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ADAPTIVE WATER URBANISM IN NAM AN HOA WARD - RACH GIA CITY - KIEN GIANG PROVINCE, VIETNAM

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Abstract

Vietnam and its lower Mekong basin region are among places that are heavily affected by global warming and climate change: sea level rise, flooding, water and soil salinization, freshwater shortages, and consequently the biodiversity negativity of a water- based land. This paper researches one of the urban planning and design in An Hoa Ward – Rach Gia City – Kien Giang Province, Vietnam where water management like many other places in the country are concerned with either just an urban beautification element or short-term solution for many urban development plans and projects.

Landscape urbanism understands ecological logics as crucial bases for urban development (both spatial and functional terms) and this helps sustain the biodiversity of which people and their activities are meant to be part of the ecological process. This research considers Water the most important element (especially under climate change scenarios) in making place for An Hoa Ward, Rach Gia, Kien Giang province, Vietnam. The research (1) analyzes the characteristics of different water courses in the area and, to what extent, people's livelihood has been transformed by water over time; then (2) based on the understandings and evaluations of relevant literature and cases studies about mitigation and adaptation to natural water characteristic, the paper proposes and discusses the possible adaptive water management solutions that environmentally and culturally sustain the biodiversity and local communities' livelihood.

Keywords: Water management, water urbanism, landscape urbanism, flood, climate change, water treatment, biodiversity, livelihood, Kien Giang, Mekong delta.

1. INTRODUCTION

Building expansion in urban areas across the blue and green zones and rural agricultural land, are commonly seen in many places, including the Lower Mekong Delta of Vietnam as shown in figure 1 below. This rapid urbanization is claimed as the main cause of climate change and global warming (Andrew, Nguyen, & Tang, 2012). Climate change has been projected to cause an increase in the number and scale of negative impacts, including disasters and fluctuating climatic conditions such as sea level rise, saline intrusion and decreasing biodiversity. The impact on people and infrastructure are great and include rising poverty and the slowing of economic growth (Blate, 2009).

According to the World Bank, Vietnam is an area that is highly impacted by climate change, especially in the Mekong River and Red River deltas (Andrew, Nguyen, & Tang, 2012). Statistical data from the government showed that, in the period of 10 years from 1997 to 2006, approximately 750 people lost their lives due to unexpected climatic disasters like flash floods and storms, their GDP has fallen by 1.5% per year. During recent 30 years, the sea level along

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Vietnam's beaches have increased (Alexandre, 2013). The Natural Resources and Environment Department announced that until 2050, the sea level will rise between 33 cm and 100 cm up to the year 2100; flood lines will expand 50 km downstream of the Mekong River. Referring to records at many tide-gauge stations, the sea level is increasing between 1.75 to 2.56 mm per year (Pham & Masahide, 2007).

Although Vietnamese people usually have to face irregular weather changes, their responses to these water – related disasters have not been all that effective. Short-term solutions, even the intervention top-down policies are not always in time and qualitative appropriations. There are not many farsighted proactive solutions to slow or prevent global warming, which needs effort from the whole population, including the authorities.

In this water-based landscape, mangrove forests are typically located between the inner land and the sea. This not only helps to protect the coastal landslide and land formation; but also helps to filtrate the water and build up its biodiversity. This mangrove forest (distinctive ecological landscape) can also promote sustainable tourism (Wood, 2019). This value, however, is under threat and may be lost due to rapid urbanization: the pressure on the mangrove forests, the reduction of biodiversity, therefore and the vulnerability of belonging to communities in the case of natural disasters and climate change. Marchand. M., (2008) suggested 5 steps for mangrove forest restoration in Vietnam, including: (i) research and development (ii) understanding of the hydrology of the site, (iii) investigation of growing mangroves, (iv) hydrological and natural restoration and (v) planting more mangroves if there is no natural recruitment (Marchand, 2008).

