# Living with Floods: Ecological Wisdom in the Vietnamese Mekong Delta: Innovative Approaches to Socio-Ecological Sustainability

**Chapter** · January 2019

DOI: 10.1007/978-981-13-0571-9_11



1 author:

Kuei-Hsien Liao
National Taipei University

# Living with Floods: Ecological Wisdom in the Vietnamese Mekong Delta

**Kuei-Hsien Liao**

## 1 Introduction

Globally, flooding is the most widespread natural hazard, posing especially high threat to cities, where the majority of flood damage occurs (Ashley et al. 2007; Dewan 2013). Despite the extensive implementation of flood control infrastructure (e.g., levees, dams, channelization, diversion channels, weirs, and pump stations) to prevent flooding, cities around the world remain vulnerable to flood hazards (Andersen and Shepherd 2013). Flood control infrastructure cannot cope with extreme flows that exceed its design capacity, and it can fail unexpectedly by smaller flows. The recognition that flooding cannot be completely prevented gave rise to "integrated flood risk management" that incorporates non-structural measures and addresses basin-scale management (Parker 2000). However, in many cities non-structural measures (e.g., warning systems, insurance, and land-use control) only play a supplementary role to flood control. Basin-scale management, which emphasizes floodwater retention in upstream rural areas to reduce downstream flood risks, addresses neither pluvial flooding nor the eventuality of fluvial flooding in downstream urban areas. Despite the change in theory, flood control still dominates the practice in urban areas (Dewan 2013). The ideology that flooding should be prevented in the first place—the "flood control paradigm"—remains unchallenged (Liao 2014). With increasing urbanization and flood risks associated

This chapter is a reprint with permission from Elsevier. Landscape and Urban Planning, 2016 Special Issue on Ecological Wisdom.

Liao KH, Le TA, Van Nguyen K (2016) Urban design principles for flood resilience: learning from the ecological wisdom of living with floods in the Vietnamese Mekong Delta. Landscape and Urban Planning, 155:69–78.

K.-H. Liao (✉)
National Taipei University, New Taipei City, Taiwan
e-mail: liaokh@mail.ntpu.edu.tw



B. Yang and R. F. Young (eds.), *Ecological Wisdom*, EcoWISE,
https://doi.org/10.1007/978-981-13-0571-9_11

with climate change, relying solely on flood control for hazard mitigation would make cities even more vulnerable. To promote flood resilience for cities, this paper argues for the alternative "flood adaptation paradigm," which concerns preventing damage when flooding occurs. We explore the ecological wisdom of living with floods in the Vietnamese Mekong Delta (VMD)—an example of the flood adaptation paradigm—and extract lessons for modern cities.

The flood control paradigm assumes that flooding is disastrous in cities; however, it is not true if cities were resilient to floods. The concept of resilience receives growing attention in flood management but is often associated with post-disaster recovery. Adopting an ecological perspective (see Walker et al. 2004), we consider resilience relevant in not only post-disaster recovery but also hazard mitigation. Flood resilience is interpreted as the capacity to tolerate flooding to avoid disaster when *undergoing*—not preventing—flooding; or when physical damage and socioeconomic disruption still occur, the capacity to reorganize quickly (Liao 2012). In short, flood resilience requires either "flood tolerance" or "quick reorganization." This concept is important to cities, which should plan for the uncertainties and eventuality of flooding in the face of climate change. Moreover, although globally flood fatalities have decreased thanks to better warning systems and evacuation programs, economic losses are increasing (Dewan 2013). Most losses are building-related (Scawthorn et al. 2006), which means intolerance of floods at the property level.

This paper focuses on the aspect of flood tolerance of flood resilience. Flood tolerance is the capacity to remain undamaged and functional when flooded, which requires adapting the built environment to floods (Liao 2012). In climate change literature, "adaptation" often all-inclusively means adjustments to actual or expected climatic conditions and their effects (UNISDR 2009), which also include flood control (e.g., Wilby and Keenan 2012). Here, "flood adaptation" contrasts with flood control, an attempt to change the flood regime. It is narrowly defined as measures to fit for the actual and expected flood regime *without attempting to change it*. The term "living with floods" also has divergent interpretations. We interpret it differently from that of the Vietnam Government's ongoing "Living With Floods" program, which concerns relocating landless poor households from VMD's flood zones (Danh and Mushtaq 2011). "Living with floods" here refers to a flood-tolerant lifestyle based on flood adaptation at the property level. It is a manifestation of ecological wisdom, which we define as wise decision concerning how humans interact with the environment based on the knowledge of it.

Nowadays, the living-with-floods lifestyle is only found in rural areas in developing countries (Laituri 2000). Although such a lifestyle appears vastly different from modern urbanism, it has enlightened flood management discourses (e.g., Cuny 1991; Thaitakoo et al. 2013; Zevenbergen et al. 2011). However, literature documenting in detail the physical aspect of living with floods is limited. The paper aims to respond to theme 2 "Ecological wisdom as actionable and practical knowledge" in the editorial by Xing (2014), with two objectives: First, it provides an account of the living-with-floods lifestyle in VMD, focusing on physical adaptation. Second, it draws from it practical lessons for urban design to promote flood resilience.

In what follows, we first introduce the background of VMD and the hamlets—Vinh An and Ha Bao—where fieldworks were conducted. We then report the fieldwork results of how the hamlets live with floods, followed by a discussion of the lessons from the ecological wisdom for modern cities. Next we propose three urban design principles for flood resilience and outline the challenges to the flood adaptation paradigm.

## 2 Background of the Vietnamese Mekong Delta (VMD)

The longest in Southeast Asia, the Mekong River runs 4800 km through China, Myanmar, Thailand, Laos, Cambodia, and forms a delta in Vietnam before entering the sea. VMD is a watery landscape consisting of Mekong's two main distributaries and a dense network of numerous natural and artificial channels (Fig. 1). It contributes to 75% of Vietnam's total agricultural-fishery-forestry production, over 50% of agricultural exports, and 90% of rice exports such that it is commonly called the "rice bowl" of Vietnam.

