

Architectural Approaches to a Sustainable Community with Floating Housing Units Adapting to Climate Change and Sea Level Rise in Vietnam

Nguyen Thi Thu Trang

Abstract—Climate change and sea level rise is one of the greatest challenges facing human beings in the 21st century. Because of sea level rise, several low-lying coastal areas around the globe are at risk of being completely submerged, disappearing under water. Particularly in Viet Nam, the rise in sea level is predicted to result in more frequent and even permanently inundated coastal plains. As a result, land reserving fund of coastal cities is going to be narrowed in near future, while construction ground is becoming increasingly limited due to a rapid growth in population. Faced with this reality, the solutions are being discussed not only in tradition view such as accommodation is raised or moved to higher areas, or “living with the water”, but also forwards to “living on the water”. Therefore, the concept of a sustainable floating community with floating houses based on the precious value of long term historical tradition of water dwellings in Viet Nam would be a sustainable solution for adaptation of climate change and sea level rise in the coastal areas. The sustainable floating community is comprised of sustainability in four components: architecture, environment, socio-economic and living quality. This research paper is focused on sustainability in architectural component of floating community. Through detailed architectural analysis of current floating houses and floating communities in Viet Nam, this research not only accumulates precious values of traditional architecture that need to be preserved and developed in the proposed concept, but also illustrates its weaknesses that need to address for optimal design of the future sustainable floating communities. Based on these studies the research would provide guidelines with appropriate architectural solutions for the concept of sustainable floating community with floating housing units that are adapted to climate change and sea level rise in Viet Nam.

Keywords—Climate change, floating houses, floating community, Viet Nam.

I. INTRODUCTION

THE coastline of Vietnam is more than 3,260km long and stretches from north to south with two fertile deltas of Red river and Mekong river that discharge into the sea. The river system and the sea do not only provide water for rice cultivation and fishing grounds for inhabitants, but also become the habitat of many Vietnamese generations. It was observed that early in the twentieth century, Vietnam had many ‘floating villages’ which included groups of fishers or boatmen [1]. Other sources indicate that the number of floating villages was not high. At the beginning of the 19th

century, there were 70 floating units in 12 old towns in the provinces of the Red River Delta and along the coast, from Quang Ninh Province to Ha Tinh Province [2]. In the 1930s, there were about 90 floating hamlets or villages located in rivers, and about 21 ones along the coast in the region from the Vietnamese/ Chinese border to the Tien Yen area [3]. In contrast, in the Central Region of Thanh Hoa to Binh Thuan provinces, where the rivers are short and the land is mountainous, freshwater bodies cannot sustain fisheries big enough to support ‘floating villages’. Therefore, such communities are concentrated in estuaries and lagoons. Since 1955 the number of ‘floating villages’ has decreased, mainly as a result of the reorganization of rural management, irrigation development, the destruction of riverine resources, and water pollution. Consequently, the Vietnamese government erased some floating villages and many families either switched to living on land or changed occupations entirely. As a result, nowadays the number of floating houses and floating villages has been decreasing in Vietnam. By contrast, in recent years, floating houses are an emerging household trend for many coastal communities all over the world. The majority of researchers have appreciated that the floating house is an effective solution which helps coastal areas adapt to climate change and sea level rise. Therefore, the aim of research is not only preserving floating houses—a unique accommodation type of traditional architecture in Vietnam, but also developing the concept of sustainable floating communities with floating housing units that help coastal communities withstand dramatic changes in climate and sea level as well as ensure a stable and permanent living for water dwellers. Most of the water dwellers are poor and low-income people who have been farmers. Therefore, floating villages emerged from farming villages. Floating communities and floating houses reflect traditional Vietnamese rural architecture. Based on traditional architecture, water dwellers modified and developed structures, materials and space of the house in order to adapt to the natural environment on the water, and to be suited to local culture. Through centuries, water dwellers accumulated valuable experience for designing floating houses with a view to the environment, the climate and the local culture. Based on analysing both the strengths of traditional architecture and the weaknesses of the current state of floating houses and floating villages in Vietnam, this paper provides solutions which are going to be architectural guidelines for a proposed concept of sustainable floating communities with floating housing units. From that, lessons

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are drawn in 4 categories: site planning, building design, energy usage and sanitation.

II. OVERVIEW OF NATURAL CONDITIONS AND CULTURAL SETTING

A. Natural Conditions

Vietnam embraces around 3,260 km of coastline from Mong Cai in the north to Ha Tien in the south. Vietnam covers a relatively complicated terrain: countless mountains, criss-crossed rivers, stretching and meandering coastlines. Between the regions, the relationship between mountains and plains on the mainland differs. The coastal zones are divided into 3 regions; south, central and north with 28 coastal provinces.

