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Topographies of Resistance, Resilience, Bathymetrical Realities, and Dynamics of the Mekong and Sài Gòn-Đồng Nai Deltas

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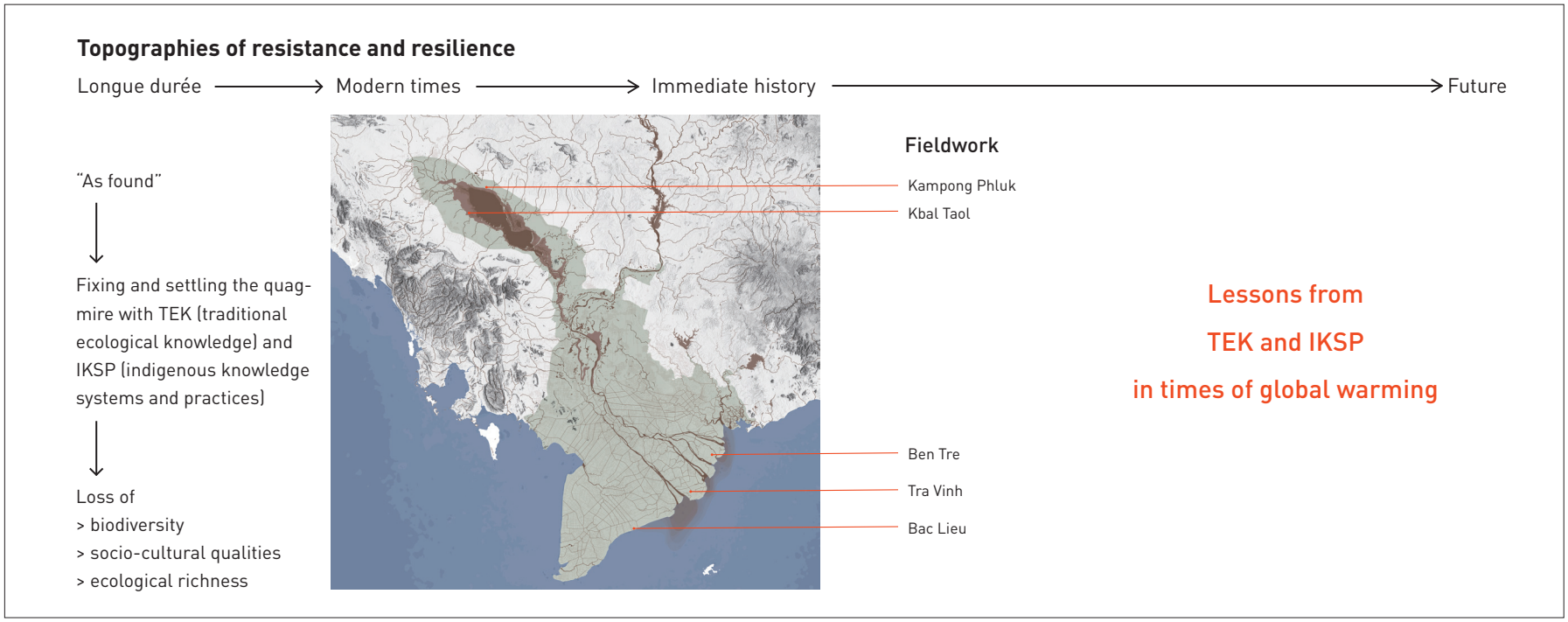
GRAPHICAL ABSTRACT



HIGHLIGHTS

- Topographical operations combine imprints of the *longue durée* and contemporary practices, and natural processes as a palimpsest continuously overwriting manmade interventions
- The "as found" water structure is the spatial register, despite of developmental delusions
- The categorial differentiation of land versus water should be replaced by degrees of wetness, and new strategies need to restore ecological systems

KEYWORDS

Micro-Topography; Quagmire; Mud; Degrees of Wetness; Vietnam; Cambodia; Resistance; Resilience

ABSTRACT

The Mekong Delta (across Cambodia and Vietnam) and the Sài Gòn-Đồng Nai Delta (where Ho Chi Minh City is embedded), like most deltas, are typically considered a vast, relatively flat water-dominated and dynamic territory characterized by always evolving variations of wetness, multiplying by that multitudes of biotopes. Ancient and modern engineering developed with this overly simplified preconception and subsequently radically transformed the entire ecotones into sharp and categorical distinctions of wet and dry, primarily to create productive and protective landscapes for humankind within abstractly ordered and static landscape structures. Fluid gradients in elevation and humidity were systematically replaced by fixed elevations. Extractive monocultures on massive scales resulted simultaneously in gigantic harvests but also the loss of ecology and biodiversity that is largely irrecoverable. The paper critically unravels the historical development of the deltas in relation to their homeopathic topography: how its manipulation framed development agendas—of productive landscapes, of settlement, and of infrastructure—and was linked to both cosmological worldviews and territorial geo-politics. The micro-topographies of the deltas were significantly altered by the mighty Khmer Empire and Nguyễn Dynasty and since the 19th century by French and American occupiers and subsequently by Cambodians and Vietnamese projects. The paper utilizes several case studies to reveal that IKSP (indigenous knowledge systems and practices) have harnessed topographical manipulation for context-specific socio-cultural reproduction. A host of local practices, often in peripheral geographies, has either escaped the relentless “modernization” process or locally adapted to and/or intelligently subverted the imposed supra-order. There is a strong resistance and resilience (subversive by humans and geological by the forces of nature including sea level rise and subsidence) to imposed topographical manipulation. The cases, arranged from the least to the most intrusive and controlling land management practices, underscore that the deltas remain a territory that is culturally, religiously, and productively nuanced by topographical transformation. At the same time, there is clearly an innate, ever-changing nature of deltaic physiography and topography, which is simultaneously an asset and a vulnerability.

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1 Flatland Geographies

The watery and volatile mosaic of the Mekong Delta is a *proof ad absurdum* (proof by contradiction) of topographical fixation in a fluid and dynamic water-and-mud plain eternally in the making and unmaking. The vast territory has been called a quagmire[1] that is continuously evolving and defined by fluctuating interplays of its (sediment-loaded) river flows, complex tidal and monsoon regimes and vegetal systems, as well as political ordering systems imposed on it by humans. Flowing surfaces of water and mud define, disintegrate, and continually remake an oscillating gradient of wetness. At the same time, humankind inscribes evermore modifications on the territory—attempting, in vain, to modify its *raison d’être* (reason for being) and requalify large components of it as a stable land mass. Natural processes of flooding, erosion, sedimentation, tidal rhythms, and monsoonal cycles are disturbed by intensive and extensive processes of micro-topographical operations—reclamation, control-oriented water management, multiplying embankment works and dikes, and road-based infrastructure development. In addition, the massive sand mining required for all engineering operations radically alters the bathymetry of the main river branches, in return catalyzing erosion, landslides, and other muddy revenges of nature, including massive subsidence that the Mekong Delta is increasingly witnessing. The *proof ad absurdum* will inevitably remain an ongoing exercise. Most recently, the delta is victim to upstream activities such as excessive dam construction, which is largely controlled by other countries and significantly alters the wetness of the mud plain in a wide variety of ways. The adjacent Sài Gòn-Đồng Nai Delta, a mud plain that merges into the Mekong Delta, is included in the study

area since the two deltas are socially, culturally, and economically inseparable.

