A historiography of Angkor's river network: shifting the research paradigm to Westerdahl's Maritime Cultural Landscape

ការសិក្សាអំពីប្រវត្តិសាស្ត្រនៃបណ្តាញផ្លូវទឹកនៅតំបន់អង្គរៈ

ការផ្លាស់ប្ដូរគម្រូនៃការស្រាវជ្រាវទៅការសិក្សាផ្ដែករប្បធម៌ទេសភាពតាមផ្លូវទឹករបស់

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Abstract

This article is an overview of the work that has been conducted so far on river usage and nautical technology in the history of Angkor, and a discussion on how maritime approaches can contribute to the creation of new knowledge by opening new lines of research that can help us reconstruct a more nuanced view of Angkor's fluvial history. Although Angkor's connection to the river network was made in the early 20th century, the compartmentalized studies that have been carried out so far on the subject of Angkor's relationship to its watery environment have resulted in interpretations that do not reflect the complexity of the subject. It will be argued here that archaeologists who do not integrate maritime approaches in studies of cultures like

Angkor, where waterways play an important role in their environment, are likely to miss important aspects of fluvial cultures. By applying concepts such as the Maritime Cultural Landscape, it will be possible to push beyond the boundaries of terrestrial approaches and discover how the environmental conditions of cultures like Angkor–with river networks as the main means of communication – resulted in the development of specific cognitive and functional traits that gave form to fluvial cultural landscapes. An example of such an approach is offered as a conclusion in an analysis of masonry bridges in Angkor's transport network.

អត្ថបទនេះ ជាទិដ្ឋភាពរួមនៃការងារស្រាវជ្រាវដែលបានធ្វើកន្លងមក ស្តីពីការប្រើប្រាស់ទន្លេ និងបច្ចេកវិទ្យាផ្លូវទឹក ក្នុងប្រវត្តិសាស្ត្ររាជធានីអង្គរ ហើយជាការជដែកថាតើមផ្លូវបាយផ្លូវសមុទ្រអាច្ចមចំណែកដល់ការបង្កើតចំណេះដឹងថ្មី តាមរយៈការបើកខ្សែស្រាវជ្រាវថ្មីដែលអាចជួយយើងឱ្យថ្ងែរទ្បើងវិញ្ញូវរកំហេញលាយទ្បុំពីប្រវត្តិសាស្ត្រផ្លូវទន្លេរបស់រាជធានីអង្គរ។ ទោះបីទំនាក់ទំនងរាជធានីអង្គរជាមួយបណ្ដាញទន្លេត្រូវបានសិក្សារួចហើយកាលពីដើមសតវត្សទី២០នោះ ការសិក្សាដោយៃបែងចែកតាមផ្នែកដែលបានធ្វើចកន្លងមក លើប្រធានបទ សម្ប៉ុន្ធភាពរាជធានីអង្គរ ចំពោះបរិស្ថានផ្លូវទឹកបានបង្ហាញឱ្យមានការបក្ស្រាយដែលមិនផ្ទុះបញ្ញ័ងពីភាពសាញ្ញ័ញ័ៃន ប្រធានបទនេះទេ។ អ្វីដែលត្រូវ ដេញដោលនៅក្នុងអត្ថបទនេះគឺបុរាណវិទូ ដែលមិនបញ្ចូលមផ្លូវបាយផ្លូវសមុទ្រ ចូលក្នុងការសិក្សារប្បេមិដែលដុចរាជធានីអង្គរ ដែលផ្លូវទឹកដើរត្តនាទីសំខាន់ ក្នុងបរិស្ថានតំបន់នោះ ទាំងជាភ្លេចចំណុចសំខាន់នៃរប្បេមិផ្លូវទន្លេហើយ។ តាមរយៈការអនុវត្តទស្សនាទានដុចជាទេសភាពរប្បេមិផ្លូវសមុទ្រ អ្វីដែលអាចទៅរួច គឺកាពុញ្ញ័ឱ្យផុតព្រំដែនមផ្លូវបាយផ្លូវគោក ហើយរកមើលថាតើលក្ខណ្ឌបរិយាកាសនៃរប្បេមិដុចរាជធានីអង្គរ ដែលមានប្រព៉័ន្ធទន្លេ ជាមផ្លូវបាយប្រាស្រ័យទាក់ទងចម្បង បង្កឱ្យមានការអភិវឌ្ឍសញ្ញាណចំណេះ និងមុខងារជាក់លាក់ដែលបង្កើតជា ទេសភាពរប្បេមិផ្លូវទន្លេយ៉ាងណា។ ឧទាហរណ៍មួយនៃមផ្លូវបាយបែបនេះ នឹងផ្ដល់ជាការ សន្និដ្ឋាន ក្នុងការភាគស្ថានកំពោរនានា នៅក្នុងបណ្ដាញដឹកជញ្ជូនរបស់រាជធានីអង្គរ។

ពាក្យគន្លឹះៈ បុរាណវិទ្យាផ្លូវទឹក រាជធានីអង្គរ កម្ពុជា មេគង្គ ទន្លេ បឹង ទន្លេសាប បុរាណវិទ្យាផ្លូវសមុទ្រ ស្ពាន

From the early stages of Angkorian studies, it became apparent that the distribution of archaeological sites was linked to river networks (Parmentier 1927: 374), however, limitations on theoretical and methodological frameworks resulted in segmented studies of Angkor's fluvial cultural landscape. Thus, the study of boats and river networks have been incorporated as undefined entities in the periphery of larger

projects that place the focus on the urban and agricultural landscapes of the region. This article aims to review the historiographic trends in the study of Angkor's fluvial history and highlight the potential of applying a maritime perspective, that is, one that integrates key aspects of water-oriented cultures (i.e. environment, boat technology and cultural activities) to the study of Angkor's relationship with its watery environment. The discussion should perhaps be initiated with a clarification of what the term "maritime" means in the context of maritime archaeology. From an etymological point of view the term originates from the Latin word mare, sea, and is an adjective that refers to things "pertaining to the sea". This narrow interpretation of the word, however, has been contested in the field of maritime archaeology, as it sets barriers to human movement around watery spaces that are not really there (see McGrail 1984, and Westerdahl 2011a). The use of watery spaces is characterised precisely by the fluidity of movement between different landscapes. Rivers have been traditionally considered as functional arteries of sea transport networks, so when the term "maritime" is reduced to things "pertaining to the sea" we need to wonder what has one to do with the extensive river networks and riverine cultures that supported sea networks. Furthermore, it has been argued that communities living in large inland lakes share common cultural manifestations with maritime communities in terms of cognitive and functional aspects (Westerdahl 2003). Since human-environment interactions in the context of seas and rivers share a common vector (boats) and there is a fluid interaction between them, it is argued here that theoretical frameworks that have their origin in the study of maritime communities can offer more nuanced approaches to inland waters as well. What follows is a critical review of available literature, followed by an overview of how the concept of the maritime cultural landscape can contribute to further our knowledge of how fluvial cultures developed in the past.

The first studies of river networks and nautical technology in Angkor

One of the earliest mentions of the nautical scenes of the Bayon temple appeared in *Voyage au Cambodge* published by Louis Delaporte in 1880. The descriptions are simple, more aimed at explaining the images than to provide an academic interpretation; nonetheless, Delaporte was probably the first to describe the boats of Angkor as pirogues. The term originally describes a boat with a shallow draft made from a single log, with no decking and a single mast used for coastal travel in the Caribbean (Marley 2010: 319), however, the term has now evolved to describe a long and narrow boat made from a single tree trunk. Although Delaporte does not provide a description of the boats, it is possible to deduce from his work – and that of Garnier (1885) – that the term refers to the construction technique (dugout). The term is used by Parmentier in his description of the naval battles of Banteay Chmar (Parmentier 1910: 209-211). This article aims to be descriptive, and not a reflection of scholarly thought, but the author furthers the confusion of specialized terminology by using the terms paddler and rower interchangeably. In paddling, the body of the paddler is used as a fulcrum between the paddle and the boat, so the paddle is not directly attached to the hull (Figure 1). Contrarily, in rowing the loom of the oar is attached to the hull through a fulcrum called thole-pin and secured with an oarlock system so that the oar can safely pivot and be used as a lever against the water to move the boat (Figure 2). The terms thus refer to radically different technologies that have different affordances and constraints and require different motor skills and techniques to move boats. By

failing to acknowledge the technological differences between the two propulsion methods, Parmentier missed an opportunity to reflect on the motivations that may have led to a change in propulsion system, its connection to military advancements, and further discussions on the origin and establishment of rowing in Southeast Asia.

