

From Coast to Inland Moats: The Maritime Archaeological Landscape and Settlement Patterns of the Western Lower Central Plain in the Late First Millennium CE

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This paper re-evaluates the ancient riverine networks of Nakhon Pathom and Ku Bua, demonstrating that they were inland settlements situated within seasonal freshwater floodplains rather than active coastal zones. By examining both terrestrial and maritime archaeological evidence, the paper proposes a transport model for the Lower Central Plain of Thailand, whereby large sea-going vessels offloaded cargo onto indigenous rivercraft destined for major inland cities. The research identifies key constraints, such as shallow, meandering inland waterways and adverse wind conditions, that prevented massive vessels from sailing directly inland. Finally, the paper suggests that continuous deltaic progradation shifted the coastline southward and silted up vital waterways, precipitating the decline and eventual abandonment of these cities.

Keywords: Dvaravati, maritime archaeology, riverine networks, lashed-lug tradition, Phanom-Surin

Introduction

In the area of Lower Central Plain, Thailand, numerous settlements can be found along the edge of the maximum Holocene marine transgression, in areas that served as seasonal floodplains during the Dvaravati period (Hutangkura, 2014, p. 26). Settlements in the northern Lower Central Plain comprise several notable cities, such as Kok Mai Den in Uthai Thani Province, Ban Khumuang In-Buri in Singburi Province, and U-tha pao in Chainat Province. These cities are situated in the region between the Chao Phraya and Noi rivers (Khaokhiew, 2018). Further east, along the Lopburi River (which separates from the Chao Phraya River) (Khaokhiew, 2018, pp. 3-19), cities such as Lopburi, Keed Kin in Saraburi Province (Kachachiva, 2008, p. 60), Dong Marum, and Promathin Tai dominated the region during the Dvaravati period. Meanwhile, settlements in the Pasak River basin are represented by the cities of Srithep in Petchabun Province and Sap Champa in Lopburi Province. In the eastern part of the Lower Central Plain, which is traversed by the Bang Pakong and Nakorn Nayok rivers, numerous rich settlements flourished. Examples in this area include Dong Lakhon in Nakorn Nayok Province, Sri Maha Poe and Sri Maho Sot in Prachinburi Province, Prarot in Cha Cheng Sao Province, and Sri Pralo in Chon Buri Province (Khaokhiew & Suphachanya, 2005, p. 60). Dvaravati settlements are typically dated to the 6th-11th centuries CE (Cœdès, 1975).

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The Lower Central Plain, which is the primary focus of this paper, is traversed by three major rivers: the Chao Phraya in the centre, the Tha Chin to the west, and the Mae Klong further west. These rivers flow into the Gulf of Thailand at various locations. Massive ancient cities were established along these waterways, including Nakhon Pathom and Kamphaeng Saen on the Tha Chin River, and Ku Bua on the Mae Klong River. This paper will discuss these locations alongside the archaeological evidence found within them.

The scope of this research covers the Tha Chin and Mae Klong River basins in the western region of Thailand's Lower Central Plain. Specifically, the study focuses on a cluster of Dvaravati settlements situated in this area and their associated finds. This paper proposes that extensive riverine communication networks existed in the Lower Central Plain during the Dvaravati period. It is designed to provide evidence showing that Dvaravati cities, while often settled near the main rivers rather than directly on their banks, were intricately linked to them by a network of canals. Furthermore, the discussion will include shipwrecks as empirical evidence of trade and contact via these water networks.

Geomorphology and the Study of Ancient Settlements of the Western Lower Central Plain

The mid-Holocene marine transgression significantly impacted the geomorphology of Southeast Asia. While early research provided a general overview of fluvial sedimentation in Thailand's Lower Central Plain (Takaya, 1969, pp. 299-300; 1972, pp. 317-319), later studies mapping "Bangkok clay" offered clear evidence that marine transgression reached Ayutthaya around 8,000 BP (Rau & Nutalaya, 1983, p. 107; Somboon, 1988, p. 203; Somboon & Thiramongkol, 1992, p. 57). Tanabe et al. paper in 2003, further refined this by modeling the maximum Holocene shoreline and the subsequent coastal progradation to the present day (Tanabe et al., 2003, p. 791).

This geomorphological context sparked debate regarding the 3rd-century CE Dvaravati settlement patterns. Initially, Wanasin and Suphachanya (1982) hypothesised that Dvaravati cities functioned as coastal ports situated along the edge of a maximum transgression bay. They proposed that ancient sea levels in this "Dvaravati Bay" reached 4 metres above present-day levels (Wanasin & Suphachanya, 1982). However, Hutangkura's paper published in 2014, criticised this spatial model for lacking chronological and paleoenvironmental support (Hutangkura, 2014, p. 17). Using palynology, Hutangkura identified four distinct ecological zones and argued that major Dvaravati cities were actually situated in seasonal floodplains rather than directly on the coast (Hutangkura, 2014, pp. 31-40).

Subsequent research emphasised the riverine and canal networks connecting these settlements (Khaokhiew & Suphachanya, 2005, p. 64). Khaokhiew proposed that western cities like Nakhon Pathom and Ku Bua functioned as inland ports linked to the sea via massive estuaries (Khaokhiew, 2018, pp. 2-5).

Site Formation Process of Dvaravati Cities in the Western Lower Central Plain

The Southeast Asian region has experienced marine transgression since the mid-Holocene. Sedimentological investigations have evaluated both the spatial extent of marine transgression and associated shifts in river systems.

In Thailand, research on marine transgression across the Lower Central Plain began in the 1970s. Early studies of deltaic sedimentation in the southern sector outlined fluvial sediment development (Takaya, 1969, pp. 299-300; 1972, pp. 317-319); they offered limited insight into the maximum inland reach of the transgression. Subsequently, isopach mapping documented the distribution and thickness of transgressive marine deposits,

termed the “Bangkok Clay” across the plain. This unit extends northward from the modern shoreline to Ayutthaya Province, providing definitive evidence of marine inundation (Rau & Nutalaya, 1983, p. 107; Somboon, 1988, p. 203). Chronological analyses further date the onset of Bangkok Clay deposition to approximately 8,000 BP (Somboon & Thiramongkol, 1992, p. 57).

In 2003, Tanabe and colleagues refined these spatial and temporal frameworks by modeling the sediment distribution, delimiting the maximum inland Holocene shoreline, and reconstructing the progradation of the Lower Central Plain from 8,000 BP to the present day (Tanabe et al., 2003, p. 791).

Geomorphological research in Thailand’s Lower Central Plain began significantly influencing archaeological interpretations of 3rd-century CE coastal settlement patterns with the publication of Wanasin and Supachanya (1982). Their study established a relationship between Dvaravati settlement distributions and deltaic progradation across the central plain. Based on sediment analysis and spatial assessments, Wanasin and Supachanya hypothesised that Dvaravati urban centres functioned as coastal port cities established along the perimeter of the maximum Holocene marine transgression. They posited that mid-Holocene Sea levels rose approximately four metres above present levels, restricting settlements to elevations above four metres and forming what they identified as the “Dvaravati Bay” (Wanasin & Suphachanya, 1982).