The mighty Mekong River (called "Lancang River" in China, 4,750 kilometers long), a Lao word meaning "mother of rivers," originates high in the Tibetan Plateau, flows through China, Myanmar, Thailand, Laos, and Cambodia, and enters the South China Sea via Vietnam. The Mekong Delta [called "Sông Cửu Long" (Nine Dragons) in Vietnamese] is defined as the basin area downstream of the gauging station in Kratie, Cambodia (between steep hills, where seasonal sandbars emerge from the meandering river that hosts freshwater for Irrawaddy dolphins), along the Mekong River (called "Tiền River" in Vietnam) and its tributaries, including the Tonle Sap which seasonally reverses its flow and the Bassac (called "Hậu River" in Vietnam). The Tonle Sap Lake, the largest permanent freshwater lake and wetland ecosystem in Southeast Asia, is also included.[2] The lake is referred as the "beating heart" of the delta since it operates as a natural floodwater reservoir, protecting downstream areas during the wet southeast monsoon season (May to October) and assuring dry season flow (November to April) with peak high water level from August to November and peak low water level from February to April. Remarkably its surface area seasonally expands from 2,300 to 15,000 km^2 and its depth from 1.33 to 10.30 meters as the water flows seasonally reverses direction.[3] Today's Mekong Delta is the third largest tidal-dominated delta plain in the world. The Sài Gòn-Đồng Nai Delta was formed by alluvia deposits of the Đồng Nai River and the Vàm Cỏ and Saigon River systems. The Vàm Cỏ River joins the Soài Rạp in the Cần Giờ Mangrove Forest and is fed by two shallow tributaries, the Vàm Cỏ Tây (west) and the Vàm Cỏ Đông (east). The western elevations average is 40 meters above sea level, while the east has a mean between 23 ~ 30 meters.[4]

Over millennia, the delta areas have expanded rapidly seaward as a complex sedimentary environment in an arcing valley of red-clay (basaltic) hills stretching from Hồ Chí Minh City to Tây Ninh. Heavy sediment loads of fine silt and clay have been carried and deposited on what is now an extremely low-lying area. In the early Holocene, sea levels rose rapidly following the end of the last ice age 19,000 years ago to reach a level of 4.5 meters higher than the present; the ancient delta's sea reached Phnom Penh, the capital of present-day Cambodia. Both freshwater and sediment discharge have changed significantly over the past centuries. In the 1960s, the annual freshwater discharge was approximately 470,000 km^3, and the estimated annual sediment flux was about 130 ~ 160 million tons. In the 1990s, the sediment discharge decreased to 110 million tons and since then has witnessed an exponential decrease due to upstream dam construction and a significant increase of riverine and coastal sand mining. Large portions of the deltas have witnessed the deleterious effects from subsidence and saline intrusion.[5]

The Mekong Delta's modern, funnel-like morphology was formed during the last 7,500 years, as sea regression began allowing for the buildup of a subaerial delta. In the meantime, land prograded 220 kilometers eastward.[5] It is an extremely flat plain, bounded by a 16-meter high topographical contour, stretching approximately 300 kilometers inland. It has a tide-and-wave dominated sediment deposition process (with an average 2.5-meter semidiurnal South China Sea tides anddiurnal Gulf of Thailand tides of 0.8 ~ 1.0 meter), and is marked by the development of sandy chenier ridges in the lower plain and a system of back swamps behind riverbanks. The back swamps are surrounded by alluvial plains and low terraces, and often had (and continue to have in diminished areas) freshwater mangroves. Much of the delta's area consisted of dense, open savannah vegetation and inundated riverine and tidal forests. In research on traditional water management in the lower Mekong Basin, Willem Van Liere has referred to the Tonle Sap Lake as the region's largest backswamp (Fig. 1).[6]

2 Iterative "Fixing" and Settling the Quagmire

The simultaneous control and exploitation of the flooding regime of the Mekong and Sài Gòn-Đồng Nai Deltas has been defined by ways of settling with/in the territory for time immemorial and been the essence of innumerable contestations—between ethnic groups, between leaders and subjects, and between humankind and the forces of nature. The highly volatile process of wrestling the deltas from its water-logged state is considered to have begun as early as 400 BCE in an area which was then 200 kilometers far from the sea.[7] The Funan Empire, which thrived from the 2nd to the 6th century CE, was an Indianized pre-Angkor society based on international trades and advanced agriculture. Early Chinese emissaries visited Funan in 245 ~ 250 CE and in the *Wou li* (annals of the Wu Kingdom) they described Funan as a sophisticated country of people living in houses raised on stilts and ruled by a king in a walled palace, who controlled trade and managed a successful taxation system.[8] Archaeological investigations of Funan[9]~[11] reveal that there was once an intricately connected system of rivers and constructed canals of 200 kilometers that connected at least a dozen of political centers throughout the higher delta lands of present-day Cambodian provinces of Takeo, Prey Veng, Kampong Speu, Kampot, and Kompong Cham. The agrarian capital of Angkor

1. Geological formation of the deltas

Borei (in present-day Takeo Province) which was linked to Óc Eo in the lower, swampy present-day Vietnamese provinces of An Giang and Kien Giang. Angkor Borei is located on the southeastern edge of an elevated escarpment that is surrounded by low-lying wetlands in all directions except the northwest. Mapping begun by French photographers and archaeologists Pierre Paris (1941) and Louis Malleret (1959) and continuing to date revealed monumental architecture were believed to be enclosed by large earthen embankments, five canals southwards from Angkor Borei (which terminated at Óc Eo), moats, and large *barays* (reservoirs). Angkor Borei was considered a strategic location since its surroundings were ideal for rice cultivation and fresh water was available in shallow sand lenses. The more than 2.5-meter-deep, 50-meter-wide, and many-kilometer-long hypothesized canals have been used for both transportation/communication and irrigation/drainage.[12] These physical traces from antiquity establish early evidence of large-scale and highly engineered micro-topographical operations in the Mekong Delta.

The rather long explanation of the earliest known transformation and inhabitation of the delta serves as a *pars pro toto* for the near continuous engineering of the existing topography and hydrology. The region's high heat and humidity and rich alluvial soils have generated (and continue to regenerate) dense tropical vegetation. The quagmire of "heavy water-saturated mud" or "marshy swampy ground"[1] required difficult and laborious efforts to clear vegetation and dig canals to drain and irrigate the territory and generate embankments and high land platforms that facilitated settlement.