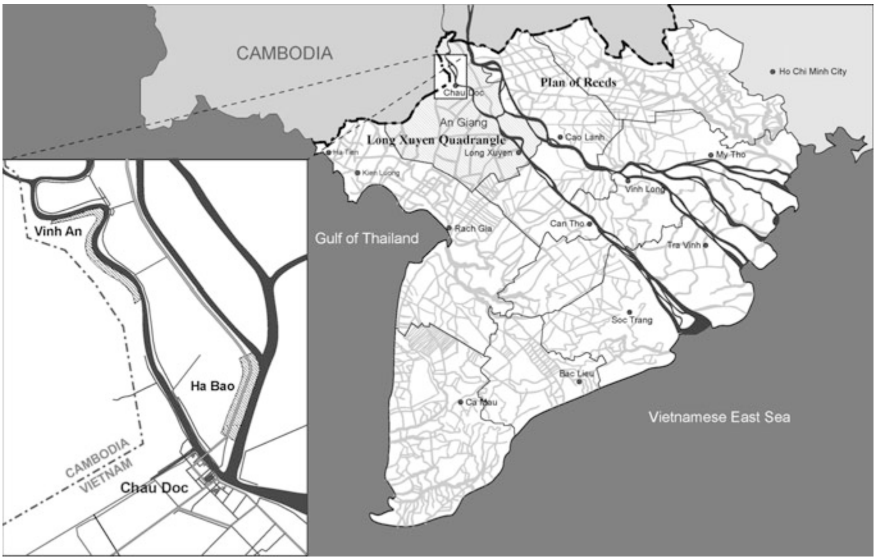


**Fig. 1** Vietnamese Mekong Delta (VMD) and locations of two study hamlets

## 2.1 Seasonal Flooding

During the monsoon season, a total area of 12,000–19,000 $km^2$ is naturally flooded. The flood regime varies across VMD. Near Cambodia, the Long Xuyen Quadrangle and the Plain of Reeds are two topographically depressed and deepest flood zones, where the flood could reach 3–4 m in some years.

For most people, flooding implies harm, but it also has economic and environmental benefits (Green 2010). In VMD, seasonal flooding is a critical development resource (Ehlert 2012). It serves as a source for agricultural irrigation and domestic water uses, increases wild fishery resources, brings alluvium to fertilize farmlands, washes out salts and toxins from the sulfate soils, carries away wastes, eliminates rats and insects, and recharges groundwater (Biggs 2010; Brocheux 1995; Tuan et al. 2007). The Vietnamese term for "flood season" is *mùa nước nổi*, which translates directly as "rising-water season" (Tuan et al. 2007). Far from harmful, the flood usually comes and goes very slowly that a local farmer likened it to a turtle (Ehlert 2012). Fishermen consider the flood season as "income season" because it brings extra fish in the flooded field; some would even call it *ổng về* (he returns), implying the flood as a friend (Nguyen and Alexander 2014).

Different floods are clearly differentiated (Tuan et al. 2007). A moderate flood (*lũ vừa*) is also called "beautiful flood" (*lũ đẹp*) because it brings livelihood resources. A small flood (*lũ nhỏ*) and a high flood (*lũ lớn*) are undesirable, for the former results in less fish and promotes weed infestation in the field after the flood and the latter can lead to disasters (Danh and Mushtaq 2011; Ehlert 2012; Nguyen and Alexander 2014).

## 2.2 Increasing Flood Control and Disappearing Lifestyle

However, the living-with-floods lifestyle is disappearing in VMD. Traditionally, people grew the native rice variety "floating rice" (*lúa nổi*) that adapts to seasonal flooding. It can grow as fast as 5 cm/day and reach 2–3 m high to survive the rising floodwater (Catling 1992). This single-cropping rice has been largely replaced by high-yield varieties to achieve multiple crops. Since the 1990s famers started to build low, "semi-dykes" to prevent floodwater from entering the field until the high-yield rice crop is harvested in July, after which the dykes are overtopped or breached and the field flooded to still benefit from the alluvium deposit. Meanwhile, the Vietnam Government also started to build "full dykes" and implemented numerous other drainage and flood control projects to reduce the area affected by seasonal flooding to maximize rice production and improve living standards. Today in VMD, there exists 13,000 km of full dykes, more than 900 sluice gates, and over 1000 pumping stations (Vietnam-Netherlands Cooperation 2011). Cities also have raised the overall ground elevation above the flood level. Across VMD more and more lands are under flood control. As of 2011, the seasonally flooded area is reduced to 10,000 $km^2$.

## 2.3 The Study Hamlets—Vinh An and Ha Bao

As the area subject to seasonal flooding reduces, the living-with-floods lifestyle is only found in relatively remote, often poor, rural areas such as An Phu District of An Giang Province, where the study hamlets are located (Fig. 1). Vinh An and Ha Bao are within the Long Xuyen Quadrangle and experience similar flood regimes: Seasonal flooding starts in mid-July/early August and lasts for 3–4 months; it peaks in October to 1–1.5 m from the ground but has completely drained by mid-November; and it rises and falls slowly at 2–5 cm/day. The hamlets also share the same spatial pattern like many others in VMD: The settlement is sandwiched between the field and the river, and the houses are distributed linearly on the river's natural levees, the flat delta's natural higher grounds (Fig. 2). Each hamlet also happens to have a part that is not subject to seasonal flooding. A cluster of houses in Vinh An is on filled land, as a result of a resettlement project for the landless poor in 2002. In Ha Bao, the houses on the field side are not seasonally flooded, as flooding has been controlled in field since 2012 for triple rice cropping.

There are also major differences. Unlike Vinh An's main road, Ha Bao's was elevated in 2003 to act as a full dyke such that it remains dry during flooding.