This model has since faced significant criticism. Hutangkura argued that relying primarily on spatial and surface geomorphological observations without robust chronological controls was insufficient to reconstruct paleoenvironments, rejecting the characterisation of Dvaravati settlements as maritime coastal ports (Hutangkura, 2014, p. 17). Employing palynological analysis tied to absolute chronological dating, Hutangkura challenged the earlier framework by identifying four distinct paleoecological zones across the Lower Central Plain: floodplain ecology, marine-freshwater transitional ecology, brackish (mangrove) ecology, and marine ecology. Consequently, the study concluded that major Dvaravati settlements were situated within seasonal freshwater floodplains (Figure 1), rather than along active coastlines (Hutangkura, 2014, pp. 31-40).

Khaokhiew and Suphachanya expanded on this geoarchaeological perspective by evaluating how fluvial transport networks, water management systems, and socio-spatial settlement patterns evolved among populations established along the paleoshoreline (Khaokhiew & Suphachanya, 2005, p. 64). Focusing on specific urban centres, Khaokhiew demonstrated that the Dvaravati centre of Nakhon Pathom was situated approximately 6 km north of an ancient marine estuary. Khaokhiew argued that a cluster of western Lower Central Plain Dvaravati sites, most notably Nakhon Pathom and Ku Bua functioned as riverine port settlements connected southward to open maritime routes via this expansive estuary, while maintaining overland and fluvial trade links with interior centres to the north (Khaokhiew, 2018, pp. 2-5).

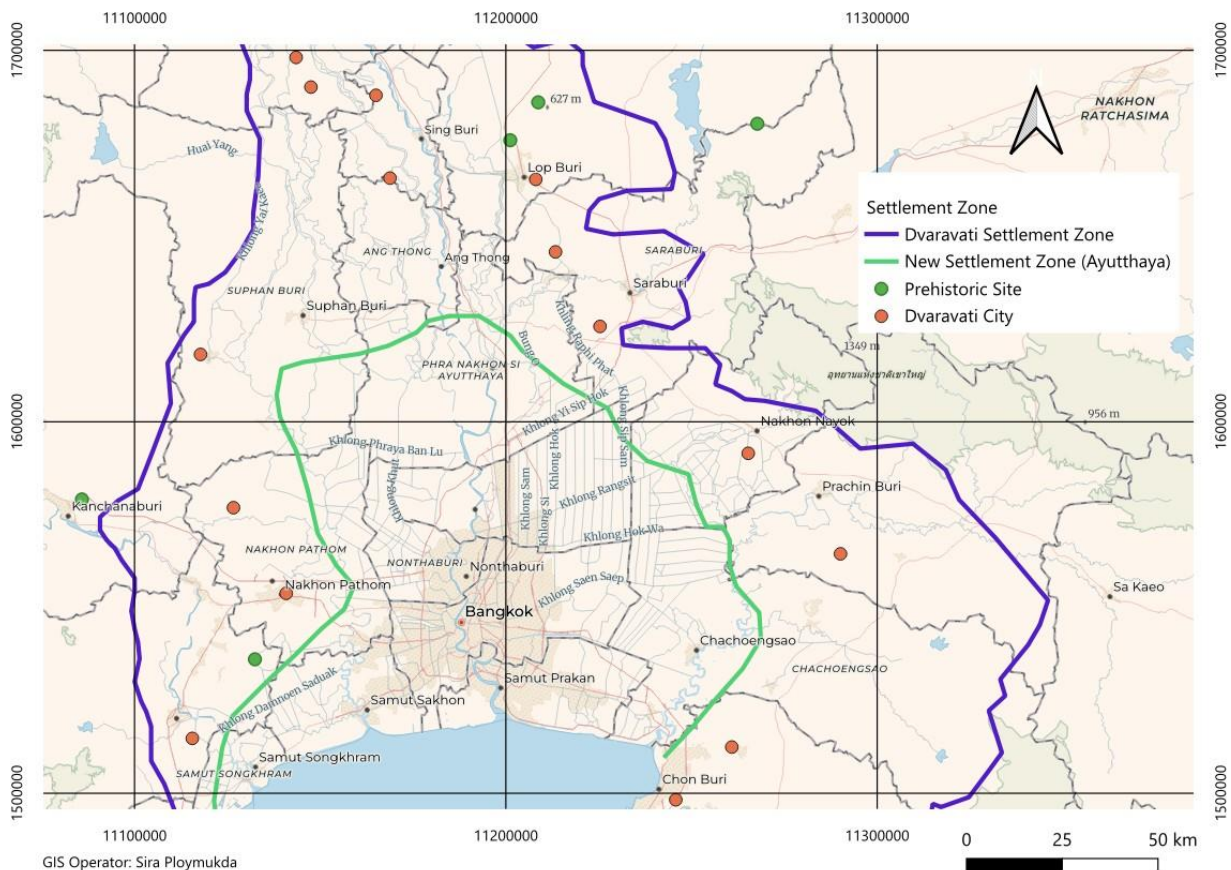


Figure 1. Settlement patterns of Dvaravati cities (7th-11th century CE) relative to reconstructed settlement zones of the Dvaravati and Ayutthaya (later) periods, illustrating the strong spatial alignment of Dvaravati sites within their projected zone. After Hutangkura, 2014.

The Riverine Network of the Western Lower Central Plain, Thailand

Focusing on Nakhon Pathom under Dvaravati influence, the ancient city is defined by a rich of Dvaravati monuments and artifacts, as well as prominent moat-and-mound earthworks that remain visible today. The settlement was connected to surrounding rivers and waterways via a complex moat network that served both for water management and regional navigation. To the north, water channels, such as the Chedi Bucha Canal seen today, further facilitated movement between the city and key trade routes (Khunsong, 2014, p. 5); it connects to an eastward canal extension excavated in 1858 to establish a waterway between the Nakhon Chai Si reach of the Tha Chin River and the city centre of Nakhon Pathom (Chao Phraya Thipakornwongsa, 1934, p. 223). This moat was historically fed from the northeast by Khlong Sam Khwai Phueak, which provided a direct shortcut from Khlong Thong Sai in the north. Additionally, Khlong Bang Kaeo (present-day Khlong Thammasala) originates to the northwest, traverses the northern moat eastward, cuts across the eastern moat, and flows approximately 20 km downstream to join the Tha Chin River in Nakhon Chai Si District (Khunsong, 2014, p. 6).

Khlong Bang Kaeo also links with Khlong Bang Ratho south of the settlement. This junction lies approximately 1 km west of where the Bang Kaeo channel meets the city moat at Buang Kum (BK), an extensive marshland formed by the convergence of three canals. While the western moat lacks direct natural canal junctions, its northwestern corner joins the modern westward extension of Chedi Bucha canal, which traverses modern

central Nakhon Pathom. From the northeastern corner of the moat, Khlong Bang Toei extends southwest for approximately 6 km before turning northwest for 22 km, discharging into the Mae Klong River at Pak Bang.