This study is based on analyses of climate change's influences on water resource issues in Vietnam, focusing on water management toward the efficient use of water resources and adaptation to the rise in sea level (as the consequence of climate change). Research concerns different ranges of water management from the regional scale (the Lower Mekong delta), urban scale (Rach Gia city), to local scale (Nam An Hoa ward). The water management proposal, however, is detailed at the local scale for Nam An Hoa ward with broader contextual considerations.

Current Water-related Issues in the Mekong Delta and Case Studies for Adaptation and Mitigation:

In the Mekong Delta, water is crucial for economic, social and cultural activities. With a dense water network and long coastal line from the East to West, for a long time, people have

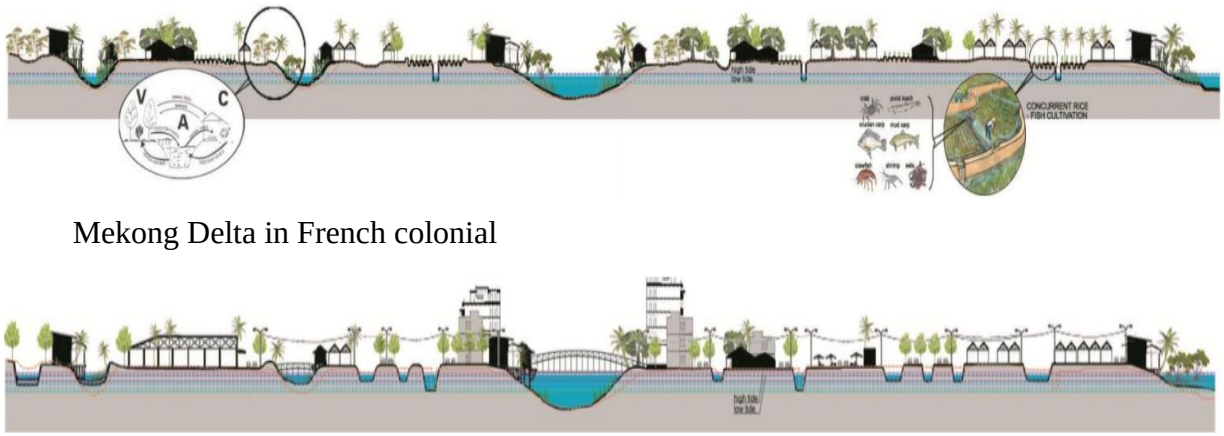


Figure 1: A typical cross section of the Mekong Delta showing the building expansion across the blue and green spaces. This may be a cause of climate change and a threat to biodiversity (Source: Nguyen, T., & Cao, V., 2016)

their own adaptation to flood and saline intrusion. According the government's projections of climate change, these two issues are also critical, affecting the lives and productivity of more than two thirds (2/3) of the areas of the Mekong Delta; including Rach Gia, Kien Giang province, a place on the West coast of the Mekong Delta. The following sections address issues with strategic solutions.

a) Flood and Flood Adaptation and Mitigations

Floods happen for three sets of circumstances: water discharge reaches the maximum water flow capability from upstream, high rainfall and the tide (Le, Chu, Fiona & Bach, 2007). In the Mekong Delta, flooding starts in July, when the rainy season comes. Heavy water flow from upstream that causes high pressure on the Mekong Delta; however, the facilities (culvert, canal system, drainage system, etc.) have not been upgraded to prevent the tide, therefore every rainy season, the Mekong Delta has to deal with the floodplain, loss of life and crops and the damage to the infrastructure such as roads, pipelines, culverts, etc. which leads to rising costs. The flood issue becomes even more serious due to the rise in the sea level. It is projected that by 2050, most of the Mekong Delta will be drowning in high sea level, which may lead to the disappearance of many commercial and economic centres. Currently, more than 20 million Vietnamese people are living on low land that could be inundated (Lu & Flavelle, 2019).

It is known that, "Give room for the river" is best known strategy in adaptation to flooding all over the world (Le & Vu, 2017). By leaving as much as the buffer zones along water channels and reservoirs, the floodplain is protected and defended, at the same time, creating water storage areas and marshy riverine landscapes, biodiversity and recreational values (Rijkswaterstaat, n.d.).