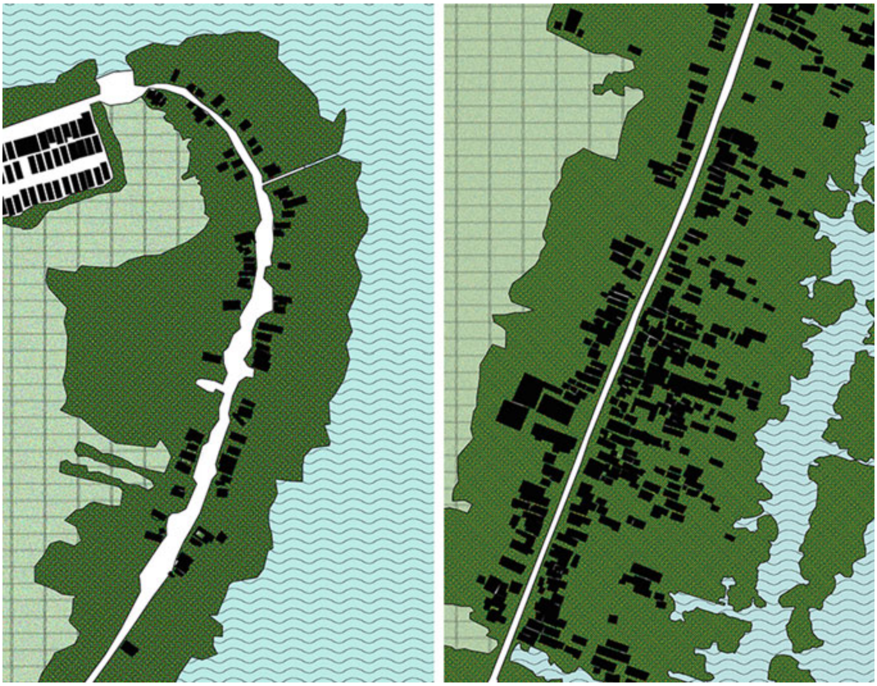

**Fig. 2** Spatial patterns of Vinh An (left) and Ha Bao (right)

Moreover, Ha Bao is close to a major town and more densely populated, while Vinh An is remote, accessible only by boat. The two hamlets are chosen because of these differences, not for comparative study, but to include multiple traits of the built environment to learn more about the adaptation details in different built conditions.

While lives in both hamlets are not easy, Vinh An is worse off, where 42% of the households are officially defined as either poor or near-poor. Households in both hamlets typically generate income across a wide range of activities, the majority of which include farming, fishing, and wage labor. In Ha Bao, many also work as street vendors and some live on raft houses for aquaculture. Although there are few professional fishermen, most households in both hamlets engage in "floodplain fishing"—fishing in the flooded field that is considered a public fishing ground—with simple nets or bamboo traps. Floodplain fishing is particularly important for landless households as a major source of income or for subsistence.

### *2.4 Fieldwork Methods*

We conducted semi-structured interviews in May, August, and November in 2014—right before, during, and right after seasonal flooding. A total of 34 households (16 in Vinh An and 18 in Ha Bao) were interviewed, with the male householder as the interviewee but in some cases other family members were also involved. The chosen interviewees are elderly, long-term residents, assumed to be most familiar with the living-with-flood lifestyle; and most were locally born. All interviewed households are at locations subject to seasonal flooding, except two in Ha Bao. Each interview lasted for 1.5–2 h, with questions regarding the flood regime, flood-related house design and renovation, traveling during flooding, flood experiences and perceptions, etc. Additionally, we also interviewed the hamlet heads of the hamlets to understand the overall conditions of the hamlets. Field observation was also conducted with regard to the overall setting of each hamlet and the physical conditions and surroundings of each interviewed household.

## 3 Living with Floods in Vinh An and Ha Bao

The Vietnamese term for the flood season—*mùa nước nổi*—connotes a time where all things appear floating on water. It is because people try to stay *above water*. This simple yet pivotal strategy allows everyday life to continue during prolonged flooding of 3–4 months. In this section, we report the interview results of physical adaptation strategies to stay above water, people's flood perceptions, and livelihood impacts of seasonal flooding.

## 3.1 Living in Stilt Houses

A common form of vernacular architecture in VMD, the stilts houses (*nhà sàn*) dominate the hamlets (Fig. 3). In the past, a typical stilt house would have a thatched or tiled roof; and its floor, walls, and stilts were made of bamboo or wood. Nowadays, more common are durable granite and concrete stilts and sheet metal walls and roofs. Gaps between the floor panels are purposefully left to enhance ventilation and to reduce the force of the waves against the floor during a stormy high flood. How high the house is raised above ground depends on the flood peak, and a household would plan to further elevate the house if the flood inundates the floor in consecutive years. However, limited financial capacity can prevent the household from building the house at a preferable height and delay further elevation.

Before 2000, the peak flood would inundate the floor of many houses almost every year for several days, even weeks. Nevertheless, people managed to live in the flooded house by elevating and staying on the bed. Most households would also uplift some floor panels to build a temporary floor on top of the submerged one. The flood in 2000 was the highest in recent decades, after which most households have managed to raise the house to more than 2 m above ground. The flood has not gone higher since. Most interviewees consider their houses high enough for now but also know that a higher flood is always possible.

The frequent inundation of the houses in the past caused limited economic losses. The floodwater drained easily because of the floor gaps. Floodwater carried away smaller household items, but most furniture and the wooden floor remained usable until a few years later. For most households, the hazard in the flood season is not inundation of the floor but when the high flood level coincides with a storm to produce large waves that could collapse the house. To mitigate the hazard, the better-off households build structurally stronger houses and deeper foundations; others reinforce the houses in the advent of seasonal flooding by tying bamboo poles between the stilts, for example. However, households in more densely

**Fig. 3** Stilt houses in Vinh An (left) and Ha Bao (right)

populated Ha Bao don't worry about the waves, which are buffered and dissipated by many other houses and densely planted trees.