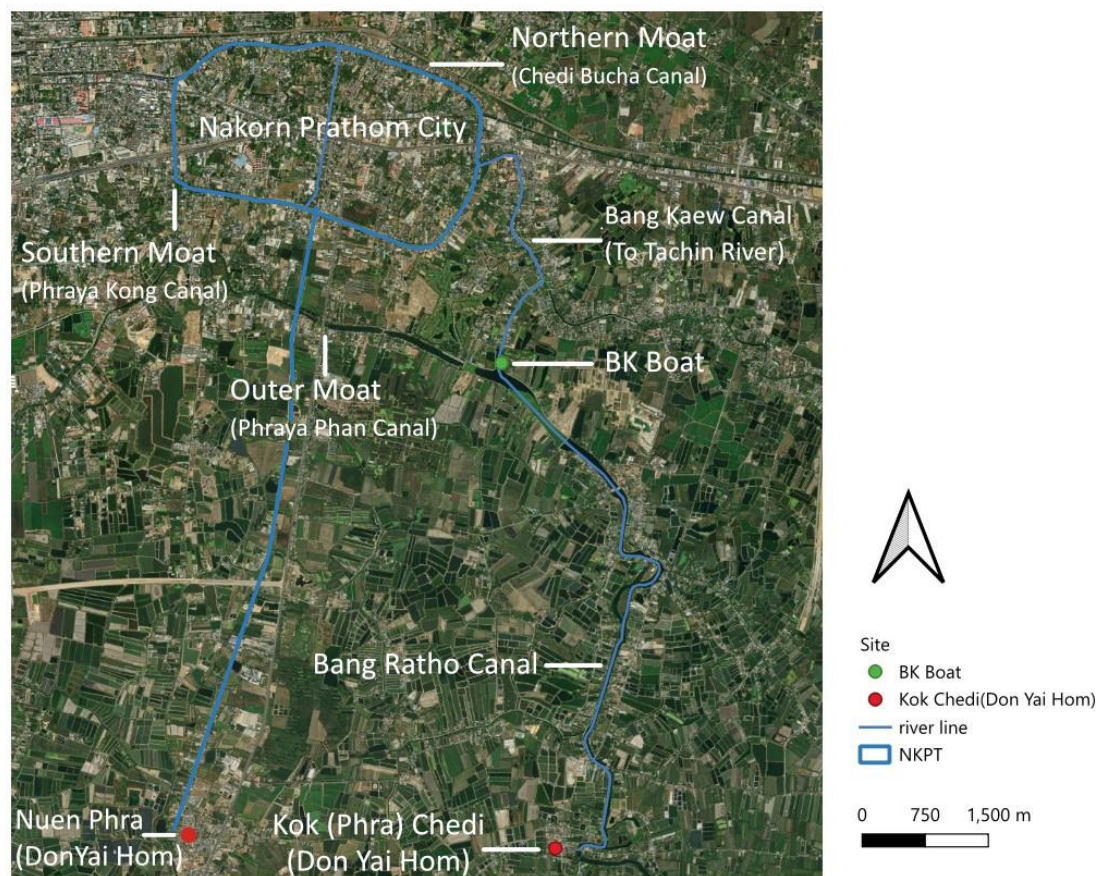


Figure 2. The canal network linking the ancient city of Nakhon Pathom to the settlement at Khok (Phra) Chedi (Don Yai Hom), indicating the find location of the BK boat.

The southern sector exhibits an even more intricate fluvial network. The southern moat, known locally as Khlong Phraya Kong (Khunsong, 2014, p. 5), connects via a short, unnamed north-south cut to Khlong Phraya Phan, an east-west channel running parallel to the southern moat. From here, the drainage network diverges into two primary branches; The Southern Branch: Khlong Thanon Khat runs directly south toward the Dvaravati settlement of Don Yai Hom, site of the Kok Phra Chedi monument (Figure 2). This channel is widely interpreted as an engineered transport canal dating to the Dvaravati period (Khunsong, 2014, p. 7). Sedimentological and spatial analyses place Don Yai Hom at the upper margin of an ancient Dvaravati estuary (Khaokhiew, 2018, pp. 4-26). Ongoing deltaic progradation displaced the coastline southward toward its modern configuration by approximately 1,000-800 BP (Khaokhiew & Suphachanya, 2005, p. 61). This environmental transformation offers a compelling explanation for the decline of Nakhon Pathom, as Khlong Bang Kaew shifted course and ceased replenishing the urban moat system (Khunsong, 2014, p. 168); The Southeastern Branch: Khlong Phraya Phan links eastward to Khlong Bang Rakam, which turns south for roughly 6 km before joining the Tha Chin River in Sam Phran District. Sediment analyses indicate that the upper reach of this channel was anthropogenically modified in antiquity, likely through dredging to enlarge a natural channel into a navigable

waterway (Khaokhiew, personal communication in 2023). Khaokhiew suggested that Nern Phra in Don Yai Hom was situated on a Dvaravati estuary bar less than 1 km from the major Dvaravati estuary. Furthermore, an ancient canal network linked Nern Phra both to the estuary and to Nakhon Pathom (Khaokhiew, 2018, pp. 3-26), which he suggests the Dvaravati people used for transport and navigation from the city to the sea (Khaokhiew, 2018, pp. 4-26).

To the west of Nakhon Pathom lies Ku Bua, a contemporary Dvaravati major city situated within the Mae Klong River basin. Ku Bua was another prominent port city of the Dvaravati period (Wicks, 1992, p. 158), as demonstrated by archaeological assemblages indicating maritime and riverine trade functions.

However, Ku Bua itself was not positioned directly along the ancient coastline. Instead, it likely functioned as an inland regional hub that relied on contemporary satellite communities serving as outports or coastal landing points. A prime example is the Kok Prik archaeological site, located approximately 3 km east of Ku Bua. Kok Prik was connected to the ancient city of Ratchaburi via Khlong Aom, a distributary canal that linked into the Mae Klong River system (Depimai, 2025, p. 6).

Occupation at Kok Prik dates back to the prehistoric period; excavations have yielded human skeletal remains alongside diverse material assemblages (1st Regional of Fine Arts Ratchaburi, 2008, pp. 79-80). The site is also recognised as an important foundation for subsequent historic-period settlement in the area (Fine Arts Department, 1991, pp. 75-76). Furthermore, Vallibhotama hypothesised that Kok Prik served as an operational port where boats docked. The site connected directly to Ku Bua via Khlong Tha Sanun (Figure 3). Regional interaction and exchange were likely conducted through this complex network of rivers and canals (Vallibhotama, 2020, p. 44).

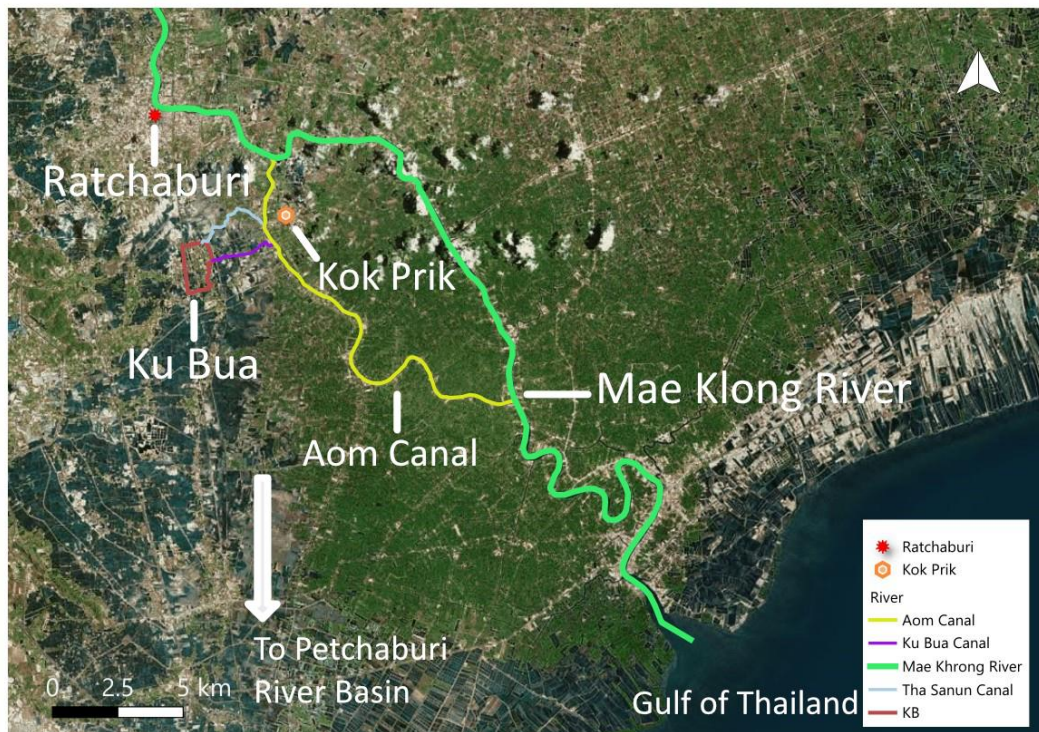


Figure 3. Regional map showing the interlinked sites of ancient Ratchaburi, ancient Ku Bua, and the Khok Prik settlement, connected via Khlong Aom, Tha Sanun Canal, Ku Bua Canal (satellite canal) and the Mae Klong River leading into the Gulf of Thailand.