Located in a tropical monsoon climate region, Vietnam is influenced by natural calamities, such as typhoons, monsoons, storm surges, sea level rises and El-Nino phenomena. Scientific research, currently being undertaken in Vietnam, indicates that significant impacts due to sea level rise may already occur. Vietnam generally has a hot and humid tropical monsoon climate. The territory of Vietnam has a long S- shape and is entirely located in the tropical belt, stretching from 8°30'N and 23°22'N which causes a high solar radiation all the year round, and the sun mainly moves in the southern sky. The northern coastal zone has a humid subtropical climate, with four seasons and with short cold winters. The temperature rarely falls below 5°C and occasionally it reaches 40°C. Rainfall and rain intensity are quite intensive. Therefore, cold wind protection in winter is a specific requirement. The central coast has a tropical climate with monsoons. In summer, hot dry monsoon brings in extremely hot temperatures, whereas the northern area is still affected by the cold wind in winter. Rainfall and rain intensity are quite large, and typhoons frequently strike this area from June to December. Due to extreme weather with massive flooding and typhoons, there are very few floating houses and floating villages in the central coastal zone. Preventing overheating and providing typhoon resistance are most crucial in this area. With its much hotter temperatures, the southern region of Vietnam has only two main seasons: a dry season and a rainy season. Genial climate with average temperature around 22°C to 27°C and storms are less common, as well as criss-crossed river systems. There are a number of floating villages located in the southern coastal zone. There are different architectural solutions to each region that respond to a specific climate and natural environment.

B. Cultural, Social and Economic Setting

Fishing activities in the coastal areas of the north and south never were of major importance. Further, the northerners were unfamiliar with seafood. Therefore, many spices were used while cooking to mask the taste of marine fish and make them resemble freshwater species. Southerners started fishing much later than the northerners. In addition, since the south of Vietnam is rich in freshwater fish, southerners never traditionally caught marine species [4]. They did not live from fishing in natural resources, but were also breeding fish in

cages under or beside of their floating houses. Fishers moved from mobile living on the boat to a permanent living in floating houses used for both living and working. The situation is different in the Central Region, where agricultural land is poor and scarce, and the swift-flowing rivers do not have much fish. There, in contrast to the northern and southern parts of the country, marine currents bring large fish stocks into nearshore waters. Therefore, migrants from the northern provinces of Vietnam who settled in the coastal area of the Central Region became marine fishers, and a new culture and way of life gradually emerged. Therefore, floating houses and floating villages are more often built in the northern and southern coastal zones than in the central ones.

III. MAIN RESULTS

A. Sight Planning

1. Planning

Asia is historically renowned for its local original principles of floating houses with a floating community which is called floating village (Fig. 1). The village community has been the basic administrative unit. in Vietnam for a long time. The floating village is a group of fishers and their families who permanently live on their fishing boats or their floating houses. There is a lack of both dwelling houses on land and farmland which forces the fishers and their families to live on rivers or in estuaries or coastal lagoons. Floating villages respect family and professional relationships. In a water-based hamlet, people with the same family name always use the same fishing gear and gather together to form a hamlet, a traditional, small and self-managed community [4]. Some five or more family floating houses are always moored together and linked together by footbridges. Residents greatly respect neighbourhood relationships, because they live in a natural environment that combines both abundant resources and numerous challenges. The struggle for survival has increased the need for mutual assistance among lagoon fishing community members [5]. All the rivers and waterways are more characteristic for their local floating markets even if more conventional markets halls or market streets offer essential sales and shopping venues for the people who live on the water [6] (Fig. 2).



(a)



(b)

Fig. 1 (a) Floating village, Lan Ha Bay, Cat Ba, Hai Phong, Vietnam,
(b) Planning of a floating village. [7]



Fig. 2 Floating market, Cai Rang, Can Tho, Vietnam [8]

The floating houses are divided into 2 types; one is used for living and another one for both living and working with cages built under or beside the floating houses for breeding fish. There are two types of compound housing in a floating village:

- Individual houses.
- Cluster of houses.

Individual households are autonomous as regards spatial, technical and architectural decisions of building design and construction in accordance with preference, income and technical upgrade of water dwellers. The autonomy seems to enhance creativity and flexibility of water dwellers in establishing abundant structural solutions adapting to the environment and climate change.

Besides the strength as characteristics of a traditional community, floating villages also have obvious drawbacks. One of the problems facing many of floating villages is lack of urban planning and public buildings that are very important for the activities of a community such as kindergartens, schools, culture houses, playing grounds for children etc. In addition, floating villages also lack parking space for boats for individual houses and public places. People could park their boat at any empty space on the water surface without a being restricted by lines. As a result, in the areas where plenty of

floating houses are located, the boat traffic is hindered leading to a congestion of boat traffic and the flow of water.

- o Lessons:
 - Planning of floating villages has to be in accordance with local planning.
 - Developing concepts for floating communities - floating villages including family floating houses, educational and recreational facilities such as schools, clinics, markets and public buildings etc.
 - According to the economic conditions, habits and purposes of owners, designers will develop two types of compound floating housing. Along the waterway routes and river banks, *lines of detached floating houses* are built for water dwellers who have good economic conditions and desire a private living (Fig. 3). The ownership of a floating housing unit imparts a feeling of responsibility for maintenance of the house facilities. These houses will be linked together as well as linked with boat parking and transportation on land by floating bridges located behind the houses. Lines of housing compounds will be appropriate and effective to be built in narrow rivers and on nearby the river banks. On the other hand, *groups of attached floating houses* for water dwellers who live with families or with people of different professional relationships (Fig. 4). Some houses are separated or linked with each other. The group of houses provides an open space not only for social, craft, and cultural activities, but also for children playing. It is not only suitable for a traditional community but also makes a balance of a stable associated foundation for houses that struggle against and adapt to climate change such as storms, floods, sea level rise etc. Moreover, water dwellers would share responsibility and budget for maintenance of their facilities, such as sewage systems, water supply. It would be helpful for water dwellers to reduce the cost of the houses. The group of floating houses would be the basic unit of a floating community. Living in a group of attached floating houses, the autonomy of water dwellings would not be unambiguous. Their dependence would be reduced in the shared spaces with shared facilities. Therefore, households would have to make a clear distinction between the shared parts and individual parts, and raise their public awareness, respect and responsibility for both the individual parts and the shared parts.



