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THE HYBRID NETWORK MODEL CALLS FOR A WATER ECOSYSTEMS PARADIGM SHIFT IN THE VIETNAMESE MEKONG DELTA

El modelo de red híbrida exige un cambio de paradigma de los ecosistemas acuáticos en el delta vietnamita del Mekong

Modelos de redes territoriais e transformações socioecológicas no delta do Mekong, no Vietnã

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ABSTRACT

As one of the world's largest rice exporters and most vulnerable low-lying deltas, the Vietnamese Mekong Delta (VMD) has undergone radical territorial transformations primarily for agricultural purposes. However, human-induced water techno-managerial changes, coupled with climate change and sea level rise—causing flooding, drought, salination, subsidence, and biodiversity loss—have disrupted the Delta's natural processes. This research investigates how these alterations exacerbate climate change impacts by analyzing human-induced fabric patterns. Employing Corboz's *Palimpsest* method, a mapping analysis identified three dominant territorial configurations: 1) Star Node Connectivity, 2) Agrarian Grid Compartmentalization, and 3) Hybrid Diffusion. The Star Network Model aligns with *Desakota* rururban patterns observed along water infrastructure. The Gridded Network Model emerges from large-scale hydraulic projects that fragment water ecosystems. The Hybrid Network Model integrates built and natural landscapes, revealing adaptation potential. While the other two models inadvertently disrupt natural systems, the Hybrid model inclines to prioritize water and infrastructure in constructing diversified ecosystems, thereby providing insights into future resilience strategies. The study proposes reframing these models as Social Ecologies to foster resilience through a paradigm shift wherein the Mekong Delta is regarded as a subject and agency within the Ecological Transition. Thereby integrating livelihoods, and infrastructure in harmony with the Delta's natural ecosystems. The findings regarding the Network Models facilitates an understanding of anthropogenic impacts across the territory and approaches to a more resilient Mekong Delta.

Keywords: territorial alterations, climate change resilience, social-ecologicies, network models, Mekong Delta adaptation.

RESUMEN

El delta vietnamita del Mekong (DMV), uno de los mayores exportadores de arroz del mundo y uno de los deltas más vulnerables, ha sufrido alteraciones territoriales radicales para la agricultura. Sin embargo, los cambios inducidos por el hombre, junto con el cambio climático y la subida del nivel del mar —que provocan inundaciones, sequías, salinización, hundimiento y pérdida de biodiversidad—, han alterado los procesos naturales del delta. Esta investigación examina cómo estas alteraciones agravan los efectos del cambio climático mediante el análisis de los patrones del suelo inducidos por el hombre. Utilizando el método del *Palimpsesto* de Corboz, un análisis cartográfico identificó tres configuraciones territoriales dominantes: 1) Conectividad del Nodo Estrella, 2) Compartimentación de la Red Agraria, y 3) Difusión Híbrida. El Modelo de Red en Estrella se alinea con la urbanización al estilo *Desakota* a lo largo de la infraestructura hídrica. El Modelo de Red Compartimentada es el resultado de proyectos hidráulicos a gran escala que fragmentan los ecosistemas acuáticos. El Modelo de Red Híbrida integra paisajes construidos y naturales, revelando el potencial de adaptación. Aunque todos los modelos han perturbado involuntariamente los sistemas naturales, proporcionan información sobre futuras estrategias de resiliencia. El estudio sugiere replantear estos modelos dentro de los marcos de los *sistemas socioecológicos* para fomentar la resiliencia mediante la integración de los medios de subsistencia, las infraestructuras y los ecosistemas naturales. Las conclusiones pretenden mitigar los impactos antropogénicos y apoyar un Delta del Mekong más adaptable.

Palabras clave: alteraciones territoriales, resiliencia al cambio climático, sistemas socioecológicos, modelos de red, adaptación del delta del Mekong.

RESUMO

O Delta do Mekong vietnamita (VMD), um dos maiores exportadores de arroz do mundo e um dos deltas mais vulneráveis, passou por alterações territoriais radicais para a agricultura. No entanto, as mudanças induzidas pelo homem, juntamente com as mudanças climáticas e o aumento do nível do mar — causando inundações, secas, salinização, subsidência e perda de biodiversidade — interromperam os processos naturais do Delta. Esta pesquisa examina como essas alterações exacerbam os impactos da mudança climática por meio da análise dos padrões de terra induzidos pelo homem. Usando o método *Palimpsesto* de Corboz, uma análise de mapeamento identificou três configurações territoriais dominantes: 1) Conectividade de Nó Estrela, 2) Compartimentação de Grade Agrária e 3) Difusão Híbrida. O modelo de rede em estrela se alinha à urbanização no estilo *Desakota* ao longo da infraestrutura hídrica. O modelo de rede em grade resulta de projetos hidráulicos de grande escala que fragmentam os ecossistemas aquáticos. O modelo de rede híbrida integra paisagens construídas e naturais, revelando o potencial de adaptação. Embora todos os modelos tenham interrompido involuntariamente os sistemas naturais, eles fornecem informações sobre estratégias de resiliência futuras. O estudo sugere a reformulação desses modelos dentro das estruturas do *Sistema Social-Ecológico* para promover a resiliência por meio da integração de meios de subsistência, infraestrutura e ecossistemas naturais. As descobertas visam mitigar os impactos antropogênicos e apoiar um Delta do Mekong mais adaptável.

Palavras-chave: alterações territoriais, resiliência às mudanças climáticas, sistemas socioecológicos, modelos de rede, adaptação ao Delta do Mekong.

1. INTRODUCTION: THE MEKONG DELTA AND ANTHROPOGENIC TRANSFORMATIONS

As a low-lying Delta, the Vietnamese Mekong Delta (VMD) is one of the third-largest Deltas on Earth. Due to its high agricultural production, the Mekong Delta is a densely populated region of over 17 million and a significant global and regional food security hub (Schmitt and Minderhoud 2023). Known as the 'Ricebowl' of Vietnam, the VMD has undergone radical territorial alterations to convert its Deltaic landscapes into agriculture. Since the 1990s, it has become one of the world's largest rice exporters, with a 50% National yield and 80% total exports. Despite this success, it has come at the cost of systemic ecosystem loss resulting from imposed engineering structures, which have obliterated the Delta's natural regenerative ecosystem processes (Scown et al., 2023), exacerbating the impact of climate change and sea level rise, with vulnerable areas in Deltas experiencing heightened levels of flooding, drought, salination, subsidence, loss of sedimentation, and biodiversity loss (Scown et al. 2023, Syvitski et al. 2022, Syvitski 2008, Edmonds et al. 2020).

The Mekong Delta's former regenerative processes, once aligned with ecological values based on deltaic ecosystems, have almost been completely obliterated in favor of models in water technological and managerial processes in hydraulic engineering. Investments in optimized ecosystem services in favor of agricultural production have propelled agrarian progress and transformed the Mekong Delta into an efficient food production region, at the expense of the Delta's water ecosystems. And the Delta's natural ecosystem processes have consequently become compounded by the combined impact of these human-induced alterations and adverse climate change trends, including flooding, drought, salinization (Eslami et al. 2021), sea level rise, and other anthropogenic processes like reservoir dams, sand and groundwater extraction, and pesticide use, causing decreased sedimentation (Kondolf et al. 2018), increased tidal flooding (Eslami et al. 2019), and accelerated land subsidence (Minderhoud et al. 2017; 2020). The combined pressures threaten the future of the Mekong with drowning and call for decisive actions (Eslami et al. 2019).

> Consequently, the research seeks to elucidate the types of territorial configurations or fabric patterns that have been shaped by human-induced processes across the Mekong Delta. Furthermore, it investigates the underlying agencies responsible for these processes and their transformative impact on the delta's natural ecosystems.

2. BRIEF HISTORICAL OVERVIEW OF THE MEKONG DELTA'S TRANSFORMATION

Centralized and decentralized mechanisms driven by investment in hydraulic technology and managerial water policy (Evers et al. 2009) have radically altered the delta, consequently transforming its territory against the laws of nature. My research findings reveal different resulting territorial configurations—defined here as Network Models—which have emerged due to key historical events. From the dredging of the first navigational canals during the early French Colonial period in the 1880s, to the artificially devised watershed management zones by 1975, new water lines have been incrementally added. Which followed by the expansion of these irrigation systems

with added hydraulic projects composed of dikes, sluice gates, and pumping systems, during the Green Revolution in the '90s, and larger-scale hydraulic projects to mitigate adverse environmental impacts by the early 2000s.

Key historical events have incrementally driven the delta's water territorial transformation. The first traces of canals were set in place during the Nguyen Dynasty (Le Coq, Trébuil and Dufumier 2004) and the first navigational canals were dredged during the French Cochinchina period as primary canal systems planned for easy water traffic navigation between urban centers (Brocheux 1995; Biggs et al. 2009; Biggs 2010). However, the most rapid progress in canalization occurred after the Vietnam War in 1975, due to political shifts that advanced water technological and managerial ingenuity. Nevertheless, since water engineering knowledge was transferred from the new Central Government located in the North (Arwin van Buuren 2019; Minkman Buuren, and Bekkers, 2021), it was far removed from the local ecological wisdom shared by the locals living in the Delta over the last century (Ehlert 2012; Liao et al. 2016). Moreover, new agrarian production incentives promoted the postwar movement to the Southern Frontier, whereby farmers returned to the countryside (Le Coq, Trébuil and Dufumier 2004).