Similarly, Depimai identified this settlement as the “Kok Prik trading community”, interpreting it as a primary riverine landing station, harbour, and maritime customs checkpoint that received incoming merchant vessels before they proceeded upriver to Ku Bua, the major trade centre of the Mae Klong basin (Depimai, 2025, pp. 320-321). Depimai summarises that Western Lower Central Thailand evolved from a prehistoric agricultural community at Khok Phlap into a trade station at Khok Phrik, before peaking as the Dvaravati cultural centre at Ku Bua. When river course changes silted up the Aom Canal, the centre moved to present-day Ratchaburi (Jayarajapuri) along the Mae Klong River. Bridging the sea and inland regions, it served as an enduring transregional trade hub connected to Zhou and Tang-Song China, the Dong Son culture, Indo-Roman networks, and Srivijaya. Religiously, it transitioned from early Theravada and animism to Pala and Bayon-style Vajrayana Buddhism under Jayavarman VII (Wat Mahathat), before Lankavamsa Theravada Buddhism eventually became dominant (Depimai, 2025, pp. 321-340).

Lashed Lugs Boat and Its Significance to the Riverine Transportation

The Bueng Kum vessel (BK) was discovered in June 2015 near Khlong Phraya Phan canal and Khlong Bang Ratho canal. The remains were uncovered during sediment dredging operations along Khlong Bang Ratho in the Bueng Kum area, situated within the archaeological perimeter of the ancient city of Nakhon Pathom.

The discovery was first reported to Puangsamli, president of the Sri Dvaravati Social Enterprise, by Nakchamnan, a local resident of Thammasala subdistrict. Nakchamnan noted that dredged spoil mounds contained numerous Dvaravati-period potsherds, both inscribed and uninscribed, alongside faunas and antlers. An initial site survey conducted later that year by local residents, researchers from the Sri Dvaravati, and scholars from Silpakorn University recovered critical Dvaravati material culture alongside structural fragments of the BK vessel (Boonyanit, 2015).

The site was subsequently inspected by officials from the 1st Regional Office of the Fine Arts Department. In 2023, the 2nd Regional Office of the Fine Arts Department collaborated with the Underwater Archaeology Division and Boonyanit, a senior librarian at the Western Region Information Centre (Sanam Chandra Palace Library, Silpakorn University), to transfer the diagnostic boat timbers into formal conservation treatment (Boonyanit, personal communication, 2023).

BK boat featured by lashed lugs tradition, it is the Southeast Asian plank fastening technique which the planks were laced by discrete lashing to the predrilled holes, then passed through the edge of each plank, and then came off at the inner face of planks and these lashing ropes cannot be seen from the outside of the hull (Manguin, 2021, p. 137). Another distinctive character is that the boat frames were laced to the cleats, lugs, or sometime called Tambuku (Malaysia) (Manguin, 1993, p. 260) as well as the using of rope to fasten the planks without the using iron nails (Manguin, 1980, p. 269).

Chinese historical archives from the first millennium CE frequently record large Southeast Asian ocean-going vessels known as *Kunlun Bo* (Manguin, 1993, pp. 261-262). Archaeological evidence confirms that the lashed-lug shipbuilding tradition flourished across Southeast Asia from the 1st century CE onward. AMS dating of lashed-lug timbers found at Khlong Thom (KT) in Krabi, Thailand, yielded a date of 85-229 cal CE, establishing it as the earliest identified example of this tradition (Piromrak, 2020, p. 41). Followed by the 3rd-5th century CE Pontian boat in Pahang, Malaysia, as also the similar style known specimen of lashed lugs boat (Manguin, 1993, p. 256; 2019, p. 402; Lacsina, 2015, p. 128).

Later vessels, incorporated a limited number of edge treenails to increase hull rigidity (McGrail, 2001, p. 289; Manguin, 2019, pp. 409; 2021, p. 137), a transitional practice that ultimately led to the complete replacement of sewing with edge-dowelling at around the 10th century CE.

Due to fragmentary remains, absolute dimensions of lashed-lug hulls vary, though they generally follow a 3:1 length-to-beam ratio typical of traditional Indonesian craft (Liebner, 2014, p. 269). Manguin reconstructed the 7th-8th century CE Punjulharjo boat in Indonesia at 17 metres in length, 5.7 metres in beam, and 2.3 metres in depth (Manguin, 2009, p. 4), which Liebner (2014) calculated could carry 115-140 tons of cargo (Liebner, 2014, p. 269). For the 10th-century Cirebon wreck, Liebner modeled the hull using deadrise angles of 5° and 10° alongside a reconstructed hull height of 4 metres (based on a 3.5-metre cargo mound). This produced dimensions of 31.8 metres in length, 10.6 metres in beam, and 4 metres in depth, with a 45-centimetre freeboard at minimum load (Liebner, 2014, pp. 269-275).

Geographically, most lashed-lug vessels in Southeast Asia and the Thai-Malay Peninsula have been almost recovered from inland waterways rather than open-sea environments (Figure 4). The Pontian boat lay in a mangrove forest 1.6 km from the sea (Gibson-Hill, 1952, p. 111; Manguin, 2019, p. 402), the Khlong Thom boat lay 2 km from an estuary along the Thom Canal (Piromrak, 2020, p. 34) and the Ban Khlong Yuan in Surat Thani, Thailand and Koh Kwang wrecks in Chanthaburi, Thailand were located along rivers and canals several kilometres inland (Khawnuna, 2014, pp. 187-188; Parnfak, 1997). Similarly, the Butuan boats in the Philippines rested in tidal flats (Lacsina, 2016, p. 98) and the Punjulharjo boat in Java wrecked in intertidal sediments (Mochtar, 2018, p. 4). Open-sea seabed discoveries remain rare exceptions, represented primarily by the Chau Tan wreck off Vietnam (Kimura, 2022 p. 115; Noriko et al., 2014, p. 144), and the Cirebon wreck located 90 nautical miles offshore in the Java Sea (Liebner, 2014, p. 5).

Applying Manguin's evolutionary typology of Southeast Asian plank-fastening techniques (Manguin, 2021, pp. 137-139), the Bueng Kum (BK) boat can be dated to approximately the 7th-9th century CE. Associated artifacts, notably cord-marked or ridged earthenware sherds, further contextualise the vessel within the material culture of the late Dvaravati period. The vessel was radiocarbon dated by Rahothon on behalf of the Underwater Archaeology Division of Thailand's Fine Arts Department. AMS dating of the rope fibers yielded a calibrated date of 642-704 CE. This aligns with other regional vessels utilising the lashed-lug plank-fastening tradition (Rahothon, 2026), and undoubtedly links the boat to the Dvaravati period.