Fig. 3 Line of detached floating houses, Ha Long Bay, Vietnam [9]

2. Building Site and Landscape

Orienting the houses is extremely vital when water dwellers start setting up a plan of a floating house. Living on the water is extremely affected by nature, wind and water waves. Therefore, floating houses and floating villages are often located in territories which are less influenced by strong winds, which have a slow water flow that is convenient for transportation. These territories also have a low salinity, the landscape and the quality of water resource are more suitable for living and breeding fish such as in the mouths of rivers, lagoons, bays which are located by the sea and protected from strong wind and tsunamis by mountains. Moreover, according to traditional experience, the south is the best direction for constructing a house. The main block frequently faces south to welcome the cool wind. In north and central coastal zones, the south direction prevents the house from solar radiation from the east and west and cold wind from the north in winter.



(a)



(b)

Fig. 4 (a) Group of attached floating houses, Ha Long Bay, Vietnam [10], (b) Vision for a cluster of four floating houses, NLE's proposed 'Lagos Water Communities Project', Nigeria [11]

In rural traditional houses, gardens and plants take a role as climatic mitigation, sources of daily green vegetables, seasonal fruits, construction timber and landscaping. Although, living on the water without land, water dwellers still keep planting trees in pots, flower vases located around their houses. These plants do not only provide a beautiful landscape for floating houses but also can take in as much cool air as possible and sunlight heat in winter as well as fence off cold wind and limit heat losses. The gardens which exist in rural traditional architecture inspire ideas of vertical garden that

could be used as climate screen to prevent solar radiation, cold wind and rain, as well as floating gardens using hydroponic systems that could be built in proposed concepts of floating houses and floating villages. Vertical garden and floating gardens would provide green vegetables for the house owners around the year (Figs. 5 and 6).

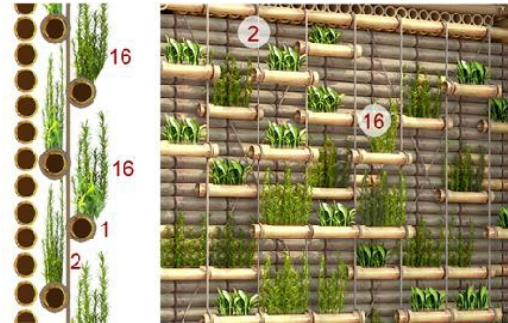


Fig. 5 Vertical garden as a climate screen [12]

B. Building Designs

1. Organization of Space

Space organisation of floating houses based on rural traditional architecture is established. The front garden, patio, main block, and back garden form the typical design chain of most rural houses in Vietnam (Fig. 7). Maintaining the characteristic of traditional architecture, fundamental spaces of floating houses also include potted plants instead of front gardens, shared patios, and main blocks. This setting creates a good microclimate for the house and convenience in daily life. The potted flowers located in front of the houses as well as the shaded patio or porch which is a transitional buffer space between the interior and exterior of the floating houses prevent flying rainwater and direct solar radiation. Floating houses also can take in plenty of cool air and sunshine, while being protected from cold wind. Furthermore, a large shaded patio seems to be an open space used for relaxing, social activities, craft or business such as cafés, tailor shops, barber shops, etc.

The main block is usually divided into two parts. The main part includes a living room possible to be used for business, crafts, Buddha prayer niche, bedrooms. The secondary part includes a kitchen, sheds, toilet, storage space and working places (Fig. 8 (a)). The whole block is not in a compact form. It is either a consecutive connection or a combination of various separate facilities including side blocks which are built for breeding fish, cattle sheds etc. The blocks are linked by narrow footbridges or terraces (Fig. 8 (b)). In fish farm villages, except for the private main house and the guesthouse, there are fish cages below the houses. Inside the floating houses, beside common furniture, there are also prominent features such as simple power supply, antennas, generators, ventilators etc. [6].

2. Structure and Joining System

In floating villages, there are two types of houses: stilt houses and floating houses. Others are designed as small boats which reside permanently on the water. The floating houses of

the village are of various sizes and types depending on the owner's economic conditions and their purposes. Some of the floating houses are built on a platform which is made of empty oil drums or pontoon-like materials, whereas others are designed like rafts and simply float on the water [6].

The floating houses which are simple timber post and beam structures, are built predominantly from lightweight bamboo,

mangrove, and wood. The flooring is made of timber planks or plywood sheets. The roof structure is mostly bamboo-leaf thatching, although corrugated sheet metal applications are often used as a substitute. Exterior and interior non-load bearing partitions are filled in with bamboo or light timber materials [15].