New knowledge of water management was promoted by the Dutch Water Sector through high-level bureaucrats and implemented by embassies and engineering consultants to translate the Dutch Delta Approach (DDA) (van Buuren 2019). Thus, Newfound DDA in the Netherlands was transferred to the Mekong Delta as one of the first Southeast Asian countries to successfully adopt the Dutch water management plans, first during the establishment of the Mekong Delta Management Plan (MDP) in the 1970s and further after the renewal of the bilateral collaboration between the Dutch and Vietnamese in 2008.

In these ways, the 1975 reunification and subsequent 1986 Doi Moi reform period led to land management changes in support of a Green Revolution. From the campaign for National food security to the episodes of devastating flood events, the emergent state of fear raised after the war had driven investment in water infrastructure advancement. The subsequent campaign to dredge canals and reform water policy changed the positions of power, by promoting the Green Revolution in the 90s, becoming a major political shift thereafter (Brocheux 1995; Biggs et al. 2009).

Although these new reforms profoundly improved the Delta's water ecosystem through productive processes, they unintentionally turned ecosystem processes away from the Delta estuary's natural cycles. In response to increased flooding and demand for rice production, canals were extended and mechanized by the late 1990s. Access to new infrastructure consequently attracted unplanned waterfronting linear urban settlements, which exerted pressure on them. Hence, processes once in tune with the cyclic cycles of the monsoon in wet and dry seasonal patterns had been superseded by more predictable unnatural processes, in favor of flood protection for safe habitation and revenue in mass rice production. New progress in technical mechanisms included the coordination of irrigation channels incorporated with sluice gates, pumping stations, weirs and dikes (Le Coq, Trébuil and Dufumier 2004).

Furthermore, States of the Anthropocene, encompassing subsidence, salination, water pollution, groundwater depletion, and sedimentation loss, were increasingly felt by the late 1990s and early 2000s. All of which were anticipated in subsequent Mekong Delta Management reports: NEDECO, Mekong Delta Plan and Mekong Delta Integrated Regional Plan (NEDECO 1993; The Socialist Republic of Vietnam and the Kingdom of the Netherlands 2013, 2020; Toan 2014). Despite these warnings, the agricultural sector continued to suffer the consequences of environmental

Fig. 1. Study area location map, set in Long Xuyen Quadrangle and the western portion of Can Tho province. Source: Author 2022. Datasource: Google Earth accessed 2019, OpenStreet-Map, accessed 2019.

degradation well into the 2010s, from water pollution to soil contamination, questioning the Mekong Delta's complete devotion to intensified rice production.

3. HYPOTHESIS AND PERSPECTIVE

Following Vietnam's Green Revolution, the process of water resource extraction and land appropriation completely altered the state of the Delta's water ecosystem. Moreover, the appropriation of territory as spaces for production and habitation created different deltaic formations. Different configurations are identified as our 'Network Models' and characterized as overlapping and competing spatial formations composed of fabric patterns. These research findings shall be further elaborated on from our mapping analysis in subsequent sections.

It is hypothesized that the gradual formation of these Network Models has increasingly ignored the Mekong Delta's natural water ecosystem, in favor of systematic progress. This points towards a need for a paradigm shift to address the Mekong Delta's heavily altered water management system. To reverse this trend, the Mekong Delta must be recognized as a *subject* of Ecological values, rather than the *object* of ecosystem services. In the effort to prevent the further state of Anthropocene, the Delta must act as an active agent in its land and waterscapes. Only by reversing the gaze could the Delta reclaim its role in sustaining resilient Social Ecologies.

To foster an Ecological Transition between human and natural processes, leading to their integration into a second nature, strategic novel approaches must be devised. By reframing the Delta as an agency for the Ecological Transition, the research focuses on building an understanding of the spatial anthropogenic changes made across the region and the different agencies behind them, as a catalyst for strategic Deltaic adaptation. Therefore, identified Network Models shall be extracted to be further investigated and characterized through the palimpsest analyses. Emergent patterns found in the Mekong Delta's fabric shall present the construction of layers over time, to build narratives of how the Mekong Delta has arrived at such an Anthropogenic structure.

Figure 1 shows the location of the detailed study area, located in the upper alluvial region of the Mekong Delta, directly south of the Bassac River and the Long Xuyen Quadrangle[1] and Can Tho.

1. The study area takes a physical territory which is shared between 3 provinces: Can Tho, An Giang and Kien Giang. For the

Fig. 2. Diagrammatic canal section in the 1800s, with levees colonized by stilt houses and forest.

The middle image in Figure 1 shows the zoomed-in case study area. And to the right, the detailed study area is shown; for clarity, the frame has been rotated north-west, and covers part of the Long Xuyen Quadrangle and Can Tho region. Therefore, all the mapping studies in this section shall be based on this frame.

When the first traces of canals were dredged before the 1800s, sparse linear settlements colonized the edges of the canals as natural sedimentation built up on both sides, creating a natural protection area from the rising waters. The diagrammatic section in Figure 2, shows the hypothetical relationship of the first stilt houses along the canal embankments, surrounded by forested areas. Ricefields, most likely cultivated as floating rice paddies, were likely cultivated in the swampy land beyond.

Figure 3 illustrates the evolution of water networks and urban growth over the decades. The map in the 1930s depicts how the first traces of canals were dredged over the swampy landscape, original alignments which has remained largely unchanged. By 1988, secondary and tertiary canals were constructed, and sparse linear settlement development emerged along the main canal corridors, and primary roads were planned alongside canals. In 2003, the nodal town expanded along with the principal city of Can Tho, and linear settlements further developed along primary canals. By 2016, rapid urban development and increased linear intensification along most canals exerted more pressure on existing conditions.

a. 1930 b.1988

purpose of this study, it shall take on the irrigation project named Long Xuyen Quadrangle, which almost covers the entire study area with exception to the Can Tho urban and western area, which makes up the rest of the study area.

c. 2003 d. 2016

Figure 3. Phasing of the LXQ area, image a. 1930; b. 1988; c. 2003; and d. 2016. Source: Author, 2022. Datasource: Google Earth history 1988, 2003, 2009, 2016 accessed 2019, OpenStreet-Map, accessed 2019.

4. RESEARCH METHODOLOGY

Please be advised that the subsequent mapping analysis in the following section shall not be based on a chronological sequencing of the territory. Instead, Network Models shall be identified and extracted from the fabric based on the hypothetical relationships established by different agencies. As such, the justification of transformations shaping the new Delta shall be made through identified actors found therein. This approach of defining Network Models between configurations of urban spaces, elements, and layers of pattern formations ultimately identifies newfound heterotopic relationships, drawing inspiration from David Grahame Shane's urban design methods in conceptual modeling (Shane 2005, 2021).

The research method is based on a layered mapping approach, adopted from Corboz's *land in Palimpsest* methodology (Corboz 1983), which is built upon the superposition of layers of historical constructs, and the use of figure-ground concepts based on Colin Rowe's *Collage City* (Rowe and Koetter 1978). For instance, novel forms of boundaries, spaces, or limits were identified to have taken shape due to different water controls across the territory, pushed by various centralized and decentralized mechanisms. Driven by various geopolitical agencies, these processes have transformed the Mekong Delta's once deltaic ecosystem, resulting in different fabric patterns.

The anthropogenic relationships created distinct forms of rationalities whereby various boundaries were set apart, as illustrated in Figure 4. They have emerged from intricate Social Ecological interactions between the Delta's ecosystem and various processes, including urbanization or industrialization progress, technological advancement, and social or societal interactions. Through a layered mapping analysis of the territory, three distinct figures of territorial development were identified. Each of these models exhibits unique configurations, albeit with overlapping elements. As mapped in Figure 4, each network model was extracted as a diagram, which serves as a conceptual abstraction of the traces that have ultimately shaped the Delta's development pattern.

Consequently, the research has identified three distinct territorial configurations prevalent across the Delta region, collectively referred to as *Network Models*, as illustrated in Figure 4. These resulting models were shaped by diverse actors and agencies and have been categorized into three distinct types: Network Models of Stars, Grids, and Hybrids. A description of each Network Model is provided below:

1. *Stars, Nodal Connectivity*
   The activities linkages, attracting urban growth between the urban-rural territories, specifically along key water and road corridors.

2. *Grids, Agrarian Compartmentalization*
   Irrigated fields, resulting from centralized and decentralized water management for rice production, led by hydraulic societies.

3. *Hybrids, Urban-rural Diffusion*
   The diversified landscapes, comprised of farming units inhabited by riverine-based locals, combining elements from Stars and Grids.

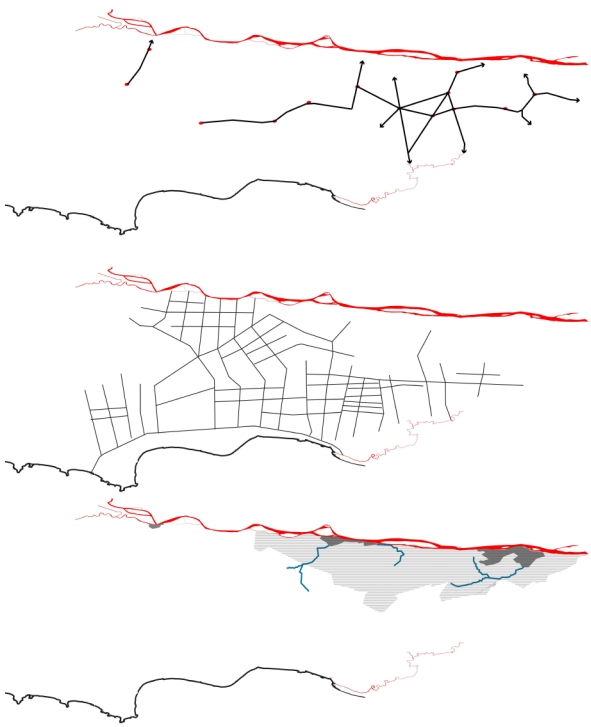

Fig. 4. Conceptual diagrams of network models: Stars, Grids and Hybrids (top to bottom).
Source: Author, 2022. Datasource: Google Earth accessed 2019, OpenStreetMap, accessed 2019.