The vessel's plank fastening technique features edge-doweling combined with discontinuous sewn planking (lacing), while the internal frames were lashed directly to carved projecting lugs (Figure 5). Wooden dowels were inserted into pre-drilled blind mortises along the seam edges of adjoining strakes. The seam-fastening pattern reveals an alternating arrangement: Pairs of stitch holes are interspersed symmetrically with four dowels. The lacing channels penetrate the plank seams to a depth of approximately 5 cm and emerge on the inboard face through oblique perforations, securing the strakes without passing completely through to the outboard surface.

Additionally, carved transverse lugs with 3 cm thickness (Rahothon, 2026), protrude along the inboard face of each strake to facilitate the attachment of transverse frames. Lashing holes were drilled obliquely through the side and lateral faces of the lugs, combining internally so that cordage could secure the frames directly to the hull without relying on treenails or metal spikes. Each lug features four paired stitch holes, several of which retain preserved organic cordage *in situ*.

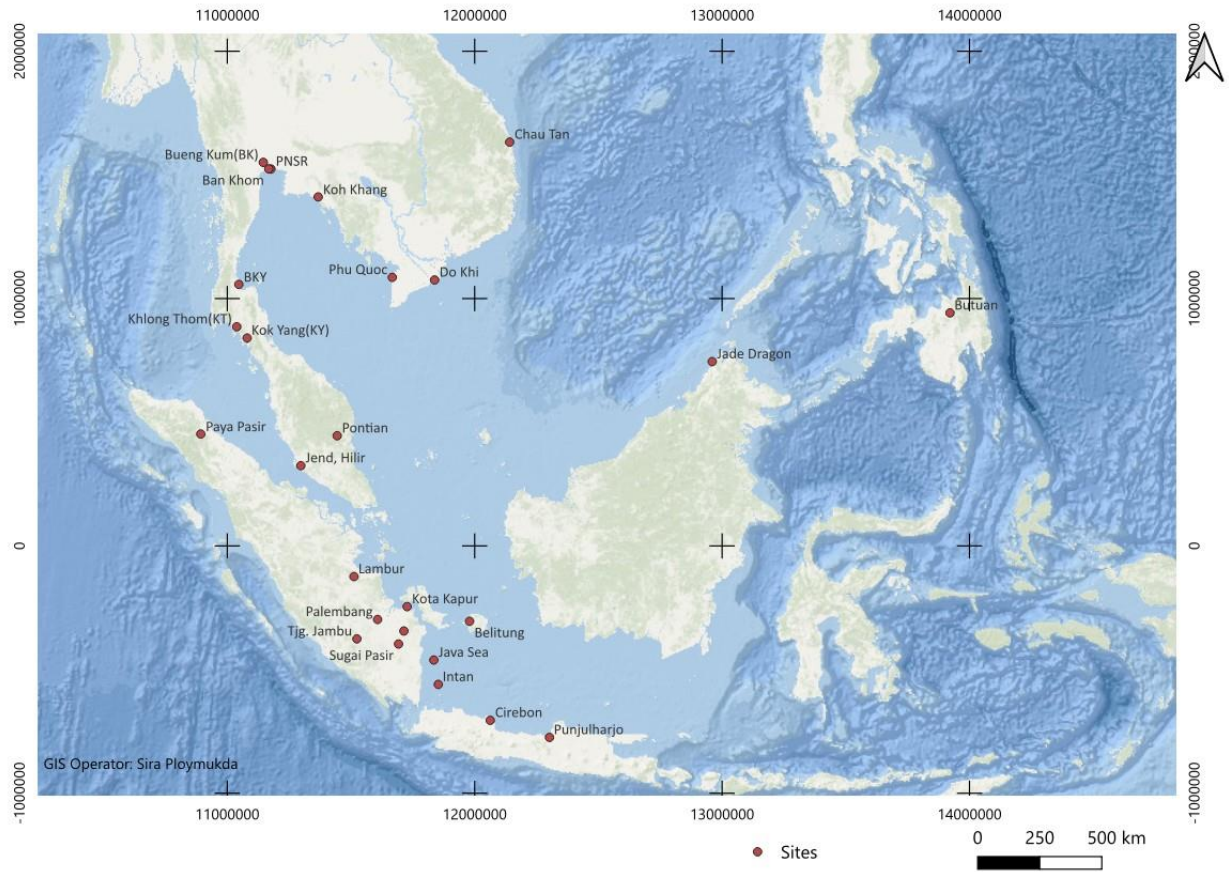


Figure 4. Geographic distribution of lashed-lug boat sites in Mainland Southeast Asia, adapted from Manguin, 2019.



Figure 5. Lashed-lug hull plank from the BK boat, showing the arrangement of wooden dowels and lacings, adapted from 2nd Regional Office of Fine Arts: Suphanburi, 2015.

The dowels retrieved from the BK vessel are slightly tapered and cylindrical, measuring approximately 2.1 cm in diameter at the head, 1.1 cm at the tip, and 13-14 cm in total length. The hull planks have an average thickness of 3.2 cm, with the dowel places centred along the seam edge, while the projecting lugs extend an additional 3 cm into the hull interior (Rahothan, 2026). Because the lugs and planks were carved out of a single solid baulk of timber, the raw logs converted into hull strakes must have had an initial working thickness of at least 7 cm.

In the lashed-lug shipbuilding tradition of Island and Mainland Southeast Asia, black cordage was predominantly manufactured from sugar palm fibers (*Arenga pinnata*) (Manguin, 2019, p. 402). Furthermore, taxonomic wood identifications recorded by Rahothan confirm that the hull planks were fashioned from *Cotylelobium lanceolatum* Craib (*Kiam* in Thai) and secured with dowels made of *Hopea* sp. (*Takhian* in Thai) which native to Southeast Asia region (Rahothan, 2026, p. 14).

Another lashed-lug vessel recorded in the Lower Central Plain is the Ban Khom boat. Discovered in 1998, the hull was buried beneath 1.5-3.0 m of alluvium within a crustacean aquaculture farm adjacent to Khlong Mahachai in Samut Sakhon Province. Khlong Mahachai connects directly to the Tha Chin River, which in turn linked into the fluvial network extending inland toward Nakhon Pathom via the canal systems described above. Site assessment reports noted that the find was in an extremely degraded condition, having suffered extensive post-depositional damage from seasonal flooding and salvaging (Wongnoi et al., 1998, p. 5) (Figure 6). A substantial assemblage of Indian and Dvaravati ceramics was recovered from the hull interior, including carinated cooking pots, globular pots, *kendi*, and storage jars, spanning a broad chronological range from the 5th to the 10th century CE (Wongnoi et al., 1998, p. 4).

According to the survey report by the Fine Arts Department, the preserved hull remains measured approximately 24 m in length and 2.5 m in beam, with strakes measuring 10-12 cm in thickness (Wongnoi et al., 1998, p. 2). These diagnostic planks confirm the lashed-lug construction tradition (Figure 7); according to Wongnoi, the overall reconstructed dimensions yield a length-to-beam ratio of nearly 10:1, deviating significantly from the broad 3:1 beam-ratio generalisation often cited for Southeast Asian watercraft (Liebner, 2014, p. 269).

