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Ancient floods, modern hazards: the Ping River, paleofloods and the 'lost city' of Wiang Kum Kam

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Abstract This paper demonstrates that the importance of rivers in northern Thailand was anchored upon society's dependence on them for sustenance and defense. Concurrently, rivers were also of deep religious and cultural significance. Hence, many northern Thai settlements were located near rivers. This resulted in their susceptibility to flood hazards. Our study investigates the interactions between the Ping River and the population of Wiang Kum Kam. Wiang Kum Kam was one of the former capitals of the Lanna Kingdom, a thirteenth- to sixteenth-century polity in northern Thailand. Described as the 'Atlantis' of the Lanna kingdom, the city was buried under flood sediments several centuries ago. Based on the floodplain sediments excavated, we argue that the city was abandoned after a large flood. Radiocarbon dating of charcoal found in the coarse sand layer deposited by the flood suggests that the deposition occurred sometime after ca. 1477 AD–1512 AD. Prior to this large flood, persisting floods in the city were noted in the Chiang Mai Chronicle and were also recorded in the floodplain stratigraphy. We show that an elongated mound on the floodplain in Wiang Kum Kam was a dyke constructed after ca. 1411 AD to alleviate the effects of persisting floods. From this story of paleofloods and Wiang Kum Kam, we conclude with two lessons for the management of modern floods in urban Thailand.

Keywords Floods · Northern Thailand · Environmental history · Wiang Kum Kam

1 Introduction

Historically, rivers were ambivalent entities in the daily lives of many northern Thais and in the Lanna Kingdom. The Lanna kingdom is a northern Thai polity, which rose to prominence in the

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late thirteenth century. Rivers in the kingdom were tamed and disciplined for survival and strategic concerns, yet Buddhist and animistic religiosity in Lanna culture mandated respect and reverence for them and for the environment in general (Darlington 2003). Seasonal floods, which affected the everyday routines of northern Thais and the landscapes of the Lanna Kingdom, complicate this seemingly dichotomous relationship. The first part of this paper elucidates the importance of rivers in the daily lives of many northern Thais in the past. Despite the centrality of rivers in the social and daily lives of the northern Thai people, Thai historiography has largely neglected the agency of rivers and floods. Making use of paleoflood indicators and environmental history analysis, the second part of this paper tells the (hi)story of an ancient Lanna city, Wiang Kum Kam, which was probably affected by frequent flooding and eventually ‘lost’ as it was buried by flood sediments. In the process, we ask and answer three questions about the city. Firstly, were there any forms of flood mitigation before the abandonment? Secondly, was Wiang Kum Kam abandoned due to persisting floods or were the inhabitants displaced by a single large flood? Finally, when did the abandonment take place? Through the telling of this (hi)story, we conclude by arguing for the importance of an environment-centered, or at least an environmentally conscious, perspective of history. It is via such environmentally conscious historical narratives that lessons can be derived for the management of future floods in Thailand.

2 Riverine societies: rivers and the everyday lives of northern Thais

Historically, water was one of the primary concerns of city planners in northern Thailand. The establishment of a town in northern Thailand was highly dependent on the proximity of rivers. Large wet-rice cultivating states with extensive irrigation networks, or ‘hydraulic states,’ were developed around river systems (Ongsakul 2005; Boomgaard 2006). The northern Thai kingdom, Lanna (thirteenth to eighteenth century), was one such hydraulic state. Irrigation systems (*Muang Fai*) were planned and executed since the late thirteenth century (Vichit-Vadakan 1989). The irrigation system did not simply provide water to the fields; it also organized social structure and affected inter-village relationships in the Lanna kingdom. Inter-village cooperation and communication was vital for the successful management of the *Muang Fai*. As rice is one of the most important staples in the Lanna diet, irrigation was strictly controlled through a series of laws and regulations. Great political power was also vested in the official in charge of the *Muang Fai*, thus highlighting the importance given to water management (Van Beek 1995).

Secondly, any Lanna settlement should be close enough to a river for water use and transport (Nid 1989; Boomgaard 2006). The importance of rivers for communication and transport is observable in settlement patterns of northern Thailand—the linear pattern of cities along rivers and streams, and the nuclear clutter of villages at the foot of hills near tributaries and/or streams (Srisaka 1989). The locations of these villages are commonly on relatively higher grounds, protected by the natural levees of rivers. Major cities in the Lanna Kingdom, such as Chiang Mai, Chiang Rai and Chiang Saen, are located next to rivers. Boats facilitated the movement of people and consumption goods around the Lanna kingdom. The Ping River was the key channel for communication with the southern cities of the Lanna Kingdom and other Siamese kingdoms, such as Ayutthaya and Sukhothai, located further south (Lebel et al. 2009). In addition, the river was utilized for defense—many towns made use of meander loops as natural moats (Ongsakul 2005), and others built moats that were connected to rivers through elaborate canal systems.

The cultural reverence and values imbued in rivers also have significant physical manifestations in northern Thailand. Notably, the locations of cities and settlements are

Fig. 1 Spirit houses are a common sight along rivers and canals in Thailand

predicated upon the symbolic presence of water in the form of rivers. Theravada Buddhism and local animist beliefs have influenced the traditional Thai worldview of the importance of natural settings—water and earth—in locating a settlement (Wilaiwan 1989). Important Lanna cities such as Chiang Mai and Chiang Rai are located on floodplains of the Ping and the Kok rivers, respectively. Ideally, the Buddhist temples in lowland settlements should be located next to rivers, as many believe that Buddha attained Nirvana while seated along a riverbank at dawn (Van Beek 1995). The presence of rivers also represents the spirit realm in the settlement. In the case of rivers, spirits were believed to embody the 'Mother of Life' (Wilaiwan 1989; Van Beek 1995). Locating a settlement near the river ensures the survival of its inhabitant, and piety toward the 'Mother of Life' means that the settlement would be further blessed with abundance and prosperity. Thus, shrines and spirit houses were, and still are, often erected along riverbanks for the worship of river spirits (Fig. 1).