The space underneath the floor is called *sàn* in Vietnamese. In the dry season, it is used for various purposes, such as shelter from the heat; raising poultry; and storage for firewood, agricultural machinery, and fishing gears (Fig. 4). During flooding, the poultry are moved either to a filled ground by the house or a floatable pen. Items stored in *sàn* often stay but are repositioned higher from the ground, but in many cases *sàn* is designed with multiple levels of shelves to avoid such trouble. If floodwater reaches the shelves, the household would build a temporary storage platform by the house.

## *3.2 Maintaining Mobility with Boats and Footbridges*

The major transportation means in the dry season are motorcycles and bicycles, which give way to boats during the flood season. Most people have learned to paddle by the age of 9 or 10. However, not every household owns a boat; some are too poor to afford one. In Vinh An, 80–90% of the households own boats, compared to 30% in Ha Bao. The low boat ownership in Ha Bao is due to the year-round accessibility of the road-dyke; moreover, most alleys are too narrow to navigate by boat. Therefore, temporary footbridges are also widely used to maintain mobility during flooding.

For short-distance trips and when the water is low (less than 2 m), people often choose to use footbridges as opposed to boats. The footbridges also have another purpose—to avoid soil erosion of the dirt road when walking in the water. In Ha Bao and more densely settled parts of Vinh An, numerous makeshift footbridges spring up in the flood season, and "monkey bridge" (*cầu khỉ*) is a popular bridge form because of its structural simplicity (Fig. 5). In Ha Bao, the footbridges are built along the alleys to connect to the road-dyke; in Vinh An they are used to connect to the nearby houses and then to the nearby grocery store. Usually of the

**Fig. 4** *Sàn*—the space underneath the house

**Fig. 5** Makeshift bridges in Vinh An (left; a monkey bridge) and Ha Bao (right) during the flood season

same clan, the households linked together by the footbridges would build them collectively. Most footbridges are made of low-quality materials such as bamboos or those readily collected from the surroundings. More durable materials would be reused in the following year, while others chopped up as firewood. In Ha Bao, there are also permanent concrete bridges, often belonging to the houses along the road-dyke or on large plots.

The height of the temporary footbridge does not depend on the peak flood but is increased incrementally as floodwater rises. During the flood season, a footbridge is usually adjusted 2–3 times. Although troublesome, it is to ensure that the footbridge is within 20–50 cm above water to minimize harm when one falls from it.

## *3.3 Flood Perceptions*

Consistent with previous research conducted elsewhere in VMD (e.g., Ehlert 2012; Nguyen et al. 2013; Nguyen and Alexander 2014), our interview results show that seasonal flooding is mostly harmless and people recognize its multiple benefits. Even those not engaged in farming and floodplain fishing know that it deposits alluvium to fertilize the field and brings more aquatic lives. Moreover, flooding supports non-potable water uses. When the sediment-laden floodwater is settled to become clear, many households use it directly for dishwashing, laundry, and/or bathing, despite others consider it too contaminated by fertilizers, pesticides, and human wastes to use. The free floodwater particularly benefits poor households, who otherwise have to pay more for tap water.

It is also understood that floods are not created equal. In general, a moderate flood comes with multiple benefits so is benign and optimal. A small flood is problematic because it not only brings less fish but also impedes waste disposal. In Vinh An, few households have sanitary systems, and a garbage collection mechanism doesn't exist. Households deal with garbage by burning in the dry season and by floodwater removal in the flood season. In Ha Bao where garbage is collected, flooding is still considered important for environmental cleansing. Too little floodwater could lead to stagnation, waste accumulation, and consequential sanitation problems. A high flood alone is tolerable but undesirable, as it requires building higher footbridges that are less stable, temporary storage platforms, and even temporary floors in the houses. A high flood with waves is dangerous as it could collapse houses. A prolonged flood is acceptable as long as the level is not too high; it is beneficial for floodplain fishing because the longer the field is flooded, the more time for fishing.

Although seasonal flooding is mostly harmless, most however consider it an inconvenience, for it takes more effort to travel on water than on the ground. Paddling is not difficult but involves risk: A boat could overturn in the wind, particular in the flooded field that resembles the open sea. Walking on the makeshift footbridge, especially balancing on the monkey bridge with heavy things, is taxing. Therefore, many people—particularly the elderly—tend to stay at home during the season, with social activities greatly reduced. The season is also a time of worries about the safety of children who have yet to learn swimming and about an unpredictable stormy high flood. Because of the inconvenience and worries associated with seasonal flooding, most interviewees consider the non-flooded counterparts of the hamlet (i.e., the resettlement area in Vinh An and the field side of Ha Bao) a better living environment. Nevertheless, for households that have easy access (e.g., permanent bridges) to the road-dyke in Ha Bao, everyday life differs little between the dry and flood season.

### *3.4 Livelihood Impacts of Seasonal Flooding*

Regardless whether their houses are seasonally flooded, people who work as wage labors in agriculture often see reduced income during season flooding, because it decreases agricultural activities—job opportunities—in the region. Although seasonal flooding provides an alternative livelihood of floodplain fishing, in recent years the amount of wild fish has dramatically decreased. Furthermore, the harvest depends heavily on the fishing gears, and poor households can only afford cheaper gears for subsistence fishing, and the yield is highly unstable. However, for those not engaged in primary industries, e.g., street vendors and traders, seasonal flooding has little impact.

## 4 Lessons for Modern Cities

Brocheux (1995: 2) uses "amphibious ecology" to describe the interaction between humans and the watery landscape in VMD during 1860–1960. The term still applies to Vinh An and Ha Bao today, as shown in the previous section. To prosper in the delta, people must learn to cope with indistinct land–water boundaries. Naturally, flood-prone cities are not different from the study hamlets, in that absolute land–water boundaries do not exist. To survive in a future of hydrologic uncertainty, modern cities need “amphibious urbanism” that is capable of operating at both dry and wet conditions. While the rural hamlets studied here are dramatically different from modern cities, the underlying ecological wisdom that gives rise to the amphibious ecology should be applicable across the board, as it concerns the fundamental relationship between humans and flood dynamics. We discuss the following lessons from the living-with-flood lifestyle for modern cities.