5. RESULTS OF THE PALIMPSEST ATLAS ANALYSIS

5.1. NETWORK MODEL 1: STAR NODE CONNECTIVITY

In the context of navigation and trade, the first canals were dredged by the French Colonies for strategic water navigation purposes, they were planned to link trade centers and urban towns. These canals were designed as radiating networks that intersected urban centers and linked across the Bassac River and seaports. The canals were designed based on traffic flow capacity, informed by road transportation planning principles. The linkage between nodal towns established at joint water and land intersections was therefore planned similarly to roads. Whereby, the water channels facilitated transportation by directly linking towns to industrial, market, and trade zones. Which resulted in the formation of many radial stars and axial corridors between destination nodes, liken to the boulevards found in Paris (Brocheux 1995; Biggs 2010). Therefore, the original rationale of canalization during the French colonial period deviated from the natural logic of the delta's floodplains in favor of water navigation.

In addition, various points of intersection have historically functioned as floating markets, serving as local meeting points whereby merchants directly sold their goods from their boats, mainly fruits, vegetables, and other food items. However, water commerce activities were supplanted by 1916 due to competition with the established Chinese communities engaged in water trade in South-East Asia. Thereafter, the French colonies switched from water-connected commerce to road-linked, land-based commerce activities (Brocheux 1995).

Defined as a Star Network Model, Figure 5 illustrates the expansion of urban nodes and linear spatial development across canals and roads as the Postcolonial fabric. This fabric is characterized by the further growth and extension of established urban centers and town plans at the intersection of primary canals. Nodal and linear settlement growth at town intersections and along extended networks of roads along the canals has further intensified. These networks have activated linkages between places of interchange, facilitating the flow of people, trade, commerce, industry, and floating markets. A closer look at the mapping reveals how ad hoc linear settlements have thickened along the water canals and upon the parallel and interconnected road networks, establishing another solid interaction between water-driven and land-based activities.

The linear settlements along roads and canals between nodal towns have significantly intensified over the decades, establishing a whole new logic of urban-rural dynamics. This new dynamic has resulted from the activation of infrastructural linkages between activities located on and off the waterfront and on land. The formation of star and nodal towns was planned within a walking radius of approximately 500 to 1km between service centers. This strategic planning had attracted additional ad hoc formal and informal linear development composed of mixed-use shophouses, accompanied by ground-level services, including shops, markets, restaurants, and other commercial activities.

Over time, the original nodal towns established at the intersection of canal channels have further expanded, as shown in Figure 6. Sprawling new linear development has emerged and is dispersed across new secondary and tertiary water channels. The Linear settlement originally established along the original canals has become denser with added development, some of which is located along new internal road networks. Activated by work-live activities, they have further grown and thickened across the fabric, especially along the linkages near the main town centers. In this

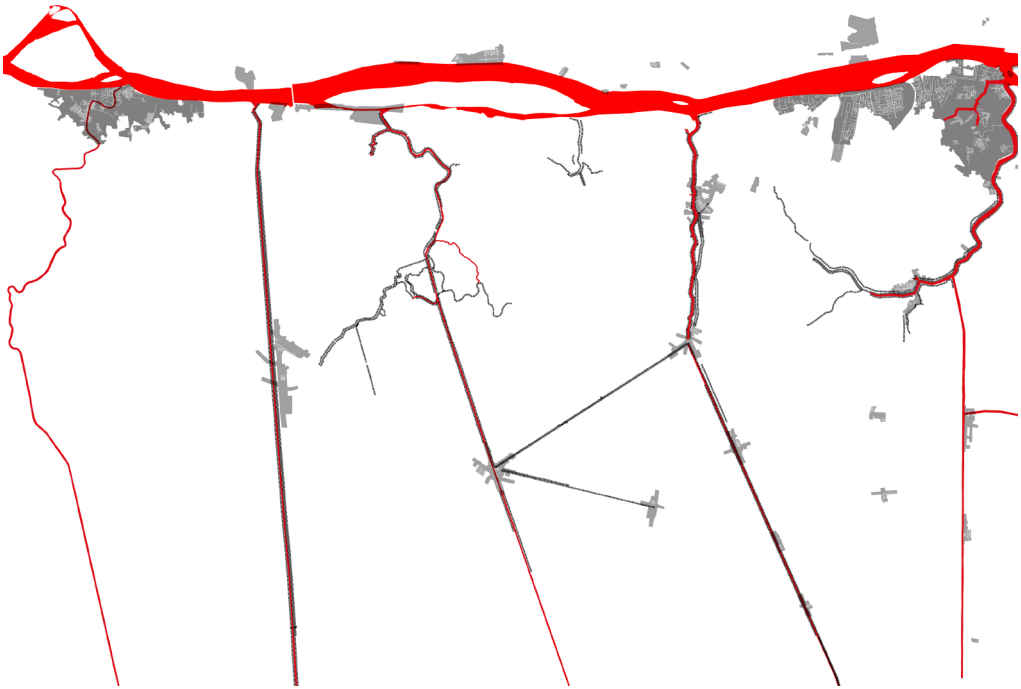

Fig. 5. Star canal formations and expansion of urban nodes through linear development along the colonial era canals. Source: Author, 2022. Datasource: Google Earth accessed 2019, OpenStreetMap, accessed 2019.

area, the development has become thicker across multiple layers, where roads and infrastructural networks were added. This thickening creates a palimpsest of linear settlement patterns, which enhance the identity of the established water channel networks while adding more pressure to land-based development, particularly along roads.

Figure 7 shows how one of Co Do's original nodal towns has expanded as a star formation, and linear settlements have intensified along its canals over fewer than 20 years. Similar to the switch from water to land-based activities identified by Phuong Nga's mapping of the Cai Rang waterfront community in the Mekong, the mapping shows how the valorization of infrastructural investment in roads (doubled up from dikes) has resulted in a turn away from waterfront activities and onto road-oriented communications networks (Nguyen 2015).

In 1998, several remote roads were constructed with linear settlements along the secondary canals. By 2002, the activities had thickened in multiple layers along the north-south axis, along the canal, and the linear settlements had expanded through the addition of road networks that provided more access along the star webs of canals. By 2014, large-scale developments had been planned along the web of water and road axes, encroaching upon the agricultural fields. These new plans have provoked more intensification not only along the axis but along the web axis, further shaping the star pattern. By 2020, this pattern becomes filled, as the secondary canals become more intensified with double-sided linear development and the blocks become more fully developed.

Fig. 6. Map showing the expansion and densification of linear settlements between original nodal towns, enhancing the radial network linkage at the intersection of canals and towns. Source: Author, 2022. Datasource: Google Earth accessed 2020, OpenStreetMap, accessed 2019.

In the 1960s and 1970s, the term "rururbanization" was coined in France (Barcelloni and Viganò 2022), to describe the rapid urban flight into the rural areas. This phenomenon was further defined by Paola Viganò, as a response against the formal urban policies, leading new villagers to construct their own homes, densifying the countryside. Similarly, Terry McGee identified the *Desakota* phenomenon in South Asia during his subsequent research (McGee 2009). Revisiting South-east Asia's Urban Fringe, McGee reassessed the challenges of Mega urbanization, discovering a similar dynamic, albeit within agrarian land. Known as 'city–village,' *Desakota* is a phenomenon whereby the extended built area located between the agrarian landscape is driven by the following activity flows:

> Distinctive areas of agricultural and non-agricultural activity are emerging adjacent to and between urban cores, which are a direct response to pre-existing conditions, time-space collapse, economic change, technological developments, and labor force change occurring in a different manner and mix from the operation of these factors in the Western industrialized countries in the nineteenth and early twentieth centuries. (Ginsburg et al. 1991)