The spirit realm is appeased annually with major festivals, during which Thais pay respect and make offerings to various spirits. Two of the most well-known festivals, *Loy Krathong* and *Songkran*, are associated with rivers and water. *Loy Krathong* is a fusion of Buddhist, Hindu and animist traditions, during which Thais thank and honor the 'Mother of Water' (*Mae Khon Kha*) for sustaining life, and they beseech the Water Goddess to 'float away suffering and misfortunes' (Agence France-Presse 2011, November 11). By floating decorated lanterns (*Krathong*) down rivers and canals, the Thais apologize and seek forgiveness for polluting rivers and water resources (Van Beek 1995). *Songkran* has its roots in an ancient Indian ritual that was conducted at the end of the dry season to ensure ample rainfall for the following rice season (Ongsakul 2005). The most sacred Buddhist images are paraded through the old cities. Buddhists along the parade route throw bowls of river water at the images, symbolically removing the residue of the old year from the image. Water is also sprinkled on friends and family to remove bad luck and bestow blessings (Van Beek 1995). During both *Loy Krathong* and *Songkran*, river water is culturally endowed with the ability to remove trouble and misfortunes.

Fig. 2 An example of a traditional northern Thai house. A 'soft layer' is created at the bottom as the house is propped up on stilts, partly for flood mitigation. Rooms are located, and belongings are stored in the second level

Water in excess and 'untamed'—floods—is a seasonal phenomenon in Thailand. During May to October, the northeast migration of warm and moist air from the Indian Ocean results in a period of high precipitation (Wood and Ziegler 2008). Therefore, the monsoon exercises regional control on annual rainfall, and consequently, river discharge. The coincidence of the monsoon period with the westward migration of tropical depression storms from the South China Sea occasionally results in large flood events (Wood and Ziegler 2008). Examples of such large events include the 1995, 2005 and 2011 floods which inundated large areas of Thailand. Increasingly, the occurrence of extreme flows is believed to be associated with the large-scale La Nina phenomenon (Lim et al. 2012).

Since the Lanna period, the northern Thais have developed ways of coping with floods architecturally. This is illustrated by the traditional houses, which are typically single-story wooden structures on stilts that are higher than the mean annual flood level (Fig. 2). These elevated structures ensure the safety of inhabitants from floodwaters. Another form of housing adaptation is the 'floating house'—a structure built on a thick bamboo raft and floats permanently at the specific place in a river or a canal (Nid 1989). Hence, while the structure is subjected to the rising and falling river levels, the inhabitants remain safe during a flood event as long as it is properly anchored. While the northern Thais have developed ways to minimize flood damages with structural adaptation, floods remain seasonal problems in northern Thailand today.

3 Toward an environmental history of Lanna

Despite the importance of rivers and water in northern Thai society, discussions in northern Thai historiography have largely neglected their influence—save for a few symposiums and related publications. This neglect is initially understandable as Thai historiography before the 1980s was highly nationalistic. The historical narratives were entrenched in the study of Siamese dynastic successions and the subsequent transition to the modern Thai state (Wyatt 1985, 1989). Historiography, in this case, served a utilitarian purpose to legitimize the rule of the Thai monarch and to establish connections between the state and the kingdom. While local histories of different regions proliferated during the 1980s, they remained largely subservient to the national narrative (Winichakul 1995). Relatedly, northern Thai historiography generally encompassed a linear mode of inquiry through tracing the rise and fall of kings and kingdoms, and the region's subsequent relationships with, and contributions to, the Thai state. This mode of inquiry and its overt connections with the Thai state have been increasingly challenged since, with the adoption of a more critical and analytical approach in historiography (see Winichakul 1995).

However, nature–society relations remain largely under-examined in the 'new' Thai historiography. Some historians and geographers have avoided the environmental aspect of historiography based on the old fear of being associated with environmental determinism (Bishop et al. 1996; Harden 2012). However, increasingly, historians have argued for the need to recognize that human beings are not the only actors in history. Non-human actors and a range of natural processes, such as climatic changes, are also creators of the past (Cronon 1993; Demeritt 1994; Endfield 2009). In this case, the environment is not simply the backdrop against which history unfolds. Instead, history is very much a product of a 'dialogue between humanity and nature in which cultural and environmental systems powerfully intersect' (Cronon 1993: 13). Unlike environmental determinism, in which nature dictates cultural behaviors, environmental history analyzes the inter-dependence and interactions between society and the environment, without either determining the outcome (Cronon 1993; Mosley 2010).

Material environmental history—the study of changes in the physical environment and their effects on human societies (McNeil 2003)—is particularly applicable to the study of the Lanna kingdom. As Lanna society constituted riverine communities, changes in river dynamics and periodic floods had direct impact on society. The desire to live near water due to practical and cultural concerns increased the vulnerability of Lanna inhabitants to floods. Despite the various architectural adaptations, a large flood event would have impacted the riverine communities significantly. Examples of such impacts on other historical southeast Asian cities are well documented. This is exemplified by research on Angkor in Cambodia (see Paz 2005; Stone 2006; Buckley et al. 2010) and Pagan in Burma (see Daw 1966). The former capital of the Lanna kingdom, Wiang Kum Kam, is a lesser-known city that has been affected by dynamics and flood pulse of the Ping River, one of the largest rivers in northern Thailand.