### *4.1 Ecological Wisdom Requires Ecological Knowledge*

While flooding is not always preferable, it is tolerable in the study hamlets. Despite the inexistence of flood control infrastructure, today the hamlets can stay safe and sound and remain functional at a prolonged flood as high as 2 m, which would likely devastate most cities around the world. Challenged by the hydrologically dynamic environment, the ecological wisdom is manifested in the act of adaptation as opposed to control. Such wisdom is rooted in the knowledge of flood ecology in the understanding of the ecosystem services of flooding. Such ecological knowledge is generated not through scientific research but through observations by one generation after another (Brocheux 1995; Ehlert 2012). When the ecosystem services of flooding are appreciated, the design of the built environment works around as opposed to suppress flooding.

This is opposite to the case in modern cities that practice flood control, which has been criticized as ecologically destructive. While the degradation of riverine habitats is obvious, the more detrimental impact on fluvial hydrology is obscure to the general public. Periodic flooding, with which native species co-evolve, is key to the ecological health of floodplain rivers (Ward and Standford 1995), yet is largely eliminated. Polluted, channelized, leveed, regulated upstream, and with little natural floodplain left, many urban rivers have lost most ecosystem services (Grimm et al. 2008). Without the ecological knowledge of flooding, it is unlikely for cities to cultivate ecological wisdom to better interact with the natural phenomenon of flooding.

### *4.2 Key Properties of Flood Resilience*

It is argued that flood resilience requires learning from floods (Liao 2012), as research shows that socio-ecological resilience to a disturbance arises from learning from that very disturbance (Berkes et al. 2003). Urban flood resilience is theorized to have three key properties: localized flood-response capacity, timely adjustments after every flood, and redundancy in subsystems (Liao 2012). We observe the first two qualities in the study hamlets, both of which are the results of exposing to, thus learning from, flooding year after year. We note that the learning need not come only from painful experiences—flooding in the study hamlets is mostly harmless, as mentioned repeatedly.

Localized, as opposed to centralized, flood-response capacity means that each household would take measures to respond to flooding (Liao 2012). By living in stilt houses, using boats and footbridges to maintain mobility, reinforcing the stilts, making temporary platforms during higher floods, etc., the households in the study hamlets essentially rely on themselves—without expecting any external agency (e.g., government) and mechanism (e.g., flood control infrastructure)—to mitigate flood hazards for them. It is flood-response capacity at the most local, property level, which derives from numerous flood experiences. On the contrary, flood control is a centralized approach, in that the authorities are entrusted to mitigate flood hazards for people, which consequentially don't feel the need to take any measure. Without local flood-response measures, flooding becomes disastrous when the centralized measure fails. Flood control infrastructure often produces a false sense of security (Pielke 1999), which erodes resilience through reducing flood risk awareness (Colten and Sumpter 2009).

Resilience does not come without cost. While many interviewees feel burdensome having to stay alert for a stormy high flood, we argue that it is exactly the wariness that constitutes risk awareness, which continues to reinforce localized flood-response capacity that make the hamlets resilient. In fact, despite the complaint about having to stay alert, most interviewees consider themselves more capable of coping with a larger flood than those who seldom experience flooding. Flood resilience of modern cities requires their residents to have flood risk awareness in the first place, such that they are willing to take property-level measures.

Another resilience quality seen in the study hamlets is timely adjustment, which is also a form of learning from floods. The adjustment needs be timely because the next big flood can occur anytime. Soon after the stormy high flood in 2000, many households in the hamlets reinforced and further elevated their houses before the flood season of 2001. This prevented them from suffering from the 2001 flood that was almost comparable to the 2000 flood. The financially limited households, although unable to do so sooner, took it a high priority and saved for it. If better off or helped with subsidies, each hamlet could have achieved system-wide, hamlet-level adjustment much earlier. On the contrary, upgrading flood control infrastructure often takes years, if not decades; for example, it took New Orleans seven years after Hurricane Katrina devastated the city. We hypothesize that when flood hazard mitigation measures for a city are localized at the property level, timely system-wide adjustments are more likely.

## 4.3 Agility as Opposed to Rigidity

It is argued that hazard-resilient communities are agile (Adger et al. 2004; Park et al. 2011). Because of localized flood-response capacity and timely adjustment, the study hamlets are agile communities. The agility also manifests in the "amphibious nature" of the hamlets, which can easily transform themselves to operate in wet conditions. When flooded, the hamlets preserve overall functionality by making changes in the subsystems, including livelihoods (from farming to fishing), transportation (from walking/biking to traveling on boats and footbridges), and physical arrangement of the houses (changing uses of *sàn* and making the temporary platforms and/or floors). Modern cities, however, are relatively rigid. Because of the dependence on centralized flood control infrastructure, many physical systems (e.g., vehicular transportation) can only operate in the dry condition and become dysfunctional when it turns wet. To become flood-resilient, cities need agility.

## 4.4 Shifting from Flood Control to Flood Adaptation Paradigm

To reiterate the lessons so far, modern cities need ecological knowledge to nurture ecological wisdom, and need to become agile by developing localized flood-response capacity, striving for timely system-wide adjustment, and turning amphibious. However, these are not possible without a shift from the flood control to flood adaptation paradigm in flood hazard mitigation. The flood adaptation paradigm, of which the study hamlets are manifestations, allows flooding to occur because it is not considered always disastrous. Only when the city periodically experiences flooding can it learn from it to nurture resilience.