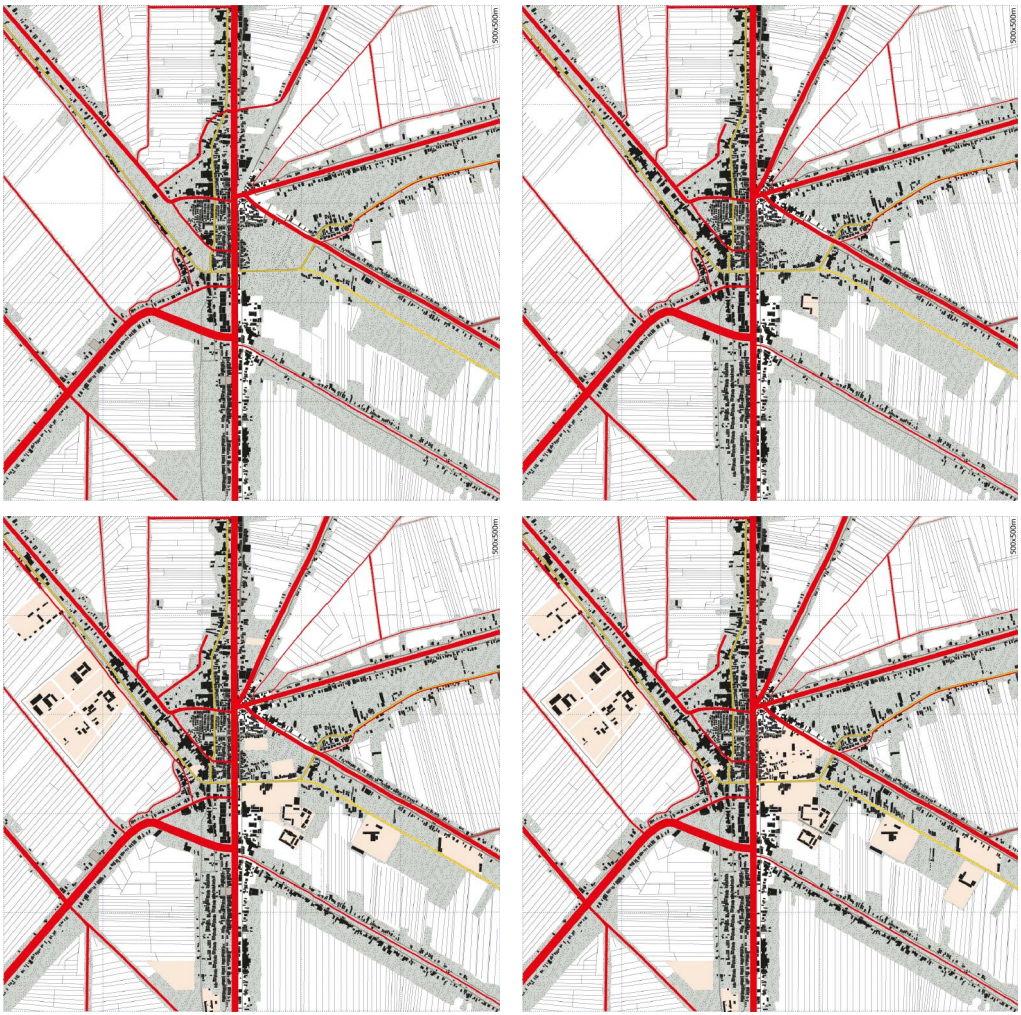

Fig. 7. The expansion of the original colonial era Star model located in Co Do town over the last 18 years. Image a. 2002; b. 2007; c. 2014; d. 2020. Source: Author, 2022. Datasource: Google Earth History 1996, 2002, 2014, 2020 accessed 2020, OpenStreetMap, accessed 2019.

Several authors have already identified the Desakota Phenomenon in the Mekong Delta region, (Desakota Study Team 2008, McGee 2009, Shannon and De Meulder 2012, De Meulder and Shannon 2018, Lawson, Guaralda and Nguyen 2022). However, this study distinguishes Desakota activities through specific land pattern formations, defined as the Star Network Model. This phenomenon aligned with Desakota culture, as the linear water and parallel road network linkages attract rapidly growing ad hoc activities, situated between urban and rural areas. This Star Network Model is created by a hierarchy of radial linear settlement expansion patterns activated by access

to intersecting water and road infrastructure. These radial connections provide access to economic and industrial infrastructure or activities.

5.2. NETWORK MODEL 2: GRIDDED COMPARTMENTALIZATION

By the 1990s, the Green Revolution had established a comprehensive hydraulic irrigation system consisting of canals, water channels, dikes, sluice gates, and pumps. Defined as a Grid Network Model, Figure 8 shows an agrarian irrigation system composed of gridded compartments, wherein a hierarchical system of primary and secondary canals was devised. Canals and channels were incrementally added as part of a systematic approach to optimize rice production. This system was enabled through the drainage or irrigation of fresh water, based on the cultivation requirements of different rice species. As a result, Figure 8 shows how the homogenous irrigation system was formed by large-scale hydraulic systems, gridded across the Delta region. The resulting water grid was driven by a hydraulic society based on water control for land appropriation and cultivation purposes (Evers and Benedikter 2009)

In contrast, extensive canals were introduced during the French colonial period. Initial canals were dredged in Vinh Te, Ha Tien, Rach Gia, and Long Xuyen, primarily for transportation and military navigation purposes. While canals were not originally dredged for irrigation purposes, technological advancements and the demand for flood and food security shifted the focus of water management from navigation to water irrigation. This transformation was achieved by extending existing canals and adding new secondary ones, thereby creating a new water management approach in the planning.

However, this shift failed to reconsider the scalar gap between the industrial and local farming scale, as recommended by the 1993 NEDECO Mekong Delta plan (NEDECO 1993). Investment in the irrigation system neglected to integrate the water management system to meet the needs of the farming unit. Consequently, the palimpsest mapping reveals a large-scale homogenous system, a massive gridded system imposed over the Delta's original swamps. Moreover, the agrarian Grid network model reveals how the entire territory has been appropriated for industrial-scale agricultural development purposes. This high-level water grid was financed and developed by the National Vietnamese government and mandated during Vietnam's all rice production based on a water-oriented policy (Evers and Benedikter 2009).

The basic mechanism for managing water drainage and irrigation relies on the interplay between the wet and dry seasons, along with the water and land requirements of the cultivated rice species. For instance, as illustrated in Figure 9, during the wet season, floodwaters draw water into the territory from the river channel and primary canal feeders. If the inundation is too high, the sluice gates located at the intersection of the primary and secondary canals can be manually closed to prevent further water ingress. Moreover, raised dike systems along the canals were designed to contain such wet-season inundations (elevated water levels) and prevent overflowing into surrounding rice fields. These dikes were typically raised between 1.5 to 3 meters or more, depending on the flooding levels. Additionally, central pumping stations may be utilized to pump water from secondary channels back to primary canals, effectively reversing the water flow during floods. Individual farmers also used their pumps to direct water according to their cultivation needs (Biggs 2012). Conversely, the water irrigation system reverses during the dry season, when water is

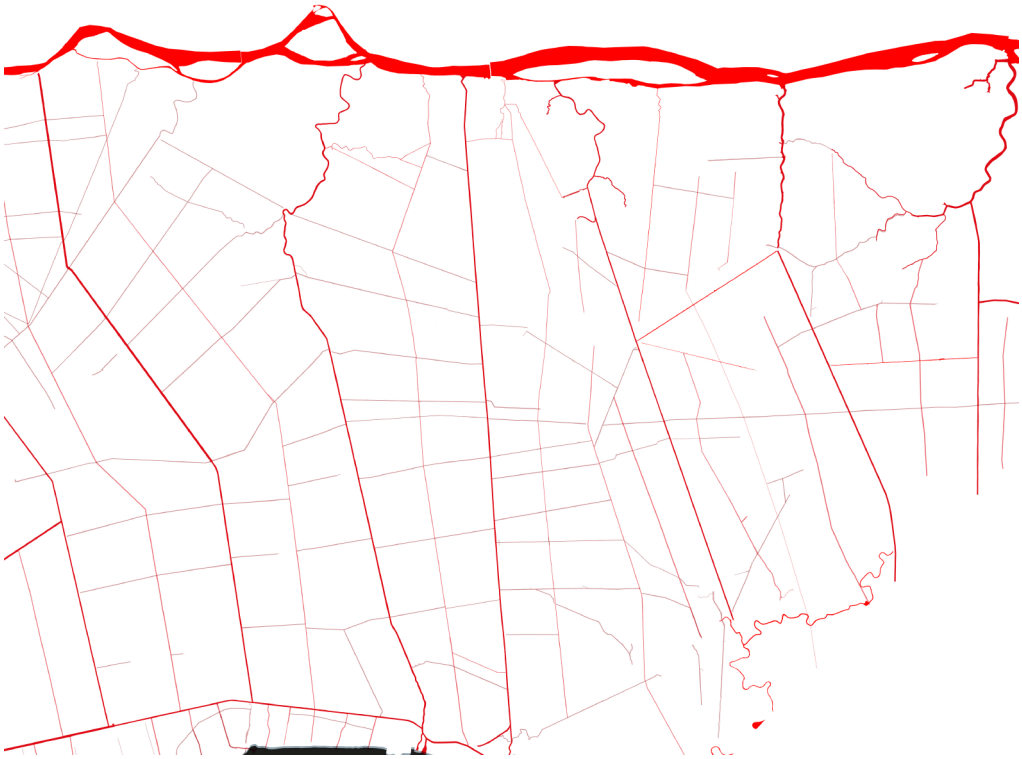

Fig. 8. Agrarian Gridded Compartments consisting of an extensive irrigation system composed of rivers, canals and channels. Source: Author, 2022. Datasource: Google Earth accessed 2019, OpenStreetMap, accessed 2019.

irrigated or pumped into the fields. This process is enabled by the same pumping systems; however, in this instance, the sluice gates may remain open, while certain gates may be closed to divert water towards areas with higher water requirements to meet specific irrigation needs.

The farming scale, comprising houses and associated gardens, had evolved from within the larger agrarian structure, as mapped in Figure 10. Land parcels along the main canals were subdivided for residential purposes, characterized by extended orchards interspersed within elongated rice field sections. This landscape pattern has established a common fabric language. Moreover, the linear settlements have valorized the dual dike and road infrastructure developed along the primary canal with increased densification. In addition to the original development along the canal fronts, they have become even more intensified on the opposite side of the water, where new roads were constructed. The comprehensive integration of houses, gardens, along diked-road infrastructure running along the canal, constitutes the thickened moment, thereby establishing Social Ecologies. These elements are the most diverse and dynamic elements across the vast, homogenous agrarian fields beyond.