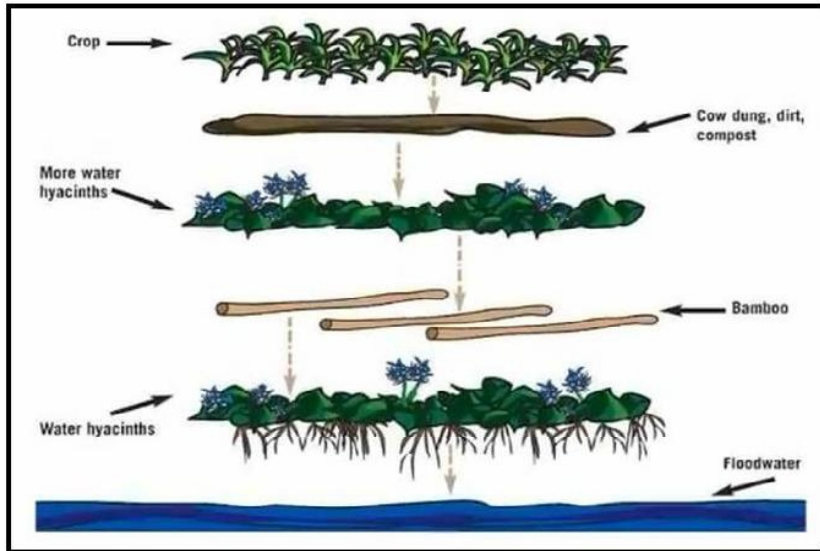
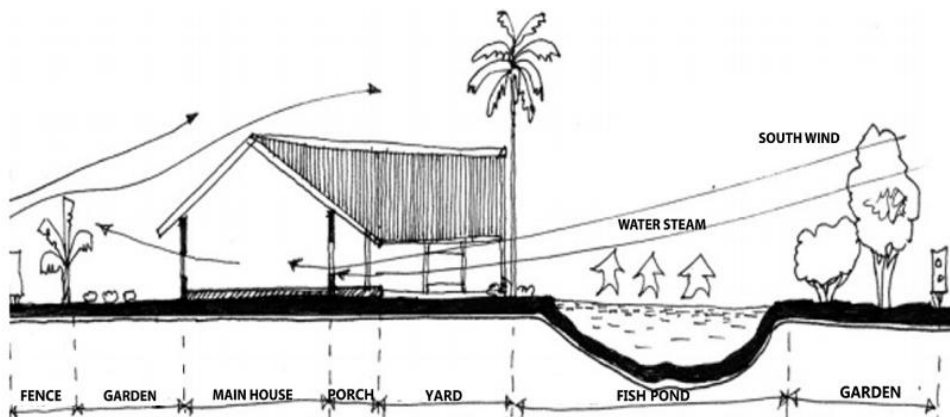
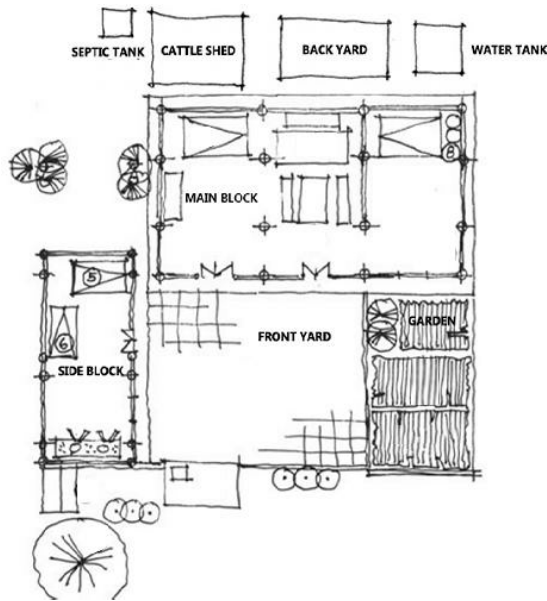


Fig. 6 Floating gardens [13]



(a)

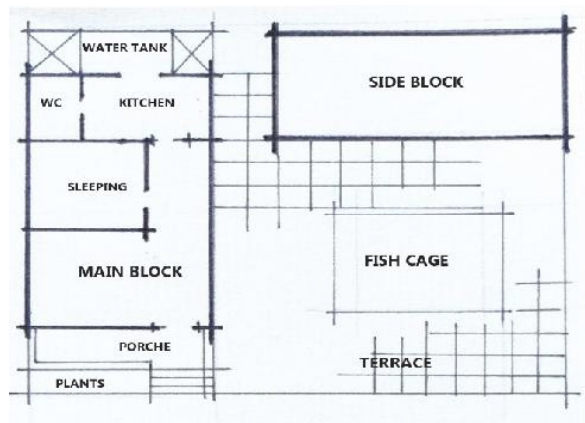


(b)

Fig. 7 Space organization of rural traditional houses [14]

○ Lessons:

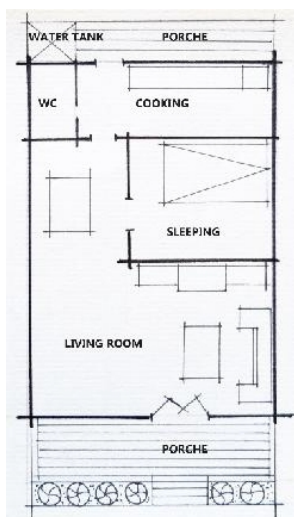
- The technology of floating structures depends on owner's economic conditions. For poor communities, water dwellers can use pontoons or recycled drums, barrels such as empty oil drums, steel drums or airtight plastic cylinder etc. to build floating platforms. Moreover, people can use wood frames or steel frames to fix drums together (Fig. 9). It would make floating platforms more stable and durable. For wealthier communities, designers can use innovative floating materials such as polystyrene EPS and concrete.
- Using timber or steel post and beam structures or other innovative structures that are light-weighted, flexible and easy to assemble and construct (Fig. 10)



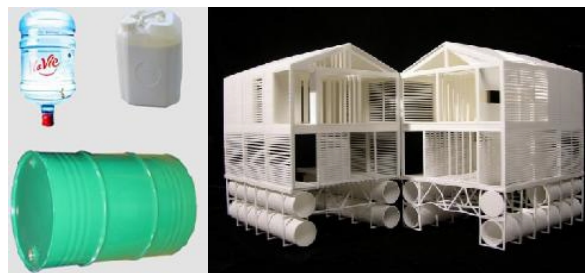
(b)

Fig. 8 Space organization of floating houses. (a) Individual floating house, (b) Individual floating house combines with fish cage.

Drawing by author



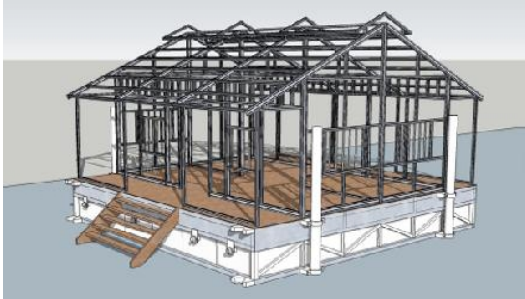
(a)



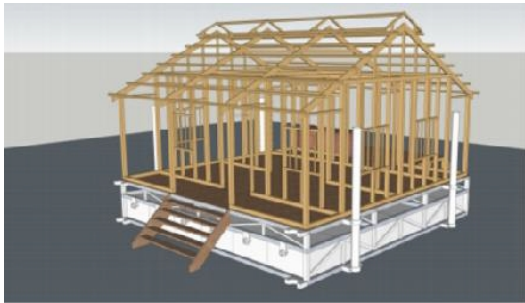
(a)

(b)

Fig. 9 Floating structure using recycled barrels, drums, etc. (a) [12], (b) [16]



(a)



(b)

Fig. 10 (a) steel post and beam structure of floating house, (b) timber post and beam structure of floating house. [17]

3. Material Usage

Materials used in floating houses are simple and delicate. Due to the economic status, water dwellers select locally available materials which are light-weighted and adaptive to climate conditions for setting up low-cost floating houses. Most of the materials used in floating houses come from natural sources and are highly environmentally friendly. The floating houses, simple timber post and beam structures are built predominantly from light-weighted bamboo, mangrove, and wood. The climate screens on the facades, gables and roofs are typically made of steel sheets, tin, wood, bamboo, reeds, palm fronds etc. In addition, water dwellers also select recycled materials to build their houses. Some of the floating houses are built on a platform which is made of empty oil drums or pontoon-like materials, whereas others are designed like rafts and simply float on the water. Using recycled materials is an effective solution to reduce the cost of houses with the aim to provide affordable floating houses in accordance with the economic status of water dwellers in Vietnam.

o Lessons

- Using light-weighted materials such as wood, bamboo, steel, polystyrene EPS etc.
- Using local materials and eco- friendly environmental materials.
- Using recycled materials.

4. Unique Features

Lessons on improving the microclimate environment: Design for natural ventilation and minimum insulation standards.

- The facades of the floating houses are often designed to allow air and gusts of wind to pass through the material, which typically includes variants of wickerwork, latticework and reed weaves, in order to make the houses as pleasant as possible in day and night time. (such as doors, screens or windows etc.) [6], (Fig. 11).
- Water dwellers maximise the area of windows (e.g. louvres) which should be shaded from sun and protected from rain. Windows are designed in the way to be able to catch the breeze and to be left open in wet conditions, such as louvres or using awning to shade windows as well as provide rain protection. Large entry doors can be opened and expanded under the hot weather conditions.
- Sloping roofs on two sides with steep slopes provide a rapid drainage of rain water. Roofing materials utilise natural resources such as wood, bamboo, reeds, palm fronds etc. which are light-weighted and have a high foam thickness needed for effective insulation and ventilation. Moreover, roof ventilation draws the heat out [18]. The roof structure is mostly bamboo-leaf thatching, although nowadays corrugated sheet metal applications are often used as a substitute (Fig. 12).
- The organisation of architecture spaces is flexible and open to increase ventilation and reduce the level of humidity (Fig. 13).
- The shaded patio or porch which is a transitional buffer space between the interior and exterior of the floating houses protects from flying rainwater and direct solar radiation. Floating houses can also take in plenty of cool air and sunshine, while being protected from cold winds.