Fig. 1:   The nautical iconography of Angkor shows in detail the different techniques used in paddling, which is completely different from rowing. Source: V. Walker.

Fig. 2:   Rowing is done facing the opposite direction of travel and with the oar attached to the boat through a fulcrum. Source: V. Walker.

The first article to take on the task of analysing the fleet of Angkor was *La Batellerie Cambodgienne* (Groslier 1917). The text sets out to discuss Angkor's fleet as represented in the reliefs, drawing comparative information from historical and ethnographic data. Like Parmentier, Groslier had a tendency to use a variety of boat terminology without providing any reflection on the reasons that lead him to use those terms. He indistinctly called the boats of Angkor pirogues, junks, and sampans without acknowledging that these terms refer to specific kinds of boats with very different characteristics. There are controversies surrounding the use of the term *junk*, which are often identified as Chinese-built ships (see discussion in Manguin 1984; 2010). The French often used the word *jonque* to refer to any traditional Vietnamese sailing vessel, but in some instances also used the term to refer to boats propelled by poles or sweeps (Brooks and Bui Quang Trach 1962: IV). However, the term *junk* originates from the Malay term *jong* and it refers to Southeast Asian-built ships of considerable tonnage (see Brooks and Bui Quang Trach 1962: IV; Manguin 1980). Hence the use of the term in early publications may be misleading. Groslier also used rower/rowing and paddler/paddling interchangeably without recognizing the different technology employed in each case, and as a result his analysis does not incorporate any reflections on the link between propulsion technology and environment (see discussion in Walker Vadillo 2016: 195-199). For his initial analysis Groslier benefitted from the work of Paul Pelliot, who translated two crucial texts for the study of boats in Angkor. The first translation, published in 1902, was of the historical account *A Record of Cambodia: the land and its people* written by Zhou Daguan, a Chinese emissary who travelled to Angkor in 1296-1297. The text contains a chapter on boat construction describing general features of the boats, where small boats are described as dugouts, and larger boats are said to be made with planks (Uk and Uk 2016: 113). This reference appears in all scholarly work discussing the boats of Angkor. The second text, a translation of the *Book of Southern Qi* (479-501 CE) that appeared in Pelliot's seminal paper *Le Fou-Nan*, has a short reference to the boats of Funan: "*On fait des bateaux qui ont de 8 à 9 tchang. On les taille en largeur à 6 ou 7 pieds. L'avant et l'arrière sont comme la tête et la queue d'un poisson*" (Pelliot 1903: 261). Based on this evidence, Groslier advanced the discussion on the boats of Angkor by establishing their main characteristics, which were: 1) made from a single log, 2) had central cabins, 3) had no anchors, and 4) had no rudders (Groslier 1917: 199). His greatest contribution was the identification of two types of hull shapes among the Cambodian boats: one with curved ends, and another one with hard angles (1917: 198). Unfortunately, he did not pursue this line of inquiry and in his following publication *Recherches sur les Cambodgiens* (1921) this observation was scrapped from his analysis. Instead, Groslier provided a more in-depth analysis of the large planked ship depicted in the Bayon, which he initially identified as a Chinese junk (1917: 202-204). In the 1921 discussion he concluded that the ship had to be either Chinese, or of Khmer construction following a Chinese design (1921: 114). Groslier also expanded his research on Angkorian boats, adding more details in terms of construction techniques and technology (ibid.: 109-114). He advanced that the dugouts were likely up to 24-25 m long and 1.5-1.8 m wide, were made from local hardwood, and identified the section amidships as the space destined for the most important character on board. Groslier acknowledged the relevance of boats in the environment in which Angkor developed, noticing that a substantial part of the land was covered in water during the rainy season (1921: 109). Parmentier also echoed this reflection and in his seminal work *L'art Khmér Primitif* he emphasized that

waterways were the preferred means of transport based on the distribution of the archaeological sites located by French archaeologists up to the 1920s (Parmentier 1927: 374). The maps elaborated by Parmentier recorded in detail the waterways of the region, including the small rivers that are often left out in more recent publications. The map elaborated by Lunet de Lajonquière (1901) is cited more often, but in both cases, it is apparent that there is a correlation between the location of archaeological sites and the river system. A recent reappraisal of Angkor's road and river network and its relation to archaeological remains shows that many sites were not connected to roads but were near rivers (Hendrickson 2007: 134).

Angkor's nautical iconography corpus kept increasing as temples were being cleared by subsequent restoration efforts. An excavation of a pond located north of the Phimeanakas temple in Angkor Thom lead by Marchal brought to light another nautical bas-relief (Marchal 1924: 303-328, Pl. XXIX). The presence of lavishly decorated barges with bows and sterns depicting fantastic animals did not go unnoticed by Quaritch-Wales, who tangentially discussed nautical events in Angkor on his book *Siamese State Ceremonies* (1931: 111-115). His main focus was the State Progress by Water of the kings of Thailand, looking particularly at the event that took place on the 3rd of March of 1926 as part of the celebrations of the coronation of king Prajadhipok (ibid.: 111). In his analysis he drew attention to the description of similar events witnessed by European travellers to Ayutthaya in the 17th century, and referenced Groslier's 1921 publication. In Quaritch-Wales's opinion, the Thai State Progress by Water evolved from similar events staged by the Angkorian kings, making the same connection to the *Book of Southern Qi* and agreeing with Groslier that the reference to the boat decorated with "the head and the tail of a fish" demonstrated an early example of decorated royal barges that could be traced as far back as Funan (Quaritch-Wales 1931: 113-114). It should be noted that the simple explanation offered by Chinese sources do not imply the existence of zoomorphic decorations in boats (i.e. use of appendages of carved wood), and instead vaguely defines the shape of the fore and aft as similar to a fish.

An updated study of the boats of Angkor – aptly titled *Les Bateaux des bas-reliefs Khmérs* – was published in 1941 by Pierre Paris, a colonial engineer and correspondent of the École française d'Extrême-Orient (EFEO) who made great contributions to the study of traditional boats of French Indochina (see Pham, Blue and Palmer 2010: 262-263). Paris's intention was to review the subject of boat representations in light of the new discoveries. Paris's work picked up where Parmentier (1910) and Groslier (1921) had left off, adding the description of the boats depicted in Angkor Wat, Tanei, Preah Khan, and north of Phimeanakas to Angkor's iconographic corpus. Paris used Parmentier's description of the boats in Banteay Chmar and expanded the description of the boats found in Bayon. His work seems to have been based on the photographs taken by the EFEO (Paris 1941: 335 f.n. 3). The article is organized in a series of descriptions followed immediately by Paris's interpretations, which are often illustrated with examples drawn from many different cultures, including some with no cultural ties to Cambodia, a view that seems to imply a classical social and technological evolutionist approach. For Paris, the design of the hulls in the naval battles looked like the *rua chalom*, a type of plank boat found in the Gulf of Thailand that he reckons must have evolved from a dugout design (Paris 1941: 340-341). Although he does not credit Quaritch-Wales, he also explores the idea that the Thai Royal Barges depicted in European engravings from the 17th

century were similar to the boats of Angkor, as well as other connections to the Bronze Drums of Southeast Asia (ibid.: 356-357), and decorated barges of Java and Bali (ibid.: 355).