By the 2000s, larger-scale hydraulic projects were managed through public-private partnerships to enhance irrigation capacity from double to triple rice crops by further elevating the dikes.

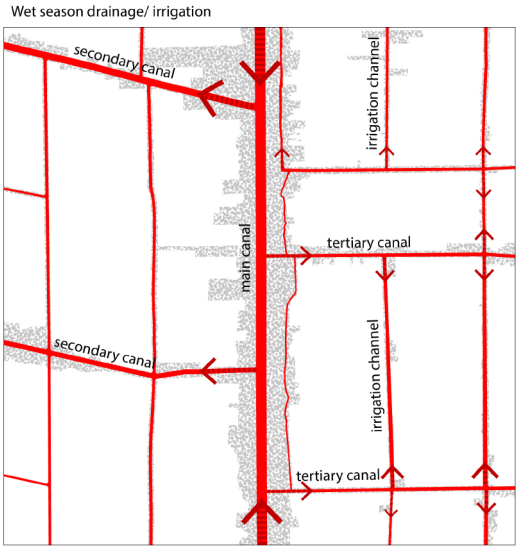

Fig. 9. Basic drainage water flow during wet season. Source: Author, 2022. Datasource: Google Earth accessed 2019, OpenStreetMap, accessed 2019.

Fig. 10. Habitat and garden scale along the main canal, nested within the agrarian structure. Source: Author, 2022. Datasource: Google Earth accessed 2019, OpenStreetMap, accessed 2019.

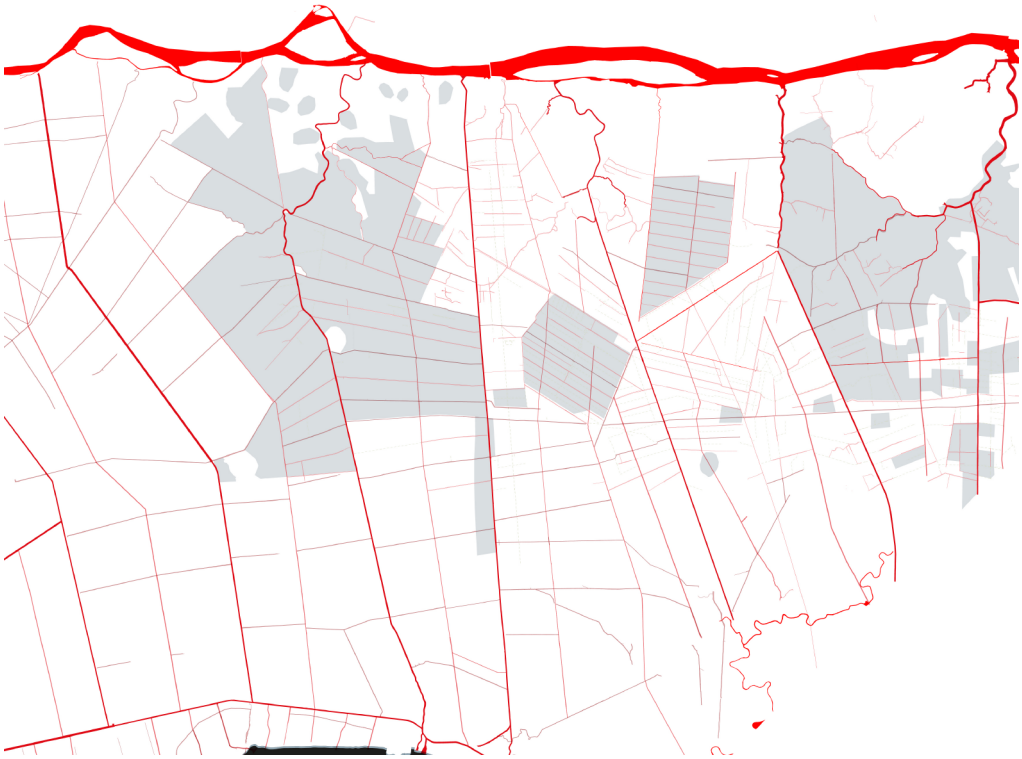

Fig. 11. Large-scale hydraulic projects are set as rice intensification zones found within the gridded agrarian landscape, as shown in gray. Source: Author, 2022. Source: Dike routes and diked areas in the Mekong Delta (Dat 2013) taken from (Nguyen 2015). Datasource: GIS Geodata GMS 2019. Google Earth accessed 2019, OpenStreetMap, accessed 2019.

Their project limits are shown in the gray zones in Figure 11. Not only do these projects augment agricultural production, but they also provide flood protection. For instance, after the 2010 flood, August dikes were proposed to complete the irrigation system in An Giang province via planned hydraulic project areas. These large-scale projects were invested in and managed through public and private sector cooperation by centrally managed companies, such as Joint Stock Construction Company No. 40 ICCO 40, and Joint Stock Dredging Company No. II DRECO II (Benedikter 2014). They were mainly financed by international organizations, including but not limited to Foreign Direct Investments (FDI), Official Development Assistance (ODA), World Bank (WB), and Asia Development Bank (ADB).

The foreign capitals mentioned above provided aid or loans in response to the development market demands in the Mekong Delta for various investments. These investments consequently contributed significantly to the modernization of the Delta. Infrastructure works encompassed water infrastructure, highways, roads, bridges, and other works. Following the liberalization period, four major regional irrigation projects were planned: Long Xuyen Quadrangle (our main

study area), the Plain of Reeds, the Trans-Bassac, and the Ca Mau Peninsula. These different projects responded to different types of water ecosystems in the region. Hydraulic projects and subprojects were subsequently planned accordingly, resulting in an increasingly complex system of canals with associated irrigation channels, dikes, embankments, sluice gates, and pumping stations. (Benedikter 2014)

The main irrigation projects located within our Long Xuyen Quadrangle and Can Tho study area include Vinh Te, Cai San, and O Mon-Xa No Canal, which have been under development for over two decades. Within the regional Long Xuyen Quadrangle hydraulic project area, the rapid extension of existing and construction of new dikes in the historical floodplains has transformed An Giang province into a network of irrigated fields, thereby safeguarding floodwaters from entering the fields during the wet season.

5.3. NETWORK MODEL 3: HYBRID URBAN-RURAL DIFFUSION

Defined as a Hybrid Network Model, these hybrid zones appear to span between urban-rural infrastructure as blue-green corridors, as mapped out in green in Figure 12. These corridors are composed of a more organic fabric, contrasting with the previous Grids Network Model. Within this mixed area, local activities appear to valorize the combination of natural environments and irrigation systems for habitat and cultivation purposes. A diversified landscape characterizes the vast areas of upland crops, which appear to extend into the agricultural fields.

These diverse landscapes were predicated on the compatibility of cultivation practices with soil types and the type of water infrastructure available. Historically, the planting of different fruit trees was guided by principles of organic agriculture, which were inherent in the local ecological wisdom of farmers across generations. Ecological wisdom encompasses the deep understanding of the Delta's natural ecosystem processes. Over time, local cultivation knowledge discovered methods of optimizing the constructed drainage and irrigation system by integrating ecosystem processes. Through this local practice, crop varieties were meticulously selected between perennial, annual, and short-term crops. Different species of crops were rotated based on their environmental compatibility and their monetary value in local markets.

In particular, this hybrid zone includes an orchard-based landscape characterized by human settlements that subsist on the dike system along rivers or canals. These waterfront settlements are mainly engaged in garden cultivation of upland crops, annual crops, and various aquaculture. They appear to be concentrated in more protected areas within the topographically elevated ground along the Bassac River's natural levee and its main tributaries. This hybrid area spans approximately 6 to 12km from the river. However, these hybrid zones also emerge around the peri-urban areas surrounding main cities such as Can Tho, and along artificially elevated areas, constructed from the resulting mounds left over from the dredging of canals.

A detailed examination of the zoomed-in hybrid zone is shown in Figure 13, which reveals the dual function of the diked road network as residential access and blue-green infrastructure for orchard cultivation. Thickened moments of linear urban settlements appear on both sides of the road, concurrently paired with extensions of diversified orchard and fruit tree plantations that extend into the agricultural fields. This suggests the establishment of micro-economic activities that benefit from the protected elevated areas along the canal embankments. In contrast, less

Fig. 12. Map showing the hybrid zones of mixed crop cultivation (in green), mainly in orchards, upland crops, annual crops, and fish farms. These zones appear to be coupled with intensified urban areas located along the river, in this case, Long Xuyen City (left) and Can Tho City (right). Source: Author, 2022. Datasource: Google Earth accessed 2020, OpenStreetMap, accessed 2019.

intensive settlements and orchard areas reside along tertiary streams due to the limited supporting infrastructure available in these areas.

Figure 14 explains the rationale behind the evolution of development along the canal, as depicted in the following section. The initially colonized land, which emerged from the dredging of the canals, subsequently created a natural protective layer along the canal embankments. This layer, composed of leftover sand from the dredging, created raised beds that attracted informal stilt housing settlements. The subsequent intensification of rice cultivation in the fields beyond led to the introduction of diked embankments directly behind these stilt houses, thereby creating an irrigation system. This, in turn, attracted land-based houses on the opposite side of the water, resulting in ad hoc property development there. These mixed-use houses consisted of elevated land beds for habitation purposes with shopfronts on the ground, which were further enhanced with orchard plantations. All these new additions benefited from protection from floods and access to new networks that connected to other destinations.