Wongnoi explained that the plank-fastening sequence exhibits an alternating pattern of two oblique lacing perforations followed by a single half predrilled dowel along the seam edge (Edge Dowelled), engineered so that cordage did not penetrate the outboard facet (Wongnoi et al., 1998, p. 2). This specific arrangement closely parallels the construction technique observed on the 3rd-century CE Pontian boat from Pahang, Malaysia (Manguin, 2021).

Unfortunately, the physical remains of the Ban Khom vessel are no longer extant. A field survey conducted by the author in 2022 at the original coordinates yielded no trace of the hull timbers, indicating that the wreck has since been entirely destroyed or lost. Consequently, targeted re-examination of the hull's shipbuilding technology is impossible, leaving the precise dating and structural details of the vessel permanently reliant on the preliminary 1998 report. However, in 2023, the Underwater Archaeology Division of the Fine Arts Department, Thailand, conducted a survey aimed at finding traces of the boat; unfortunately, the remains of the Ban Khom boat could not be found (Underwater Archaeology Division, 2023). Nonetheless, although physical details of the boat have been lost, its significance to maritime archaeology remains vital. Its location and associated artifacts provide insight into inland transportation along river systems, its construction offers insight into the distinctive shipbuilding traditions of Southeast Asia, and it helps researchers understand how Dvaravati communities communicated across different settlements, as well as the social and cultural life of the Dvaravati people.

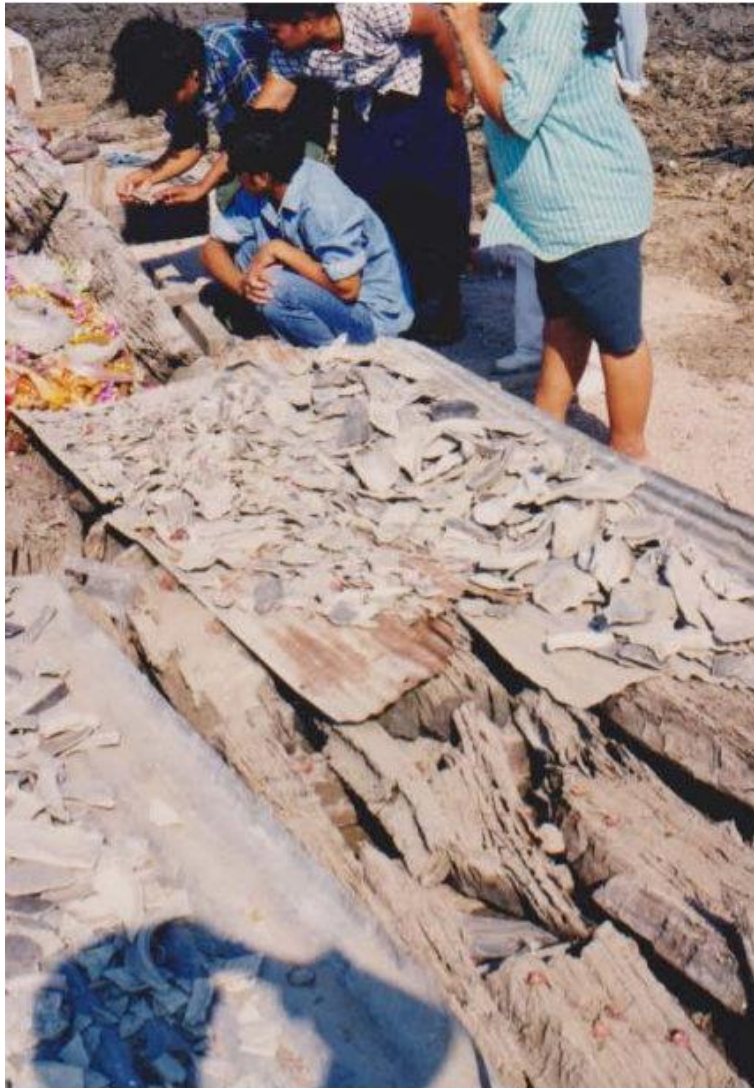


Figure 6. Salvage excavation of the Ban Khom site in 1998, showing degraded boat planks during recovery (Wongnoi et al., 1998).



Figure 7. A plank from the Ban Khom boat, displaying a protruding lug on its surface (Underwater Archaeology Division, 2023).

The only actual evidence of sea going vessel found within the Lower Central Plain, Thailand is informed by investigations of the 9th-century CE Phanom-Surin shipwreck (PNSR) in Samut Sakhon Province (Jumprong, 2019, p. 228). The wreck is closely associated with mid-to-late Holocene sea-level fluctuations and provides direct material evidence of Southeast Asian maritime trade networks during this era (Jumprong, 2019, p. 228; Khunsong, 2015, p. 214; Kimura, 2022, p. 108; Ploymukda, 2022, p. 46). Located approximately 8 km inland from the modern coastline (Jumprong, 2019, p. 233), the vessel lies within a paleochannel that formed a functional river course during the Dvaravati (Chaimanee, 2014, p. 16).

Palynological and geoarchaeological analyses by Ploymukda (2016, pp. 93-94) revealed that the PNSR foundered within an active marine depositional environment (Ploymukda, 2016, pp. 93-94). Site formation assessments indicate that the vessel grounded on an underwater shoal or sandbar and was subsequently abandoned when salvage efforts failed (Ploymukda, 2016, p. 91; 2022, pp. 44-45). Ultimately, the location, archaeological and chronological context of the Phanom-Surin wreck corroborate the model that major Dvaravati urban centres were situated well inland rather than directly along the contemporary shoreline (Jumprong, 2019, p. 228; Khunsong, 2015, p. 214). The vessel likely facilitated transoceanic contact via inland riverine networks.

Discussion

The paper agreed at the point that Dvaravati settlements in the western Lower Central Plain of Thailand functioned as authentic riverine polities, where canal systems supplied freshwater and served as primary arteries for trade, transport, and communication flowing southward toward the Gulf estuary (Khunsong, 2014). This is clarified by the discovery of the lashed-lug boat at Bueng Kum (BK), provides concrete proof of riverine transit in Nakhon Pathom, and reinforces the close inter-settlement connectivity across the Lower Central Plain. Second, while Ku Bua lacks direct shipwreck evidence, surrounding archaeological assemblages strongly suggest that regular riverine exchange persisted between the primary urban centre and its satellite settlements (Depimai, 2025; Vallibhotama, 2020).

A second, vital consideration centres on how riverine transportation was actually carried out during the Dvaravati era. Large seagoing vessels, such as the Phanom-Surin (PNSR) ship, undoubtedly reached the coastal margins of Dvaravati settlements, bearing cargoes into the regional trade network (Jumprong, 2019, p. 245). Because these inland cities depended so heavily on long-distance commodity exchange (Saraya, 1989), Khunsong has suggested two scenarios for Nakhon Pathom: Either its residents actively widened the canals to accommodate larger merchant vessels, or the city was gradually abandoned as shifting waterways disrupted vital access routes (Khunsong, 2014). Yet, assessing these waterways through the practical lens of maritime archaeology raises a critical doubt: Could a vessel of such immense scale have navigated straight to the city through an inland canal under one hundred metres wide?