It is at this time that epigraphic information starts exerting its influence in the study of boats; Paris quotes the work of Coedès (1929: 326), who inferred from the epigraphy that there had been a naval battle between the people of Angkor and the neighbouring Champa. Coedès continued the discussion in an article from 1932, where he ratified his position that both the naval battles at Banteay Chmar and Bayon were the same representation of the Cham naval attack of 1177 and the celebrations of the victory of Jayavarman VII (Coedès 1932: 76-78). The connection between the naval battles represented in Banteay Chmar and Bayon thus became intertwined with this Cham invasion in later studies. Paris agreed with Groslier that the fleet of Angkor comprised dugout boats destined exclusively to inland waters (ibid.: 337-338), and that they were propelled by paddles (ibid.: 354) although he also continued to equate rowing at times to paddling. Paris concludes that the Khmer of Angkor were not sea-going people, preferring to stay in inland waters. So, while Coedès's assumed the naval invasion came from the sea, Paris suggested that the Cham fleet was fluvial (Paris 1941: 338). No further reflection ensued on how the environment would have affected the movement of a sea-going fleet navigating through inland waters or of a river fleet navigating through the rapids of Sambor, nor hypothesised on the location of a Cham river fleet in a space largely controlled by Angkor (see discussion in Walker Vadillo, 2016: 195-199).

Paris's article was the first and last comprehensive study of Angkorian boats of the first half of the 20th century, although Poujade published two ethnographic articles (Poujade, 1946a, 1946b) on the boats of Indochina, in which he discussed the connections between contemporary examples from Cambodia and the boats depicted in the Angkorian bas-reliefs. Nevertheless, the extensive archaeological work conducted by the EFEO provided substantial epigraphic material to start piecing together the history of Angkor from a historical approach.

In 1944 Coedès presented *Histoire ancienne des états hindouisés d'Extrême-Orient* the first version of what ended up being his most influential work: *Les États hindouisés d'Indochine et d'Indonésie* (1964). Coedès was not so much interested in the technical aspects of boat design and construction as he was in understanding the evolution of trade routes. His work is a good example of the way later historians such as Kenneth Hall (1985; 2011) continued to look at river trade following relations between maps and the location of archaeological material (both sites and stelae). Although not fully explored, Coedès was aware of the limitations that the environment imposed on trade routes; citing Father H. Bernard, he mentions that the deltas of Southeast Asia were covered by dense vegetation and inhospitable interiors that made them difficult to cross (1968: 26). Coedès identified the Phapheng – Khone falls as the logical terminus for the trade routes crossing the Khorat Plateau from the West based on the idea that the Khmer homeland was based around Wat Phu (ibid.: 28). His work is particularly useful to grasp the variety of historical sources that mention travel by water and other maritime-connected traditions, such as "burial by water", a Funanese tradition recorded in the *Book of Southern Qi* wherein the bodies of the dead were deposited in the river (Coedès 1968: 59). However, despite references to nautical, maritime, and fluvial activities, it was not Coedès's intention to

generate a detailed study of Angkor's waterborne trade networks but rather to make a chronological progression of the history of Cambodia following the sequence of events documented in the epigraphy (ibid.: 247). Perhaps the most influential piece of his work for the study of Angkor's fluvial activities was the expansion on his initial proposal of a Cham naval invasion of 1177, this time echoing Maspero's proposition in *Le Royaume du Champa* (1928: 164 cited in Coedès 1968: 166) that a Chinese pilot had helped the Cham navy to travel up the Mekong River to invade Angkor. There is no reflection on the reasons why a Chinese pilot would have been needed to navigate upriver, when the Cham were indigenous to the region and had a long-standing connection to Angkor.

Following Coedès's work, Lawrence Briggs – an American diplomat who served as consul in various places of Southeast Asia – published an influential work for the English-speaking world titled *The Ancient Khmer Empire* (1951). As Mus pointed out, Briggs's work summarized half a century of French scholarship, and added valuable insights on the state of the question at the time (Mus 1952). Though Briggs considered the Funanese a maritime culture, as opposed to the inland character of the Khmer (Briggs 1951: 30), his interest in boats and waterborne communications was tangential. Concurrently, he discussed the road network uncovered by Lajonquière (1901) as a stand-alone subject, without discussing its role as a part of a wider communication network that included waterborne transport. His work was nonetheless very influential in the English-speaking scholarly world and remains amongst the most cited. Gibson-Hill, who based his knowledge of Angkor on Brigg's work, used his discussion on the Pontian ship found in Malaysia as an opportunity to refute Paris's theory that the boats of Angkor were related to the *rua chalom*, positing instead that the hulls shared more similarities with the *perahu buatan Barat* and the *perahu payang* boats of Malaysia (Gibson-Hill 1952: 122-124). He then used Briggs's summary of the history of the Khmer empire to point out that the influence of the Khmer extended as far as the Malay Peninsula (ibid.: 124). Gibson-Hill, who was curator of the Raffles Museum in Singapore, had travelled extensively in Southeast Asia and was able to find further similarities between the design of the Angkorian hulls and those of the Botel Tobago and of the Orembai of the Maluku islands, suggesting that the design was very old (ibid.: 127). Gibson-Hill also provided a very insightful, albeit seldom referenced, digression regarding Paris's appraisal of the planked vessel of the Bayon as a Chinese junk, calling into question his identification of the ship and suggesting that it was most likely of local construction, possibly a Wangkang hull which Gibson-Hill considers to be of Funanese origin (ibid.: 126 f.n. 6, 127-128). Unlike previous publications, Gibson-Hill's grasp of nautical terminology is clear and accurate. His is one of the few articles on Angkorian boats that base the argumentation on the technological aspects of ship design.

Though only tangentially relevant to the study of Angkorian boats and waterborne communications, the work of Wang Gungwu *The Nanhai trade: a study of the early History of Chinese trade in the South China Sea* (1958) provided translations of Chinese texts with references to ocean-going ships during the Funan period (1958:31-45). Osborne, on the other hand, analyzed the role of Sambhupura in the network of communications that linked it to the Annamite range in his article *Notes on early Cambodian provincial history: Isanapura and Sambhupura* (1966: 447). His later works also contain references to the role of the Mekong River in Cambodian history,

recounting the difficult navigation encountered by the Mekong expedition of 1866–1868 (see Osborne 1975, 2001). Subsequent studies of the boats of Angkor were concerned with the interpretation of the individual reliefs instead of offering an integrated approach that would include environmental and cultural aspects of fluvial culture. For example, Bénisti published an analysis of the nautical representations of the frontons in Ta Nei and Preah Khan, comparing them to other regional examples of art but without further comments on the boats themselves (Bénisti 1963). Similarly, Bernard-Philippe Groslier focused his interest on the interpretation of the naval battles, which he assumed to be the representations of the alleged 1177 Cham invasion of Angkor (Groslier 1979: 165-168, 176). But perhaps his most important contribution to the study of Angkor's fluvial culture was his suggestion that the construction of Vat Nokor, near the confluence of the Tonle Touch River and the Mekong River, was connected to the importance of the Tonle Touch for the Khmer (Groslier: 1973: 367).

River network analysis and nautical technology in the 1970s and 1980s

The 1970s was a convulsive period in the history of Cambodia. In 1970 king Sihanouk was ousted by General Lon Nol. The Khmer Rouge, an insurgent communist group, opposed the government of Lon Nol and eventually took over the country in 1975. The fall of Phnom Penh in April of that year marked the start of the darkest years of Cambodian history: foreign embassies pulled out of the country and the Khmer Rouge initiated forced evacuations from the cities to the countryside and mass killings of what they considered to be counter-revolutionaries. Among the latter were bureaucrats, intellectuals, and educated Cambodians (Clayton 1998). The political instability of the region affected the archaeological projects in the country. The EFEO was forced to close its research centre in Cambodia in 1975 and archaeology in the country came to a halt. Research after this period had to rely on previous archaeological work and it appears that as a result historical approaches to the study of Angkor gained more relevance.