Figure 15 presents a comprehensive Palimpsest map of all the Network Models that constitute the study area's landscape pattern, in the Mekong Delta. It depicts the interconnected layers as complex systems and subsystems of the Star, Grid, and Hybrid Network Models. This palimpsest map

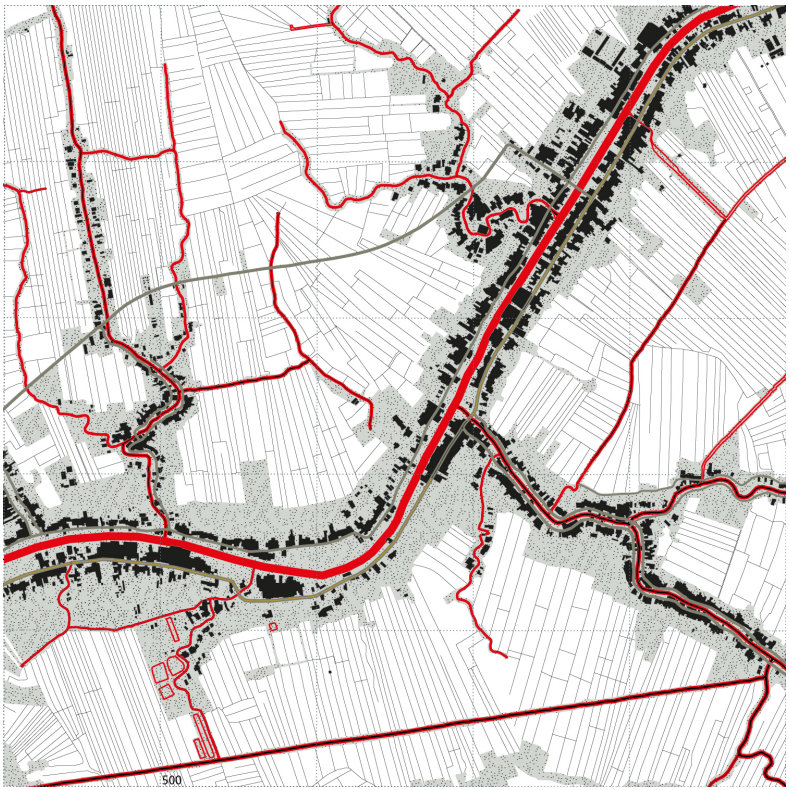

Fig. 13. Map showing a detailed area illustrated by the organic growth in the hybrid model, characterized by the densification of settlements along diked road networks with large extensions of orchard cultivation areas. Source: Author, 2022. Datasource: Google Earth accessed 2020, OpenStreetMap, accessed 2019.

Figure 14. Section showing the upgrade from river stilt housing development along a natural levee to an embankment raised by dikes on both sides, further constructed as road access. On the land side of the roads, new modern shophouses were constructed with raised orchard beds. Elaborated by author.

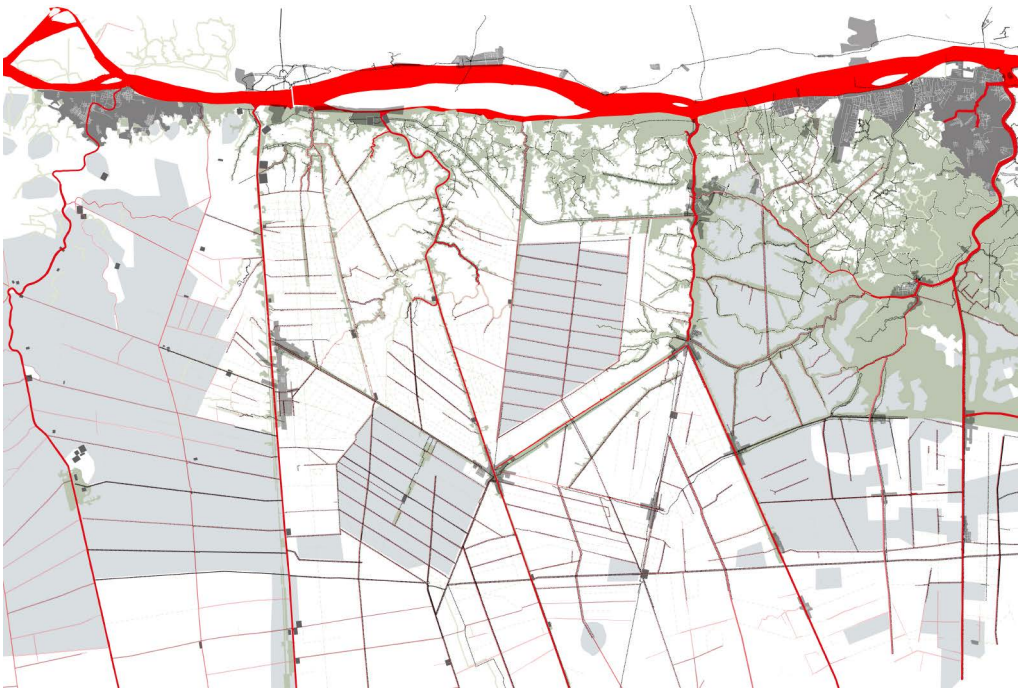

Fig. 15. Map showing how overlapping these layers, including French colonial canals, systems of hydraulic projects, urbanization patterns, and diverse landscapes. Source: Author, 2022. Source: Dike routes and diked areas in the Mekong Delta (Dat, 2013) taken from (Nguyen, 2015) Datasources: GIS Geodata GMS 2019. Google Earth accessed 2019, OpenStreetMap, accessed 2019.

comprises all the layers presented before, including the French colonial canal layers, the hydraulic projects, urbanization patterns, and diversified Social Ecological landscapes. All these overlapping layers illuminate the different processes and agencies that have shaped the territory. These forces driving the Delta are influenced by various powerful agencies that control water resources. These agencies engage in a dynamic interaction that "compete, superimpose, and react" as described by Boelen et al. (2016) as Hydro-Social Territories. Territorial transformations emerging from overlapping hydrological projects, informal economic activities, and growth across the urban-rural milieu, and increasingly heterogeneous land cover, have led to complex interactions. Paradoxically, the Delta's water ecosystem services have enabled the very territorial transformations that have subsequently threatened its natural resources. As defined by Boelen, these types of hybrid zones undergo constant modification and reorganization across the territory through the competing actions taken across multiple actors, actants, and at different scales.

Figure 16 shows a more detailed study area, whereby the identified Network Models of Stars, Grids, and Hybrids were found to overlap. These overlapping patterns signify the intricate interactions generated between the top-down managerial operational processes and the bottom-up local responses to novel resources. The study area has been framed to clarify the geographic

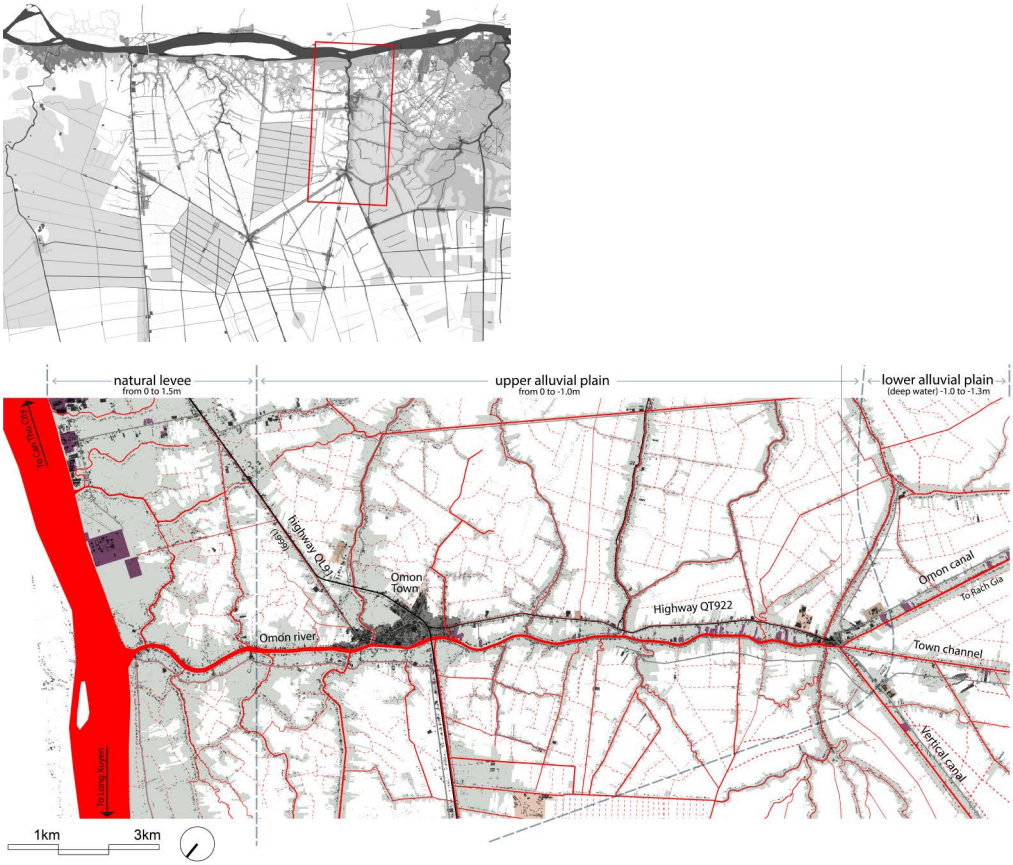

Fig. 16. Map of the study area in O Mon and Thoa Lai district, showing the complex relationship resulting in the overlapping phenomena identified in the Star, Grid, and Hybrid network models. Elaborated by author. Sources "The relation between land use and subsidence in the Vietnamese Mekong delta," GIS Land Use 2009, Courtesy of (Minderhoud et al. 2018). Datasources: GIS Geodata GMS 2019. Google Earth accessed 2020, OpenStreetMap, accessed 2019.

relationship as a Transect. This Transect study (drawn from left to right) commences from the primary River branch originating from the Mekong River to the left, proceeds to the natural levee (which spans about 10-15 km), and transitions from the upper alluvial to the lower alluvial plain. These geographical features provide insights into the locations and utilization of natural water ecosystems across the Transect.