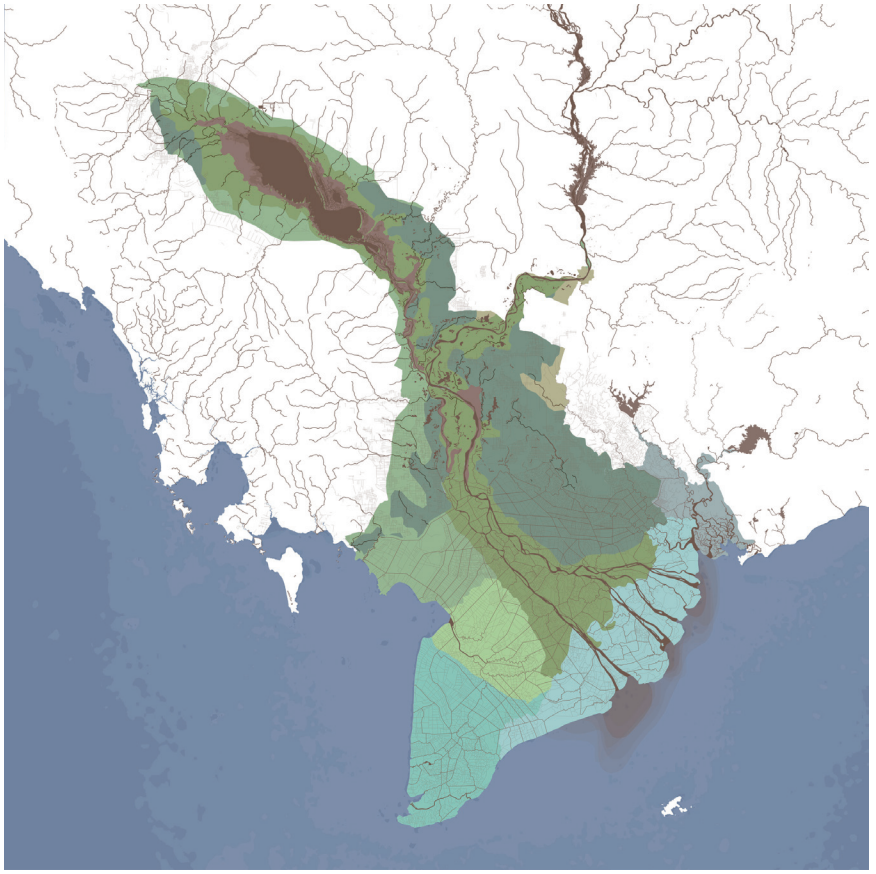
There have been progressive empires—from the Angkorian in Cambodia to the Vietnamese Cochin-China Empire of the Nguyễn Lords (1600–1774) to the Vietnamese Cochin-China Empire of the Nguyễn (1802–1862) that initiated settling with/in (in the sense of both inhabiting and dealing with the landscape) the delta. External colonizing forces accelerated the process, with the French Indo-China/Cochin-China (1862–1945) which transformed nearly the entire territory into an extractivist agro-industrial enterprise, Japanese occupation (1941–1945) and as an American protectorate with the Republic of Vietnam (1955–1975) which wrought long-lasting death and physically and socially destructive alterations to the topography and hydrology. Meanwhile, the Khmer Rouge (1975–1979) amazingly engaged radically in the extractivist agricultural production to finance the revolutionary restructuring of society and culture.

In more recent decades, neo-liberal influenced regimes (that tend to mimic the colonial extractivist policies) have developed quite particular and sophisticated systems of water management that allowed for various productive landscapes and ways of setting. Large lending institutions, including the World Bank (WB) and Asian Development Bank (ADB), as well as direct foreign investment are driving massive hard engineering projects that are flattening and raising the deltaic topography. Nonetheless, it was the French colonial enterprise that marked a crucial turning point when it came to scale and economic character, rather than the nature of the physical operations on the territory, that almost necessarily defined the topography as, by the nature of the terrain, the quagmire. A red line through all the grand schemes—from the pre-Angkorian times to today—was the belief that the region's wetlands and swamps where, from an imperial, revolutionary

or national perspective alike, are “wastelands” (a common worldview[13]). Low-lying topography was a deterrent to nation building and existing or surviving indigenous settlement traditions (but with mostly folkloristic value for touristic exploitation). The constant antagonism of actual earth and water—instead of the recognition of the territory as mud (in all variations of waterish mud and muddy water)—has led to the continual creation of more productive and useable “earth” by draining and excessive land filling.

All these go hand in hand with the mutation of a seemingly organic, continuously evolving fluvio-geomorphological organization of the territory into a seemingly fixed geometrical order. The patchwork of grids, with all conceivable scales and geometric variations, almost completely blankets the territory. It is noteworthy that until the recent massive urbanization, the whole transformation of the territory invariably began from the water and the construction of a water (infra)structure. It is a gigantic water lace and, as a fractal, reproduces itself into the smallest scale of mesh sizes and patterns. It is the region’s most important defining spatial structure. Additionally, one could argue that the bathymetry of the unique and incomparable lace of water elements is the result of the real base topographical operation that created and defined the current Mekong Delta. Looking to the Mekong Delta from its bathymetry—instead of merely topography—makes evident the illusionary fixedness of the entire operation. Maintaining navigable depth of canal floors, managing the bathymetry of rivers, combatting erosion of banks of rivers, canals and channels (not to mention coastal defense), repairing landslides along riverbanks (also due to excessive sand mining in the riverbeds) become challenges which are extremely difficult due to the logics of the region’s natural processes.

Yet, all is not uniform. Instead, the territory is highly differentiated by the underlying geological structure, which is heterogenous and active, resulting in specific geographies, micro-topographies, and complex hydraulics; the deltas can be broadly classified into eight important agro-ecological areas, excluding isolated (granite and limestone) hills and the Seven Mountains (Thất Sơn) area in Vietnam (Fig. 2). The areas correspond to soils (with various levels of salinity and acidity) and water conditions and drive the resource intensive productivity of the landscape. Embedded within the agro- and aqua-cultural landscape are also a few and relatively small reserves of nature that are protected by national and international law. The region’s richly interlaced river and canal systems and submerged forests are today home to Kinh (Vietnamese), Khmer, Chăm, and Chinese ethnic groups. The



2. Agroecological areas of the Mekong and Sài Gòn-Đồng Nai Deltas

indigenous knowledge systems and practices (IKSP)①[14] of local farmers and fishermen have created a territory with a rich gradient of wetness[15]~[18].

Gradients of wetness and slight, even minimal differences in topography, generate an astonishing biodiversity where everything is, to a certain degree, about simultaneity: land and water, forest and salt marshes, flora and fauna, birds and fish. Successive enterprises of hydraulic works allowed for the “green revolution” to flourish

① IKSP (indigenous knowledge systems and practices) is a term that is commonly used in The Philippines. It is similar to TEK (traditional ecological knowledge), a notion conceptualized in anthropology, but with a strong focus on everyday customs and practices.

(beginning with fertilizers and pesticides for agriculture and more recently with antibiotics for aquaculture). The agricultural-based economy was initially grounded in subsistence, but since colonial times it has been overwhelmed by an escalating race of ever-increasing economies of scale and productivity gains. Mangroves, which covered substantial parts of the “as found” landscape, have been cleared for settlement, exterminated by chemical warfare and lost in the conversion of brackish water landscapes into highly profitable (and environmentally problematic) shrimp farming.

According to van Liere, the oldest settlements were near the backswamps, and the natural levees were most likely not settled since they were covered with dense vegetation which would have required effort to remove. Traditionally, Mekong farmers preferred the alluvial plans where broadcast rice could be watered by natural flooding, because reclamation was relatively easy and there was a gentle flood regime. It was only later that more land clearing, levelling, and bunding of fields at the farm level (and through a cooperative effort at the village level) accommodated rice transplanted from nursery beds. The bunded-field (areas enclosed with small earthen dikes) farms were reclaimed from heavily forested low terraces and the work of clearing vegetation and rudimentarily leveling fields was labor-intensive. David Biggs, the environmental historian, has also noted that traditional locations of settlements in the delta responded to the complex hydrology and microtopography. In the progressive layering of settlement, those located on elevated land called miệt vườn (garden strips) became the densest areas. “The alluvial banks along rivers and canals as well as more ancient sand hills (gò) make up most of the high grounds (two to three meters above sea level) in the delta.”[19] The hydrologist Henry R. Anderson also noted that sand ridges (giồng) are typically several kilometers long, about 100 meters wide and average 3 ~ 5 meters above sea level (but can reach up to 8 meters).[20]

During progressive domestication processes, many micro-topographical variations and differentiations were replaced by a simple and categorical trichotomy: water (rivers, canals, and irrigation ditches), lowlands (paddy fields), and highlands (natural and man-made, including river or canal embankments that are generally stabilized by tree planting, landfill areas for urbanization, and naturally higher elevations of alluvium with orchards and vegetable production). Over time, gradients and transitions in the landscape were systematically exchanged for borders: organic for geometry, curves for orthogonal. Porous environments, where different habitats interpenetrated and overlapped, mutated