Due to the political instability of the country during the 1970s research centres had to close their offices and fieldwork came to a halt, forcing later studies to rely on previous archaeological work. As a result, historical approaches gained more relevance. The study of Angkor's relationship with waterborne communications became part of historical narratives but was not the main subject of research. Wolters, for example, discussed Jayavarman II and his military exploits, but without discussing the existence of a fleet in detail (1973), as well as the conquest of North-western Cambodia in the early phases of the Khmer Empire looking specifically at Chinese historical accounts (1974). Though his main interest was the polity of Malyang, he reviewed the environmental conditions of the region and the lengths of travel by land, but fell short of discussing how this affected waterborne communications (see Wolters 1974: 371-372). Groslier reconstructed the Angkorian landscape – including the rivers that were later canalized – and its development over the centuries in his paper *La cité hydraulique angkorienne: exploitation ou surexploitation du sol?* (1979: 181) and provided a toponymic reference to a place used for river crossing by boat translated by Coedès as "barque pour traverser" (ibid.: 163), showing the importance of toponymy in the reconstruction of fluvial cultural landscapes. Economic historian

Kenneth Hall continued the trend of historical analysis in his seminal book *A History of Early Southeast Asia: maritime trade and societal development 1000-1500* published in 1985 and revised in 2011. Hall's work challenged Coedès's idea of an Indianized Southeast Asia and emphasized local agency in the development of polities in the region. His work nonetheless relies in the classical works of Coedès and other French scholars, as well as Briggs, albeit with differing interpretations. Although the focus of his book is maritime trade, Hall devotes a chapter to the temple-based economy of Angkor wherein he briefly discusses river trade (Hall 2011: 180) but his approach is mostly conjectural. Similarly, Higham referred to river trade in his book *The Archaeology of Mainland Southeast Asia* (1989) as an undefined factor that supported the rise of the polities in the region (Higham 1989: 247). The presence of canals linking Angkor Borei to Oc Eo and the sea are mentioned in these studies, but no discussion ensues on why the people of Angkor Borei would prefer to invest herculean efforts into making canals rather than use the rivers they had readily at hand (i.e., the Mekong and the Bassac).

The most detailed work on Angkorian boats from the 1970s comes from the French historian Jacq-Hergoualc'h who published *L'armement et l'organisation de l'armée khmére aux XIIe et XIIIe siécles* in 1979, translated into English in 2007. In this overview of the armies of Angkor, Jacq-Hergoualc'h dedicated a full chapter to discuss the fleet of Angkor and that of their enemies. His work is centred on the publications of Groslier (1921), Paris (1941), Pelliot (1903), and Coedès (1929; 1932), without mention to Gibson-Hill's work. He accepted Coedès's interpretation of the naval battles, assuming that they showed a confrontation with the Cham during the attack of 1177, and agreed that the boats were dugouts, had shallow drafts, were elongated but broad at the centre, had rudders, and were propelled by rowers (2007: 128). Jacq-Hergoualc'h diverged from earlier interpretations by proposing that the similarities between the two fleets were an indication that the boats were not true models but rather a free interpretation of the Khmer artists, even though the Khmer art of the Bayon temple has been regarded to include historical representations of Angkorian life (Roveda 2007: 322), that traditions such as the Water Festival racing boats in Cambodia involves boats decorated with zoomorphic animals, and that the Thai royal barges show striking similarities with the boats depicted in the battles, as noted by Quaritch-Wales (1931: 111-115) and Paris (1941 356-357).

Another piece of research to take into account is that of Eveline Porée-Maspero who dedicated substantial space on her article *Jonques et po, sampou et sampan* – where she discusses the origin of these boat names from a linguistic point of view – to the analysis of the planked vessel in the Bayon, disagreeing with the conclusion that the ship is a Chinese junk as had been suggested by Groslier (1921), Paris (1941), and Needham (1970), and proposing that the boat is Khmer or Southeast Asian built (Porée-Maspero Eveline 1986: 76). She credited Malleret for asserting that the Pontian boat probably came from Oc-Eo (Malleret 1960: 120-121), even though his publication is eight years older than that of Gibson-Hill, who first proposed the idea and whose work Porée-Maspero mentions in passing on other matters (see Porée-Maspero 1986: 74). Although focused on ethnographic research, her studies on Cambodian agrarian rituals titled *Étude sur les rites agraires des Cambodgiens* (1962, 1964, 1969) include several references to boats and nautical traditions that provide some details on boat construction and ritual behaviour (1964: 370-371). Although no

mention is made to Angkor's rich nautical iconography, Loofs-Wissowa uses Porée-Maspero's comments on boat races in the Mekong to digress on the connection between the nautical representations of the Dong Son bronze drums, boat races, and fertility rights (1991: 46-47), a line of thought worth perusing further.

Fluvial and nautical studies in the 1990s and 2000s

The political stability attained by Cambodia in the 1990s resulted in a new phase in the study of Cambodian archaeology. The inclusion of Angkor on the UNESCO's World Heritage list in 1992 paved the way for a new wave of archaeological projects marked by the return of the EFEO in 1990 and the establishment of other international research projects such as the Greater Angkor Project (GAP) from the University of Sydney (established in 2002), the Lower Mekong Delta project (LOMAP) from the University of Hawai'i at Manoa (established in 1996), the Japanese team for Safeguarding Angkor (JAS) supported by the government of Japan (established in 1994) and the Royal Angkor Foundation (RAF) supported by the government of Hungary (established in 1992). While the interpretation of pre-Angkorian and Angkorian inscriptions continued to be a matter of debate among historians (see Vickery 1998), archaeologists were regaining the ground lost during the years of the Khmer Rouge conflict and started to call for research approaches anchored in the archaeological context (Stark and Allen 1998: 176; Pottier 2000: 112). The main archaeological projects that have been conducted so far have revolved around the urbanization of the Angkorian landscape, which has resulted in a comprehensive map of Angkor's seat of power north of the Tonle Sap Lake (Evans et al. 2007) that keeps expanding as LiDAR is applied to other areas of Cambodia (Evans et al. 2013; Evans & Fletcher 2015; Evans 2016), further details on canals are also being presented (see Pottier 2004: 135), while new data on the paleoenvironment of the area is furthering our knowledge on past environmental conditions (see Buckley et al, 2010, 2014; Lieberman and Buckley 2012).

The publications that have come out of this new phase of archaeological inquiry have agreed on the relevance of river networks, canals, and associated infrastructure (Im 1998: 58-71; Pottier 1999; Fletcher et al. 2003; Fletcher, Evans and Kummu 2003; Pottier et al. 2012: 2606), but the subject has yet to receive full attention. Jacq-Hergoualc'h wrote about the boats of Angkor again in 2001, when he published "Quelques représentations d'embarcations monoxyles en Asie du Sud-Est" in a special number of *Techniques & Culture* that focused on nautical themes. In this article he repeats the theories set forth on his study of the fleet of Angkor and links them to other representations of dugout boats in Southeast Asia, expanding the similarities between the boat representations in Dong Son Bronze drums and those of Angkor that were discussed by Paris in 1941. In the same volume there is another crucial article by Hoc Cheng Siny titled "Le touk Khmer" (Hoc 2001). Hoc, an archaeologist and ethnographer by training, provides a detailed account on the construction processes involved in the making of Cambodian dugouts. Although he initially connects the article to the boats of Angkor, he does not discuss how the ethnography relates to them. His work nonetheless raises very important issues regarding the construction process and the rituals involved in it, and it is probably the most relevant work conducted so far in the study of nautical technology in Cambodia. The nautical scenes found in Khmer art have been discussed by Roveda as part of his wider work on