In the study hamlets flooding brings inconvenience and worries, and in some cases income reduction, as reported earlier. The former problems are mainly due to the lack of resources to have structurally sound houses and footbridges, and the latter related to livelihoods in agriculture and fishery that are sensitive to environmental changes. As also reported, flooding has little impact on those with easy access to the road-dyke and other livelihoods. Therefore, if modern cities were to be flooded periodically, the same problems are unlikely to occur because cities generally have more resources and most urbanites don't engage in primary industries. Furthermore, the flood condition—prolonged flooding of 3–4 months—of the study hamlets is vastly different from what many cities are naturally subject to, which might be significantly shorter durations of flooding.

We stress that the argument for the flood adaptation paradigm is not to romanticize the lives of the study hamlets, where many households suffer from poverty. While debatable, whether their poverty is associated with seasonal flooding is beyond the scope of this paper. But many interviewees commented that lives were much better when there were much more fish during the flood season when the river was less polluted.

Although today's cities are more complex and connected, it is not impossible for cities to transition to the flood adaptation paradigm and become flood-tolerant in the long term. It requires a shift of the focus of flood hazard mitigation from the river to the built environment and the approach from engineering to urban design.

## 5 Urban Design Principles for Flood Resilience

The aforementioned lessons from the ecological wisdom in VMD are practical for urban design, here refers loosely to the design of the urban built environment. While it involves many professions, this section mainly concerns design and planning. Urban design professionals have strived for unconventional relationships between urbanism and hydrologic dynamics that are not mutually exclusive (Shannon 2013). Increasing flood catastrophes, coupled with climate change impacts, have given rise to urban design concepts that take flood hazards into accounts (e.g., Rodriguez et al. 2014; Thaitakoo et al. 2013). To make the lessons of the ecological wisdom of living with floods actionable, we translate them into three urban design principles: Urban design should (1) anticipate and accommodate flooding, (2) incorporate the ecological process of flooding, and (3) reveal the flood dynamics to the public. These principles complement the existing concepts. We explain each principle and provide existing design examples and emerging design solutions to demonstrate its actionability.

### *5.1 Urban Design Should Anticipate and Accommodate Flooding*

A consequence of the flood control paradigm is that urban design rarely factors in the eventuality of flooding and assumes flood hazard mitigation a business of hydraulic engineering. The study hamlets demonstrate an environmental design that anticipates and accommodates flooding as a normal part of the living environment. It is often asserted that the city, densely populated with high land values, has no spare space for floodwater. However, such assertion is not valid because there exist design measures that could allow cities to anticipate and accommodate flooding (Liao 2014; Shannon 2013; Zevenbergen et al. 2011).

Pilotis architecture—buildings supported by ground-level columns—is essentially the modern form of the stilt house. It is not uncommon in urban areas and has been built at a large scale, as exemplified by Singapore. Eighty-five percent of the city-state's population resides in public housing estates that are high-rise buildings on pilotis. Locally known as the "void deck," the ground floor of the building serves as open space, while promoting ventilation and public security (Fig. 6).

**Fig. 6** "Void deck" of a public housing block in Singapore

Also allow buildings to accommodate floodwater are permanent flood-proofing measures, such as utilizing water-proof flooring, wall, and furnishing; and raising the electrical fixtures (Bichard and Kazmierczak 2012). Furthermore, "amphibious houses" that sit on land but can float vertically during flooding have been materialized in the Netherlands and UK. In the short term, the government can incentivize the adoption of flood-proofing measures that do not require structural changes. However, in the long term it is best that all buildings in the low-lying areas are elevated or can float above the highest flood level. It is especially necessary where the waters are severely polluted and flooding can cause disease outbreaks. To achieve system-wide (i.e., at the district or city scale) architectural adaptation, the government might need to subsidize the flood adaptation for the financially challenged households.

Compared to buildings, it is relatively easier to accommodate flooding in open space. An early example is Boston's Emerald Necklace designed by Fredrick Law Olmsted in the 1870s. Arguably, allowing open space to flood has emerged as a trend in recent years. A recent example is the Bishan-Ang Mo Kio Park in Singapore, designed to flood periodically by the river running through it, functioning both for recreation and flood hazard mitigation. Design professionals also engage themselves in decentralized sustainable stormwater management. Bio-swales, rain gardens, and wetlands are increasingly incorporated into open space to encourage stormwater retention, storage, and infiltration; such that green spaces increasingly become green infrastructure to have the hydrologic benefit of flood mitigation (Gill et al. 2007). Hard-surfaced plazas, playgrounds, and sports fields can also accommodate flooding, as exemplified by the Watersquare Benthemplein in Rotterdam.

As for mobility during flooding, modern cities can also utilize aboveground linkages as the study hamlets do. For example, in HafenCity, a riverfront development in Hamburg, a network of permanent bridges exists to connect different buildings above the flood level (Fig. 7). It should be easier to establish an aboveground pedestrian and vehicular network in high-density, mixed-use urban areas where sky bridges and elevated highways have existed, such as Hong Kong. Lower-density urban districts would have to depend on temporary footbridges set up during flooding, as has been practicing in Venice. Where neither a permanent nor a temporary bridge network is feasible, public boats or amphibious vehicles could be a solution.

## 5.2 *Urban Design Should Incorporate the Ecological Process of Flooding*

Ecologically more sensitive mitigation approaches have appeared in recent years, as demonstrated by the "Building with Nature" program in the Netherlands and the

**Fig. 7** A bridge in HafenCity, Hamburg that would allow connection between the buildings aboveground during flooding

European Water Framework Directive that encourage flood hazard mitigation to work with nature (Barbedo et al. 2014; Green 2010). In ecological restoration, "controlled flooding" has been carried out as part of environmental flows in some rivers in developed countries (Poff and Matthews 2013). However, cities are often excluded from these ecological approaches.

While in the study hamlets the beneficial medium floods are clearly distinguished from hazardous stormy high floods, in cities flooding is considered nothing but hazardous. Flood control infrastructure seldom discriminates between different floods such that smaller, ecologically critical floods are eliminated along with larger, hazardous ones. Making cities flood-tolerant would provide a chance to re-introduce ecologically critical flooding and could consequentially restore some ecosystem services of urban rivers (Liao 2014). The restoration of flooding as an ecological process can first take place in riverfront parks that used to be part of the natural floodplain. By re-naturalizing the open space and the river channel to resemble the natural channel-floodplain environment, a new ecosystem could emerge as periodic flooding shapes the aquatic and riparian habitats over time. For example, the restoration of River Isar in Munich demonstrates that a riverfront park can go beyond recreation and mitigation to also embrace the ecological process of flooding.

