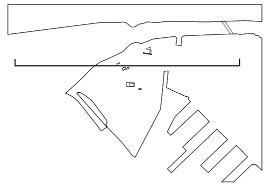
The Philippines has one of the highest poverty rates (22.6%) in Southeast Asia and a slum population percentage exceeding 40% (Asian Development Bank, 2009). In contrast to its neighbors, the Philippines has not reduced its rate of slum dwellers in recent decades, maintaining it at more than 40%. As a result, the Philippines faces significant urban inequalities (Singh, 2015).

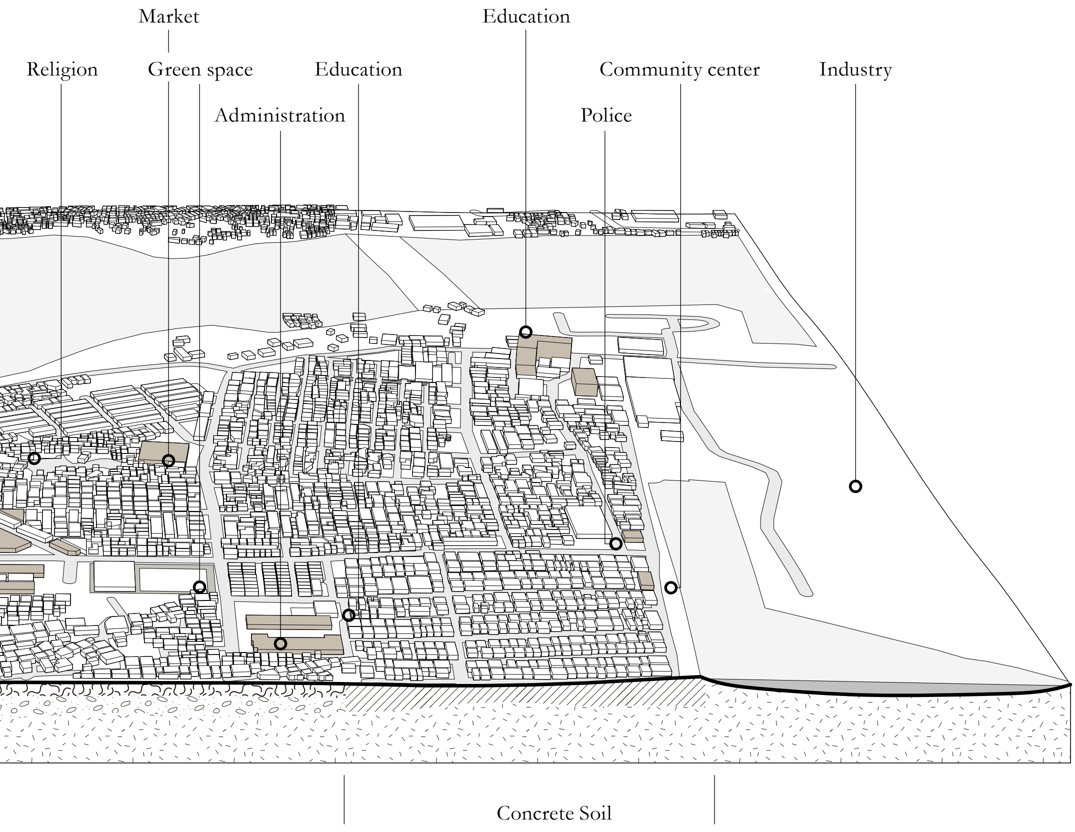
Over the past 50 years, Manila's population has grown enormously; it is projected to exceed 25 million by 2030. This population surge has prompted significant city expansion and increased service pressure (Singh, 2015). The rapid population growth has outpaced the city's capacity to provide adequate housing, forcing many into substandard living conditions. The slums of Manila span both the city center and its urban outskirts. Unmanaged urban population growth and expansion can be traced to changes in the landscape. The increase in urbanized areas has reduced the ground's ability to absorb excess water, leading to higher surface runoff and an increased risk of flooding, exacerbating poor living conditions. Many

Above | Aerial view of the Baseco compound slums in Manila after the fire that happened in March 2022. Due to the density and poor condition of urban settlements, fires can easily start. Photograph by Hartmut Schwarzbach, 2022.

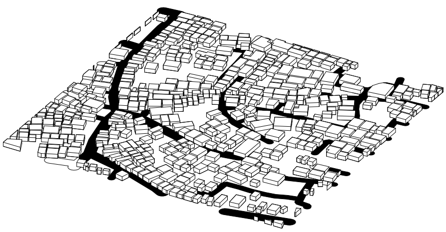


Public Space and Infrastructure | Public spaces and infrastructure are primarily situated along the main street, showcasing more uniform terraced houses. Data: Cadmapper, 2022.

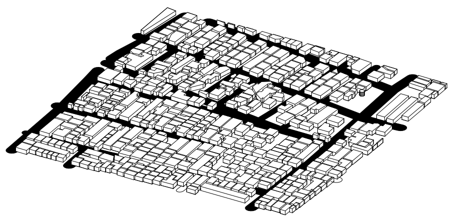




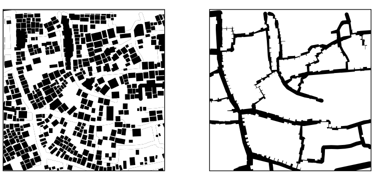
Market
Religion
Green space
Education
Administration
Education
Community center
Industry
Police
Concrete Soil



Irregular



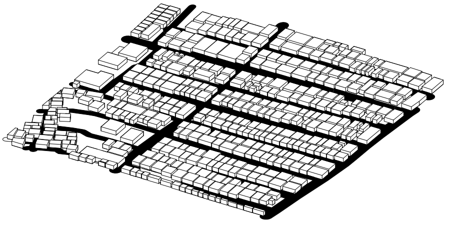
Grid 1



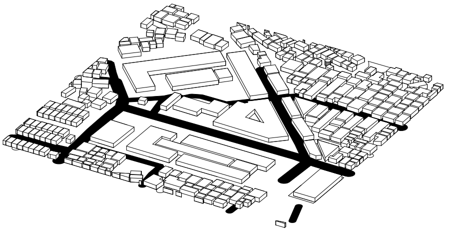
Informal
Squatters

Formal
Terraces house

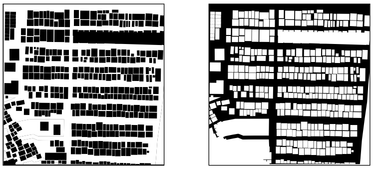
Pattern Types | Four distinct pattern types can be identified in BASECO, closely tied to the social structure and development process. Data: Cadmapper, 2022.