Angkorian bas-reliefs (see for example (Roveda 2005: 284-285, 405-407, 431-435, 440-441; 2007: 291-323, 353). His later publications (Roveda 2007) benefited from Vickery's analysis the Cham naval invasion of 1177 that concluded that there is no evidence in the epigraphic data to support such claim (Vickery 2005: 58). This was incorporated into Roveda's work, who favoured the idea that the battles represented a celebration (2007: 353), which would be more in line with the everyday life activities that surround the battle in Bayon temple. Little attention has been given to a plank-
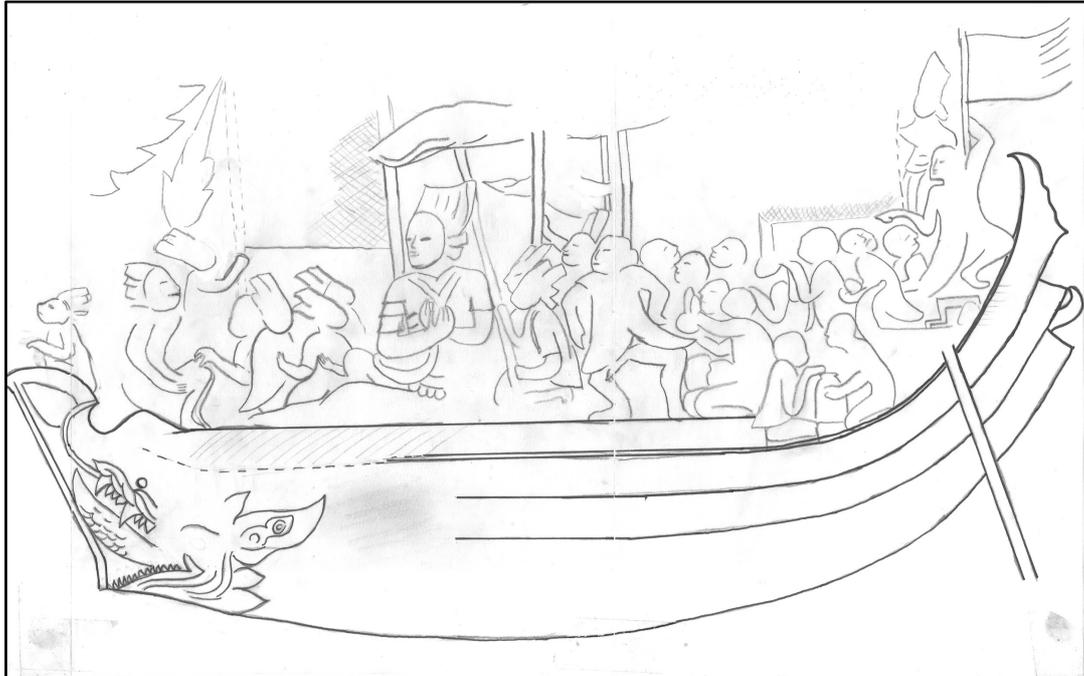

Fig. 3   Plank vessel located on the left side of Banteay Chmar's naval battle. Source: V. Walker.

built vessel depicted next to Banteay Chmar's naval battle (Figure 3); Pottier reckons the faint traces in the upper section could depict sails (Pers. Comm.), but perhaps even more interesting is the fact that the two plank vessels found in Khmer nautical iconography are associated with foreign crews in what seems to indicate a relation between boat-building techniques and group identity (see Walker Vadillo 2016: 154-162). New paintings of boats in Angkor Wat were found by Walker Vadillo, including what appears to be a Dutch VOC ship (Figure 4) (Walker Vadillo 2009), and upon further analysis of the walls of Angkor Wat, further paintings were discovered including a large vessel (Tan et al. 2014) and a European-rigged mast -a comprehensive iconographic corpus of nautical iconography from the Angkor period can be found in Appendix 3 of Walker Vadillo (2016). More importantly, two historical boats were discovered, the first in 2006 that dates to the 15th c. (An 2014), and a second one found in Angkor Thom dated to the 13th c. (Handley and Sen 2016). Initial material analysis confirm that boats were made from *koki* trees, a local hardwood, and that they were dugouts (see discussion in Walker Vadillo 2016: pp. 130-148, appendix 4).

Fig. 4   A sketch of what seems to be a VOC ship from the early 1600s painted in the west gopura of Angkor Wat. Source: V. Walker.

Archaeological evidence has demonstrated the existence of fixed and oscillating nodal interfaces (i.e., villages on stilts or floats respectively) positioned between terrestrial and lacustrine systems, which highlights the use of water transport during the Angkor era (Pottier et al. 2012). However, while the studies of maritime trade networks and associated ships have received considerable interest elsewhere (see for example Manguin 2004: 282-308; Miksic 2003; Manguin 1993; Manguin 1980), and some attention has been granted to the study of river trade systems elsewhere in Southeast Asia (Bronson 1977; Manguin 2009: 434-485;   Miksic 2009), the critical analysis of river networks in Cambodia has remained on the periphery of studies on Angkorian road networks (see Im 1998; Hendrickson 2007; Lorrillard 2010, 2014a, 2014b). Similarly, the monumental remains of bridges along the Angkorian roads have not been considered within the context of navigation. Bruguier, for example, mentions that trans-shipments could have taken place in the vicinity of masonry bridges (2000: 534-535), but fails to critically examine the impact of this type of construction on river navigability and river networks. The same absence can also be found in Loofs-Wissowa in his discussion on true and corbelled arches (1986), and in Hendrickson's digression on stone bridges (2007: 135-139), see discussion below.

Hendrickson often reiterates the importance of river basins and waterborne transportation, but the terrestrial approach that he applies to his studies makes it difficult for him to fully address the role of water transport in Angkor's communications landscape. For example, Hendrickson uses water catchment analysis to determine the relationship between temples and rivers (Hendrickson 2011: 94-98) but does not discuss river navigability, nautical technology, or geographical limitations to watercraft, and often removes rivers from his maps (see Hendrickson

2010: 448-449). As a result of treating road and water networks separately, he proposes that the temples of Banteay Chmar, Banon and Banteay Prei Nokor – which were constructed during the reign of Jayavarman VII – were not connected to the visible road network (2010: 493), without highlighting the fact that Banteay Chmar and Banon are located in places with access to the Sangker River Basin, and that Banteay Prei Nokor is located in Kompong Cham where seagoing ships still arrive from the sea to this day and within easy access to the Tonle Touch (Walker Vadillo 2016: 90-125), the river that was identified by Groslier as being of great importance for the Khmer (Groslier 1973: 67). Most importantly, Hendrickson reiterates the relevance of seasons for transport and the necessary combination of water and land transport (2007: 255, 262), a factor without which it is difficult to fully grasp the functioning of Angkor's transport system. Hendrickson also suggests that the ditches on the sides of the elevated roads could have acted as canals for water transport during the rainy season (2007: 130-131). In studying Angkor's road network in Wat Phu, Lorrillard came to the same conclusion although he does not credit Hendrickson (Lorrillard 2014b: 74-76). In both cases there are no references to the technical aspects involved in using these canals for water transport, nor the logistics involved in using these canals as anything else than opportunistic waterways with rafts made *ad hoc*. Lorrillard's work in southern Laos provides additional details in terms of land and river routes connecting both sides of the Mekong River (see Lorrillard 2014a). Although he does not discuss navigation, data on this matter can be found in Garnier (1885: 86, 125-128, 148), Madrolle (1930: folded map) and Great Britain Naval Intelligence Division (1943: 442).

Integrated approaches to the study of fluvial networks

The majority of the studies related to Angkor's fluvial cultural landscape that have been reviewed in the previous section rely on the same historical, iconographic, and ethnographic material presented by Groslier in his 1921 publication, and by Coedès's suggestion of a naval attack by the Cham in 1177. The lack of a maritime perspective in the analyses of these sources have led to a consensus that oversimplifies nautical technology and downplays Angkor's interactions with its aquatic environment. For example, the current literature assumes that the boats of Angkor were somewhat homogenous following a single tradition (i.e. fluvial watercraft made from a single log with the implication of a narrow hull), but studies on nautical design suggest that function and environment give rise to different hull types (Steffy 1998: 10-11). This variety of design is patent in Vietnam, where the coast line shows at least six different traditions of boat construction including sailing rafts, basket boats, and planked ships (see Pham, Blue and Palmer 2010: 265-273). The geographic analysis of Angkor's territory suggests that there were different environments where boats could have been used: sea-river, lake, canals, ponds, and rivers with rapids. The conditions on the Tonle Sap Lake allow for the development of flat hulls that offer good initial stability, but the rapids of Prek Patang and Sambor would have required hulls with narrower and rounder beams that offered less initial stability but better final stability (see McEwen 2006: 29-33). Just by evaluating the function of the boats and the environment in which they were used it is possible to suggest that Angkor probably developed various types of hulls, thus the idea of a single type of boat design for Angkor needs to be challenged.