### *5.3 Urban Design Should Reveal the Flood Dynamic to the Public*

The study hamlets intimately interact with the physical and ecological aspects of flood dynamics and therefore are capable of harnessing and preparing for seasonal flooding. However, urban rivers are often segregated from the public by levees or floodwalls, out of sight, out of mind. Furthermore, the flows are often regulated that urban rivers appear unchanged all year round. The lack of river–people interaction and flow regulation lead to little public concern with river health and a low awareness of riverine dynamics, including the failure to appreciate flooding as a natural phenomenon.

Accommodating harmlessly floods in the city, particularly in open space, can reveal the flood dynamics to the public, which could lead to a better public understanding of it. The concept of eco-revelatory design—design that reveals natural processes (Brown 1998)—has been around for a while. The decentralized features of sustainable stormwater management can be considered eco-revelatory designs that reveal the hydrologic processes of stormwater runoff. Similarly, a riverfront park that incorporates the ecological process of flooding can make visible a series of phenomena associated with flood dynamics, such as seasonal changes of water level; increases in fish and other aquatic species; sedimentation, debris deposition, and erosion; water quality improvement; and the development of biotopes out of the sediments and debris brought by a flood over time.

These phenomena would serve for valuable public education of flood ecology and help cultivate public appreciation of the positive side of flooding in the city.

## 6 Challenges to the Flood Adaptation Paradigm

We have demonstrated the plausibility of a shift to flood adaptation paradigm through three urban design principles and associated design solutions, inspired by the ecological wisdom of living with floods in VMD. Nevertheless, today flood control is still widely considered paramount for cities. When flood control is the priority in flood management, it is unlikely to widely implement flood adaptation measures. Two perceptional challenges need to be overcome to make the paradigm shift possible.

First, the negative image of flooding continues to be promoted through media and government policies. Even in VMD, where people harness the benefits of flooding, contemporary media frequently imply it as an enemy (Nguyen and Alexander 2014). Around the world most flood management schemes deal with flooding solely as a problem, entirely ignoring its ecosystem services. The public may understand how flooding can be beneficial in rural areas but may be difficult to consider so in urban areas. Flood hazard managers, urban designers, and river ecologists need to collaborate to further explore the ecosystem services of flooding in cities and communicate the findings to the public.

Secondly, since the flood adaptation paradigm focuses on localized flood-response capacity, it means more responsibility for property owners. However, the perception that the government is solely responsible for hazard mitigation is prevalent, and it has prevented wider implementation of adaptation measures (Bichard and Kazmierczak 2012; Johnson and Priest 2008). For example, research in the Netherlands and UK shows the most people would not invest to prepare for flooding because they consider the government responsible for flood control (Bichard and Kazmierczak 2012; Terpstra and Gutteling 2008). In the study hamlets, however, most interviewees consider without hesitation that themselves, rather than the government, should be most responsible for damage prevention. The reasons behind the perceptional discrepancy require further investigation. Nevertheless, it is argued that local flood risk awareness, a sense of ownership of the problem, and financial incentives are important for people to willingly adopt flood adaptation measures (Lamond and Proverbs 2009; Wilby and Keenan 2012). In recent years, policy makers in Germany and UK have started to promote personal responsibility in flood safety (Green 2010; Johnson and Priest 2008). With the political will, the challenge might be overcome if the government would redirect the tremendous resources in flood control to flood adaptation.

## 7 Concluding Remarks

Ecological wisdom can be actionable and practical knowledge. Studying the ecological wisdom of living with floods is not merely a nostalgic journey to recognize a traditional, yet disappearing lifestyle. We also demonstrate that it has important implications to modern cities, informing actionable and practical urban design principles for flood resilience. Fundamentally about mediating the relationship between human activities and hydrologic dynamics, flood management requires ecological wisdom. The living-with-floods lifestyle in VMD exemplifies a more harmonious, as opposed to conflicting, relationship. For cities to cultivate a similar relationship, it should be recognized that flooding is a natural part of urban dynamics and can be socioeconomically benevolent. The relationship between the city and flooding should not be reduced to hazard management. A paradigm shift from flood control to flood adaptation could lead to a future, in which urbanites safely live with and benefit from flooding, akin to the time-honored ecological wisdom in VMD. Urban design plays an indispensible role to realize the paradigm shift. We have put forward the actionable design principles and solutions. The challenge, next, is to take the real actions.

## References

Adger WN, Brooks N, Bentham G, Agnew M, Eriksen S (2004) New indicator of vulnerability and adaptive capacity. Tyndall Centre, Norwich

Andersen TK, Shepherd JM (2013) Floods in a changing climate. Geogr Compass 7(2):95–115

Ashley R, Garvin S, Pasche E, Vassilopoulos A, Zevenbergen C (eds) (2007) Advances in urban flood management. Taylor & Francis, London

Barbedo J, Miguez M, van der Horst D, Marins M (2014) Enhancing ecosystem services for flood mitigation: a conservation strategy for peri-urban landscapes? Ecol Soc 19(2):54. https://doi.org/10.5751/ES-06482-190254

Berkes F, Colding J, Folke C (2003) Navigating social-ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge

Bichard E, Kazmierczak A (2012) Are homeowners willing to adapt to and mitigate the effects of climate change? Clim Change 112:633–654. https://doi.org/10.1007/s10584-011-0257-8

Biggs D (2010) Quagmire: nation-building and nature in the Mekong Delta. University of Washington Press, Seattle

Brocheux P (1995) The Mekong Delta: ecology, economy, and revolution, 1860–1960. Center for Southeast Asian Studies, University of Wisconsin-Madison, Madison