3. Productive landscape of the Mekong and Sài Gòn-Đồng Nai Deltas

in a juxtaposition of clear categories: water, paddy fields, and highlands that are stabilized with trees (Fig. 3). Topographically or bathymetrically defined, and unstable in reality, the lace of water structures is of extreme relevance. It is the main register of the Mekong Delta. It is also the most important and uninterrupted space of multiplicity that covers the whole delta. Most water channels and canals regulate—depending on the season—drainage or irrigation, and serve as fishing ground like all rivers and creeks a means of transport, and continue to host (a sadly decreasing) variety of species. The biodiversity of the water elements and their embankments starkly contrasts with the amazing extractivist monoculture of the surrounding lowlands. It seems that the whole ecological system of the delta is nowadays compressed into the water elements and their embankments. It is in this crunch zone, the compression of water elements and their embankments—

4. Interweaving of water and road infrastructures in the Mekong and Sài Gòn-Đồng Nai Deltas
5. Location of five case studies (two upstream and three downstream)

accounting for roughly 12%② of the delta's surface—that the whole range of water/land transitions and height/wetness gradients can be found today. It is where vegetation and fauna, other than productive monocultures, can still thrive. It is evident (and not surprising), but nevertheless noteworthy, that nearly the whole road system (until the coming of highways) encroaches on the embankments of rivers and canals (Fig. 4). The roads can be understood as collateral advantage generated by the construction of the Mekong Delta's register of the water networks of all kinds and scales. No wonder that the road structure underpins the heterarchical character of the Mekong Delta (regardless of all the policies that apply notions of hierarchy and centrality).

The Mekong Delta results from a dynamic interplay between the as found condition of the Tonle Sap and its floodplain, the sandy chenier ridges in the lower plain and a system of back swamps behind riverbanks, that are surrounded by alluvial plains and low terraces with mangroves—all elements with unique ecologies. The sub-regions are generated by the warp and woof interweaving of variations in soil (qualities), and the layered water register—generated over centuries of hydrological endeavors which modified the complex and layered riverine system. Such a dynamic interplay generates a wide variety of agro-ecological conditions, resulting in a multitude of local specificities, which explain themselves by the interaction between the as found soil, topographical and water conditions and the range of topographical/bathymetrical interventions on meso- and micro-scales overtime. It turns the Mekong Delta into an always evolving mega mosaic of local variations. It is indeed as Louis Malleret noted on the front page of his monumental archeology of the Mekong Delta, "this world is nothing else than mud and people passing by,"[21] leaving traces somehow that stay or simply erode, remain in use, are abandoned, or are simply reclaimed by nature.

Following episodes of intensive fieldwork and location-based sectional drawing, five cases—two upstream in Cambodia's Tonle Sap and three downstream near Vietnam's South China Sea coast—are developed to reveal the complex relation of topographical manipulation to local customs, worldviews and subsistence practices (Fig. 5). The topographical and bathymetrical operations are highlighted in relation to the

② Calculated from 2022 GIS drawing by RUA (Research Urbanism and Architecture) as the total water surface area of the topographical area below 16 meters above sea level and within the indicated Mekong and Sài Gòn-Đồng Nai Deltas region.

sacred landscape, particular ways of settling with changes of water levels and productive landscapes. They are arranged from the least to the most intrusive and controlling land management practices and underscore that the delta remains a territory that is culturally, religiously, and productively nuanced by topographical transformation.

3 Scattered Tombscapes and Sacred Forest Domains

Throughout the delta, the sacred landscape is the flipside of the productive landscape that is heterarchical and formed by a combination of government-led initiatives (including numerous war cemeteries and heroes' monuments) and local proto-anarchistic activity. The formal expression of the dispersed network of churches, pagodas, and temples reflects the plurality of both the delta's ethnicities and belief systems. Additionally, a vast vernacular constellation of ancestral tombs is dispersed within the landscape—as elevated markers in low-lying rice fields, on the margins of remnant forests, woven into the urban and rural settlement tissues. "Like salt and pepper, scattered over a plate, they flavor the cultural landscape […] Ancestral tombs are an obvious, self-evident part of the spaces of ordinary daily life and the everyday landscape. Spatially, life and death, the ordinary and extraordinary are naturally co-present."[22] Many clusters of tombs stand in stoic isolation while others are part of a more organized structure of cemeteries—including areas of geometrically organized (refugee) resettlements of the 1950s and 1960s and recent expansions within the productive landscape (Fig. 6). Tomb landscapes appear as rhizome-like fabrics that are continuously and tactically adapted. The landscape of the dead—since tombs are, in principle, sacred and therefore untouchable—suppresses the exploitation of land-use by market forces that nowadays mercilessly invades the territory of the living and causes a land-consumptive fever of development. Overall, they are the least intrusive regarding topographical manipulation since they tend to occupy either naturally elevated relief or discrete areas of artificial fill. In some instances, particularly in the larger, organized cemeteries, there are substantial fill operations to protect the tombs from seasonal flooding.

Just as the landscape of tombs subversively resists the market, so too are other sacred spaces that defy everyday controls and preoccupations and have an intimate relationship to land, water, vegetation, and topography. In terms of their siting, the Khmer temple complexes, or *wats*, explicitly create a powerful relationship with the landscape (Fig. 7). For the ethnic Khmer population③ who live dispersely in the Lower Mekong River Delta (Vietnam) and plains and highlands surrounding the Tonle Sap Lake of Cambodia, *wats* are more than religious structures, but part of an entire spiritual and socio-cultural ecology—serving as sites for a communal/cultural house, study halls of monks and

③ There are approximately 1.3 million Khmer speakers living in the Mekong provinces of Vietnam (primarily in Trà Vinh, Sóc Trăng, Kiên Giang, An Giang, Bạc Liêu, Cần Thơ, and Vĩnh Long), and 15 million in Cambodia. The Khmers in Vietnam are referred to as Khmer Krom; Krom means low or below (the southern lowland).

6. Omnipresence of the sacred landscape: cemetery in HCMC's west (Bình Tân District)

6 © RUA, 2022

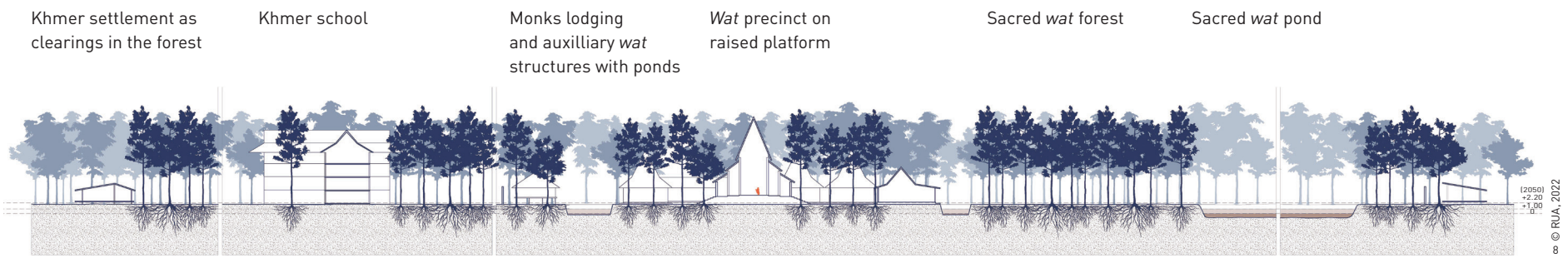
7. A complex of forest, pond, and platform *wat* in Trà Vinh.