This question is best addressed through modern experimental reconstructions of contemporary Indian Ocean traders most notably the *Jewel of Muscat*, a full-scale replica of the 9th-century Belitung wreck. Sea trials of this vessel demonstrate that such craft required substantial water depth and wind velocity to remain operational. Displacing 55 tons and ballasted with 15 tons of stone, the *Jewel of Muscat* drew at least two metres of water. While its deep-V hull effectively resisted leeway and enabled the ship to point up to 51 degrees off the wind, it still demanded a stiff breeze of 15 to 18 knots merely to make headway (Vosmer et al., p. 415). By comparison, the Phanom-Surin (PNSR) vessel was approximately 30 percent larger, implying an even deeper laden draft and an even higher wind threshold. Although experimental trials cannot provide the exact historical parameters, such

as the precise wind speeds, draft, or displacement of the archaeological wreck, they nevertheless serve as a vital benchmark for understanding the operating limits of this vessel type. The author neither argues that massive ships could navigate narrow canals, nor dismisses the possibility proposed by previous scholars that certain canals were expanded to accommodate larger vessels or heavier traffic sailing directly to inland cities (Khaokhiew, personal communication in 2023). Consequently, the author also maintains that transshipment, where travelers offloaded cargo from ocean-going vessels onto smaller riverine craft guided by local navigators, remains a critical factor that cannot be overlooked.

The idea of transshipment mentioned above is supported by the evidence of indigenous watercrafts found in the study area such as BK boat and Ban Khom boat. The typical lashed-lug boats of the region were built with distinctly flat hull bottoms, often featuring a deadrise of merely five to 10 degrees (Liebner, 2014, p. 273). Even an imposing vessel like the 17-metre Punjulharjo boat found in Indonesia, capable of hauling up to 140 tons of cargo, stood only 2.3 metres deep in total hull height (Liebner, 2014, p. 272; Manguin, 2009, p. 4). A basic ship capacity estimate shows that, even when loaded to near capacity, the vessel maintained a draught of under two metres of water, allowing it to skim lightly across shallow channels in contrast to a heavy ocean trader, which would easily run aground due to its massive draught. This can be observed in the Ban Khlong Yuan (BKY) lashed-lug boat, dated to the late 9th century CE (Rahothan & Vosmer, 2023, p. 3), and displayed at the Underwater Archaeology Division, which clearly reveals a relatively flat U-shaped hull profile (Figure 8).



Figure 8. Reconstructed lashed-lug boat (BKY) on display at the Underwater Archaeology Division, Fine Arts Department, Thailand. Discovered in Southern Thailand, it exhibits a U-shaped hull profile and dates contemporary to the BK and Ban Khom vessels.

These structural differences in the boats facilitated navigation across the estuarine landscape. As stratigraphic coring south of Nakhon Pathom around Ban Don Yai Hom, the ancient estuary of the Dvaravati river system, identifies the dark marine and estuarine Bangkok Clay at depths of three to four metres below the modern surface, suggesting an ancient fairway of very modest depth (Khaokhiew, 2018, pp. 3-25). When the tide ebbed, that water level dropped precipitously, exposing mudbanks and sunken hazards. Long before the era of

modern sounding equipment, nautical charts, or satellite guidance, steering a heavy, deep-draft ship through these invisible shoals was a perilous gamble; a single misjudgment would leave the vessel stranded or broken, adding another entry to the archaeological record of shipwrecks (Adams, 2013, p. 17). To compound the hazard, the river's current reversed and surged with the rise and fall of the tide (Sirisup, et al., 2014, p. 26), fighting the helm in confines far too narrow for dynamic maneuvering. The author believes that the boatbuilding traditions, characteristics, and purposes found in the Western Lower Central Plain of Thailand can be explained through the model proposed by Adam as "The characteristics of the operating environment therefore exert powerful practical and mechanical constraints on the possible ways in which a vessel can be made" (Adams, 2013, p. 17).

The wind presented an equally insurmountable obstacle. While broad seasonal monsoons powered maritime transit across the open seas of Southeast Asia, inland river systems operated under entirely different aerodynamic conditions. Even when monsoonal winds blew steadily, the meandering courses of natural waterways rarely aligned with the prevailing wind direction, making sail-powered river navigation highly problematic especially for the massive ship.

All of these operational constraints point toward a different historical reality: a structured system of estuarine transshipment. Rather than attempting a treacherous passage upstream, massive ocean-going vessels likely anchored in sheltered roadsteads within outer estuarine zones, such as Ban Don Yai Hom for Nakhon Pathom, Kok Prik for Ku Bua, or comparable coastal nodes across the Gulf. At these maritime gateways, foreign cargo would have been transferred onto broad, shallow-draft river craft or barges. Manned by local navigators intimately familiar with shifting mudbanks, tidal fluctuations, and capricious river breezes, these lighter crafts were uniquely suited to maneuver through winding, shallow waterways, safely conveying valuable trade commodities inland to the urban markets of Nakhon Pathom and Ku Bua.

However, before reaching a final conclusion, it is important to consider the Mid-to-Late Holocene sea-level dynamics. Given that palaeo-sea levels reached a maximum of approximately four metres above present levels, ancient settlements were established on higher ground safe from flooding. Crucially, coastal waters did not remain permanently at this peak, but fluctuated significantly due to seasonal and tidal variations. Both Nakhon Pathom and Ku Bua were strategically situated above the maximum high-water mark of the Dvaravati coastal progradation, occupying land typically characterised as a seasonal floodplain (Hutangkura, 2014, pp. 31-40). Water was diverted into the elevated settlement via secondary canals, while the city moats functioned simultaneously as reservoirs. The spatial distribution of shipwreck sites suggests that smaller, shallow-draft vessels navigated inland waterways toward the city with far greater ease than deep-draft ships.

In the case of Nakhon Pathom, this is beyond doubt; Khaokhiew's sedimentological research demonstrates the existence of paleochannels that allowed vessels to access the settlement (Figure 9). The author suggests that two potential routes used by the Dvaravati people to connect Nakhon Pathom to its satellite settlements ran through Khok Phra Chedi and Noen Phra. However, the two settlements mentioned earlier were likely not the initial transshipment points, but rather the final stops before reaching Nakhon Pathom. Primary transshipment would have occurred farther out in the shallow waters of Dvaravati Bay, around the current location of the Phanom Surin shipwreck, as large ocean-going vessels could not have sailed directly to the satellite settlements (Figure 11).

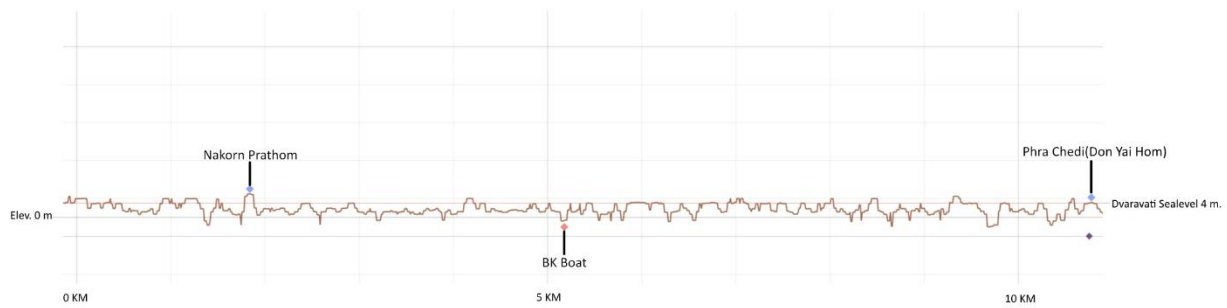


Figure 9. Terrain elevation cross-section from Nakorn Pathom to Khok (Phra) Chedi (Don Yai Hom), highlighting the BK boat site.