Grid 2



Public space



Informal
Linear
squatters

Formal
Public buildings

squatter settlements have encroached upon riverbanks, with construction methods involving garbage that obstructs water flow and degrades soil quality (Singh, 2015). From the 1980s to the 2000s, Baseco Compound experienced a concerning annual growth rate of 10.77%, nearly five times the Philippine average of 2.17% (Su and Mlčák, 2014). The primary driver of urban growth is the expanding slum areas.

A persistent social issue is the challenge faced by new migrants in obtaining legal status in slum areas, leaving many unprotected and lacking legal tenure (Su and Mlčák, 2014). In 1982, the BASECO compound was established as a barangay, which legalized the early settlers. This status enabled legal residence and can be seen as a catalyst for population growth in the compound. Since then, the BASECO population has grown exponentially (Limos, 2021). Other, less traceable reasons also contributed to the rapid population increase in the area. In the early 1980s, the government sequestered the shipyard through the 'Presidential Commission on Good Government' (PCGG) following the end of Ferdinand Marcos's dictatorship, leading to a significant population increase under the newly established president, Corazon Aquino (Limos, 2021). Many families were displaced during Marcos's rule due to government construction projects and quickly relocated to Baseco (Limos, 2021). The political shift in administration enabled those displaced by gentrification in the Manila city center to move into the newly established BASECO barangay and construct their homes. Reports indicate that 69% of residents in BASECO during this time had previously lived in the city and were forced to relocate to slum areas similar to Baseco (Limos, 2021). Although the new BASECO settlers were primarily former city residents, much of Manila's population growth can also be attributed to rural-to-urban migration, particularly following World War II (Singh, 2015). Higher incomes and better livelihood opportunities were the primary factors attracting migrants to the metropolitan area and its surroundings. The agricultural landscape has undergone significant shifts; new land use has transformed rice paddy fields into industrial and residential areas in the metro zone (Singh, 2015).

Manila exemplifies urban sprawl, reminiscent of what American cities experience (Singh, 2015). From the 1980s to the 2000s, many middle-class families relocated to the suburbs, altering the landscape as rice paddy fields gave way to malls, upscale residential complexes, and real estate developments that exerted immense pressure on farmland. However, due to deeply interconnected politics and long-term land ownership, the farming community often lacks adequate influence in the urban sprawl process—that is, land conversion—ultimately leading to declining urban conditions in the heart of the Manila Metropolitan area (Singh, 2015). Manila regions, such as the central business districts of Makati, Ortigas (Mandaluyong/

Pasig), and Bonifacio Global City (Taguig/Makati), illustrate the classic dual-city contrast found in many global metropolitan areas, highlighting the divide between gentrified sections and slums (Singh, 2015).

It is essential to recognize that individuals moving into Baseco belong to a specific underprivileged segment of Philippine society. Reports indicate that only 81% of Baseco's population completed elementary school, while the national average is 91.8%. The education index for Baseco residents is alarmingly low. Only 25.36% of individuals in Baseco graduated from elementary school, and fewer than 1% pursued a college education.

Furthermore, a significant portion of Baseco's population belongs to the religious minority practicing Islam, which makes up 17% of Baseco's residents (Su and Mlčák, 2014). Muslim immigrants escaping the Islamic conflict in Mindanao found refuge in Baseco, settling there in the late 1980s for employment and better economic opportunities (Ogena, 2012). It is common for Muslim migrants to face severe discrimination, especially in urban areas outside of Mindanao. Unfortunately, this has led many Muslim migrants, including women and children, to become involved in illicit activities (Ogena, 2012). As a result, Muslim migrants outside Mindanao are vulnerable to extremist groups that exploit religious and cultural identities for recruitment and justify violence based on religion and race (Ogena, 2012).

Baseco's living conditions are significantly worse than the Philippine average and those found in other slums in Manila (Su and Mlčák, 2014). Despite Baseco achieving Barangay status, it still struggles to provide essential services such as water, electricity, and sanitation, unlike other slums. Baseco received its first electricity lines only at the end of the power crisis in the Philippines, which began under President Fidel V. Ramos in 1992. In comparison, other slums had already secured direct access to electricity by that time (Su and Mlčák, 2014). Currently, only 79% of Baseco residents have access to electricity, as compared to 97% of residents in other slums in Manila. Furthermore, the only reliable freshwater sources in Baseco are canister-purified water and tap water. Tap water accessibility in Baseco stands at just 12.9%, vastly lower than the 97% coverage reported by Maynilad (Maynilad Water Services, 2024.). Access to toilets in Baseco is at 65%, compared to 70% across other slums in Manila (Su, 2014). There is a notable income disparity between Baseco residents, those in other slums, and the national average. The monthly income per person is 170 PhP to 19,830 PhP in Baseco, with a median of 1,800 PhP (Su and Mlčák, 2014).

Major Land Reclamation

Reclamation Process

Between 2001 and 2002, a series of activities and discussions regarding land reclamation in the Baseco compound (Barangay 649, Zone 68) emerged. Numerous organizations and parties participated in addressing Baseco's social issues. Among them, Kabalikat sa Pagpapaunlad ng Baseco (Kabalikat) was one of the most active and vital organizations. It began collecting data and conducting research in 2001. At that time, Baseco was recognized as a high-priority area for urban renewal by the Pasig River Rehabilitation Commission (PRRC) and the Asian Development Bank (ADB). In August 2000, the ADB and the Philippine government signed an agreement for the Pasig River Rehabilitation Project (PRRP), which aimed to improve the river's water quality, establish 10-meter-wide Environmental Protection Areas (EPAs) along the banks, and promote urban renewal up to 500 meters from the river. This agreement reassured Baseco residents about their living conditions while raising concerns about potential eviction, prompting them to seek additional reclaimed land for housing and legal residence rights. The new government intended to grant rights to area residents for political reasons (Murphy, 2012).

After extensive surveys and numerous rounds of negotiation, the government officially announced in February 2001 that the Baseco compound would be designated a legal residential area, as declared by President Gloria Macapagal-Arroyo. They also reached an agreement to reclaim land in the Baseco compound. However, during the project's preparation, a fire devastated Baseco, causing hardship for around 3,000 impoverished families. After the fire, victims were housed in a relief center. In April 2002, the government commenced the reclamation process, deploying considerable force to do so. They prohibited residents from returning to rebuild their homes. To expedite the project, they deployed fully armed soldiers and over one hundred trucks loaded with earth to fill the area. The project was completed within a month, during which time they reclaimed approximately 52 hectares of land. With the government's assistance and support from many NGOs like Kabalikat, disadvantaged individuals from the city and original residents could live here (Murphy, 2012).