7 © RUA, 2022

for Khmer children as traditional festivals and play spaces. The mundaneness of everyday practices is embedded within larger traditions and resonates worldviews. There is a pervasive mingling of the public/private, sacred/profane, living/dead, recreation/ritual. At the level of village, the *wat* is considered a "stronghold" to protect and preserve the capital and traditional culture of the Khmer people.[23] According to the belief system, "all things, including trees, land, and water resources, are all controlled by 'gods,' and people must strictly abide by the ban on the killing of creatures and contaminating water sources as two important components of the rules."[24][25] There is not only the application of ordering concepts for temple complexes, sacred gardens, and sacred ponds, but also the profane, yet "protected" residences surrounding temples. In terms of topography, these areas are most commonly located on naturally higher, forested lands. There is a land-levelling operation to create the temple compound. The *wats* are further elevated on a plinth and ancillary buildings are often elevated on stilts.

In Trà Vinh, a Vietnamese coastal province between the Hậu and Tiền Rivers, the Khmer Krom counts as more than 30 percents of the population (the second highest percentage after Soc Trang) and has over 100 *wats* and settlements.[26] The densely forested areas of the *wats* and settlements are evident in the broad expanse of the otherwise reclaimed open landscape. The highly choreographed sets of structures are built on high ground—natural or constructed through draining, cutting and filling—and surrounded by forests and/or lines of palm trees (Palmae). Trees are in general used on "higher" land in the Mekong Delta, amongst others as an evident means to combat erosion on embankments. In this case, the *wat* complex distinguishes itself by its carefully constructed (micro-)topographies and vegetation. As walled, forested domains, they appear as oases in the vast expanses of flat, shimmering rice and nowadays fast spreading aquaculture fields. Several gates give access to the temple precinct which is designed in the form of an isosceles triangle centering around the number three. There is always a main hall (in the center) which faces east, mortuary tower with urns and an assembly hall (all sitting on elevated platforms with stairs and roofs of three levels, each consisting of three folds) and secondary assemblages of monks housing, all carefully arranged in relation to (water) gardens, stairs, platforms, and corridors. All are embedded within the walled forest domain, which is elevated above the surrounding lowlands. Bà Om Pond, located in Trà Vinh's western periphery, is considered a "pearl" of the Khmer in the city.[24] The 1,100-square-meter sacred pond is also functional: it has low sand banks planted with large-shadow *Dipterocarpus alatus* trees which filter and hold freshwater. The pond nearby Ao Ông serves as freshwater reservoirs for the local villages when they are surrounded by salty water in the dry season. The Bà Om Pond is an important site for the Ok Om Bok Festival (full moon day in October) when offerings are made to the gods of Moon, Water, and Land "to thank them and to apologize for possible pollution of the land and water that human beings may cause during cultivation and in daily activities."[24] The role of the forested *wats* and ponds continues to adapt to both state regulations and evolving local traditions. Since 1975, and becoming stricter as time progresses, the government's banning of "superstitions" and the on-going process of Viet-ization of Khmer culture together with various development and improved service provision have challenged the sacred component of the *wat* (for instance, schools and government buildings are very often competitively located next to the *wat*). At the same time, economic development policies of the province's Department of Cultures, Sports, and Tourism have turned many *wats*, forests, and ponds of Trà Vinh into tourist attractions (Fig. 8).

8. Bà Om Pond and the *wat* complex in Trà Vinh



4 Stand-Stilt and Floating Living with/in the Tonle Sap Lake

Inhabiting the environs of Cambodia's Tonle Sap Lake is directly tied to the flood-induced changes on land and water, and to topography and bathymetry. The hydrodynamics of the lake has led to several researchers[27]~[31] to define a gradient of topographic and micro-agroecological zones between the lake and its surrounding dikes. The lake's floodplain consists of distinct habitat groups related to abiotic conditions, namely altitude and flood frequency:

1) Open water: –1.0 ~ 0 meters of sea level elevation, under water 12 months a year;

2) Gallery forest: 2.0 ~ 8.0 meters of sea level elevation, annual flood duration of 8 ~ 9 months;

3) Seasonally flooded habitats dominated by shrublands and grasslands: 5.0 ~ 8.0 meters of sea level elevation, flooded 3 ~ 5 months;

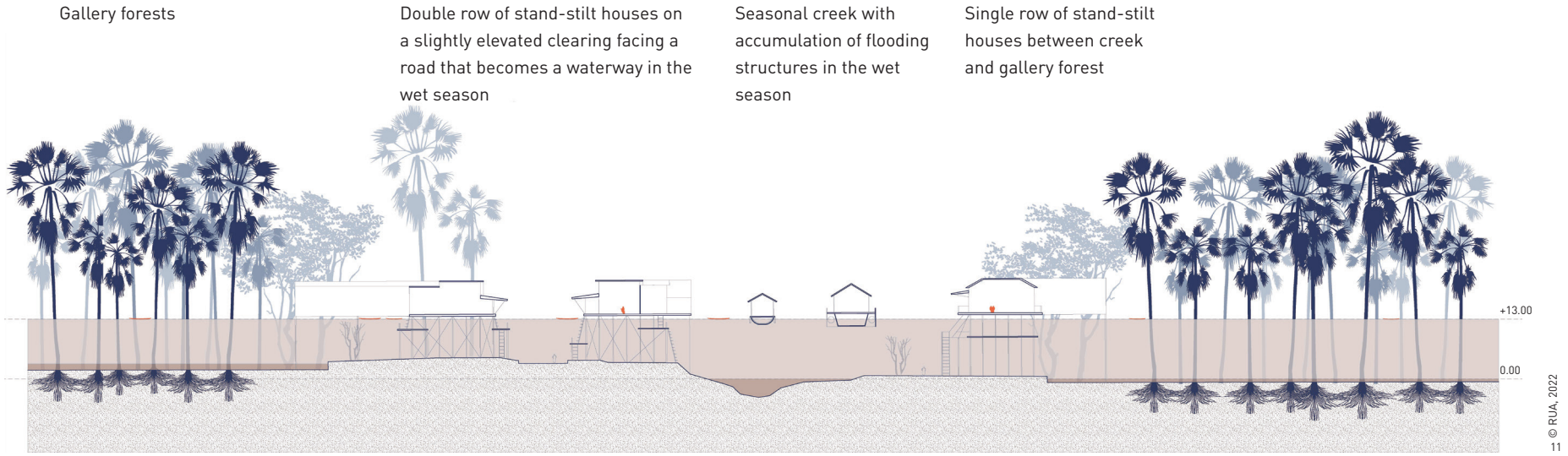
4) Transitional habitats, presently dominated by abandoned agricultural fields of receding rice/floating rice, and lowland grasslands: –5.0 ~ 8.0 meters of sea level elevation, flooded 1 ~ 5 months;

And 5) rainfed habitats, consisting mainly of wet season rice fields and village crops: 8.0 meters and higher of sea level elevation, flood duration less than 1 month.

Each area is further defined by biotic conditions (plants, fish species, and other wildlife)—all which correspond to various livelihoods and ways of settling with/within the watery environment.