(a)

(b)

Fig. 11 The façade of floating houses are made of wickerwork, latticework, and reed weaves. (a) [12], (b) [6]

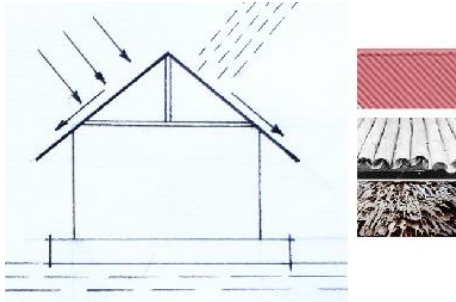


Fig. 12 Sloping roof structure of floating houses (drawing by author)

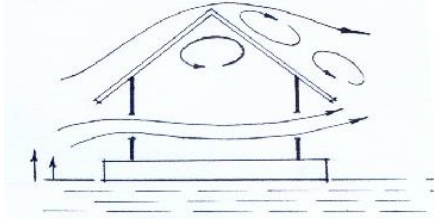


Fig. 13 Ventilation of floating houses (drawing by author)

C. Energy Usage

- Lessons from the advantageous use of the rain water

The natural water source inside a rural traditional house often allows an effective and sustainable use. Apart from the open well system, rainwater is also collected and kept in domestic tanks for use in daily life. However, few domestic water tanks on the floating houses are not enough to provide rainwater for water dwellers. Therefore, they have to buy on land fresh water bottles for drinking and cooking. In the proposed concept of floating houses, designers will consider

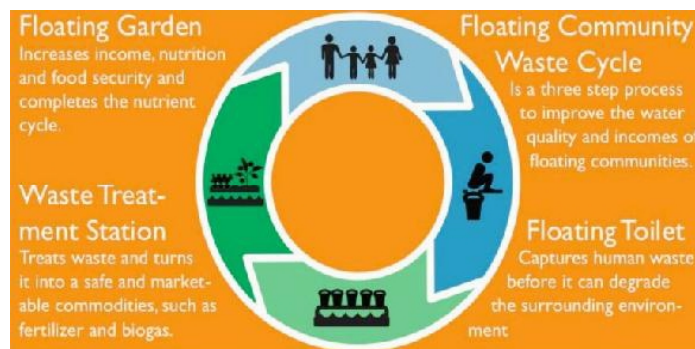
appropriate locations and capacities of domestic tanks. In addition, designers could offer an idea of converting salt water into drinking water. It is possible to get a feasible solution which provides a huge capacity of freshwater for daily life use.

- Lessons from taking advantage of the sunlight

Water dwellers use the sunlight not only for drying clothes but also for drying sea food, storage or business. Moreover, designers could offer an idea for floating houses that are equipped with solar panels to provide electricity.

D. Sanitation

Almost all people living on the water use water from the river to wash their clothes, clean food and for cooking. There are not any sewage system and septic tanks for toilets. Everything goes directly into the river. Especially in the floating markets which attract a lot of tourists and business, there are no any public floating toilets. Domestic and business wastes which enter the river and float on the water surface lead to water and air pollution. The smell and bacteria in the sewage create health hazards for the water dwellers. Therefore, in order to build sustainable floating houses and floating communities, designers should offer solutions and technologies for floating community waste management which is culturally appropriate, reliable, economically efficient and environmentally viable for the future, in particular toilets for floating family housing as well as floating community toilets and floating community waste management stations (Fig. 14).



(a)