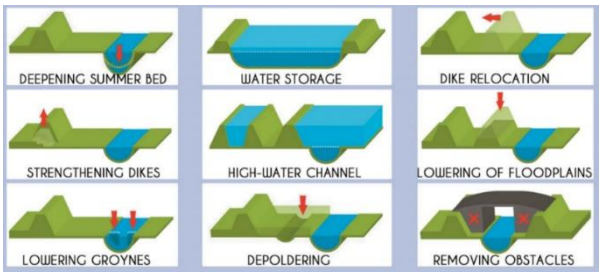


Figure 2: Strategic methodology of project "Room for river"
(Source: Nguyen & Cao, 2016)

In addition, according to Vu and Truong (2019), roads, especially trunk roads, have always been protected in emergency cases including natural disasters and hazards, where people gather and wait for support in dealing with floods and salinization. Roads are also crucial elements as are dams and hard dykes as commonly seen in the Netherlands (Rijkswaterstaat, n.d. and Vu and Truong 2019). The Megacity Project (Schmidt, 2011) also suggested hard dykes by circle roads with control gates around the island of District 4, HCMC. While soft dykes go along well with 'Room for the river' in larger scale contexts, 'roads as hard dykes' is appropriate mitigation to protect smaller areas from flood and salinization (Rijkswaterstaat, n.d.).

b) Saline Intrusion

Generally, saline intrusion has increased because the permeable capability of the sea water followed small cracks in sediment layers and was able to penetrate inland with the tides. The water management program of New York showed that bore holes for fresh underground water could also lead to salt water intrusions/occupations (WRD, n.d.).

According to the projections by the IPCC, in the Mekong delta, every 100 centimetres rise in the sea level results in flooding and salination of land up to a hundred kilometres from the coast (Rijkswaterstaat, n.d. and Vu and Truong 2019). The lack of fresh water flowing from Bassac River is also the main reason for saline intrusion. Mr Nguyen Hoang Hiep, Deputy Minister of Agriculture and Rural Development in the 1st Meeting of Mekong Committee Vietnam 2019 at Tien

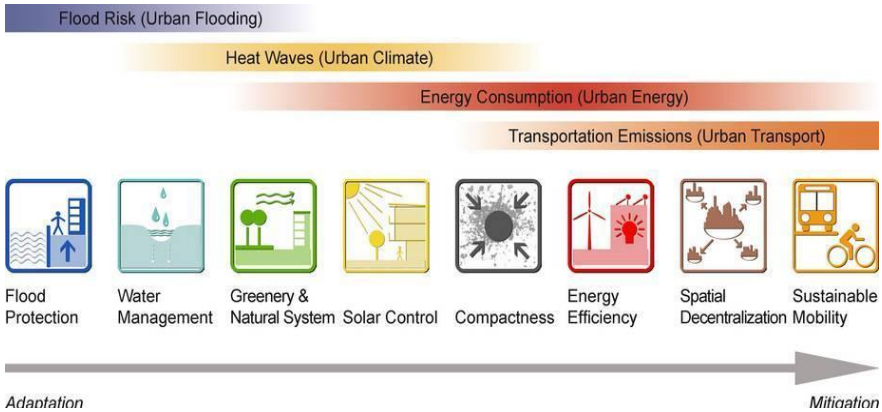


Figure 3: Climate change adaptation and mitigation by Megacity Project (Source: Schmidt, 2011)

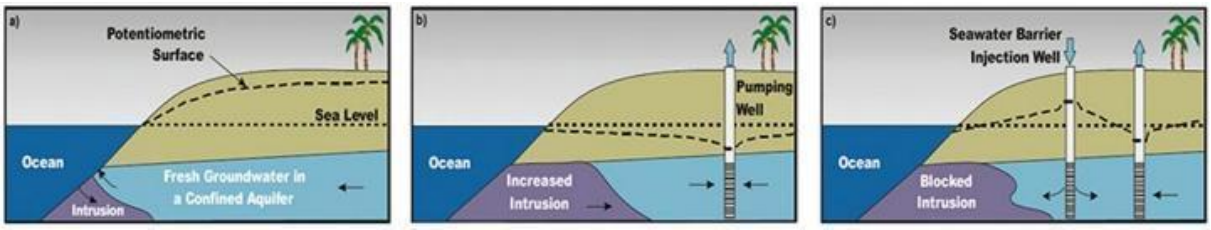


Figure 4: Process of saline intrusion based on resident usage of fresh water (Source: WRD., n.d.)