Wiang Kum Kam was deemed suitable for settlement as it was located next to the Ping River, making it easily accessible for trade and travel. The surrounding floodplains were also conducive for wet-rice cultivation (Ongsakul 2005). During the late thirteenth century, Wiang Kum Kam served as the royal capital of the early Lanna Kingdom. However, according to the *Chiang Mai Chronicle*, after a mere 5 years of royal occupancy at Wiang Kum Kam, King Mengrai moved the capital to Chiang Mai in 1296 AD (Wyatt and Wichienkeeo 1995, pp. 33–40). One of the reasons for this migration was recurrent flooding (Van Beek 1995). The dual impact of ponded water and sediment deposition in the city was almost certainly difficult to manage. This is ironic as 'Wiang Kum Kam,' in northern Thai dialect, literally translates to a 'fortified town that controls the water' (Van Beek 1995). Based on the large number of temples (*Wat*) in the city, Wiang Kum Kam continued to thrive as an important town for commerce and religion after the establishment of Chiang Mai. However, the city was later buried by flood sediments. For centuries, Wiang Kum Kam existed only in legends and stories until it was 'rediscovered' and excavated in the late 1980s.

Texts such as the *Chiang Mai Chronicle* and the *Lanna Chronicle* provide records of environmental hazards in the Lanna Kingdom. Notably, the *Chiang Mai Chronicle* referred to instances of catastrophic floods and earthquakes during the Lanna period, for example:

> *… in the ka met year, s. 645 (1283/84 AD)… He had stayed there three years when the town was flooded in the middle of the rainy season, and the elephants, horses, cattle and buffalo had no place to go. [That place] has been called Chiang Rua to the present day. (pp. 33)*

> *In the same year (1545 AD)… on the fourth waning, at dusk, there was a very loud earthquake. The finial of the Maha Chedi Luang and that of the reliquary of Wat Phra Sing broke off and nine other reliquary also were destroyed. (pp. 110)*

As Endfield (2009) asserts, such records can be supplemented with the study of physical evidences left on the landscape. Important information about floods is usually stored in 'nature's archive' of sedimentary records (Mosley 2010). Sedimentary records can potentially reveal the degree of flood risk faced by the inhabitants of Wiang Kum Kam. It can also give insights to the greatest extent of flood hazards that shaped societal response. Thus, there is logic in integrating paleohydrological research techniques in the environmental history research of Wiang Kum Kam. Velechovsky et al. (1987) conducted an in-depth study of the floodplain stratigraphy at Wat E-Kang, one of the many temples in Wiang Kum Kam. Based on the stratigraphic analysis, they postulate that the city was buried by a massive layer of sediments deposited by a single large flood. They further assert that this flood led to the eventual abandonment of the city. As detailed geochronological dating is lacking from the study, the authors could only estimate a time period in which the flood occurred. With respect to architectural styles and archeological inscriptions at Wiang Kum Kam, they place the flood and the abandonment of the city between 1527 AD and 1831 AD.

In more recent studies, Hinz et al. (2010, 2011) have unearthed evidences of a natural levee and a paleochannel of the Ping River within the ancient city through soil resistivity studies. An area of sediments with high electrical resistivity values near Wat Meng Rai and Wat Nan Chang suggests the presence of coarse bedload deposits associated with an in-filled river channel. This finding is consistent with the historical records—Wiang Kum Kam was originally located on the western bank of the Ping River; it is located on the eastern bank today (Fig. 3). Therefore, it appears that the Ping River had altered its course after the establishment of Wiang Kum Kam. From antecedent paleoflood studies in Wiang Kum Kam, it is obvious that important connections exist between the riverine environment, the rise and the eventual decline of the city. Our field investigation attempts to provide a more complete environmental history account of the fate of the city.

4 Field site and methods

Wiang Kum Kam is located in northern Thailand, Chiang Mai Province, Saraphi district. It is approximately 7 km south of Chiang Mai City. Thirty-four temple ruins were excavated from early 1980s to 2002 (Harbottle-Johnson 2002). The majority of these ruins lie on the western side of the proposed paleochannel of the Ping River (Fig. 4). The floodplain behind Wat Mengrai and Wat Nan Chang within Wiang Kum Kam was chosen for

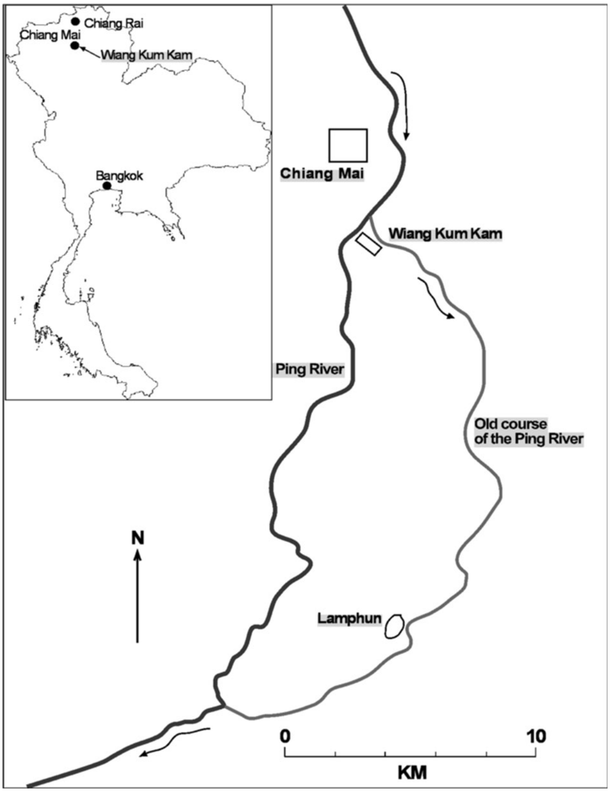

Fig. 3 The hypothetical paleochannel of the Ping River based on historical records (modified after Wood et al. 2004)