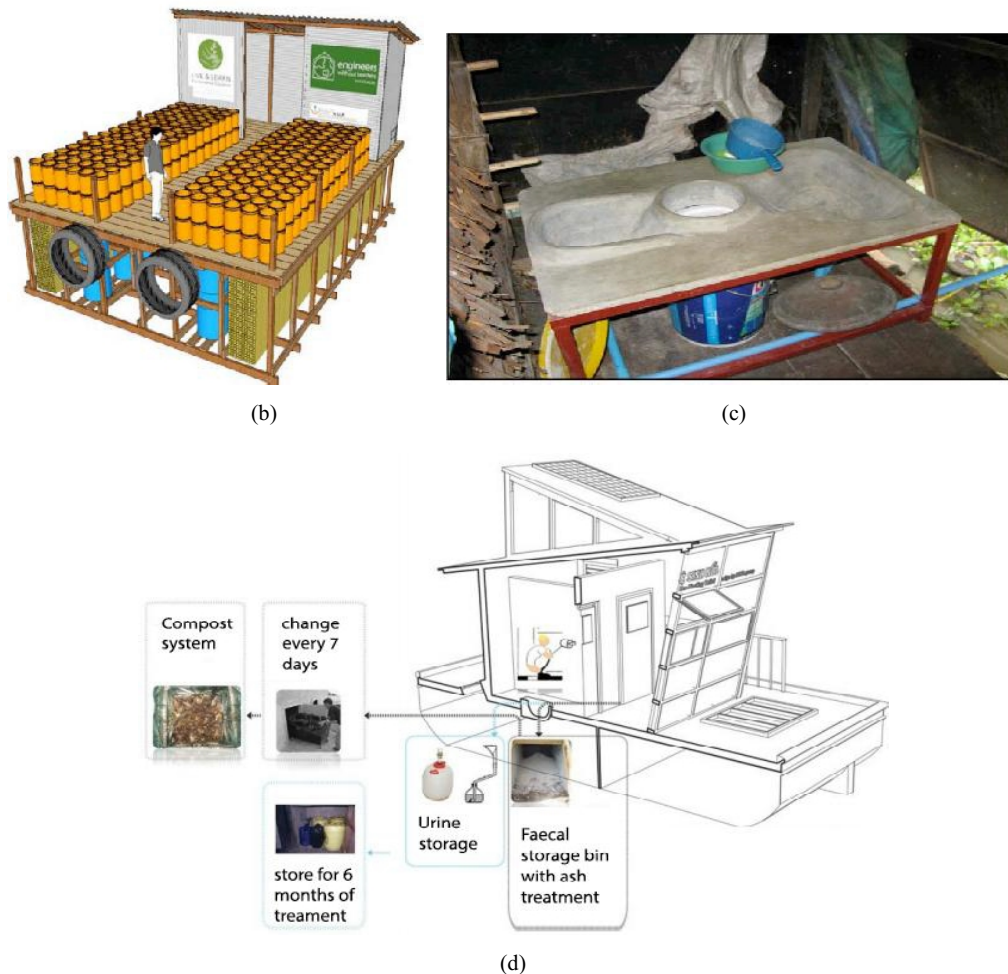


Fig. 14 (a) Idea of floating community waste management cycle, (b) Design of floating community waste management station, (c) A floating toilet prototype under trial in Phat Sanday [19], (d) [20]

IV. CONCLUSION

Floating houses are an unusual type of accommodation which is built on the water. Due to transportation difficulties and extreme impacts on climate and the environment, the floating houses lack facilities that provide a standard quality of living for water dwellers, such as water supply, electric and sanitary installations etc. Therefore, in order to develop a concept of sustainable communities with floating housing units, designers should propose solutions to solve the drawbacks of floating villages as well as preserve and develop precious values of traditional architecture which have to be adapted to climate, cultural and socio-economic conditions. In analysing the four components of architecture of floating houses in Vietnam, the research paper accumulates various helpful lessons for the design of floating houses and floating communities such as lesson on microclimate, lesson about garden and plants, lesson on local and friendly environmental materials, and lesson on how to use natural resources etc. Based on these lessons, the research paper develops and establishes design recommendations to approach a concept of

a sustainable floating community with eco-friendly floating houses.

Recommendations for sustainability:

A. Sight Planning

1. Planning

- Planning of floating villages has to be in accordance with local planning.
- Developing concepts of floating communities - floating villages include family floating houses, educational and recreational facilities such as school, clinics, markets, public buildings. According to economic condition, habits and purposes of the owners, the designers will develop two types of compound floating housing: Line of detached floating houses; Group of attached floating houses (Table I).

2. Building Site and Landscape

- o Lessons about plants and gardens.
- Floating houses and floating villages are often located in territories which are less influenced by strong winds, have

a slow water flow, and which are convenient for transportation. These territories are also characterised by a low salinity. The landscape and the quality of the water resources are perfect for living and breeding fish such as in the mouth of rivers, lagoons, bays located by the sea and protected from strong wind and tsunamis by mountains.

- The main block frequently faces south to welcome the cool prevailing wind. The southern direction also prevents the house from solar radiation from the east and west and a cold wind from the north in winter in the north and central coastal zones.
- Developing floating garden concepts.

B. Building Design

- o Lessons for improving the microclimate environment.

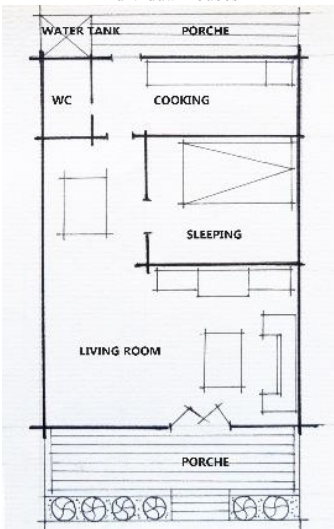
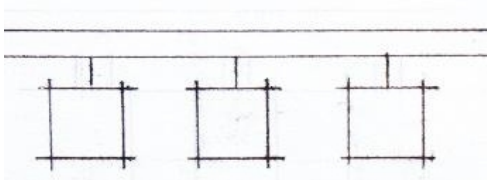
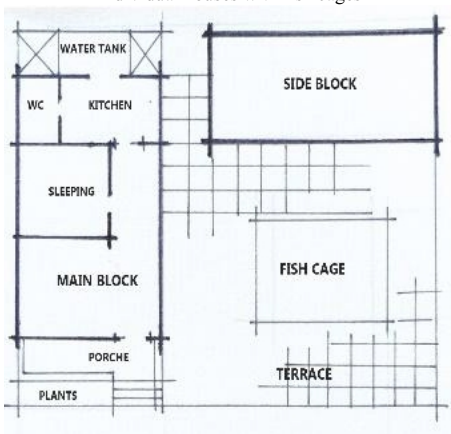
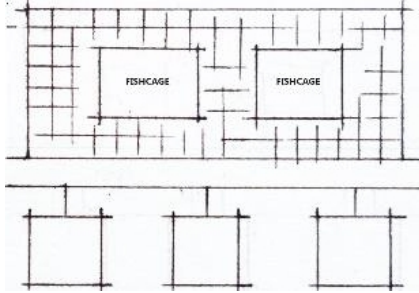
1. Organization of Space