Although most of the reclamation work was completed by the end of 2002, it continued afterward. After settling 6,060 families, the second reclamation stage began in 2004. Between 2004 and 2005, the government reclaimed the Baseco compound. National Solid Waste Commission (NSWC) Executive Director Albert Magalang assured the public that compost materials would fill the reclamation area in 2003 after being transported to the Baseco Compound in Tondo, Manila (Brago, 2003).

The materials utilized for the reclamation project primarily consisted of construction waste from Pier 18 and other waste materials. By the end of 2005, 56 hectares of land had been reclaimed, attracting many poor people to gather there. These individuals also invited their relatives from the city to join them (García-Villalba, 2020). Several floods struck the Baseco compound from 2005 to 2007, leading to numerous formal and informal reconstruction efforts. Residents faced hardships due to floods and stormwater surges. In 2008, the government proposed a new reclamation project to reclaim Baseco beach, which was completed before the end of 2009.

Reclamation Methods

The Philippine Reclamation Authority (PRA) initiated its first reclamation project in 2002. The filling materials were sourced from composted waste at Pier 18 (Lee-Brago, 2018) to reduce trash and create new land. With six million tons of garbage produced daily in the Metropolitan Manila area, approximately 1,200 tons were transported to the Pier 18 dumpsite from the City of Manila and Navotas. The waste dumped at the site was either removed by truck to the Rodriguez facility (400 tons) or transported by barge to the Tanza facility (800 tons). This waste was compacted at these controlled dump sites and sent back to Baseco in Manila as landfill material (AEA Technology, 2003). According to Nene F. Barry's study (2013), 45% of the kitchen waste (MMDA, 2003) generated in Metro Manila could be collected as organic waste for composting, potentially yielding 22.5% of the total garbage weight in compost for land reclamation.

In 2008, the PRA proposed an additional 10-hectare reclamation on the southern edge of Baseco as an extension of the previously constructed land. An embankment, raised 2 meters above the soft soil foundation, was proposed to protect the filling sands and the area behind them from coastal erosion. Economic viability was essential for a project with a 1.2 km shoreline. A geotextile tube was chosen as the containment wall on the existing breakwater. Its excellent filtration and drainage properties helped resist erosion while allowing it to be filled with local soil and sand, significantly reducing the costs associated with boulders and enabling it to absorb high incoming wave energy (Maccaferri, 2015).

The Evolution of Informal Settlements

In 2002, after reclaiming 52 hectares of land, new houses were constructed with support from the government and NGOs (Galuszka, 2014). In 2004, NGOs assisted residents with reconstruction efforts during the second phase of the reclamation process (Rossini, 2020). At this stage,

Above | View of the Baseco compound slums in Manila. The soil consists of waste and sediment. Photograph by Hartmut Schwarzbach, 2022.
Right | Kids in the urban settlement of the Baseco compound. Photograph by Hartmut Schwarzbach, 2022.

terraced houses developed along the inner edge of Baseco, while squatters were placed in a regular grid pattern with perpendicular roads.

By the end of 2005, most reclamation work was completed. Informal settlements then expanded rapidly, covering the entire Baseco compound. These low-quality settlements formed a chaotic pattern compared to the residences built before 2005. However, due to frequent fires and floods, parts of Baseco underwent reconstruction efforts led by residents, Kabalikat, various NGOs, and the government. For example, in 2007, Habitat for Humanity and the city of Manila transformed 1,000 newly built housing units into shelters for victims of three major fires in the Baseco compound (Habitat for Humanity, 2007).

Since 2008, numerous upgrading projects have been implemented in Baseco. The spread of informal settlements has resulted in significant social and environmental challenges. Fires, floods, solid waste pollution, and water pollution have severely affected the safety and quality of life of impoverished local residents. Public amenities, including schools, a barangay hall, a health center, markets, basketball courts, playgrounds, and shipping facilities along the central commercial district, have been constructed or maintained since 2014 (Hwang and Feng, 2019). Physical defenses have also been built by local communities and through land reclamation to protect against floods and storms (Valenzuela, Esteban and Onuki, 2020).

Additionally, the coastal area has long been used as a dumping ground, both legally and illegally, leading to severe pollution as well as geological and environmental issues along the coast and around the river mouth. Many initiatives have been launched to address these ecological concerns. Since 2012, mangrove forests have been planted to act as a buffer zone (Valenzuela, Esteban and Onuki, 2020). In 2019, the government and various organizations focused on this issue. President Rodrigo Roa Duterte announced a clean-up initiative and encouraged public participation (Manalo, 2019). This rehabilitation effort, led by the government, received enthusiastic responses from people across various sectors. Approximately 5,000 individuals, mainly from the 13 Mandamus agencies, local government units, and the private sector, participated in January 2019 (Miguel, 2022.). The water issue was addressed with assistance from the government and NGOs. After 2019, solid waste pollution, mainly plastic pollution, decreased, and the environment gradually began to recover (Villanueva, 2025).

Current Situation

Over the past two decades, Baseco has developed into several blocks, including Gawad Kalinga, Habitat for Humanity, the New Site, Dubai 1 and 2, Gasangen, Playa, and others. According to existing surveys, the government, NGOs, and local residents participated in this block-development process in various ways.

The Gawad Kalinga block was constructed by the NGO of the same name. This organization received funding from various sources and support from both formal and informal participants. In total, the organization built 2,000 houses, primarily terraced ones, providing housing for thousands of low-income families (Smith, 2020).

Habitat for Humanity also helped to build one of the blocks. Fires have been common in Baseco; due to poor living conditions and illegal electricity use, they could ignite easily and spread rapidly (The Associated Press, 2010). After a fire, this NGO assisted in constructing more than 1,000 houses for those who lost their homes (Smith, 2020).

The New Site block was among the first constructed after reclamation. The municipality planned it and implemented a grid road system, but local residents largely carried out the construction work. Therefore, the development process in this block is considered both formal and informal. This area is the only one filled with solid concrete, making it more stable than the surrounding sections, and its residents have legal residency (Smith, 2020).

The Gasangen block was primarily inhabited by informal settlers, which made it particularly prone to fire. After a significant fire, this area was rebuilt with participation from the Urban Poor Associates (UPA), which assisted in part of the reconstruction efforts (Smith, 2020).

Dubai 1 and 2 are two newly constructed blocks. They were built according to the People's Plan, which was mainly facilitated by Kabalikat (Murphy, 2012). As previously mentioned, they undertook extensive work to gather resident input and develop an appropriate plan for this newly reclaimed area. From the outset of all projects, they prioritized protecting residents' rights (Murphy, 2012). The government funded this construction after receiving the People's Plan (Smith, 2020). Dubai 1 was completed in 2016, while Dubai 2 was finished in 2018.