Additional problems are encountered in the literature with the use of technical terms that define boat types without providing a definition of what they mean when terms such as pirogue, junk, or sampan are used – sometimes interchangeably – in relation to the boats of Angkor. Similarly, the confusion over rowing and paddling and what it means in terms of affordances and constraints for boat movement limits previous discussions. On the other hand, analyses of the naval battles do not include reflections on logistical and strategic problems of naval invaders coming from afar travelling on boats overloaded with soldiers who had no handrails to hold on to, space to sit down, or a canopy to protect them from the inclemency of the weather during such a long journey. Paris's proposition that the invading Cham came through the river system across the Annamite range (1941: 338) raises more questions than it answers: why would the Cham have a river fleet if waterborne threats would most likely come through the sea? If they did, would it be feasible to haul large boats through the jungle since there are no direct waterways from the coast to the Mekong through the Annamite range? Or were the boats made *ad hoc* for the purpose of the battle? If the invading forces were coming from Stung Treng, how stable would the soldiers had been if they had to cross the Prek Patang and the Sambor rapids standing up with no place to hold on to? Would the width and length of the boats made it possible to cross the rapids safely? Surely the length of the oars would have prevented this type of propulsion to be used in the rapids, so hooks poles and paddles would have been needed. Where would they store the oars with a boat already crowded with people? Furthermore, where were the water and the food stored to feed soldiers and rowers? By taking the boats out of their environmental and technological context these questions have been left unasked.

Moving on now to consider waterborne networks, current theories have also been proposed with no regards to the limitations imposed by the environment and by nautical technology. Since Parmentier's initial attempts to analyse the boats of Banteay Chmar (1910: 209-211), their study has been dissociated from the study of waterborne transport. What is more, the use of inscriptions to map river communications has not been followed up with more in depth analysis of the affordances and constraints of the environment on river trade except for the acknowledgement of the Phapheng-Khone Falls as a blockage to direct river trade through the Mekong River. This represents a wider trend in archaeology pointed out by Van de Noort wherein socio-economical practices are considered with no regard for the practicality of the artefacts' journeys, and the skill and knowledge required for waterborne transport (Van de Noort 2011: 235).

Maritime approaches to the study human-environment interactions

Looking at the shortcomings of the literature, it seems that an integrated study of Angkor's connection to water as a space for human activities provides a more complex view of the subject and allows for the use of a wider array of data more effectively. By analysing the entanglement between environment, nautical technology, and social activities surrounding boats, it is possible to provide more nuanced approaches to the study of river networks or contextualise sites that may have been used as ports in the past. This can be done by determining river navigability, defining expected transport zones, discovering the nautical technology available for water transport, analysing the impact of climate and climatic oscillations

in navigation, and teasing out other cultural traditions connected to watery spaces and the use of boats that may determine certain choices or cultural expressions. Although there are other useful theoretical approaches to the study of maritime communities, such as Van de Noort's cultural biography of boats (2011) - which does not steer far from Gosden and Marshall's 'The Cultural Biography of Objects' (1999) -, the theoretical framework that has managed to unleash a paradigm shift in archaeology and present a new agenda for future work (Flatman 2011: 311) is that of the Maritime Cultural Landscape.

The Maritime Cultural Landscape (or MCL) is a cross-disciplinary mode of archaeological research where the customary divide between land and sea is erased to give way to a comprehensive study of human use of watery spaces (Westerdahl 2011b: 733). It serves as a way to counteract the excessive emphasis that traditional studies have placed on cultural activities taking place in land (Westerdahl 2011a: 338). These activities often leave behind monumental remains that are easily identifiable in the landscape, whilst remains associated with the human use of watery spaces are less visible (ibid.). The MCL theoretical framework was initially proposed by Westerdahl in the 1970s as a result of archaeological survey that he undertook in the Swedish Norrland coast between 1975 and 1980. At the time Westerdahl realized that to fully understand underwater archaeological remains he had to develop a seamless approach that would also address the remains found on land (Westerdahl 1992: 5). This approach, which stemmed from previous anthropological and ethnographic studies conducted by Nordic researchers, was centred on the analysis of the cognitive landscapes of the past, that is, the way humans ordered and engaged with the functional aspects of their surroundings (Westerdahl 1992: 5). Westerdahl's attempt to broaden the reach of maritime archaeology reflected an increasing desire of maritime archaeologists to address maritime cultures from an anthropological approach (see Gould 1983). This theoretical framework considers that in order to fully understand maritime cultures, it is important to explore all kinds of human relationships to the sea or any large bodies of water (Westerdahl 2011b: 754). Thus, remains such as coastal dwellings, ancient ports, anchorages, boat houses, roads, forts, place names, stories, songs, terminology, and social practice are inextricable parts of the complex network that made up past maritime landscapes (Westerdahl 1992). The nature of the data naturally results in the need to use interdisciplinary or cross-disciplinary approaches that are entrenched in a broad and geographically oriented landscape perspective (Ford 2011: 1). The ability to combine different sources of data (i.e. environmental, archaeological, historical, iconographic, ethnographic, and linguistic) centred on the cognitive processes of maritime communities makes the MCL particularly useful for areas where archaeological remains are elusive, or for activities that would not have left visible traces in the archaeological record directly, but which can be inferred by proxy. It has been noted that conservatism among maritime communities is often the result of little environmental change and an early optimization of boat design (Hunter 1994: 263), which makes ethnography an invaluable resource for research. However, ethnographic work can be problematic because the uncertainty generated by aquatic spaces is likely to have exaggerated the effect of these spaces on society (see Hunter 1994: 264), so this should always be taken into consideration.

In his work in Scandinavia, Westerdahl has noted that relict patterns of transportation have been in active use until recently, especially in nodal areas (Westerdahl 1992: 6). Though this should not lead to a unilineal evolutionary approach, the landscape contains multiple layers of use throughout history that can be studied through archaeological remains as well as other immaterial data – cognitive or indicatory, such as place names or the cognitive perspective of local traditions (ibid.: 5-6). Therefore, the MCL engages with both material and immaterial remains to blend in together the multifaceted aspects of maritime cultures without creating artificial boundaries that may not have existed in the past. This way, it offers a versatile way of understanding past human activities that may be difficult to grasp with material remains alone. As Flatman argues, "the concept's theoretical model is frequently more tangible, more approachable, and certainly more understandable than its observable archaeological reality […]" (2011: 312).

Westerdahl's theoretical model is not without its critics. Hunter reckons that although cultures may have maritime components, a balance should be sought to avoid missing non-maritime groups within seemingly maritime communities (Hunter 1994: 261–262). The issue relies on groups whose main activities, while belonging to communities that are dependent on aquatic resources, are not maritime in nature (i.e. industrial production or preparation and organization of trade). Hunter argues that maritime components are reflections of the broader culture and form an integral – not separate – part of the economic and social elements of a given culture (ibid.). The "maritimeness" of a community is therefore directly proportional to its reliance on aquatic resources, but terrestrial aspects of these communities should not be overlooked. Similarly, Van de Noort argues that Westerdahl's anthropocentric approach leads to the perception of the maritime space as "encultured landscape", and therefore underestimates the sea's agency as co-constructor of the landscape (Van de Noort 2011: 229). Hence in the application of MCL there must be a balance between terrestrial and maritime, and between human and nature. By focusing on the entangled elements that make up a cultural landscape, it is possible to strike a balance between human agency and other-than-human agencies.