Brown B (ed) (1998) Eco-revelatory design: nature constructed/nature revealed. Special issue: exhibit catalog. Landscape J

Catling D (1992) Rice in deep water. The Macmillan Press, London

Colten CF, Sumpter AR (2009) Social memory and resilience in New Orleans. Nat Hazards 48:355–364

Cuny FC (1991) Living with floods: alternatives for riverine flood mitigation. Land Use Policy 8(4):331–342

Danh VT, Mushtaq S (2011) Living with floods: an evaluation of the resettlement program of the Mekong Delta of Vietnam. In: Steward MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta. Advances in global change research 45
Dewan AM (2013) Floods in a megacity: geospatial techniques in assessing hazards, risk and vulnerability. Springer, New York
Ehlert J (2012) Beautiful floods: environmental knowledge and agrarian change in the Mekong Delta, Vietnam. ZEF development studies. Berlin, LIT
Gill SE, Handley JF, Ennos AR, Pauleit S (2007) Adapting cities for climate change: the role of the green infrastructure. Built Environ 33(1):115–133
Green C (2010) Towards sustainable flood risk management. Int J Disaster Risk Sci 1(1):33–43
Grimm NB, Faeth SH, Golubiewski NE, Redman CL, Wu J, Bai X, Briggs JM (2008) Global change and the ecology of cities. Science 319:756–760
Johnson CL, Priest SJ (2008) Flood risk management in England: a changing landscape of risk responsibility? Water Resour Dev 24(4):513–525
Laituri MJ (2000) Cultural perspectives of flooding. In: Wohl EE (ed) Inland flood hazards: human, riparian, and aquatic communities. Cambridge University, Cambridge, pp 451–468
Lamond JE, Proverbs DG (2009) Resilience to flooding: lessons from international comparison. Urban Des Plann 162:63–70
Liao K-H (2012) A theory on urban resilience to floods—a basis for alternative planning practices. Ecol Soc 17(4):48
Liao K-H (2014) From flood control to flood adaptation: a case study on the Lower green River Valley and the City of Kent in King County, Washington. Nat Hazards 71:723–750
Nguyen VK, Alexander K (2014) Farmers' perceptions of and responses to annual flood events in the Vietnamese Mekong River Delta: adapting to climate change impacts. In: Lopez-Gunn E, Stucker D (eds) Adaptation to climate change through water resources management: capacity, equity, and sustainability. Earthscan, London
Nguyen HT, Tuan LA, Tran TT, Bastakoti RC, Lebel L (2013) Multi-level governance and adaptation to floods in the Mekong Delta. In: Daniel R, Lebel L, Monorom K (eds) Governing the Mekong: engaging in the politics of knowledge. Strategic Information and Research Development Centre, Selangor, Malaysia
Park J, Seager TP, Rao SC (2011) Lessons in risk versus resilience-based design and management. Integr Environ Assess Manage 7(3):396–399
Parker D (ed) (2000) Floods. Routledge, London
Pielke RA (1999) Nine fallacies of floods. Clim Change 42:413–438
Poff NL, Matthews JH (2013) Environmental flows in the anthropocene: past progress and future prospects. Curr Opin Environ Sustain 5:667–675
Rodriguez CNAS, Ashley R, Gersonius B, Rijke J, Pathirana A, Zevenbergen C (2014) Incorporation and application of resilience in the context of water-sensitive urban design: linking European and Australian perspectives. WIREs Water 1:173–186
Scawthorn C, Flores P, Blais N, Seligson H, Tate E, Chang S, Mifflin E, Thomas W, Murphy J, Jones C, Lawrence M (2006) HAZUS-MH flood loss estimation methodology II: damage and loss assessment. Nat Hazards Rev 7(2):72–81
Shannon K (2013) Eco-engineering for water: from soft to hard and back. In: Pickett STA, Cadenasso ML, McGrath B (eds) Resilience in ecology and urban design—linking theory and practice for sustainable cities. Springer, New York, pp 163–182
Terpstra T, Gutteling JM (2008) Households' perceived responsibilities in flood risk management in the Netherlands. Int J Water Resour Dev 24:555–565
Thaitakoo D, McGrath B, Srithanyarat S, Palopakon Y (2013) Bangkok: the ecology and design of an aqua-city. In: Pickett STA, Cadenasso ML, McGrath B (eds) Resilience in ecology and urban design—linking theory and practice for sustainable cities. Springer, New York, pp 427–442

Tuan LA, Hoanh CT, Miller F, Sinh BT (2007) Floods and salinity management in the Mekong Delta, Vietnam. In: Be TT, Sinh BT, Miller F (eds) Challenges to sustainable development in the Mekong Delta—Regional and national policy issues and research needs. The Sustainable Mekong Research Network, Bangkok, pp 15–68

UNISDR (UN International Strategy for Disaster Reduction) (2009) Terminology on disaster risk reduction. UNISDR, Geneva

Vietnam-Netherlands Cooperation (2011) Towards a Mekong Delta plan. Synthesis of water sector assessment

Walker BC, Holling CS, Carpenter SR, Kinzig A (2004) Resilience, adaptability and transformability in social-ecological systems. Ecol Soc 9(2):5. URL: http://www.ecologyandsociety.org/vol9/iss2/art5/

Ward JV, Standford JA (1995) Ecological connectivity in alluvial rivers ecosystems and its disruption by flow regulation. Regulated Rivers Res Manage 11:105–119

Wilby RL, Keenan R (2012) Adapting to flood risk under climate change. Prog Phys Geogr 23 (3):348–378. https://doi.org/10.1177/0309133312438908

Xing W-N (2014) Doing real and permanent good in landscape and urban planning: ecological wisdom for urban sustainability. Landscape Urban Planning 121:65–69

Zevenbergen C, Cashman A, Evelpidou N, Pasche E, Garvin S, Ashley R (2011) Urban flood management. CRC Press, London