Giang date 19th June 2019 was informed that, 'Due to many Water Power Stations built in the upper stream of the Mekong River, the seasonal flood tendency in the Mekong has changed and will become less in the future'. In Feb 2019, the Mekong delta witnessed a soil fertility deduction of 95% and faced with salinization 1 to 2-months earlier than before due to later and less seasonal flooding. The salinization also extended previously from 60 km to 90 km and up to 130 km in 2016 from Vam Co River (Long An province). At the river mouth of the Mekong toward the East Sea, saline recently goes up to 50-75 km compared to the average of 40 km previously (Mau & Thanh, 2019). In Jan-Feb 2020, Salinity of 4g/l

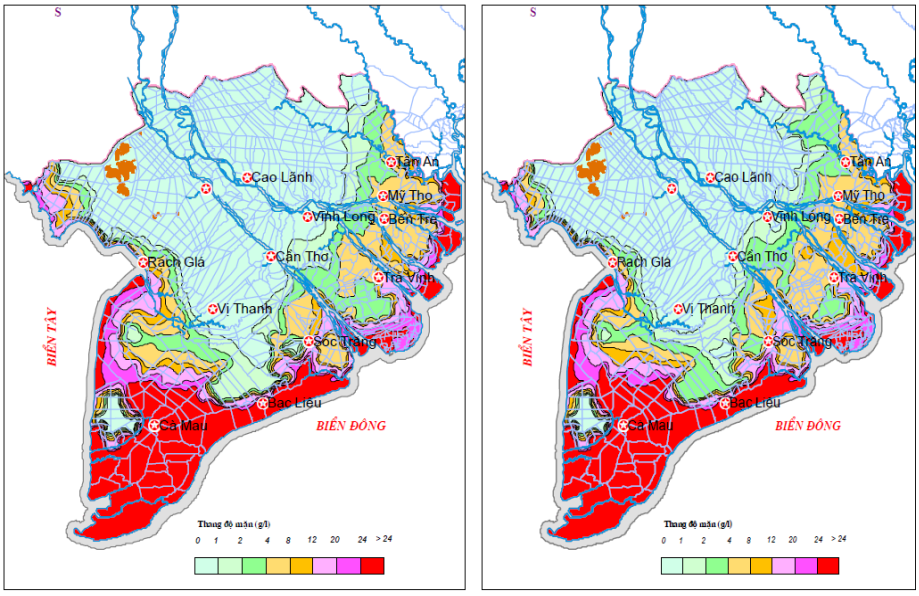


Figure 5: Salinity in Mekong delta, the existing (2000) and provision 2050 (Source: SIWRP, 2012)

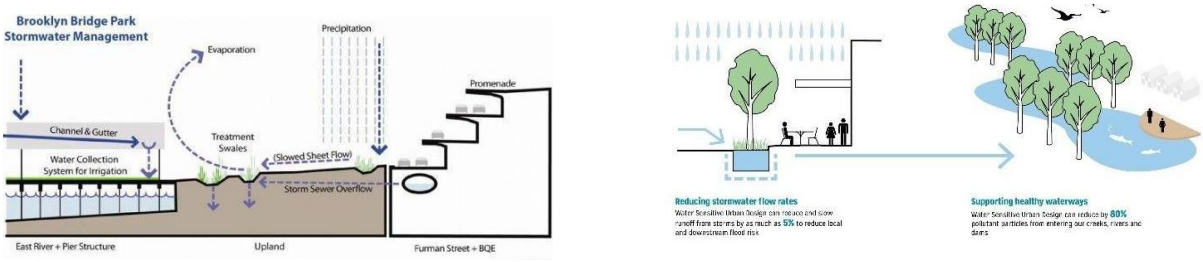


Figure 6: Water management concepts from WSUD (Source: Melbourne Water, n.d.)

possibly goes inland of up to 45–55 km depending on different river mouths resulting in an undesirable impact on 129.000 ha of rice fields in Tien Giang, Soc Trang, Ben Tre, Tra Vinh (Bui, Cong & Chuong, 2019).