What bridges can tell us of encultured fluvial landscapes

A good example of the problems that may arise with the dissociation between terrestrial remains and their fluvial context is the study of Angkor's road and river networks. Although as seen above authors like Parmentier (1927) and Hendrickson (2007, 2011) have been quick to point out the relevance of river networks, the study of Angkorian roads and associated infrastructures have been conducted without due consideration to water transport. A very good case study to highlight how the archaeology of fluvial cultures like Angkor can benefit from theoretical frameworks that stem from maritime archaeology (especially the MCL) is the masonry bridges found in Angkor's road network.

Dozens of masonry bridges are found within a 100 km radius from Angkor, all of which were constructed along the major road networks (Bruguier 2000: 534). Large bridges are made using corbelled arches, while smaller structures are culvert-like (Loofs-Wissowa 1986; Hendrickson, 2007: 138). No true arches are found in Khmer architecture (Loofs-Wissowa 1986), a feature that would have allowed the people of

Angkor to expand the width of the spans (i.e., the space between the intermediate supports of a bridge), which is an important issue for navigation and nautical design as will be seen later on. Wooden bridges, on the other hand, have not been identified in the archaeological record, but they are mentioned in one inscription dated to the 11th century (Jacques 1968: 606) and examples have been found in the iconography (Bruguier 2000: 541; Groslier 1973: 16; Roveda 2007: 435), with the assumption that construction techniques would have been similar to those used in modern times (Hendrickson 2007: 138). Scholars have wondered about the reasons that would have led the people of Angkor to restrict the use of masonry bridges in such a short periphery, with Bruguier proposing that such use was probably connected with a symbolic demarcation of Angkor's core territory (2000: 535-536). Continuing with this vision of territorial control, Bruguier also posited that masonry bridges would improve military movement, and therefore their construction was likely linked to military control of the territory (Ibid.: 542). Dating the structures also proved controversial, as some argued that they were tied to Jayavarman VII (Boisselier 1966: 107; Dumarcay 1992: 134), while others assumed that they were constructed after the Cham sack of Angkor in 1177 to replace the wooden bridges burnt during the attack (Parmentier 1948: 119-120). Upon reviewing the subject, Hendrickson rightly points out that Vickery's revision of the 1177 attack, compellingly rejecting it, rendered this idea of burnt wooden bridges and masonry replacements obsolete (2007: 137). He concludes that even if there is no evidence to suggest that masonry bridges were erected before the 12th or 13th centuries, the increasing activities in the East road from the 11th century onwards necessarily implies the existence of masonry bridges dated to this period (Hendrickson 2010: 491).

Fig. 5: the span of Khmer bridges like this one of Spean Praptos are narrow and long. This limits nautical design and makes transit very dangerous. Source: V. Walker.

The analyses presented above have focused on bridges in relation to the road network, but how do they relate to the river network? Bruguier mentions in passing that trans-shipments would have occurred where bridges are found, and that this, together with the presence of hospital chapels and rest houses, made these areas important economic spaces (2000: 535-536). However, he felt short of discussing what this meant in the context of navigation. As hinted above, masonry bridges were made using corbelled arches, so there were strict limitations to the width of the spans. This means that wherever one of these bridges were placed, navigation would have been limited to very narrow boats capable of fitting in such a small space (Figure 5). This risky manoeuvre would have only been possible during the dry season. During the rainy season the water levels would have raised so high that no boat would have been able to navigate through the gaps (if there were any). Therefore, wherever a masonry bridge was built, the king was making a conscious choice of blocking the waterway. Similarly, culvert-style bridges would have acted as a blockage even for the smallest boat (Figure 6). The construction of such structures in the context of a fluvial culture (where water transport is likely the most important means of transport) points to the construction of unnecessary man-made transit points that would have been used by the state as a means of control (i.e., of goods and people moving in or out of their territory). This is confirmed by Groslier's observations of how in the ancient road between Angkor and Banteay Chmar, the derelict bridges of Angkor were now a serious problem for navigation during the rainy season, and that local people had to seek alternative routes to bypass the blockage imposed by them (Groslier 1973, p. 367). A similar observation was made by Aymonier, who noticed that in order to make the river navigable, the local people had cleared a section of the Spean Thma Bridge (Aymonier 1904: 55). This connection between masonry bridges and economic activities can be seen in the two rivers that surround Banteay Chmar. The river to the East is called Stung Kompong. The Khmer term *kompong* or *kampong* (kaṃvaṅ /kəm'wɔŋ/), appears in Cambodian inscriptions very early and it describes a river port, landing, crossing place, or wharf (Vickery 1998: 440-441; Harris 2007: 89), so the name of this river translates loosely as River Harbour, and concurrently, it does not have masonry bridges in its intersection with Angkor's West road. The river on the west side, however, does not carry this term on its name and it is cut off by a laterite bridge. So here we see a relation between river usage and bridge construction. As Manguin pointed out in his study on upstream-downstream relations during the Srivijaya period, when rivers are used as the primary means of communication, they must remain open for navigation (Manguin 2009: 472). Elements that block these waterways, such as stone bridges, might be interpreted as technologies for surveillance and control used to oversee, regulate, or tax river transport, and therefore they need to be considered in relation to water transport in addition to land roads.

Fig. 6: culvert-style bridge. This type of construction prevents fluid movement of boats. Source: V. Walker.

In this context it is important to consider the role of wooden bridges in water transport, and to do that we must look at the way they are constructed. The modern bamboo bridge between Kompong Cham and the island of Koh Pean can be a good example to understand how bridges were made and what role they played in Angkor's transport network. The Koh Pean bridge has become the subject of a documentary project 'The Bamboo bridge' by anthropologist Juan Francisco Salazar (https://vimeo.com/243601859), and in his teaser the local people explain that the bridge has been traditionally built by the local community every year during the dry season, and taken apart at the start of the rainy season. Workers get paid for their contribution after toll fees are collected. The time it takes to construct the bridge is approximately two months. The structure is created using a series of bamboo pillars placed closely together, but the versatility of bamboo allows constructors to leave a very wide gap in some sections to allow boats to pass through. Historical accounts show that the Khmer had the resources and the ability to move the required man-power to build such structures in the 1600s. During a conflict with the Dutch VOC, the Cambodians constructed two bamboo bridges (pontoon-style) across the Tonle Sap River in less than 4 days (Van der Kraan, 2009: 53-55). At the risk of being anachronistic, it seems that the construction of bamboo bridges as needed may not have been an insurmountable task for the Angkorian population, especially if it granted them the ability to link roads while keeping rivers navigable. Furthermore, the use of rafts and pontoons have been documented in the iconographic record (Figure 5) (see Bruguier 2000: 541, 548; Roveda 2007: 351; 2005: 435). Bruguier sees them as military structures based on the reliefs (2000: 541-542), however, the inscriptions indicate that ferries were used where bridges could not be constructed (see interpretation of the term kompong in Vickery 1998: 440-441; Harris 2007: 89). I would argue that there is no reason why these structures would not have been used by commoners as platforms from where to work, or places where to live (i.e. floating houses), as floating bridges that adapt to water levels, or as floats to ferry people