sediment stratigraphic studies. The site was chosen for two reasons. Firstly, it is directly adjacent to the paleochannel of the Ping River, and an elongated mound on the floodplain postulated to be part of an old levee system (Hinz et al. 2010; Velechovsky et al. 1987) is also found within the site. Secondly, the rapid expansion of residential, industrial and agricultural areas, and roads in the area since the 1980s has prevented further excavations of temple ruins and the advancement of geophysical studies (Wood et al. 2004). The area behind Wat Mengrai and Wat Nan Chang is currently not utilized for residential or industrial purposes. The sporadic patches of longan trees and high density of weeds suggest that the area is a lowly maintained agricultural land and is likely disturbed minimally. Hence, it is accessible and suitable for the excavation of flood sediments.

The study of floodplain stratigraphy in Wiang Kum Kam was carried out by hand augering into sediments at eight locations on the former floodplain within the city ruins with a regular AMS 4″ auger (Fig. 5). Twenty-five 10-cm cores of floodplain sediments, extracted from each auger hole—2.5 m deep from ground level—were classified based on sediment grain size. Five auger holes (A1–A5) were located along a straight-line transect in the floodplain, each of them approximately 10 m apart, from the mound crest toward Wat Meng Rai. Situating the holes along a straight line allowed us to check the consistency of distinct flood layers, in case of stratigraphic disruption by bioturbation (Baker 1987). The transect ended at approximately 20 m from Wat Meng Rai as

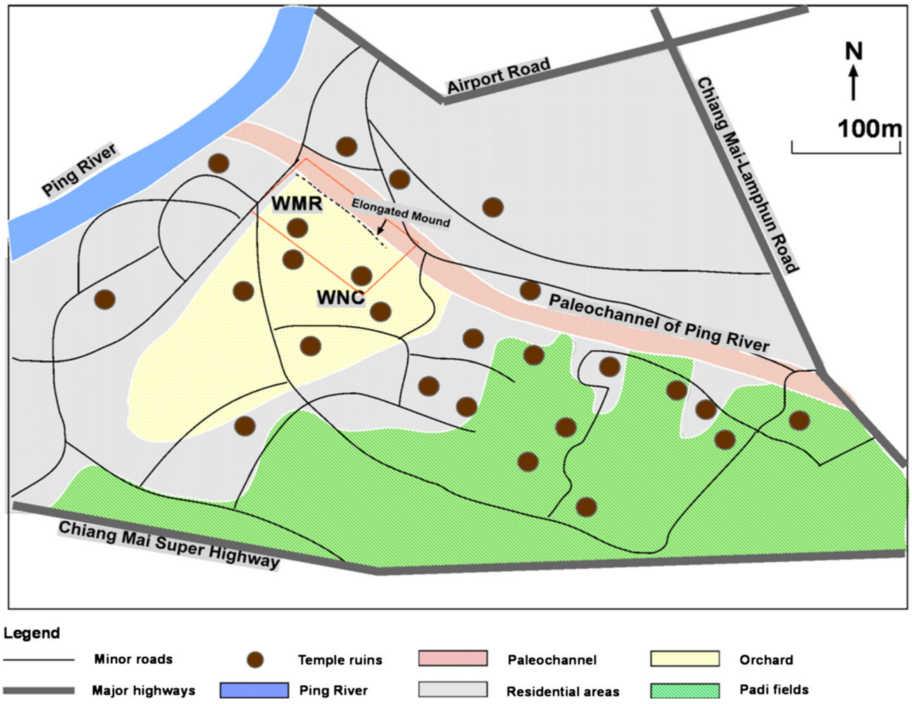

Fig. 4 A map of Wiang Kum Kam. Thirty-four temple ruins were excavated from the 1980s to early 2000s, all but three of the ruins are on the western bank of the proposed paleochannel of the Ping River. The study site is highlighted in orange—the old floodplain behind Wat Meng Rai (WMR) and Wat Nan Chang (WNC), directly adjacent to the paleochannel of the Ping River. Also, within the study site is an elongated mound

excavation work had disturbed the stratigraphy of the sediment profile around the temple. Two additional holes (A6, A7) were augered on both sides of the transect to further ascertain the uniformity of the flood layers. The location of A6 was chosen specifically because of its proximity to the elongated mound. Hole A0 was also located in the paleochannel of the Ping River.

Two carbon samples were also picked out from the sediment stratigraphy for C_{14} radiocarbon dating. The first sample (WKK1) was a small piece of dry charcoal located in the exposed excavated face at Wat Nan Chang. WKK1 was embedded in a coarse sand layer at a depth of 1.15 m from the current ground level. The sample is likely allochthonous, quite possibly organic matter entrained by floodwaters and deposited with the coarse sand layer. Thus, this sample was expected to provide the maximum limiting age of the flood deposit. The second sample (WKK2) was a fragment of an animal bone found in a clayey-sand layer, 2.35 m deep in A1, on the elongated mound adjacent to the paleo-Ping River channel. Again, this sample is likely allochthonous. A sediment core, extracted from the first layer of coarse gravelly sand from the paleo-Ping River channel, was also sent for optical stimulated luminescence (OSL) dating. This layer is representative of the last time the Ping River flowed in the paleochannel, north of the mound.