Playa Block primarily consisted of informal settlements, which grew and expanded with the rise of squatters. Because the houses in this block were built too close to the sea, residents in this area necessarily worry about eviction. The government and other authorities announced a requirement for a 20-meter cleared area near the coast. The law also mandates a 3-meter setback for residences close to the sea. As a result, the inhabitants of Playa Block and many other informal settlements face a significant threat of eviction.

The terrain in the Baseco compound is higher in the east and lower in the west, with an average height of about 6.7 meters (PhilAtlas, n.d.). This elevation results from the area's development from the previous breakwater. The eastern part has a more solid foundation than the west,

Right | Aerial view of the Baseco compound coast showing sea pollution caused by household waste. Photograph by Hartmut Schwarzbach, 2022.
Below | The Baseco compound consists of waste and sediment from Manila Bay. Photograph by Adam Cohn, 2014.

making the western area more susceptible to subsidence and flooding.

The water flow map shows where most of the surface runoff is directed. According to the map, surface runoff in the Baseco compound primarily flows toward two main streets. Near the coastal area, it ultimately drains into the sea. This map illustrates that the two main streets are at a lower elevation, which may lead to drainage issues. Additionally, onsite pollution can quickly spread to the ocean if the runoff reaches the sea unaddressed.

Baseco urgently needs a comprehensive drainage system to manage stormwater effectively. The primary drainage approach has been arbitrary surface drainage, where water accumulates near the roads and is drained into the surrounding neighborhoods. However, the challenge lies in the two main roads being lower than the surrounding areas, complicating unregulated drainage. These drainage issues will also create further problems, such as pollution and deteriorating living conditions (Smith, 2020). Green space has gradually increased over the past two decades. The upgrade program in Baseco has contributed to improved public spaces (Hwang and Feng, 2019). Nevertheless, the current condition of parks and green spaces still requires enhancement. Five small green spaces and parks are located in Baseco. They are scattered throughout neighborhoods, near public buildings, and along the beach. Although the beach has been cleaned and mangrove forests planted to enhance environmental quality, Baseco's five main green spaces still have a long way to go before they are suitable and healthy public spaces for the local community.

Pattern Type

In Baseco, both formal and informal settlements coexist. For various reasons, they have developed into several distinct patterns. There are three main types of patterns: grid patterns, irregular patterns, and public space patterns. Within grid patterns, two unique subtypes can also be identified.

The first type of grid primarily exists in the Gawad Kalinga and Habitat for Humanity blocks. These two blocks received funding from different NGOs, with some oversight from the government. The houses are terraced; most were constructed at the same time and arranged in lines and grids. Both formal and informal forces played a role in the building process, contributing to the neighborhood's regular pattern.

The second type of grid pattern is found in the New Site block. Informal settlements are aligned along perpendicular roads, creating a linear connection from west to east. The grid pattern emerges from the road system planned by the administration. Formal forces influenced the planning, while informal forces affected the construction process. Together, these two factors resulted in the grid pattern in this area.

A bird's eye view reveals that the public spaces are situated at the west end of the main street, stretching west to east. Numerous schools, religious buildings, and public facilities are located there. In this pattern, public buildings are the dominant features, and traffic flows conveniently. Roads and squares surround the public buildings, and formal factors play a crucial role in shaping this pattern.

The irregular pattern occurs in the layout of informal settlement blocks in Baseco. This pattern developed over an extended period alongside the growth of informal settlements. It can now be found west and south of Baseco (Di Pinto, Rinaldi and Rossini, 2021, p.202). With the reclamation process, the Baseco compound expanded from east to west. After more land was reclaimed in the west and south, informal settlers gathered and gradually occupied the area. These self-organized buildings today cover over 60% of Baseco and most offshore regions. Due to the lack of regulations, these neighborhoods exhibit higher density, less green space, lower living standards, and poor conditions, making them more vulnerable to disasters and prone to fires (Di Pinto, Rinaldi and Rossini, 2021, p.202). The irregular patterns often align with the original roads and topography, forming aggregated or centripetal settlements near water, roads, and public facilities.

Interrelation Between Society and Patterns

Since 2002, when new land reclamation began, Baseco has transformed from a community of around 6,700 to at least 60,000 people (PhilAtlas n.d.). Many impoverished individuals have settled here and constructed their homes with formal and informal assistance. Residents of informal settlements, particularly those in irregular-pattern blocks, tend to have lower education levels and incomes. Many individuals in this area still lack landowner status and decent living conditions (Aydin and Sirin, 2020). Income, calculated in Philippine Pesos, reveals that earnings in this area are relatively low, significantly below the national average (Aydin and Sirin, 2020).

The shape of the patterns is linked to Baseco's social structure, with the form and distribution of informal settlements reflecting prevailing social conditions and serious social issues.

Problems and Responses

Due to the adverse factors stemming from Baseco's distinct geographical conditions and reclamation process, informal settlers encounter social and economic challenges and threats from natural disasters, ecological degradation, and environmental pollution.

Natural deposits of the Pasig River delta and artificial reclamations underlie the Baseco compound. The natural composition consists of terrestrial sand and mud, lying about 6 meters deep on the clay seabed, which is soft and loose. The waste disposal landfill positioned 3 meters above the natural sediment (Oman, Videčnik and Rubin, 2018) is viewed as unstable and inadequate for urban development as reclaimed land. The compacted material is primarily utilized in urgent contexts (Barry, 2013), particularly in relation to the relocation project. While the PRA was directed to perform soil compaction work following the completion of the reclamation (Valenzuela, Esteban and Onuki, 2020), Baseco still contends with a weak land foundation, facing the risks of land liquefaction and subsidence.