Figure 16 illustrates how the phenomenon is driven by the Star Network Model configuration, which is identified to the right where three major canals intersect. The Omon Town Channel and Vertical canals converge at the focal point where Thoa Lai Town center was established. These canals radiate outwards into branches of water channels, serving as water traffic routes between town centers, approximately 15km apart. Further along the Omon River, an intricate relationship exists between

the formerly channeled Omon River and a constructed highway (QT922). Whereby layers of linear Desakota-driven settlement have extended between Omon Town and Thao Lai Town, connected by the river-highway corridor. This growth pattern encompasses urbanization and industrial activities that have progressively densified along the parallel highway connecting the two towns.

Concurrently, the map in Figure 16 illustrates how the Grid Network Model was formed through the implementation of red irrigation networks by the Hydraulic Society to promote rice production. These layers of irrigation channels were superimposed upon the original canals and watercourses. They were integrated with high dikes (complete with road), strategically elevated above the flood levels of primary canals and streams. This approach served as a top-down mechanism to shift the rice cultivation capacity from double to triple annual harvests.

Conversely, the mixed zones represented in gray by the Hybrid network model show a propensity for Social Ecological resilience. This extended gray zone merges the characteristics found in the other two Network Models. It incorporates the linear settlement pattern found in Desakota and the valorization of the water networks, which were developed through the irrigation system. All these elements are intricately combined to create a mixed-use Hybrid zone. This hybrid zone comprises orchards, family farming units, and other activities such as shopfronts and aquaculture. It demonstrates a bottom-up dynamic response to the top-down infrastructural construction plans. This resilient potential highlights the ability for Hybrid Network Models to bridge the resources generated from top-down processes with the local knowledge derived from bottom-up approaches. Which emerges as novel Social Ecologies with the potential to reframe the challenges inherent in anthropogenic processes.

6. DISCUSSION 1: STAR NETWORK MODEL

The findings from the initial palimpsest mapping conducted in the Star Network Model underscore the imperative for further investigation into the accelerated Anthropogenic impact. Primarily due to the ad hoc linear development activities prevalent across urban and rural linkages. The identified rapid linear settlement pattern along water canals and associated roads has indirectly catalyzed artificial transformations by exerting strain on existing infrastructure. This subsequent growth was recognized as a Desakota phenomenon, represented by the ad hoc bottom-up response to water management and infrastructural investment.

Paradoxically, the local farmers' original "living with the water" paradigm was challenged by the introduction of diked roads. Thereafter, these road networks attracted Desakota activities, which rapidly intensified. This inversion, from a history of waterfront-oriented activities in harmony with the water ecosystem, to land-based activities turned away from the rivers and canals, resulted in the capitalized use of land appropriation. Consequently, these activities have become increasingly alienated from the water system. This phenomenon is exacerbated by the peri-urban densification, which relies on the installation of flood defense infrastructure and significant land alterations.

The Desakota culture represents a glocalized response to the interplay between top-down and bottom-up urbanization and industrialization processes. This mainly manifests along the main road and water infrastructure, facilitating communication between urban and rural areas. Actors leveraging road-based infrastructure gain access to urban activities through investments made in commerce, services, real estate development, and industry. These Desakota-oriented

endeavors involve shop owners, families residing in shop houses, traders from designated open markets at designated centers, and real estate developers. Furthermore, larger operations drawn by investment in water and road infrastructure include production-based industries, primarily focused on rice processing, gravel, sand, and minerals resource extraction, and the transportation or trade of agricultural yields and construction materials.

The Desakota situation essentially exploits the interaction between nature and the built systems to support livelihoods (Desakota Study Team, 2008). Desakota's growth has subsequently intensified linear urbanization and industrial activities across road networks between town centers, significantly altering the original land and imposing environmental strain. The process of building land intensification entails transforming the land from its natural soil state into compressed soils or asphalt-covered areas to support building foundations. This, coupled with densified urban areas, necessitates the provision of fresh water, which is often extracted through the exploitation of groundwater, leading to land subsidence (Minderhoud et al. 2018). Moreover, polluted stormwater runoff from impermeable paved surfaces in urban areas is discharged into designated ground drainage. Many of these systems release the water back into rivers without undergoing any treatment, thereby polluting the water and further hindering the replenishment of groundwater.

7. DISCUSSION 2: GRIDDED NETWORK MODEL

Powerful Hydro-politics in the Delta have shaped the formation of an irrigated land pattern, identified as the Grid Network Model. The establishment of the Delta-wide canalized water management system was meticulously funded through agencies in water technological and managerial operations. Consequently, the water control mechanism facilitated the manipulation of the Delta into productive agrarian landscapes. These mechanisms were further enhanced by substantial investment and implementation of numerous large-scale hydraulic project zones, strategically distributed across the Mekong Delta.

The amalgamation of numerous hydraulic irrigation projects has shrunken the Delta's natural watershed by diverting flood waters into unforeseen areas. These hydraulic interventions have raised water levels and shortened the inundation period, occasionally diverting water to vulnerable urban districts such as Can Tho City and Long Xuyen City. A series of detrimental cycles of anthropogenic impacts also proceed flood diversion: Previous swamp land prepared for rice production becomes irrigated land, rendering it incapable of self-cleansing during the flooding season. Consequently, the soil remains with heightened levels of acidification and a lack of nutrients due to the absence of sedimentation. Subsequently, necessitating an increased utilization of chemical treatment due to infertile (acidic) soils, which, in turn, contributes to water pollution and biodiversity decline.

Planning tools associated with the implementation of water management policies have transformed the delta's floodplains and landscape into a matrix of grid-based agricultural compartments. These land modifications have introduced another rationality, as a substantial structure has been superimposed upon the Delta's water ecosystems. These gridded structures have consequently and inadvertently obliterated the inherent resilience of the Delta's self-regenerating floodplains and associated water ecosystem processes.

Lastly, the zoning of the Delta into agricultural, industrial, and urban areas, as a planning tool focused on monofunctional land-use planning, has fragmented its natural geomorphology.

Furthermore, as a planning approach based on monetary values, this type of land appropriation and preparation primarily relies on setting boundaries. As a land management approach that values land certainty and security, determined by its monetary yields defined by its land parcelization type, it is unsurprising that this approach contradicts the Delta's natural cyclical processes. As an economic land management approach, the Delta management plan completely overlooks the Delta's fluid water ecosystems processes, whereby space and time continuously flow and change with the wet and dry seasons.

8. DISCUSSION 3: HYBRID NETWORK MODEL & PARADIGM SHIFT

The palimpsest findings of the Hybrid Network Model offer a glimpse into the concept of 'reversing the code.' This approach involves a bottom-up process that leverages existing water ecosystems while simultaneously capitalizing on the top-down investments in irrigation infrastructure. Unlike the other two models, which result in the further exploitation of the Delta's altered water system—Grids through irrigation and Stars through Desakota—the Hybrid model provides mutual benefits to the Delta, leading to enhanced landscape diversification. This factor contributes to a more resilient response to the global economic and industrial forces at play. The Hybrid Network Model effectively leverages the new infrastructure with existing ecosystems to produce mutually advantageous combinations of landscapes.

Emerging as a Hybrid Network Model, the blue-green corridors with extended gardens appear to encroach upon the agricultural fields. These corridors comprise an interwoven dynamic of cultivated landscapes and built constructs, where work and living typologies are adopted. The subsequent local response to large-scale infrastructural investments involving dikes doubled down as roads, is to harness it into the locality through small, ad hoc interventions that safeguard habitats (flood-protected dwellings) and facilitate micro-economies in garden cultivation. Many of these gardens stem from the waterways and extend into the agricultural fields, comprising a diverse array of orchards, shrimp ponds, vegetation, and farm animals.

The resulting hegemonic structure is hypothesized to be an evolutionary component of the Desakota phenomenon (from the Star Network Model), with more relevance to local knowledge regarding ecological wisdom. In addition to farming industries that have profited from the infrastructural investments made for agriculture, Desakota activities have also benefited from the transformed water-road networks of the Delta. Furthermore, local farmers utilized access to network systems to support their farming micro-markets by cultivating more varieties of crops based on land compatibility. This has resulted in the interplay between the provision of ecosystem services (soil, fertile ground, irrigation) and infrastructural capacity (water, sewage, energy).