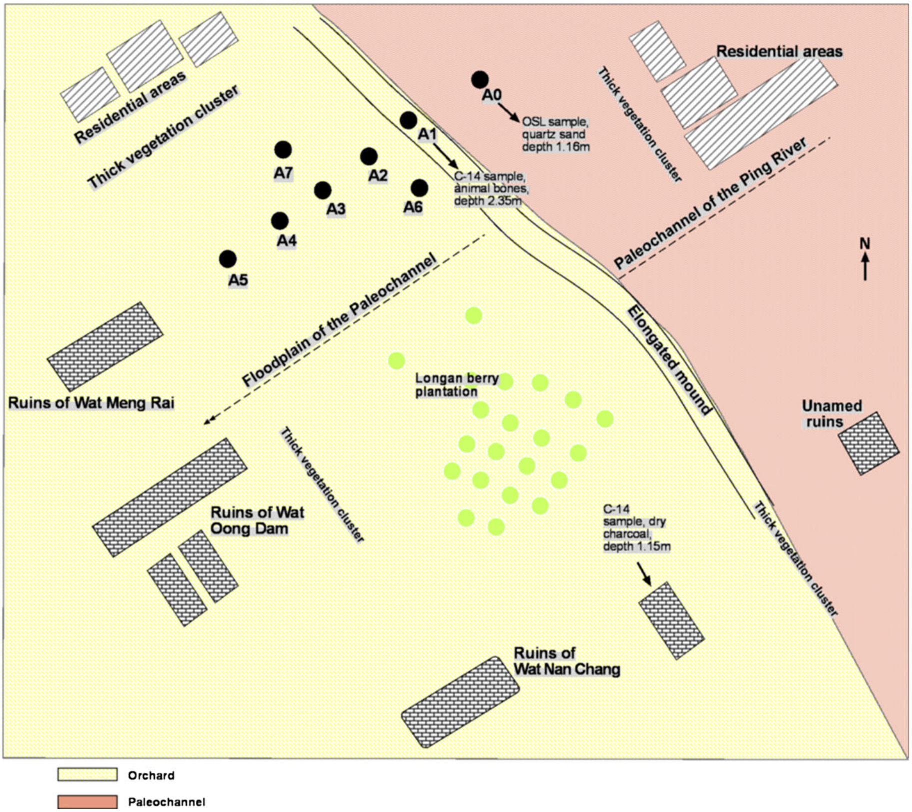

Fig. 5 Diagram showing locations of auger holes A1–A7 on the old floodplain of the paleochannel, and A0 on the paleochannel. The diagram also depicts the locations of the C_{14} carbon samples and OSL sample

5 Results: historical information in the sedimentary record

5.1 Not a natural levee but a man-made dyke

Previous paleoflood studies of Wiang Kum Kam (Velechovsky et al. 1987; Hinz et al. 2010) had identified the elongated mound at the study site to be a natural levee of the paleochannel of the Ping River. It was preserved following the avulsion of the Ping River. According to Hudson (2005), natural levees consist of multiple discernable flood stratums from separate events. Deposits of sand and coarse silt are also observed in natural levees due to the sudden reduction in flow velocity as the water leaves the channel and into the floodplain (Hudson and Heitmuller 2003; Hudson 2005). However, the sediment stratigraphy of the elongated mound exhibited neither of these characteristics. Instead, a massive, uniform layer of yellowish brown fine sandy silt dominated the stratigraphy—up to 1.9 m (Fig. 6). This evidence suggests the possibility that the elongated mound is not a natural levee.

The stratigraphy of A6, located next to the levee, on the old floodplain, further supports this possibility. The stratigraphy of A6 displays two distinct facies—the bottom and top stratums (see Friedman and Sanders 1978; Brakenridge 1988). The bottom stratum refers

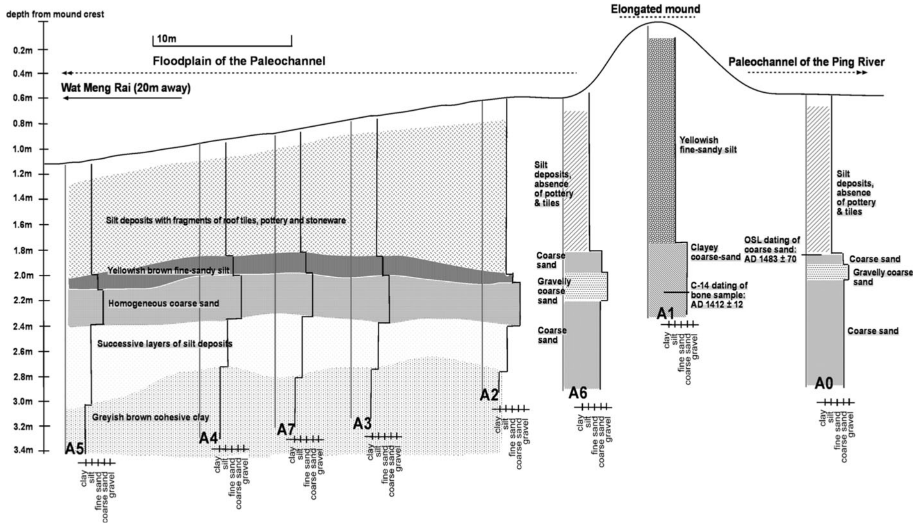

Fig. 6 A cross-sectional diagram of the floodplain stratigraphy revealed by the auger holes A0–A7. A consistent layer of coarse sand (~0.3 m) was found on the floodplain of the paleochannel. The elongated mound—initially proposed to be a levee of the paleochannel (Hinz et al. 2010)—is actually a man-made dyke. C_{14} dating of animal bones found 2.35 m deep suggests that the dyke is built after ca. 1412 ±12 AD. The topography behind the elongated mound raises sharply toward the mound, instead of sloping gently down as a levee should. This further suggests that it is likely man-made. OSL dating of the first layer of coarse sand in the paleochannel revealed that the last time it occupied that channel was ca. 1483 ±70 AD.