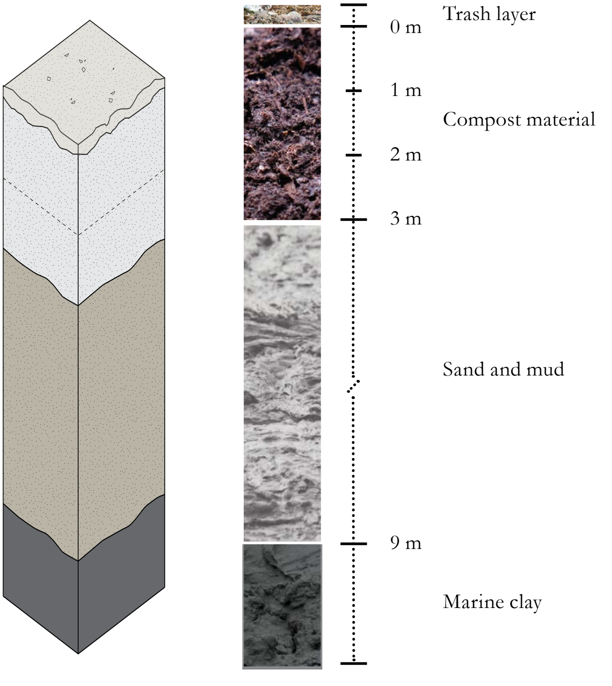
Meanwhile, land subsidence elevates the water surface level, delaying rainfall runoff and exacerbating flood and tidal incursions from potential storms. The sediment in the Pasig River also reduces the water depth around Baseco, making it more difficult for currents to carry away excess accumulated water (Kelvin, 2014), thus increasing the likelihood of significant surges in Baseco. Consequently, while frequently impacted by tropical storms (averaging 20 cyclone strikes annually in the 2010s) and wave effects during the southwest monsoon, Baseco is at considerable risk of inundation from storm surges, tsunamis, and floods due to its limited defensive infrastructure and ineffective drainage system.

The loss of mangroves diminishes resilience to coastal hazards. A satellite image showed that wild mangroves were present along the southern coastline of Baseco before formal reclamation in 2002 (Valenzuela, Esteban and Onuki, 2020). However, due to large-scale landfill activities and the expansion of settlements, nearly all of the mangroves were lost.

Baseco also struggles with pollution because of its geographical location and the absence of an adequate solid waste management system. It is reported that 63,700 tons of plastic waste are carried annually by the Pasig River into Manila Bay (Laurent et al., 2017). With new squatter colonies established along the banks of the Pasig River and its tributaries within Metro Manila, garbage is dumped into the numerous waterways flowing into Manila Bay. The situation worsens during the dry season as the flow of the Pasig River reverses when the water level in Laguna de Bay decreases, causing trash in the ocean to flow back and accumulate on Baseco beach.

Meanwhile, the waste disposal situation within Baseco is also problematic. With over 12,000 families in Baseco, each household generates an average of 2.19 kilograms of mixed waste daily (Benosa, 2017), which is disposed of without restrictions. The City of Manila's waste collection contractor has also noted inadequate capacity for regular garbage collection in Baseco (Benosa, 2017).

When examining how different groups respond to these issues, their attitudes, roles, and levels of participation vary noticeably. With regard to extreme shocks like coastal hazards, informal settlers tend to have a



Soil Profile | The soil profile of the BASECO compound consists of marine clay, sand, and mud, topped with compost and trash materials. Data: American Society of Landscape Architects, 2022.

relatively passive response, lacking foresight and disaster preparedness. The collective community's strength is seen as more constructive and forward-thinking, capable of providing a larger scale of construction and protection for its members. For instance, after Typhoon Ketsana in 2009, residents had to bear the costs of their losses, and the only household-based adaptation to flooding was to raise their floors and furniture. The community, however, offers warnings, conducts evacuation drills, and assists in building makeshift seawalls and clearing drainage lines. However, these measures can only be viewed as preventive and remedial. They cannot address deficiencies at the planning and construction levels and may be more effective when confronting extreme events such as large storm surges or tsunamis (Valenzuela, Esteban and Onuki, 2020).

On the other hand, various management measures aimed at enhancing the built environment are making significant strides under the guidance of NGOs, along with the active participation of governments and residents. In 2010, Kabalikat, in collaboration with NGOs Mercy Relief and Urban Poor Associates, raised funds and mobilized people to launch the mangrove project. This initiative sought to shield the community from storm surges and improve the neighborhood's landscape quality. After their initial trial, the mangroves reemerged at the mouth of Baseco Beach in 2012, nearly a decade after they had vanished. Despite challenges such as a relatively slow growth rate due to polluted compost material and exposure to multiple typhoons in 2014–15, mangrove patches were successfully established by 2016. The success of this grassroots project has drawn the attention of environmental agencies like Metropolitan Manila Development Authority (MMDA) and the Department of Environment and Natural Resources (DENR), encouraging their involvement in the planting initiative alongside government organizations (such as the Pasig River Rehabilitation Commission) and political figures (notably Senator Cynthia Villar) to pursue similar ideas along other coastlines (Hwang and Feng, 2022).

NGOs also play a vital role in solid waste management and cleanup operations. Initially, the informal recycling industry filled the gaps in solid waste management governance by segregating waste, selling recyclables to junk shops and transporting residuals to collection points or city garbage trucks. Public welfare organizations later concentrated their efforts to address Baseco's difficult situation. Catholic Relief Services (CRS) engaged barangay officials to evaluate the issues and helped devise a solid waste management plan. This is under the same law (RA 9003) that mandates the establishment of a Materials Recovery Facility. The local government worked with businesses and NGOs to develop a waste management system to promote environmental awareness and generate income for families (Benosa, 2017).

In 2019, the Manila Bay Rehabilitation Program was launched under the directive of the Supreme Court, with Baseco included as part of the project. The environmental agency DENR was assigned to coordinate with judicial agencies and other relevant stakeholders. Solid waste management was a key focus of the DENR's plan, which also included initiatives like mangrove planting and cleanup activities. NGOs such as PAMALAKAYA (a local fishing group), along with volunteers and local residents, reacted positively and were eager to assist (Nazario, Damicog and Panaligan, 2019). While significant work still needs to be done to tackle the root causes of upstream pollution, this underscores a robust sense of community commitment to environmental improvement.

In conclusion, due to the organizers' lack of awareness and metrics regarding disaster prevention in the reclamation process, planning, and construction, Baseco faces elevated safety hazards and threats in an area with challenging geographical conditions that faces frequent natural disasters. The highly destructive threats posed by storms and floods have been somewhat alleviated through subsequent community-led defensive construction efforts, but they cannot be fundamentally resolved. Fortunately, Baseco is gaining increased attention and support from NGOs. Various measures are gradually being implemented under the leadership of non-governmental organizations and resident volunteer groups. These initiatives focus on management aspects such as improved solid waste management, mangrove planting, and daily beach cleanups. Some efforts have attracted governmental interest and formal support, successfully uniting settlers to build their vibrant homes collaboratively. Such activities strengthen community bonds (Navarra, 2016) and gradually enhance Baseco's environment.