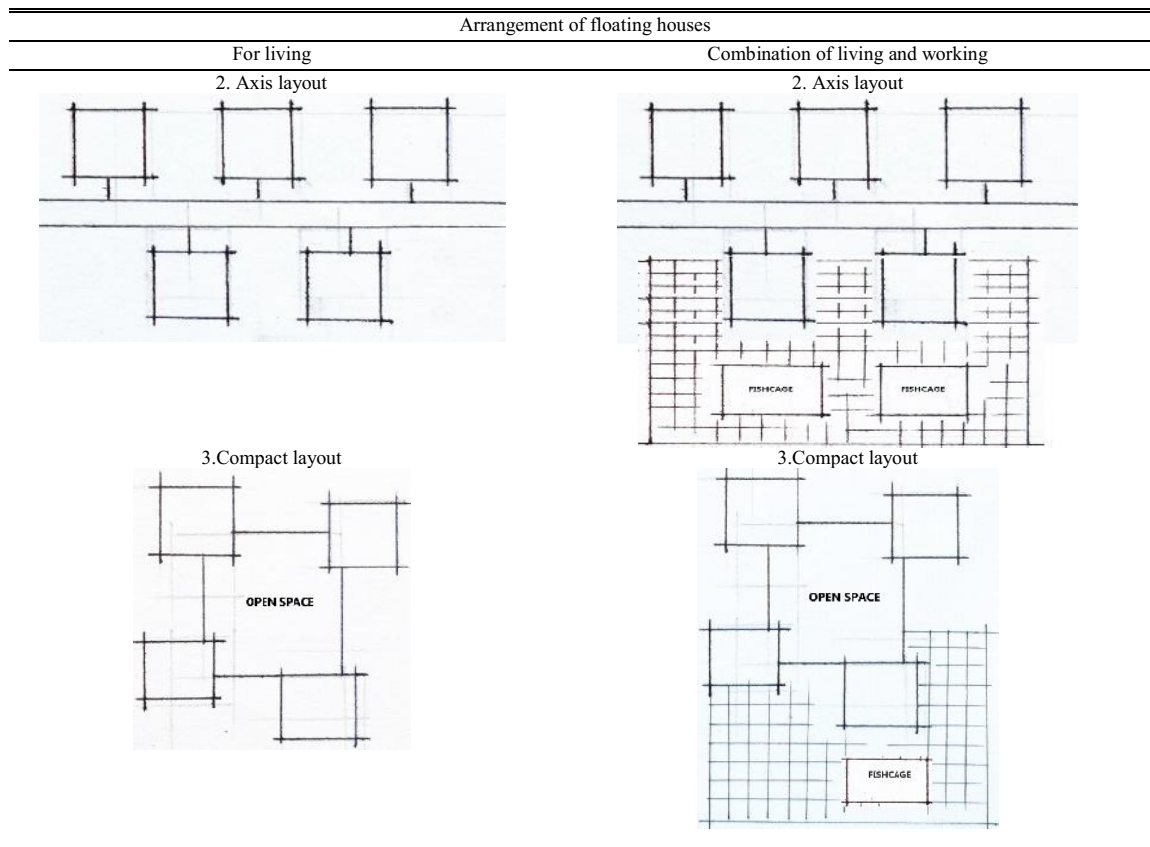
- The organisation of architectural spaces should be flexible and open to increase ventilation, and to reduce the level of humidity.
- The design would be based on local architecture, according to cultural, social-economic conditions.

2. Structure and Joining System

- The technology of floating structures would correspond to the owner's economic condition. For poor communities, to reduce the cost of houses, floating platforms can be built with recycled floating materials such as oil drums, barrels etc. For wealthier people, designers can use innovative floating structure such as EPS, concrete etc.

TABLE I
PROPOSED ARRANGEMENT OF FLOATING HOUSES IN THE FLOATING VILLAGES
Arrangement of floating houses

For living Individual houses	Combination of living and working Individual houses with fish cages
 <p style="text-align: center;">Housing cluster Cluster configuration 1. Straight line layout</p> 	 <p style="text-align: center;">Housing cluster Cluster configuration 1. Straight line layout</p> 



- Using timber or steel post and beam structures or other innovative structures which are light-weighted, flexible and easy to construct.

3. Materials

- Using local materials and eco- friendly environmental materials
- Using recycled materials.
- Using light-weighted materials.

4. Architectural Features

Architectural elements should be designed for natural ventilation, minimum insulation standards and adapted to tropical climate (patio, porch, door, window, roof etc.). Moreover, the form of floating houses should ensure their stable position on the water.

C. Energy Usage

- o Lesson about natural resources such as rainwater, sunlight etc.
- Developing a concept of self-sufficient floating houses using natural resources such as rainwater, sunlight and renewable energies such as solar panels, wind turbines.

D. Sanitation

- Development of sewage systems and septic tanks.
- Development of floating toilet concepts.

- Development of floating community waste management cycles.

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