to the coarse sediments deposited on the channel bed, which are subsequently preserved due to the lateral migration of the channel, while the top stratum consists of the layers of fine sediments, deposited by flood events (Brakenridge 1988). Friedman and Sanders (1978) have argued that the presence of the top and bottom stratums is the best sedimentological evidence of a meandering river. The stratigraphy of A6 suggests that part of the paleochannel was located on the floodplain. In this case, it is doubtful that the 'levee,' proposed by Hinz et al. (2010), was part of the natural paleochannel morphology as it is located on an old meander bend of the paleochannel. We propose that the elongated mound is instead a man-made dyke erected by the inhabitants of the city as a form of structural flood mitigation. It likely formed the base of a wall on the side of the city (see Velechovsky et al. 1987). The animal bone excavated at 2.35 m in A1 is dated cal AD 1411 ±12—thus, it is likely that the dyke was constructed after AD 1411 ±12.

5.2 Deposits from a high-magnitude flood event

On the old floodplain of the paleochannel, multiple layers of fine silt deposits were unearthed at depths ranging from 1.3 to 2.0 m, with respect to the mound crest (Fig. 6). Below this lies a thin, uniform layer of silty fine sand, followed by a 0.3-m-thick-coarse sand layer at depth 2.1–2.4 m, with respect to the mound crest (Fig. 6). The formation of floodplain stratigraphy is based on non-continuous sedimentation. Multiple layers of sand and silt/mud represent different episodes of deposition by various flood events (Brakenridge 1988). Color changes and grain-size differences are key indicators of non-continuous deposition. The coarser mean sediment sizes are representative of high energy, while finer mean sizes are indicative of lower energy flow conditions (Brakenridge 1988; Rapp and Hill 2006). The multiple layer fine silt deposits found in A5, A4, A7, A3 and A2 are slackwater deposits related to water ponding when the Ping River overtopped its banks (Fig. 6). Such deposits are indicative of a lack of flow competence and hence low energy flow conditions.

On the other hand, the consistent coarse sand layer at 2.1–2.4 m is a sedimentological remnant of a higher energy flow condition when coarse-grained sediments were deposited on the study site (Brakenridge 1988; Fig. 6). Sand deposits are usually overlain by a thin stratum of silt/fine sand, deposited as the flood recedes and decreases in flow competence (Knox 1987; Knox and Daniels 2000). The possible presence of flood couplets (pairing of coarse sand overlain by fine sand/silt) explains the consistent layer of yellowish brown silty fine sand overlying the sand layer observed in the study site.

Assuming that sediment source conditions have remained unchanged overtime, Knox and Daniels (2000) further proposed that flood magnitudes are also closely associated with certain stratigraphic signatures. Alluvial deposits with high percentages of coarse sand are proxies of former large floods, while the percentage of coarse silt vis-à-vis the amount of fine silt and clay shed light on the magnitude variability of small floods (Knox and Daniels 2000). Therefore, it is possible to conclude that the flood event that deposited the coarse sand layer in Wiang Kum Kam was of a larger magnitude than the successive floods which deposited silt/mud.

Comparisons of the paleoflood deposits with contemporary Ping River flood deposits can contextualize the paleoflow conditions that resulted in the various depositions. In a study of the 2005 Ping River flood, Wood and Ziegler (2008) found clayey coarse-silt and clayey-silt deposits 100 and 200 m from the Ping River, respectively. They postulated that a weak current had flowed over the study site in the floodplain and inundated the area to an average depth of 1.2 m (Wood and Ziegler 2008). The study also showed empirically that sediment texture decreases with increasing distance from the channel (see Kesel et al. 1973; Wood and Ziegler 2008). The clayey-silt deposits of the 2011 floods were visible on the ruins of Wat Meng Rai at the time of our field investigation (Fig. 7).

Based on the 2005 and 2011 sedimentary records of the Ping River flood, two conclusions can be deduced about the coarse sand layer at the study site and the associated paleoflood. Firstly, it is likely that the deposition of the sand layer took place before or during the avulsion of the Ping River to its current location. The paleochannel is about 20 m away from the study site, while the present-day Ping River channel is about 350 m away. Therefore, it is unlikely that flooding from the current channel had deposited coarse sand due to the long distance—at a distance of 300 m from the river, clayey-silt deposits would be expected (based on the findings of Wood and Ziegler 2008). The geochronological dates of the coarse flood deposit and the first layer of gravelly coarse sand in the paleochannel further support this deduction. Radiocarbon dating of the coarse sand deposit suggests that the flood occurred after the period of ca. 1477 AD–1512 AD. OSL dating suggests that the last time the Ping River flowed through the paleochannel was between ca. 1412 AD and 1552 AD. The OSL and radiocarbon dates suggest both events happened in the early sixteenth century. The closeness of these dates supports the conjuncture that the avulsion of the main channel of the Ping River occurred due to the large flood recorded in the sediment stratigraphy. Relatedly, considering the proximity of city to the paleochannel and the coarseness of the flood deposit, the impact of this particular flood event on Wiang Kum Kam should be more destructive than the 2005 and 2011 Ping River floods.