Conclusions

The reclamation of Baseco is a story of layered transformations—of land, governance, and human resilience. It unfolds through the interplay of formal and informal forces that have, over time, shaped both the physical landscape and the lived realities of its residents. The settlement's origins date back to 1903, when reclamation was managed by official bodies under the U.S. colonial administration and state-owned enterprises. Decades later, in the late 1970s, informal settlers began occupying the area, building homes on naturally formed sediments in the absence of state intervention. What started as scattered, makeshift dwellings gradually grew into a thriving yet vulnerable community, eventually recognized as a residential zone. Migration into Baseco came not from choice but from necessity—a quiet exodus driven by unseen social forces that constantly push the urban poor to the city's margins in search of shelter and belonging.

Starting from 2001, the area's transformation accelerated, driven by the combined efforts of land reclamation and settlement development. Each phase reflected a careful balance between formal and informal approaches. Government agencies handled the technical reclamation in three stages—structural, procedural, and administrative—while NGOs, local leaders, and residents managed the human side of resettlement, advocating for inclusion and dignity in decision-making. Once the land was reclaimed, construction moved forward in both cooperation and tension: government projects laid the groundwork, NGOs supported community organization, and residents built, rebuilt, and maintained their homes through collective effort. These acts of rebuilding—whether after fires, floods, or social and environmental decay—became an ongoing story of adaptation, illustrating how communities endure and evolve even amid uncertainty.

Several lessons emerge from Baseco's story. First, reclamation, often seen as a practical solution to urban overcrowding, conceals ecological and social risks. Planning and disaster management must account for these long-term impacts instead of just reacting to them. Land reclamation shouldn't be pursued solely as a technical solution but as a deeply social effort that demands foresight, accountability, and environmental awareness from authorities.

Second, Baseco's experience shows how poverty shapes priorities. For residents struggling daily to meet immediate needs, the idea of future safety can feel distant. Livelihoods often take precedence over long-term resilience, which makes communities more vulnerable to the hazards they face. Issues like insecure land tenure, environmental degradation, and limited resources further increase this vulnerability. Therefore, instead of relying only on top-down solutions, there's a critical need for bottom-up empowerment—systems that increase community agency, improve living conditions, and develop collective capacity to predict and manage risks.

Ultimately, Baseco's story demonstrates that urban development is more than just a technical process—it's deeply human. The intersection of disaster risk, poverty, and environmental change shows how history, politics, and daily struggles are interconnected. Baseco stands as living proof of resilience, with its residents continually transforming reclaimed land into a space of life, identity, and hope. Future reclamation and landscape-urban planning must incorporate this human dimension—recognizing residents not just as passive individuals but as active co-creators of space, capable of resilience, adaptation, and transformation.

Authors' Contribution Statement

This chapter results from the course *Urban Landscapes: Theory, Method, and Critical Thinking* in the master's program of landscape architecture at TU Delft for the academic year 2021–22. During the course, Liyun Chang, Anna Gorokhova, Yi Lu, and Chuhan Zhang wrote the initial paper, supervised by Laura Cipriani and Denise Piccinini. Liyun Chang, Anna Gorokhova, Yi Lu, and Chuhan Zhang prepared the drawings.

Laura Cipriani revised the publication in six steps: rewriting some sections, writing the conclusions subchapter, editing the entire chapter, and selecting and securing image rights for the included photos. Sari Naito conducted a bibliography check on the chapter. Finally, a native English speaker reviewed the text.

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2 | Leslie Spit
Location
Leslie Spit | Toronto | Canada
Coordinates
43° 37’ 34” N | 79° 19’ 46” W

3 | Texcoco
Location
Texcoco | Mexico City | Panama
Coordinates
19° 26’ 19” N | 99° 9’ 2” W

4 | Panama Canal
Location
Panama Canal | Panama
Coordinates
9° 7’ 55” N | 79° 41’ 13” W

5 | Marker Wadden | Galgeplaat
Location
Galgeplaat | Eastern Scheldt | Netherlands
Marker Wadden | Ijsselmeer | Netherlands
Coordinates
51° 34’ 6” N | 3° 55’ 50” E
52° 34’ 59” N | 5° 22’ 10” E

6 | Lagos
Location
Othodo-Gbame | Lagos | Nigeria
Makoko | Lagos | Nigeria
Eko Atlantic City | Lagos | Nigeria
Coordinates
6° 27’ 50” N | 3° 30’ 48” E
6° 30’ 2” N | 3° 23’ 19” E
6° 24’ 26” N | 3° 25’ 15” E

7 | Maldives
Location
Thulusdhoo | Maldives
Coordinates
4° 13’ 1” N | 73° 32’ 30” E
Location
Hulhumalé | Maldives
Coordinates
4° 12’ 60” N | 73° 32’ 24” E

8 | Kuttanad
Location
Kuttanad | Kerala | India
Coordinates
9° 20’ 17” N | 76° 24’ 41” E

9 | Hong Kong
Location
Central and Wan Chai | Hong Kong | China
Coordinates
22° 16’ 59” N | 114° 10’ 4” E

10 | Changxing Island
Location
Changxing Island | Dalian | China
Coordinates
31° 24’ 30” N | 121° 41’ 28” E

11 | Baseco
Location
Baseco | Manila | Philippines
Coordinates
14° 35’ 29” N | 120° 57’ 29” E

12 | Conclusions

Sand, Silt, and Scrap in a Sinking World

Laura Cipriani

Land reclamation is more than just a set of engineering techniques; it is an act that connects human desires to inhabit, produce, and survive with the power to significantly reshape the landscape. It reveals the tension between necessity and ambition, care and control, and the memory of nature versus the need to redefine its boundaries. Technological innovations have made land reclamation more efficient, but they also raise important questions: Which ecosystems are being sacrificed? Which communities are being displaced? How are natural balances impacted? How much can Earth's crust be altered? Is there a limit, and if so, what is it?

Humans are, in essence, the creators of land. But what if we adopt a non-human or more-than-human perspective? Instead of viewing land conquest from the sea as domination, we could listen to the sea and its inhabitants—fish, shells, mangroves, and sediments. By blending a primarily utilitarian view focused on human development with an ecocentric approach, we can embrace the interconnectedness and wholeness of the natural world.

Land reclamation is more than just a collection of engineering methods; it is an act that links human desire to inhabit, produce, and survive with the ability to drastically reshape the landscape. The micro-stories presented—Leslie Spit in Toronto, the Panama Canal, Mexico City, Marker Wadden and Galgeplaat in the Netherlands, the city of Lagos, the islands of the Maldives, Kuttanad in India, Hong Kong, and Dalian, as well as Baseco compound in Manila—highlight the tension between necessity and ambition, care and domination, and the memory of nature versus the need to redefine its boundaries.