There are historically two particularly noteworthy settlement typologies in the Tonle Sap. In the mid-19th century, Khmer people began to seasonally move onto the lake for subsistence fishing: this presence that became more common and permanent after the Khmer Rouge disbanded.[32] The first is floating settlements—currently housing approximately 80,000 people[32] in more than 50 villages[33]—they literally relocate themselves every few months as response to the changing topography and bathymetry. The movements and morphology of entire villages is highly dependent on their specific location and nuanced in relation to the dynamic water flows, widths, and bathymetry of waterways. They are formed and reformed as seasonal configurations. According to Nuorteva, Keskinen, and Varis, many floating villages "follow the changing lake shore, migrating several kilometers a year."[34] According to Tijen Roshko, today, settlement in floating villages is driven by a lack of land tenure, family disputes, economic issues, and lack of education and skills.[35] Floating villages consist of relatively small and simply constructed structures, most often with bamboo frames and palm leaf panels, but as well with inexpensive off-the-shelf construction materials, including corrugated metal sheets, MDF (medium density fiberboard), plywood, and laminated chipboard, and various prefabricated elements.[35] All the structures—housing, schools, churches, mosques, *wats*, petrol stations, shops, and social gathering areas—are constructed on separable bamboo rafts, and they float due to the buoyancy of metal barrels. As amphibian-type structures, they are sometimes disassembled from the barrel structure to inhabit stream banks. The five villages (Thvang, Kampong Prahok, Anlong Ta Uor, Prek Toal, and Kbal Taol, a total population of over 10,000) around the Prek Toal Core area of the lake's biosphere reserve, serve as interesting examples of subsistence communities permanently floating in the floodplain (Figs. 9, 10).[36] All the villagers are dependent on fishing and entire villages relocate in relation to the dynamic water level. Most generally, they congregate in the lake and its shore and in and along local streams for the dry season, and retreat furtherly inland during the wet season to avoid large waves and storms that frequent the lake's open waters. They also tend to have a configuration of linear rows that are dispersed and centrifugal during the dry season versus more concentrated and centipedal during the wet season. The floating villages are a living demonstration of *bricolage*, in the notorious distinction that Colin Rowe theorized between engineering: the abstract and preconceived, long-term, strict and expensive, controlling over all necessary resources and the spontaneous, opportunistic, agile and economic, working with available resources at hand.[37]

9. A fishermen's floating village toward the lake in the Prek Toal area in the wet season



10. A fishermen's floating village close to the lakeshore—Kbal Taol
11. Kampong Phluk standing stilt village

The other remarkable settlement type, outside of the Prek Toal core area, to the southeast, is the stand-stilt structure, located on or near patches of inundated gallery forests (with freshwater mangroves) and a stream, linking villages to the lake. Typically, two rows of 6 ~ 9-meter-high stilt structures face one another, along a road in the dry season and a waterway in the wet season. The buildings, dependent on wealth, are typically 3 ~ 8 meters wide and 6 ~ 20 meters long. The more than a century-old standing stilt commune of Kampong Phluk, on the eastern edge of the lake in Prasat Bakong District, Siem Reap Province, covers 14,249 hectares including settlement in three villages (3,707 population in 2019).[38] The area appears as an elevated clearing in the flooded forest. Most of the inhabitants are engaged in subsistence-scale fishing, which is more active in the dry season (Fig. 11).

Today, both settlement types still exist and resist successive waves of development policies and the uneven competition for fishing rights that have been systematically organized through concessions since colonial times. They demonstrate *proof ad absurdum* how to inhabit (also deal with) a dynamic landscape where water (depth and wave intensity) and land (height and wetness) alternate their presence seasonally. Topographical or bathymetrical intervention is absent. Settling immerses in the transformation of the as found condition.

5 Coconut Land

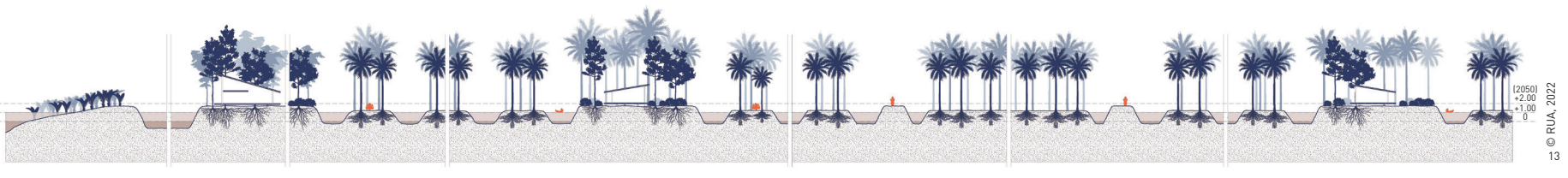
The downstream province of Bến Tre consists of three islets (An Hóa, Bảo, and Minh) formed by the four major branches of

12. Sand ridge coconut farms in Bến Tre

Tiền River—the Đại, Ba Lai, Hàm Luông, and Cổ Chiên—where the alluvial fan meets the South China Sea. The landscape is marked by numerous sand ridges and mounds, and the islets are crisscrossed by a fine-meshed system of canals and ditches that "navigate" between and around the ridges and mounds and are important for both transportation and irrigation. The hydrological regime is tied to the semi-diurnal tidal regime of the South China Sea, hydrological regime of the Tiền River where level of salinity vary greatly (0 ~ 12% and 12% ~ 30%, respectively) in wet and dry seasons.[39] The extremely flat terrain has rice fields, orchards, and vast coconut gardens, which thrive on the sandy loamy soil and brackish water (Fig. 12). Bến Tre is known as the land of coconuts and since French colonial times the perennial crop has become an industrialized and economic tree. In 2018, the coconut area of Bến Tre reached over 72,000 hectares (primarily in the upstream districts like Giồng Tôm, Mỏ Cày Bắc, and Mỏ Cày Nam), accounting for 42.5% of Vietnam's total coconut area (the largest percentage) and 0.6% of the global.[40] It hosts a range of species to support coconut production (with yields of more than 600 million coconuts/year) for the domestic and export market, and the region specializes in various coconut-based products including refined products (e.g., coconut candy, desiccated coconut, canned coconut milk, activated carbon, pure coconut oil, high value coconut masks made from nata de coco) and roughly processed products (e.g., raw coconut oil, raw nata de coco, coconut fiber and its products, sintered coal). The comprehensive value chain also includes a burgeoning handicraft industry. According to Bến Tre's Department of Agriculture and Rural Development (DARD), there is a mandate to make 30% of the coconut plantations organic by 2030.[41] In a study by the Ministry of Natural Resources and Environment (MoNRE) in 2010 to 2011, it was noted that although the region produces massive yields, most coconut gardens remain in the hands of individual farmers, the area of which averaged 0.5 hectares with a tree density of 170 trees/hectare.[42]

The geomorphology of Bến Tre evolved over millennia through sediment accretion (and its brackish water with clay mud, which is very fertile, rich in humus). Settlement naturally occurred on the higher sand ridges. The more than 300 year history of coconut farming has manipulated the topography to enhance agricultural productivity of this crop. Coconut plantations consist of alternating strips of raised beds and trenches. Local operations of soil cut and fill allow for both irrigation/drainage and improved soil conditions for the coconut trees; the 50-centimeter raised bed enhances thickness of arable land to avoid flooding. In many cases there is highly productive double cropping, with cocoa (and other crops) on the raised beds and fish/shrimp farming in the ditches (Fig. 13). Individual houses are located on strips of higher land,

13. Cut and fill, mounds, and irrigation channels of coconut farms in Bến Tre



and are dispersed within the clearings of vast coconut gardens. The coconut gardens inscribe themselves in the mesh of irrigation canals, and are organized within the more fine-mazed water distribution system through the creation of the raised plantation beds.