Fig. 7 Clayey-silt deposits of the 2011 Ping River flood at Wat Meng Rai in the study site

6 Discussion and synthesis: an environmental history of Wiang Kum Kam

The founding of Wiang Kum Kam by Mengrai in 1286/1287 AD was documented in the *Chiang Mai Chronicle*. Like many other Lannathai cities, proximity to the Ping River was an important influence in choice of location:

> *In the rwai set year, s. 648 (1286/87 AD), King Mengrai moved to build Wiang Kum Kam. He built a moat around the city on all four sides, channeling the flowing waters of the Mæ Raming (Ping River). He built a palisade on all four sides of the city, and had a great many dwellings and buildings constructed.* (Wyatt and Wichienkeeo 1995:57)

However, the mention of Wiang Kum Kam in the *Chronicle* ceased following Mengrai's decision to take up royal occupancy at Chiang Mai in 1291/1292 AD. Thus, the historical narrative behind the demise of Wiang Kum Kam remains unknown. Drawing on the historical information in the sedimentary record, archival materials and architectural styles, we propose an environmental history of Wiang Kum Kam after Mengrai's migration to Chiang Mai.

The non-continuous, distinct layers of silt and mud deposits at the study site show that flooding was not an uncommon phenomenon in Wiang Kum Kam. This is also reflected in the *Chiang Mai Chronicle*. Like present-day Thailand, the floods were probably seasonal and/or induced by hydroclimatic events such as tropical storms. As the important temples and the heart of commerce—the market—were located along the Ping River (Wyatt and Wichienkeeo 1995; Harbottle-Johnson 2002), the inhabitants of Wiang Kum Kam had to devise ways to cope with such persisting floods. The construction of a dyke along the old Ping River channel was one such flood-coping structure. The radiocarbon date of the animal bone found at the bottom of the massive sandy-silt fraction (depth of 2.35 m), which constituted the dyke, suggests the structure was possibly built around ca. AD 1411. Also, the lack of pottery and roof tiles in A1 and A6 alludes to the lack of human

Fig. 8 Incorporation of tradition Lanna architecture styles into modern Thai architecture, specifically the elevated soft layer for flood prevention. The pictures were taken at an architecture exhibition in Chiang Mai showcasing the works of students from Chiang Mai University

occupation and/or permanent structures immediately adjacent to the old Ping channel. Hence, there had been a deliberate attempt to avoid the floodwaters. This is not unlike the land-use planning schemes contemporary riverine communities undertake. Thus, the initial societal response to the persisting floods was not to abandon the city, but to attempt to live with and adapt to the floods with structural means.

However, the dyke was unable to protect the city from all flood inundations. The dyke could be breached and/or overtopped during large flood events. The flood that deposited the sand layer was likely a case when dyke was breached, as there are no sedimentological traces of flood deposition on the dyke itself. According to the results of the carbon dates, the coarse sand layer could have been deposited after ca. 1476 AD–1512 AD. The coarse sandy nature of the deposit suggests that this is a high energy and highly likely destructive flood—a flood destructive enough to warrant the abandonment of the city. This deduction is supported by the architectural evidence. The youngest temple ruin, Wat Nan Chang, is classified to be of early sixteenth-century Lanna style—no newer styles were adapted in Wiang Kum Kam (Velechovsky et al. 1987; Harbottle-Johnson 2002). This is uncharacteristic as many northern cities adopted the Burmese architectural style as part of a broader cultural exchange following the Burmese occupation in 1558 AD (McDaniel 2011; Sthapitanonda and Mertens 2012). Thus, the city may have been abandoned before the Burmese occupation or during early Burmese rule. This time period corresponds to the radiocarbon dates of the high-energy flood—1476 AD–1512 AD was a period directly before Burmese rule. Considering the discontinuities in architectural influence and the carbon dates, it is logical to deduce that a high-energy flood occurred during early sixteenth century and that it had indeed resulted in the abandonment of Wiang Kum Kam.

A catastrophic flood event was recorded *Chiang Mai Chronicle* during the early sixteenth century. It was reported that around 1524–1525 AD, Chiang Mai was flooded and many who 'had come to the market at Si Phum [within Chiang Mai city] were drowned' (Wyatt and Wichienkeeo 1995: 108; Grabowsky 2004: 23). King Mengrai had chosen the location of Chiang Mai partly for its relative distance from the Ping River, and also because the site is about 12 m higher than Wiang Kum Kam. These factors protected the new city from constant susceptibility to seasonal floods. If Chiang Mai was badly inundated in 1524–1525 AD, the extent of the hazard experienced at Wiang Kum Kam would have been much worse. As the carbon sample is allochthonous, likely organic matter entrained by the floodwaters, it provides the maximum age of the flood event—between ca. 1476 AD and 1512 AD. Thus, it is possible that the 1524–1525 AD flood recorded in the *Chronicle* was the high-magnitude event that had caused the abandonment of the city, and the area was subsequently converted to agricultural fields with small settlements.