Although this provision can impose additional pressure on the territory, possibly leading to anthropogenic impacts, the intensification between urban and rural linkages across diversified blue-green corridors holds the potential to transform the currently homogenous fields into ecologically resilient territories. The Mekong Delta's territorial relationship between the water channels, urban centers, and land networks presents an opportunity to adopt new approaches that foster Social Ecological resilience. Resilience that integrates the water processes, interactions between institutions involved in water and landscape management, socio-economic interactions

between farmers and traders, various industrial practices in land cultivation for food production, and more rural-urban drivers. For these reasons, the research raises the following question:

> How can lessons learned in the Hybrid Network Model inform the redesign of various hydraulic projects, hybrid land mosaics, and rururban Desakota patterns, to create space for a more Social Ecologically resilient Delta in confronting the water ecosystem threats in the Mekong Delta?

9. DISCUSSION 4: THE EVOLUTION OF HYBRID MODELS

The Mekong Delta has entered the Anthropocene due to the compounded effects of water control enabled by water management of hydraulic infrastructure, resource exploitation, and intense land-altering development processes. In response, local farmers and settlements have further exploited the transformed land, with their agenda for ensuring the combination of habitat and micro-economies, through live-work garden and pond cultivation patterns, unintentionally exacerbating the altered state of the Delta.

The palimpsest study has elucidated the evolution of three major Network Models over the past decades. Demonstrating how these models have progressively transformed into increasingly complex systems and subsystems, albeit inadvertently contributing to the anthropogenic state. Territorially, the Network Models discovered in Stars, Grids, and Hybrid patterns exhibit a complex set of dynamics distinguished by the interaction between local and global driving forces. The palimpsest research finds that these dynamic fabric patterns have consequently transformed into Social Ecological combinations. As new combinations, these heterogeneous configurations are characterized as hegemonic fabric patterns formed over periods, by various driving forces, all leading to intricate territorial (re)configurations.

These configurations can either create more integrated or fragmented relationships across the urban-rural fabric. When fragmentation occurs, it often reveals a spatial mismatch and a scalar gap in land-use planning, hydraulic management, and land ownership patterns. The reconfiguration of deltaic land, particularly to support intensified zones of agrarian production and urbanization, has exacerbated environmental impacts, including flooding, salination, erosion, water pollution, and other factors. Although territorially productive under their respective agenda, the combination of these models has also contributed to the environmental challenges faced by the transformed state of nature.

10. THE FINDINGS IN THE HYBRID MODEL CALL FOR A PARADIGM SHIFT

In contrast to the other two Network models, the Hybrid Network Model demonstrates resilient Social Ecological processes that have the potential to reverse the code resulting in anthropogenic outcomes, thereby illuminating the pathway toward an Ecological Transition. Reversing the code can be achieved through the progressive ecological diversification of land and its integration into farmers' processes and livelihoods. As illustrated in the section depicted in Figure 15, the incremental transformation of land from the local utilization of gray infrastructure networks, in

combination with associated dwellings and cultivated gardens, serves as evidence of beneficial Social Ecological interactions.

This hybridization of processes, encompassing the combination of blue-green infrastructure, the Desakota colonization dynamic, and the diversification of landscape cultivation, demonstrates existing resilience that remains untapped. This untouched informal procedure should be integrated into the Delta's formal territorial planning process. The resilient land diversification patterns exhibited by the Hybrid Model necessitate a paradigm shift to further foster the diverse state of hybrid combinations, regarded as Social Ecologies. By mutually benefiting rather than exploiting the Mekong Delta's landscape and water ecosystems, the Hybrid Model may further develop a multitude of landscape and ecological combinations and cultivation processes.

Consequently, to work harmoniously with the Mekong Delta's ecosystems, a new perspective must be fostered. Instead of solely focusing on the many agencies that have transformed it over time, we must post-rationalize the Delta's natural states and its altered states. To recognize the Mekong Delta as a 'terrestrial constituent' (Bruno Latour 2018) and agency of change, we must shift the focus from utilizing the Mekong Delta solely for ecosystem services. Rather than becoming an *object* of commodity in ecosystem services, the Delta transforms into a territorial *subject* through which to redefine climate change thresholds and promote Social Ecological resilience. As a social production of material culture, the Delta equally reacts to climate change's impact on humans and nonhumans alike. Therefore, the Mekong Delta's *Water as Subject* paradigm shift will elevate it to an equal territorial actor and participant in the ongoing discourse of Social Ecological progress (Vigano 2022, Vigano et al. 2023). The Mekong Delta shall ultimately serve as a catalyst, paving the way for valuable lessons, informing novel water ecosystem processes, and reframing the climate change phenomenon towards an Ecological Transition.

11. CONCLUDING REMARKS: THE URGENT NEED FOR RESTRUCTURING ANTHROPOGENIC PROCESSES IDENTIFIED IN THE THREE NETWORK MODELS

The three Network Models were shaped by anthropogenic processes that transformed the Mekong Delta's estuary characteristics. The construction of extensive hydraulic works accelerated environmental degradation by precisely controlling water flow, direction, and quantity through water pumps, sluice gates, and dikes. This subsequently affected the Delta's water and soil quality. Anthropogenic processes began with the division of floodplains into water management units and the appropriation of swampland for agriculture. Powerful state actors and private organizations driven by agrarian production-oriented water policy invested in the agricultural sector. Furthermore, engineered water techno-managerial projects associated with irrigation were incrementally planned and constructed, with progressively larger-scale water works. Lastly, local responses leveraged access to new infrastructure with natural resources through different land appropriation and cultivation practices.

The palimpsest analysis findings delineate Grids, Stars, and Hybrid Network Models, thereby answering the research question regarding territorial configurations resulting from human-induced processes across the Mekong Delta and the agencies behind them. The Star Network Model unveils a radial pattern of linear growth along intersecting waterways, resulting in urban-rural

development patterns characterized by Desakota, as intensified linear settlement development along key infrastructure. This phenomenon shifts away from the "living with the water" paradigm by capitalizing on land-based driven densification along network infrastructure. Financed by influential Hydro-political actors, the Grid Network Model presents large-scale hydraulic infrastructural networks superimposed in a gridded pattern. Facilitated by advancements in water technological and managerial procedures, the resulting agrarian irrigation systems enabled substantial agricultural production. Consequently, diverting the Delta's natural flooding patterns hinders the Delta from its self-regenerative processes. The first two dynamic Network Models emerged from general forces, the interplay between top-down and bottom-up processes. These interactions generated territorial dynamics in favor of Hydrological constructs, contradicting the laws of nature and inadvertently erasing the Delta's natural states. However, the Social Ecological resilience emerges from the identified Hybrid Network Model, which challenges these Hydro-political processes, revealing overlapping patterns of dynamic Social Ecological resilience. By reversing the code wherein a more mutual interrelationship is formed between nature and humans, the pattern of blue-green corridors integrated with productive habitats signifies a shift towards rethinking the relationship between anthropogenic and natural processes. Therefore, the Hybrid Network Model's combination of landscape and built systems presents an opportunity for Social Ecological Resilience. This proposed paradigm shift, characterized by the reframing of Water as Subject, transforms the Mekong Delta's water ecosystem as agency, thereby facilitating a resilient Ecological Transition.

Interest is taken in the countercurrent process between top-down and bottom-up forces, as Desakota coupled with blue-green ecological systems evolve into increasingly hybrid and heterotopic forms and processes, representing an evolution of Social Ecological resilience. The central question now revolves around how these actors will collaborate within this Hybrid Network Model and 'reverse the codes.' Which entails the reversing of the current exploitation of the Mekong's water territory into ecosystem services by approaching the Delta's resilience through the integration of its inherent ecological values with novel Social Ecologies. The research findings provide design research recommendations to address the subsequent question: *how can reframing hydraulic projects, hybrid landscapes, and rururban patterns generate space for a more Social-Ecologically resilient system in facing the water ecosystem threats in the Mekong Delta?*

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SHORT CV

Sylvie Nguyen is currently a guest researcher at Wageningen University Research (WUR), specifically in the Soils, Geography and Landscape division, as a postdoctoral mobility awardee from the Swiss National Science Foundation. Her Ph.D. was completed under Professor Paola Vigano, the section director of *Territories of Urbanism* at the Swiss Federal Polytechnic School of Lausanne (EPFL). Her research at WUR focuses on the Vietnamese Mekong Delta, which has experienced systemic loss of biodiversity, and the disruption of natural ecosystem processes due to the compounding effects of climate change. Her research objectives aim to reevaluate the history of Delta Management Plans by bridging the knowledge gap between the current planning process and the Delta's physical characteristics as a territorial-based mechanism, to be reframed by urban design frameworks. Her research approach integrates scientific research advancements in environmental science and expertise in Nature-Based Solutions in water-sensitive urban design, to incorporate solutions as Delta Management strategies. As a former urban designer, she has led urban design projects across various integrated project types within multi-disciplinary engineering, urbanism, and landscape, spanning different countries such as the US, Hong Kong, China, and Vietnam. In her capacity as a core faculty member at the University of Hong Kong, she has provided lectures and coordinated and developed the Transit Oriented Development (TOD) core urban design studio for the Master of Urban Design program. Her Ph.D. dissertation titled "Atlas Narratives of Anthropogenic Transformation across the Vietnamese Mekong Delta's urban-rural Territories: Water Ecosystems as driver for the Social Ecological Transition" explores the impact of anthropogenic transformation on water ecosystems and their role in driving a social-ecological transition. She holds a Doctor of Science (Ph.D.) from EPFL, a Master of Architecture in Urban Design from Harvard University (GSD), and a Professional Bachelor of Architecture from Woodbury University in Los Angeles.