For centuries, land reclamation has played a vital role—a transformative process that turns previously unusable spaces into livable areas, converting marshes into farmland, lagoons into cities, and coasts into strategic ports. Ancient civilizations had already altered alluvial plains to secure agricultural resources, and today, large-scale megaprojects are building artificial islands, urban neighborhoods, and coastal infrastructure. Throughout history, land reclamation has significantly influenced settlement patterns and development paths, profoundly affecting the relationship between humans and the environment. The methods vary—from wetland drainage to sediment dredging, from hydraulic filling of coastal zones to 'poldering,' which drains marshlands with dams and pumps. Each technique depends on factors such as equipment availability, geological conditions, and intended uses—and comes with associated environmental and social consequences.

Technological innovations have made these processes more efficient and ambitious, but they also raise profound questions: Which ecosystems are being sacrificed? Which communities are being displaced? Which natural balances are being compromised? The images of dredges dumping sediment on coral reefs, destroying their fragile structures, powerfully illustrate the contradiction of this practice: creating new habitable spaces often involves erasing other, essential ones. It means changing the distinctiveness of places and the identities of their inhabitants.

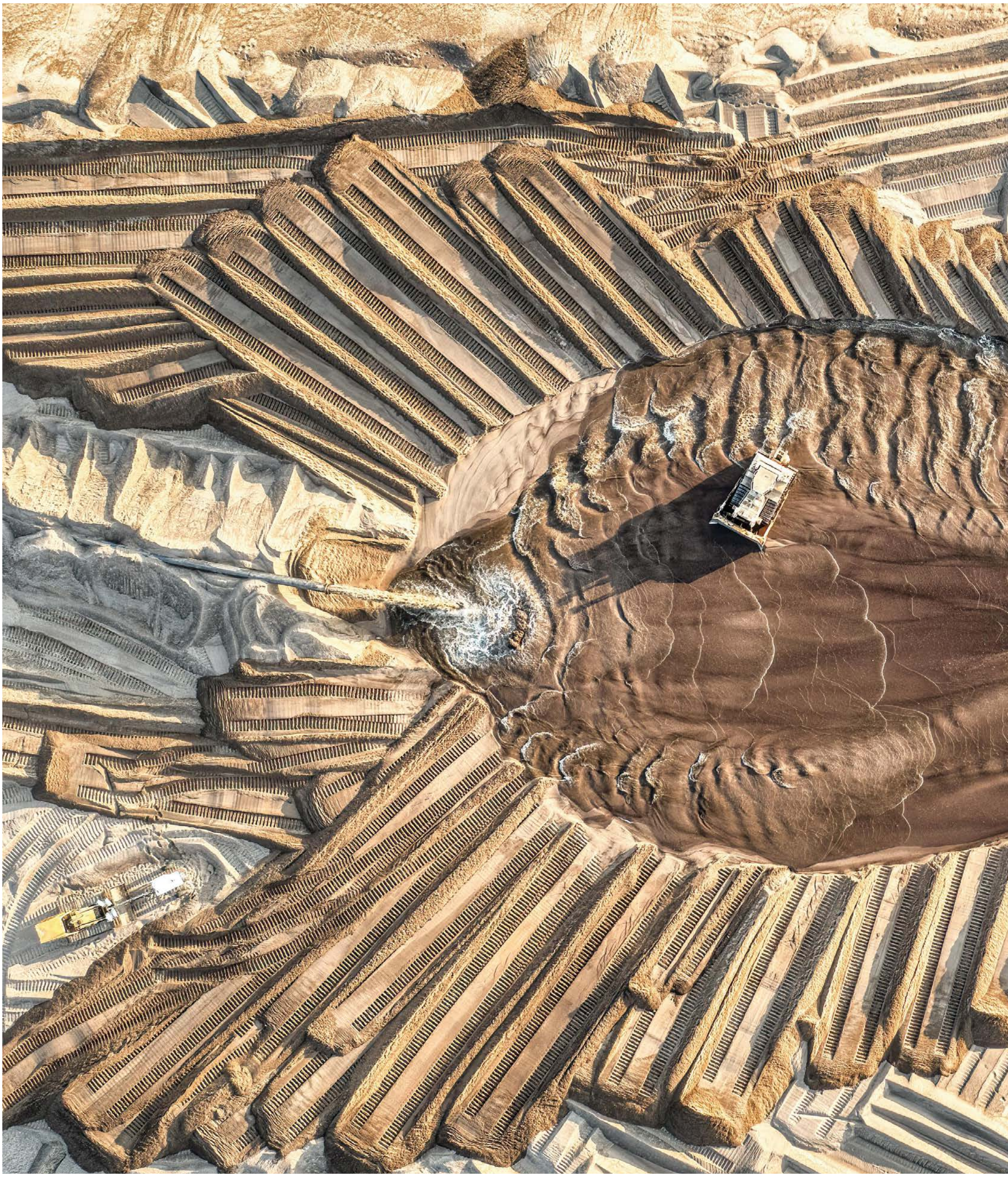
Land reclamation thus appears as an ambivalent practice: a tool for transformation but also a source of ecological and social vulnerability. It highlights the tension between the urgency to expand urban areas and the need to protect finite resources, as well as the desire to conquer new land and the importance of preserving existing ones. As Phil Macnaghten and John Urry argue in their book '*Contested Natures*' (1998), nature is never neutral; every decision about how to use, protect, or change it involves power dynamics. Nature is always political: whoever controls nature also controls resources, territories, and cultural narratives. That's why environmental conflicts go beyond just ecology—they also involve social justice, rights, and power sharing.

The case studies were selected from various geographic regions. Each culture, across different times and locations, influences and shapes the landscape by integrating its impact into the natural environment through cultural, technological, and artistic knowledge. Whether ancient or modern, each culture has left its mark on the landscape by constructing cities, designing agricultural fields, building irrigation canals, reshaping terrain, claiming lands and seas, and exploiting, excavating, and utilizing resources. The landscape reveals different ways of interacting with the natural environment and also highlights the phenomenon of cultural emulation. The examples illustrate how Western thinking has influenced, and continues to influence, coastal reclamation, especially in Asia today. The outdated imperialism of a Western interventionist approach does not align well with other contexts and fails to reflect current coastline changes, which are shifting from expansion to retreat from the sea.