6 From Mangroves to Salt to Rice to Aquaculture to Energy

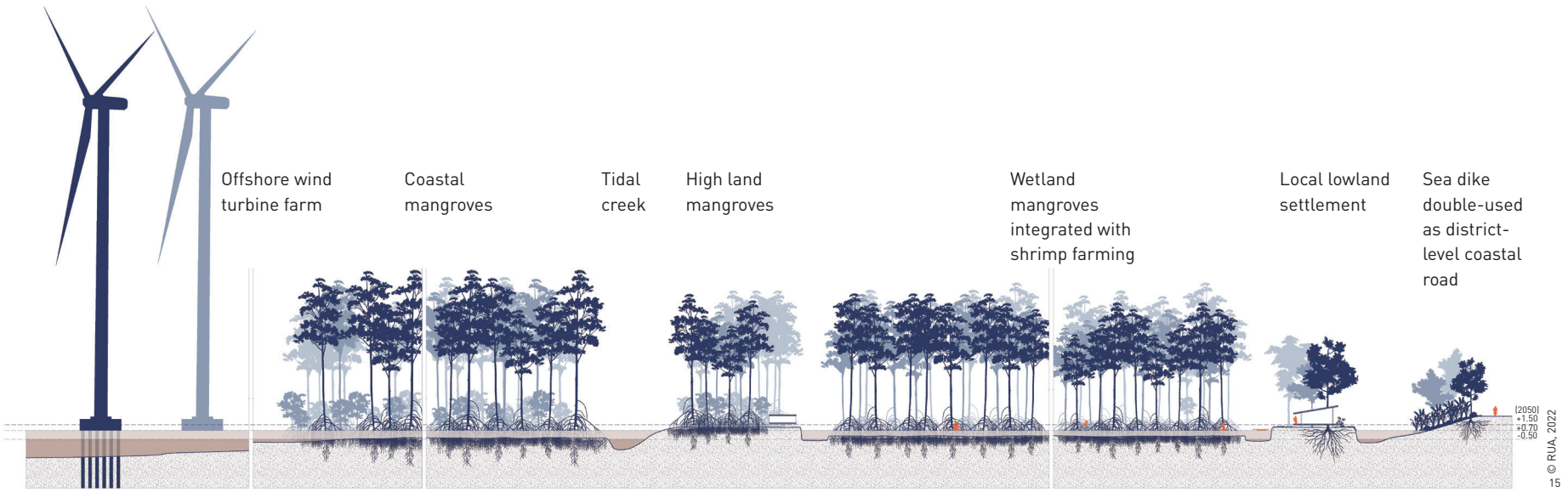
The South China Sea coastal plain is a distinctive region in the delta, historically defined by alternating rows of sand ridges and backswamps parallel to the sea. It is also an area marked by the strong impact of the semi-diurnal system of the South China Sea and diurnal system of the Gulf of Thailand. Mangrove forests are an important component of the tidal wetland ecosystem. Mangroves are the world's most productive and biologically complex ecosystems while also amongst its most fragile ecosystems. They thrive in hot, muddy, salty conditions that would kill most other vegetation. They work as connectors between aquatic and terrestrial ecologies and historically were breeding grounds for fish and other marine fauna, stopover spots for migratory birds, and hunting and grazing grounds for megafauna. They prove to be excellent water cleaning devices (not without being in the vicinity of growing cities) and furthermore store large amounts of carbon in biomass and soils, regulating sediment and water flows and providing coastal protection from the ravages of storms and floods. They actually "stabilize/fix" the plastic mud mass and make altitudes increase, be it very incrementally. They are considered particularly valuable in the context of increasing sea level rise and saline intrusion.

Bạc Liêu (population 1,062,959 in 2021) is a coastal province located in the southeast of the Mekong Delta. Its topography is very flat. The terrain slightly slopes from northeast to southwest, from the sea to the mainland. Bạc Liêu has 56-kilometer-long coastline which is characterized by a dynamic process of accretion and erosion. Originally the whole region was a quagmire and covered with mangroves. Different waves of development went hand in hand with systematic logging and draining on the land. The province (as well as its border provinces Sóc Trăng to the east and Cà Mau to the southwest) reveals a worrying tendency of a rapidly decreasing quantity and quality of mangrove forests. According to remote sensing monitoring research by Thi Cam Hong Huỳnh et al., in Bạc Liêu, mangroves declined precipitously due to wars, forest fires, logging of fuelwoods, conversion to agriculture and increasingly and alarmingly fast to aquaculture (highly profitable tiger-shrimp farming), and coastal development.[43] At the same time, most of the province is affected by saline intrusion. At one point in the history of the delta, Bạc Liêu took advantage of this situation and the area became the largest salt producer in the Mekong Delta. In the 1990s, the government built large dikes and sluice gates for sea defense to control saline intrusion and expand paddy production. The natural, direct relation of large parts of the mangroves with the sea was threatened. From 1994 to 2000, the area for rice cultivation dramatically expanded. At the same time, market force prompted farmers to invest in aquaculture (primarily shrimp farming), causing numerous conflicts of interest (Fig. 14). Sluice gates also create three distinguishable ecologies in the province all based on micro topographies and soil quality: 1) rice/fruit and vegetable production in the eastern districts, 2) a mixed rice and rice/aquaculture environment in the central districts and, and 3) a western area of saline/acid soils for a wide variety of sea-based products. Anthropogenic activities dramatically altered both the hydrology and biodiversity of the region to a point where it is no longer self-renewable.

Since 2000, aquaculture expanded aggressively in the central districts of Bạc Liêu. Lowlands and mangroves have become—through endless topographical operations—a sea of pond patterns, each pond stereotypically covered with a thick black plastic and each with minimal green on its embankments. Bạc Liêu is without doubt a top market for earth movers—small and large—plastic foil, and aquaculture antibiotics. With each operation the mosaic of paddy fields, orchards, and mangroves incrementally mutates into a dense configuration of ponds, ponds, and ponds, each of

14. Invasion of shrimp farms and wind turbines into the coastal mangroves of Bạc Liêu

14



15

15. Wind energy production and organic shrimp farming in the mangroves in front of the sea dike

them mechanically simulating the natural breeding grounds of shrimps, a shallow coastal water, reversing the centuries-old tradition to turn water-dominated terrain categorically in high and low lands by remaking a water-defined terrain in plastic. Today, aquaculture and fisheries are the main industries of the province (it generates a much higher revenue than the very labor-intensive cultivation rice or fruit). This drastic shift causes a profound socio-economic and ecological restructuring. The province also now has the distinction as being one of Vietnam's leading areas for transition to clean energy (particularly with regards to wind turbines, but also solar). The Bạc Liêu Offshore Wind Farm in Vĩnh Trạch Đông commune has 62 wind turbines constructed on the coastal mudflats, and the power generated is connected to the Vietnamese power grid (Fig. 15).[44]

7 Resistance and Resilience

Over the last two millennia, settling in the Mekong Delta has invariably meant dealing with the muddy water and waterish mud, step by step, transforming the quagmire into what it is today—a fabulous mosaic of productive landscapes with gradients of wetness, cascading infinitesimally from Kratie to the Tonle Sap and along the tributaries of the lower Mekong finally the South China Sea, descending a mere few meters over a few hundred kilometers. Over time, iterations continuously occurred between, on the one hand, imperial, colonial, revolutionary and national large-scale engineering schemes, defining precise and stable topographies and bathymetries out of the dynamic and organically formed wetlands and marshes, and, on the other hand, persistent and ingenious highly localized systems of settling—from the perspective of both inhabiting and dealing with—in the Mekong Delta. All the iterations intertwine with the dialectics between the state and communities, between the abstract engineering logic and concrete and local everyday practices, often subverting and resisting the imposed or supposed. The result is a unique interplay between the topography, hydrology, technology, and changing social and economic imperatives that resists stasis and continuously unfolds.