As only one high-energy flood event was recorded in the floodplain stratigraphy, it is highly likely that it is the event that altered the course of the Ping River. The close coincidence of the OSL dates of the paleochannel (ca. 1412–1552 AD) and radiocarbon dates of the high-energy flood deposits (ca. 1476 AD–1512 AD)—both events were estimated to have occurred around the early sixteenth century—suggests that the avulsion and flood were connected. The high-flow capacity and competence of such events meant that a large amount of sediments were transported and subsequently deposited—hence, filling the original channel with coarse sediments, drastically altering channel flow (Slingerland and Smith 2004). We have also considered the possibility that the Ping River is an anastomosing river. Such rivers often engage in extra-channel processes, such as overbank deposition and avulsion (Makaske 2001), which can deposit coarse sediments near the channels. In this case, the flood may have been merely a trigger for larger channel processes causing the river avulsion. The effects of the avulsing river, however, would still be devastating for the settlement in its way.

Through the course of this study, it is clear that history and human settlement cannot be understood without considering the prior influence and agency of the environment. For the case of Wiang Kum Kam, the Ping River—though not the only factor—was central in the rise and eventual decline and abandonment of the city. The flood pulse of the river had mandated two forms of societal response—firstly, adaptation and defense as observed by the construction of the dyke, and secondly, the last resort—abandonment and migration.

7 Conclusions: ancient floods, modern hazards

In theory, technological improvements and the increasing expenditure on structural flood mitigation methods should have rendered river management more effective (Baker et al. 2000). Despite this, inhabitants of many Thai cities—including Bangkok, Ayutthaya and Chiang Mai—are still at high risk from the seasonal flood hazards. From July 2011 to December 2011, these cities experienced the worst floods in decades. Approximately 13.6 million people were displaced and the death toll stands at 823 (AFP, 'Thai Floods death toll tops 800,' 2011 December 31). Economic damages and losses amount up to a hefty US$45.7 billion by December 2011 (World bank 2011). While there were multiple flood mitigation projects immediately following the floods in 2011, the concerns for inundation in northern Thailand have since rapidly dwindled. De Vries (2007: 42) claims that 'while flood concerns [in north America] are high in the immediate aftermath of any flood event, this concern quickly dissipates.' Arguably, this is also the case for urban Thailand. The short-term nature of flood concerns and memories result in largely reactive measures toward floods, represented by the barriers of sandbags and concrete, erected only with the onset of impending floods.

Relegating flood concerns to the backburner also means that the didactic potential of environmental (hi)stories, such as the floods at Wiang Kum Kam, is unfulfilled. They are remembered vaguely as distant legends or ancient history with little connections to the present—the physical deterioration of Wiang Kum Kam following the deluge of 2011 is a material testament to the lack of interest in flood (hi)stories. We argue that the connections between the past floods and present hazards exist, and they are important. Cronon (1993) suggests that the wisdom of environmental (hi)story lies in the form of *parables*, not policy recommendations or predictable certainties. It is through these stories that the past can act as analogies to present conditions from which we draw lessons and values applicable for the future. Past societies and technological contexts differ markedly from the present, and historical knowledge of past flood events do not—and cannot—directly inform the modification flood management policies (Cronon 1993; Endfield 2009). In fact, to draw straightforward parallels between the past and the present/future is counterintuitive (Endfield 2009). Following the 2011 floods, Thai lawmakers submitted a parliamentary motion to discuss the possibility of moving the capital to provinces in the east or northeast (Agence France-Presse, 2011, November 15). However, it is logistically difficult—if not impossible—and fiscally insensible to abandon and relocate modern metropolises such as Bangkok or Chiang Mai as the inhabitants of Wiang Kum Kam once did.

The (hi)story of Wiang Kum Kam and its relationship with the waters of the Ping River illustrate an important lesson for modern urban planners in Thailand. Structural methods of river and flood management—flood water diversion, artificial dykes and levees—do not guarantee a flood-free environment for urban development and expansion. In fact, this 'levee love affair' (Tobin 1995) may foster a false sense of security, increasing risks to flood hazards as riverfront developments proliferate. This lesson is made obvious when the large-scale river engineering works, which followed the large floods in 1983, 1995 and 2005, and failed in 2011 (Ziegler et al. 2012a). The engineering bias in flood management stems from the view of floods as anomalous natural events, deviations from the state of normalcy to which society returns to on recovery (Bankoff 2002). It is convincingly assumed that when properly implemented, engineering solutions and technocratic top-down flood management schemes can minimize and 'tame' the effects of such 'abnormal' events. As appealing as this view is to the human ego, it has proven to be quite problematic.

This leads us to the implicit lesson in the (hi)story of Wiang Kum Kam: the need to re-examine one's views toward rivers. Instead of being cities which 'control the water,' as Wiang Kum Kam had aspired to be, perhaps floods would be less of a problem if cities *respect* the water. Here, we ponder the extent that some vulnerable Thai cities could be redesigned to further incorporate rivers and water into the everyday urban experience. Small-scaled 'green' engineering is important in this case to modify the material landscape (Ziegler et al. 2012a, b). For example, the in-filled canals in Chiang Mai and Bangkok could be gradually reopened to allow more water drainage. Such small measures can encourage longer-term changes in attitudes, which in turn may spur more grassroots initiatives such as 'Clean up the Canals of Bangkok,'[1] and vernacular architectural modifications to contemporary dwellings, incorporating flood-sensitive designs from the past (Fig. 8). While these measures also do not guarantee a flood-free city, the changes in

[1] See: https://www.facebook.com/pages/KPIS-Clean-Up-the-Canals-Of-Bangkok/463671687015255.

attitudes toward rivers and their natural flood pulse would make urban dwellers more prepared for floods.

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