In this book, we explored how the creators of new lands—the land-makers—are fundamentally humanity. If we adopt a non-human or more-than-human view, we quickly see that the traditional dichotomies of West-East, North-South, and developed-developing countries become outdated, even in the context of land reclamation projects. The idea of conquering land from the sea should be replaced with listening to the sea and its inhabitants—the fish, shells, mangroves, and sediments. The utilitarian perspective, which emphasizes human development, can be combined with an ecocentric approach that recognizes the interconnectedness and wholeness of the natural world. I believe that the example of Marker Wadden and 'Building with Nature' does not meet these criteria but instead deepens the contradictions about how, why, and to what extent reclamation is used. The well-known phrase '*God created the world, but the Dutch created the Netherlands*' aptly describes the Dutch efforts—building dikes, canals, and water management systems—to protect their lowlands from the sea. It also clearly demonstrates the anthropocentric dominance in the Nordic concept of land creation. Man replaces God in 'making' the landscape, literally '*landschap*' in Dutch, meaning 'land-making.' How much can the Earth's crust be altered? Is there a limit, and if so, what is it? Recent land reclamation projects have such widespread impacts that they highlight the need for humans to step back and adapt to the site and its culture.

The material elements themselves—whether earth, sand, sediment, or scrape—convey the language of the landscape and should be listened to accordingly. Anne Whiston Spirn, in her renowned book '*The Language of Landscape*' (1998), writes: '*Landscape has all the features of language. It contains the equivalent of words and parts of speech patterns of shape, structure, material, formation, and function. (…) Landscape is a scene of life, a cultivated construction, a carrier of meaning. It is language*' (Spirn, 1998, p. 15).

In a time marked by climate change and rising sea levels, land reclamation



Above | Aerial view of excavators working on sandy terrain in Reads Landing, Minnesota, United States. Photograph by Tom Fisk, 2023.

is unlikely to fade away. It might continue as a form of adaptation, but will increasingly need to incorporate new kinds of ecological and participatory planning in the broadest sense. Developing a landscape language that can listen to places and their inhabitants offers hope for the future. Perhaps the future of land reclamation is less about 'reclaiming' land from the sea and more about 'reconciling' the sea with the land—moving beyond simply creating new spaces to building balanced relationships where humans can coexist without erasing or dominating, but instead preserving the living geographies around us.

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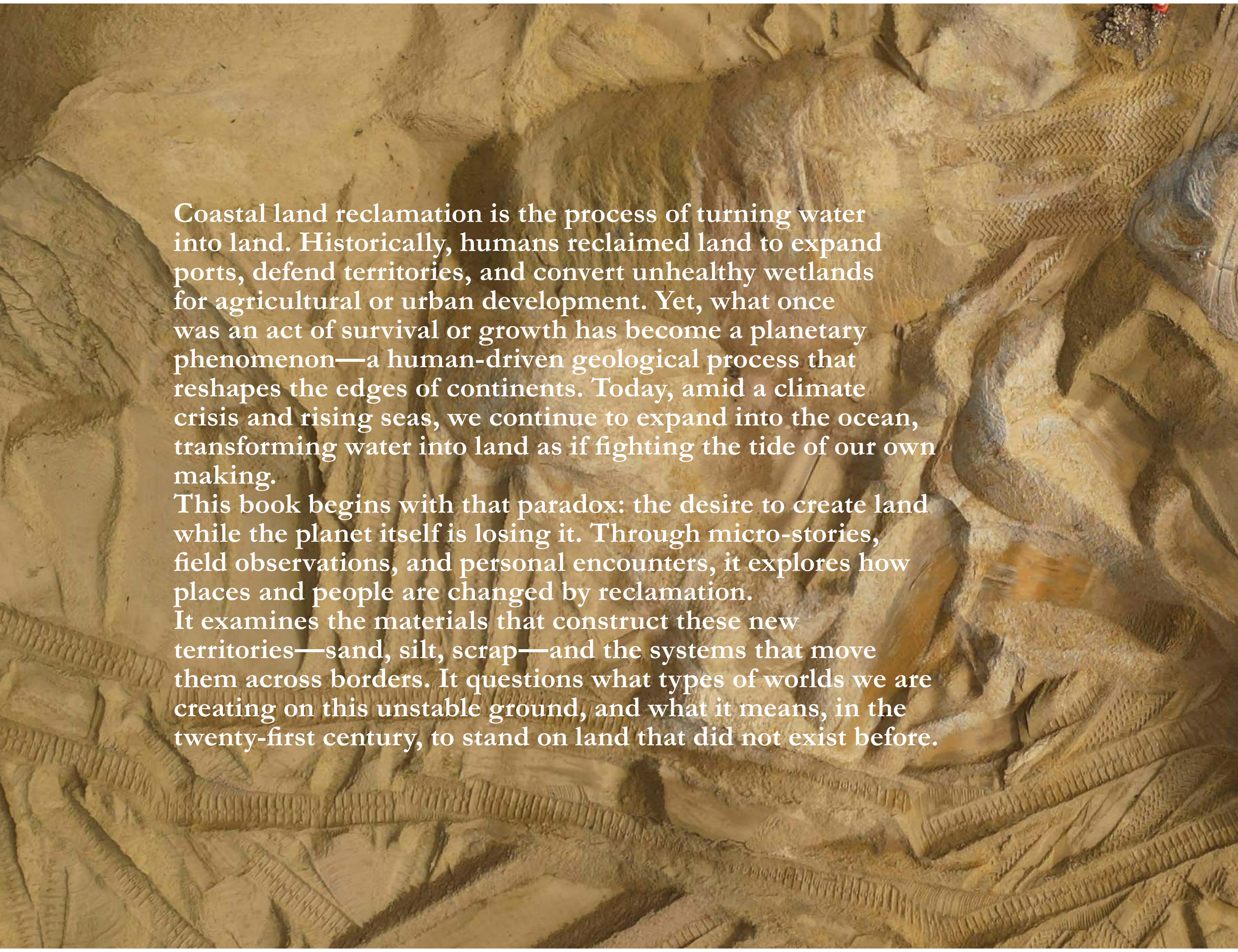
Published in November 2025 by
TU Delft OPEN Publishing



Coastal land reclamation is the process of turning water into land. Historically, humans reclaimed land to expand ports, defend territories, and convert unhealthy wetlands for agricultural or urban development. Yet, what once was an act of survival or growth has become a planetary phenomenon—a human-driven geological process that reshapes the edges of continents. Today, amid a climate crisis and rising seas, we continue to expand into the ocean, transforming water into land as if fighting the tide of our own making.

This book begins with that paradox: the desire to create land while the planet itself is losing it. Through micro-stories, field observations, and personal encounters, it explores how places and people are changed by reclamation.

It examines the materials that construct these new territories—sand, silt, scrap—and the systems that move them across borders. It questions what types of worlds we are creating on this unstable ground, and what it means, in the twenty-first century, to stand on land that did not exist before.

ISBN: 978-94-6518-168-4
DOI: https://doi.org/10.59490/mg.212
TU Delft OPEN Publishing