Among all the forces, nature invariably reclaims its dominant place. The archeological remnants of the canals radiating southwards from Angkor Borei, with moats and large barays demonstrating a revenge of the muddy nature of the Mekong Delta. While under the aegis of the WB, ADB, and other lenders and backed by investments from Japan, China, the Netherlands, and other countries, new (invariably larger scale) blueprints are unremittingly unfolding, and will continue to redefine the delta's micro-topographical and bathymetrical "print plate" in an attempt to stabilize its physical terrain and increase its economic productivity. And yet, the natural processes and anthropogenic climate disruptions will undeniably impact

these blueprints: global warming will radically change rainfall patterns (causing both devastating floods and droughts that were inconceivable until recently) and cause sea level rise (with a gigantic impact for this region as the world's most settled low-lying lands), while systemic and irreversible subsidence is the natural consequence of exaggerated ground water extraction and accelerating urbanization. A redefinition of the relation of water/land, topography/bathymetry is necessary either by intelligent reconceptualization of humankind's action, or by the merciless laws of nature. It seems imperative that not only the perpetually hard engineering perspective informs the resetting of terms, but also the highly localized systems of settling with and within waters that communities developed over millennia. The practices that demonstrate how to work with/in the natural forces of water and land (instead of invariably fighting the muddy realities) deserve more attention than they currently receive from planning professions and policy makers.

Both large-scale engineering projects and IKSPs of the delta's inhabitants have transformed the territory's topography into a rich gradient of wetness—defining a mosaic of dwelling environments and productive landscapes. As taken earlier form Louis Malleret, the deltaic "world is nothing else than mud and people passing by"[21]. This "passing by" continuously produces and reproduces the landscape by topographical operations, at small and large scales, strategic and tactic, turning mud into water and "high" and "low" land (registered on a scale of centimeters). Clearly, the challenges of global warming and the relentless building of dams upstream, are inevitably, radically, and dramatically shaking up the "muddiness" of the Mekong Delta to unprecedented degrees. It will necessitate the continued interplay of hard and soft engineering, but in radically new ways. It will require the invention of wholly novel modes of inhabitation with wetter and dryer, warmer and more vulnerable ecologies. Undoubtedly, the Mekong and Sài Gòn-Đồng Nai Deltas will prove a laboratory for testing humankind's ingenuity in the impeding crises of transforming topography and territories for lives and livelihoods. Working with the muddy forces of nature, that anyways will have a dominant role in this transformation, seems more significant than indicated.

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湄公河和西贡内河三角洲的抵抗力、韧性、水文环境及动态变化的地形学研究

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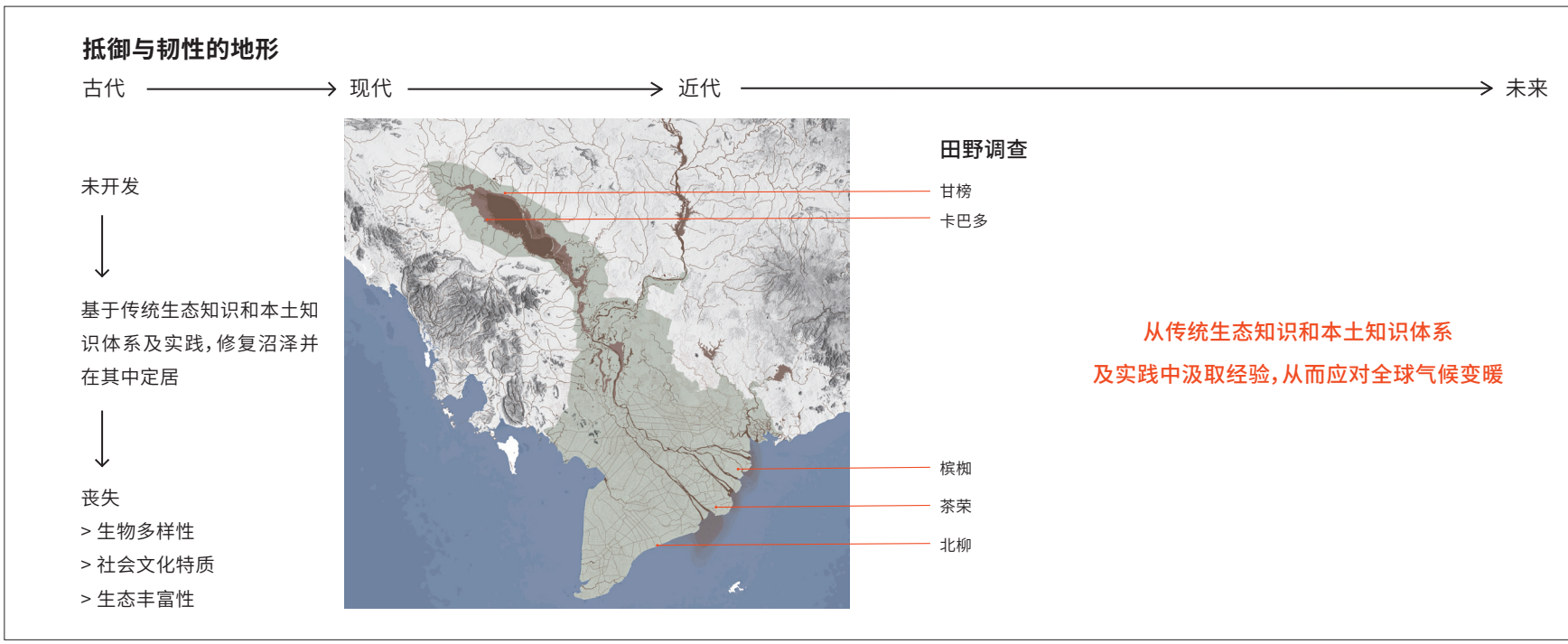
图文摘要



摘要

湄公河三角洲和西贡内河三角洲与大多数三角洲一样，通常被认为是一个广阔、相对平坦的动态水域，其特点是水体形态丰富多样，生物栖息地众多。在这种过于简化的理解之下，古代和现代工程学为了在人造生产性和保护性景观中建设抽象意义上的有序而静态的景观结构，将整个交错群落区彻底转变为干湿分明的区域，海拔和水湿条件的流动梯度也逐渐被固定的海拔高度所取代。大规模攫取式的单一耕作在带来巨大收获的同时，也造成了生态和生物多样性的丧失，而且这种丧失在很大程度上是无法修复的。本文批判性地揭示了三角洲的历史发展与其顺势地形之间的关系：如何利用地形来制定生产景观、居住环境和基础设施的发展规划，以及如何将地形与宇宙世界观和领土地缘政治联系起来。通过案例研究，本文揭示了本土知识体系及实践利用地形改造所进行的特定社会文化再生产。通常而言，边缘地区的大量当地实践要么逃脱了无情的“现代化”进程，要么在当地适应和 / 或巧妙地颠覆了强加的超秩序，体现了（对人类颠覆力和大自然地质力）强大的抵抗力和韧性。这些土地管理实践案例的侵扰性和控制性各不相同，但都强调了三角洲仍然是一个在文化、宗教和生产上都因地形变化而产生微妙变化的地区。同时，三角洲的自然地貌和地形显然具有不断变化的内在特性——这既是一种天然的资产，也是一种脆弱的劣势。

文章亮点

- 地形改造是古代印记和当代实践的复合体，人工干预措施在自然过程中不断演变
- 无论发展蓝图多么宏大，“未开发的”水体结构仍是当地的主要空间类型
- 应以水湿程度取代干湿分明的区划，并采取新的战略来修复生态系统

关键词

微地形；沼泽；淤泥；水湿情况；越南；柬埔寨；湄公河和西贡内河三角洲；抵抗力；韧性

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