Ku Bua, however, presents a different scenario, as maritime archaeological evidence remains inconclusive. Nevertheless, topographic cross-sections reveal that both Ku Bua and Kok Prik occupied elevated mounds above the ancient sea level, making them suitable for human habitation and suggesting the viability of cargo transshipment between the two sites (Figure 10).

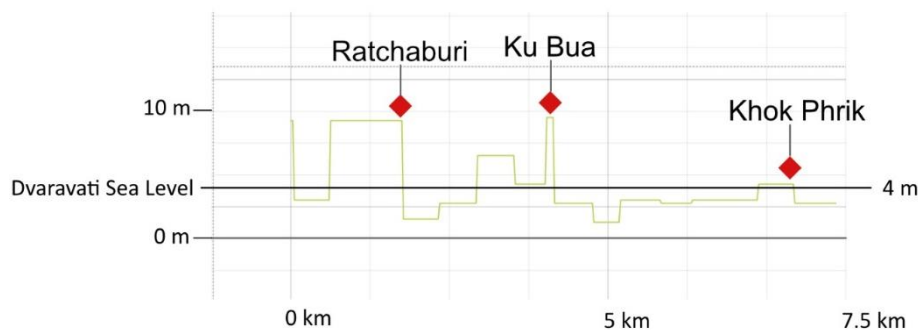


Figure 10. Topographic cross-section showing relative terrain elevations across ancient Ratchaburi, Ku Bua, and the Kok Prik settlement.

Kok Prik lies about 2 kilometres from Ku Bua. This proximity suggests that the actual transshipment point from ocean-going vessels to riverine craft might not have been Kok Prik itself, but rather another location, with Kok Prik functioning instead as Ku Bua's trade zone (Depimai, 2025; Vallibhotama, 2020). Furthermore, Ku Bua's external connections likely extended beyond the Mae Klong River corridor (Figure 11). Secondary waterways connected Ku Bua with contemporary settlements flourishing across the Phetchaburi River basin, a region of thriving trade from the prehistoric era through to historical times, as evidenced by archaeological sites such as 2 millennium BCE Don Yai Thong site recently excavated by the Fine Arts Department (Fine Arts Department, 2026).

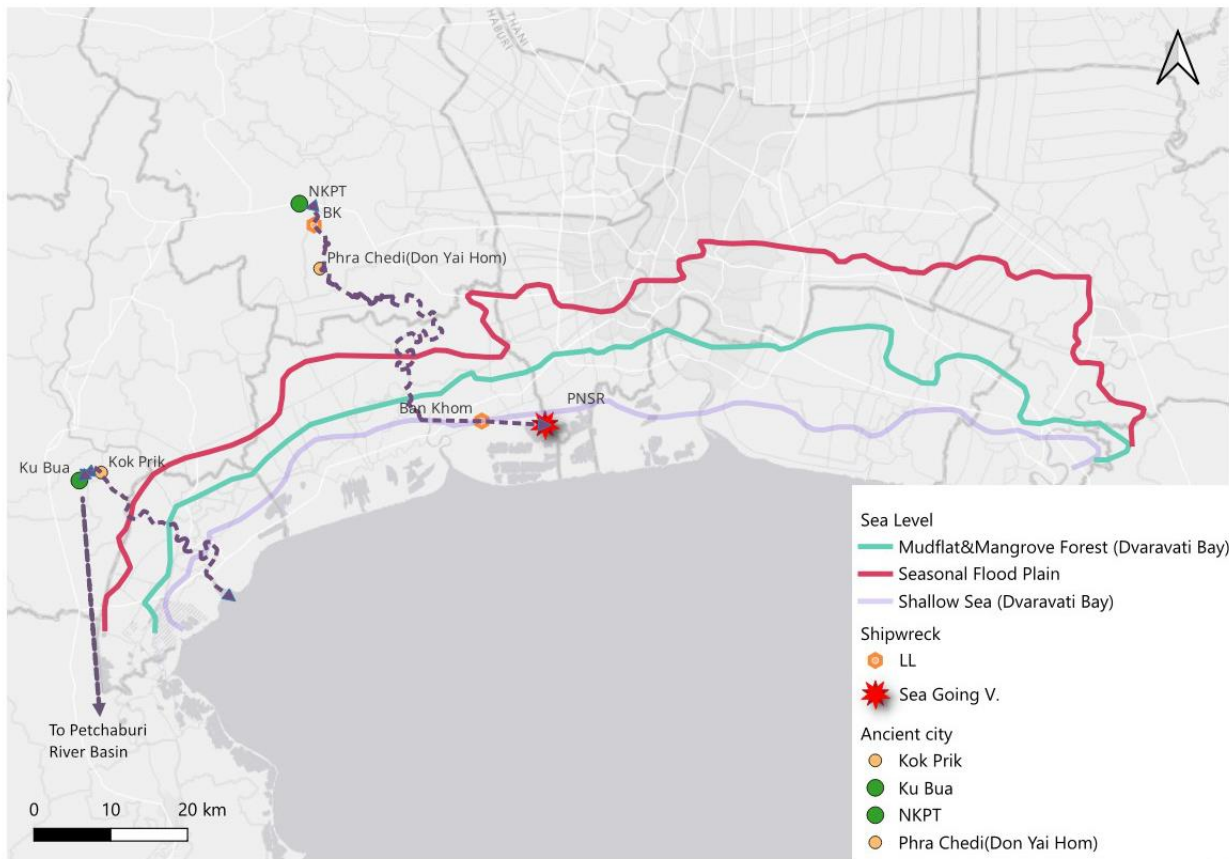


Figure 11. Ancient settlement distribution across the western Lower Central Plain of Thailand, illustrating a predictive model of potential riverine transport routes alongside the palaeogeography of the Dvaravati Bay. Layer of Sea level reconstruction is adapted from Hutangkura, 2014.

Conclusion

Geoarchaeological and nautical evidence demonstrates that Dvaravati urban centres in the western Lower Central Plain, principally Nakhon Pathom and Ku Bua, were not coastal ports, but inland riverine polities situated within seasonal freshwater floodplains. Instead of being located along the seafront of an open “Dvaravati Bay”, these cities relied on engineered canal systems, moats, and natural river networks within the Tha Chin and Mae Klong basins to sustain communication and trade.

The practical mechanics of maritime transit indicate that deep-draft, ocean-going vessels could not have navigated these narrow, shallow, and meandering inland waterways. Hydrodynamic constraints, shifting shoals, and unfavorable river winds would have made sailing such massive ships almost impossible.

Instead, trade operated through an estuarine transshipment system. Transoceanic merchantmen anchored at outer coastal outports, such as Ban Don Yai Hom and Kok Prik, where goods were transferred onto smaller craft, as evidenced by the Bueng Kum and Ban Khom vessels and their associated artefacts. These shallow-draft boats transported cargo through the local canal network to major trade sites. Ultimately, it can be inferred that as continuous deltaic progradation pushed the coastline southward and silted up vital waterways, this delicate river network broke down, contributing directly to the decline and eventual abandonment of these inland Dvaravati centres.

Nevertheless, this paper is limited by the number of sites examined. The author suggests that conducting further field surveys, expanding the scope of inquiry, and incorporating a broader sample of ancient settlements in future research will significantly advance our understanding of transport and maritime trade. Such work will not only illuminate cross-cultural maritime interactions, but also to explain finer details concerning the people involved in ancient riverine transportation in Thailand.

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