across rivers when bridges were not available. As the intersection between road and river networks, wooden bridges would still be important economic spaces where river farers and road users could stop to conduct economic, social, and religious activities. The economic opportunities and services provided in these spaces (not only hospitals and temples, but also nourishment and lodging) would have been appealing enough for the tired river farer to stop. There was therefore no need to create a barrier with a masonry bridge, and in any case a wooden bridge could also serve as a barrier to force a stop. If we look further into the temporal nature of these wooden constructions, it is worth noticing that the Koh Pean bamboo bridge is taken apart every year due to the rainy season. Any structure constructed across the river would have been affected by the debris and the increased flow (both in volume and current) from torrential rains. Dismantling the wooden bridge would prevent the pile up of debris on one side of the bridge and prevent the river from damming up. Aymonier pointed out that the solid construction of the Khmer masonry bridges enabled them to resist flooding and absorb the shock of debris (1902: lxii; 1900: 108), but this does not evaluate how the build-up of debris behind the bridge would have transformed it into a dam that would pose a serious risks to those living around and downstream of the bridge. Furthermore, if the riverbanks had soft soil or the river shifted from year to year, masonry bridges may have become useless over time.
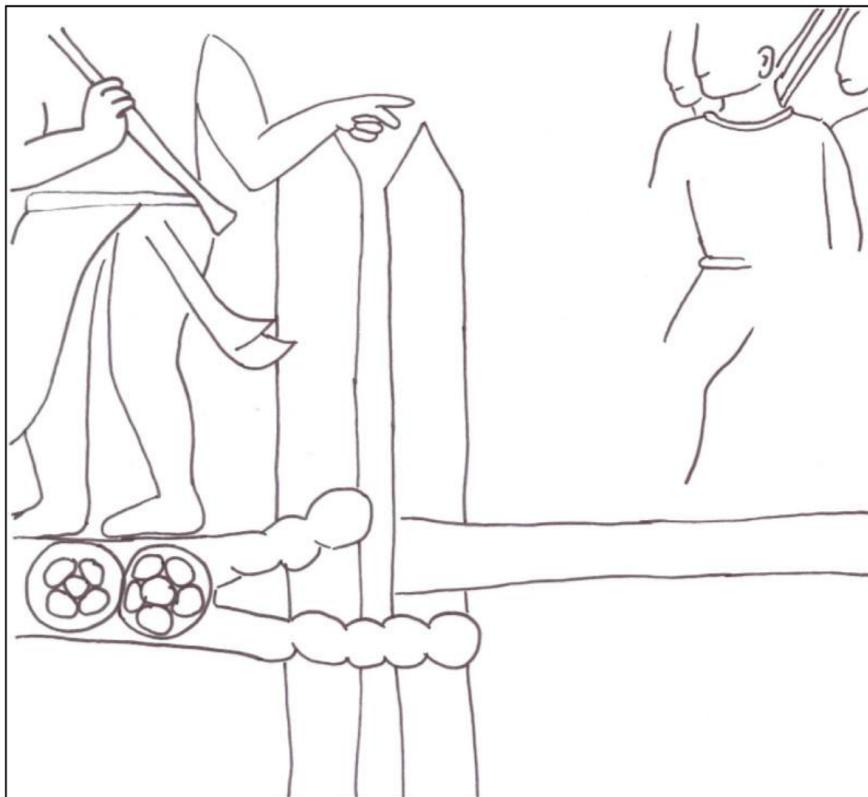

Fig. 7:   Drawing of a raft (bundles are represented as flower-like shapes under the soldiers' feet) moored to a platform. Source: V. Walker.

Based on the above, it seems that masonry bridges presented a series of problems that likely did not make them appealing to the people of Angkor, and probably that is the reason why they are not found up until the 12th or 13th century. In searching for a

reason why they do appear after these dates, it is worth exploring a different line of inquiry that gravely affects navigation: climatic variability. Navigation is tightly linked to the environment, even more so in an area like Cambodia where rivers are monsoonal and depend on rainfall (see Douglas 2005: 196). The dry season shows how lack of rain leads to a decrease in water volume in the region's monsoonal rivers, which in turn restricts navigation or makes it impossible. The shallow depth and narrower width of the river, along with high riverbanks, constricts waterborne transport capacity as they impose conditions on the size of the boat (width and draft) and the cargo it can carry, and make it difficult for cargo to be transported up the riverbank. If we take a modern example, goods shipped in the area above the Phapeng-Khone falls decrease over 50% during the dry season due to limitations to the boats' drafts. This is the main reason why, as pointed out by Hendrickson (2007: 255, 262), seasonality plays a big role in Angkor's transport system. Recent reconstructions of the paleoclimate suggests that Mainland Southeast Asia experienced low rainfall in the mid-13th century (Lieberman and Buckley 2012: 1057), thus we should consider whether the expected deterioration or reduction of waterborne transport in the context of prolonged periods of low rainfall could have led to changes in Angkor's transport system and, eventually, to the construction of masonry bridges. A reduction in waterborne transport capacity would have made it difficult for Angkor to function as an urban centre, and the need to improve the capital's immediate connections through the road network at the expense of rivers may have been seen as a priority in rivers that were deemed to be expendable. With the reduction of rain and the need to ensure connectivity, fears of masonry bridges blocking waterways or becoming dangerous dams during the rainy season would have been an acceptable risk. I have argued elsewhere that the mega-monsoons of the 14th and 15th centuries described by Buckley et al. (2010, 2014) and Lieberman and Buckley (2012) would have had a devastating effect in Angkor's riverine transport network, and likely contributed to Angkor's collapse (see discussion in Walker Vadillo 2016: 84-85), but if the prolonged droughts documented in the 13th c. are taken into account, it seems plausible that Angkor's river transport system begun deteriorating as early as the 13th c., and that bridges were made to enhance road transport at this time. This would reflect the systemic vulnerability to climate variations of Angkor's infrastructures proposed by Penny et al. (2018) and would better explain why there are no masonry bridges dated to an earlier period.

Conclusion

The analysis presented above shows how the maritime perspective contained in theoretical frameworks such as the Maritime Cultural Landscape can contribute to academic discussions. In this case, it is possible to break away from the question of whether the people of Angkor had the ability to construct masonry bridges before the 12th or 13th centuries or not, and change the question to why would they be interested in constructing permanent structures that would pose a risk to local communities and would effectively block navigation in a 100 km radius from the centre of power. Analysing the problem in the context of water transport, we see that the environment and the resources available made temporary structures more suitable, not only because they could accommodate river transport and therefore retain river navigability and road access, but also because they could be safely removed during the rainy season, at which point pontoons, boats, and rafts would be used to move

people across rivers far more safely. Therefore, when the kings of Angkor chose to block waterways with masonry bridges, they did so knowing what it was at stake, the proof of which is found in the choice of rivers that were blocked and the ones that were left open for navigation (see discussion in Walker Vadillo 2016: 66-119). This choice should therefore be seen as a conscious decision to block rivers either to control access by water, and/or because the river was expendable (i.e. did not have great economic or political value), and land transport therefore took precedence over water transport. The logical question that follows is why now, what changes could have prompted sacrificing rivers in the 12th or 13th c. in a region where rivers are known to be extremely important for communications and connectivity? Following Bruguier's idea that masonry bridges were part of important economic zones (2000: 535-536), it could be argued that bridges were used to force a stop, but the services provided in these areas and the economic opportunities they offered would have been appealing enough to traders to stop on their own accord when bridges were made of wood, as pointed out above. Fast troop deployment has also been considered (Bruguier 2000: 541-542), but it should be noted that the iconography clearly shows some troops being deployed by water in the bas-reliefs of Bayon and Banteay Chmar, while armies on foot crossed rivers using pontoon structures even when the deployment included elephants (see Roveda 2007: 351; 2005: 435). The change from wooden to masonry bridges therefore suggest alterations to the way the people of Angkor managed their landscape, which leads us to raise questions as to what prompted the change at this time. While improvements in road transport technology could be proposed, the iconography and the ethnography does not indicate great changes to pulled carts, which have remained roughly the same until the present. However, the climatic variation documented in the 13th c., which brought about long periods of low rainfall, does provide grounds to suspect that changes in landscape management could have been due to a diminished capacity of waterborne transport. As explained above, navigability of rivers depends on water levels, so a reduction of rainfall in monsoonal rivers would have resulted in considerable restrictions to navigation and waterborne transport, especially in small and medium-size rivers. If we consider the knock-on effect that prolonged low-rainfall would have had in Angkor's transport network, it seems logical to propose that during the 13th c. small and medium-sized rivers lost their strategic value in Angkor's transport network, at the same time that road transport gained importance around the core of the capital. In this context, it would make sense for the kings of Angkor to choose to seal off economically-irrelevant rivers by using masonry bridges that would enhance road transport. If this analysis is correct, the majority of the bridges should date to around the mid-13th c. So by taking a maritime approach and envisioning how masonry bridges relate to navigation, new avenues of research can be suggested in the discussion of Angkorian masonry bridges.

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