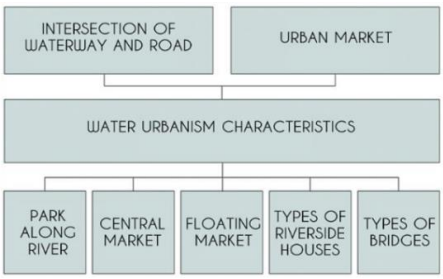
To resolve salinization problems, there is a tendency to create reservoirs to save fresh water from upstream and rain during the wet season; this preserved water is discharged and washes out the salt water in the dry season. The moderation of underground fresh water exploitation also helps to prevent saline intrusion. For places where current pumping wells are overloaded, they could be contaminated by seawater barriers, and are gradually subsiding due to underground fresh water use and reservoir discharges (WRD, n.d.). Other case study programs include the Water Sensitive Urban Design Program (WSUD) in Australia, the Low Impact Development (LID) in the US, the Sustainable Drainage System (SuDS) in the UK: the popular program of facilities and urban design that solves the problems of water resources (storm water, groundwater, wastewater, water supply, etc.) by using green zones (such as wetlands, softscape, sand filter, local plants, etc.) integrated with blue zones (such as ponds, rivers, creeks, basins, swales, etc.) and permeable materials in urban buildings.

3. Nam Hoa An – current Issue of a Water-base Settlement in Mekong Delta, Vietnam:

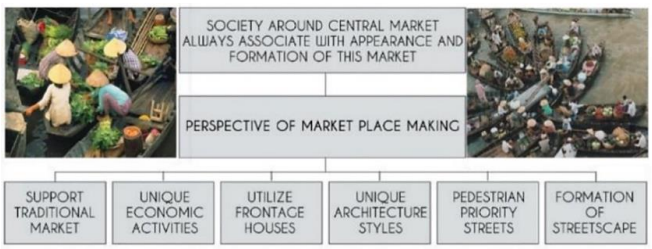
Mekong Delta Vietnam, is a water – dominated land that is highly affected by tides and annual seasonal salinity with an area of 1,7 million hectares of salinity soil, which affects both aquaculture and agriculture here for a long time. The water-based social cultural and economic characteristics of the majority of local communities. Therefore, in dealing with climatic conditions, they have been adaptive traditions over time. These characters are highlighted in Figure 6 and 7.

3.1 Nam An Hoa – Rach Gia Kien Giang

Nam An Hoa is a ward in the South of Rach Gia city, Kien Giang province, Vietnam. Nam An Hoa Ward has an area of 4.47 km², a population of 17,099 people (in 1999), population density is 3,825 people/km². From the first time when Rach Gia city was formed, people settled along the canal, and more concentrated in the North than in the South due to higher terrain in the north. Nam An Hoa Ward is in the lower land at the South, therefore, less crowded compared to settlement in the north and middle of Rach Gia. Hydrology in Nam An Hoa Ward is affected by apparent horizon, tides and prevailing wind directions as in Figure 8.



Market place making theory of Vietnam
(Source: Mu, & Walle, 2009)



Characteristics of a water urbanism of Vietnam
(Source: Them, n.d.)

Figure 7: Distinctive water-based social cultural characteristics of Mekong Delta Vietnam

The Topography

Using GIS, a map information tool, to apply geographical information to produce maps showing (by colour) different layers of geographical elements, to represent and manage geographical features in space or a specific subject, and serve a certain purpose.

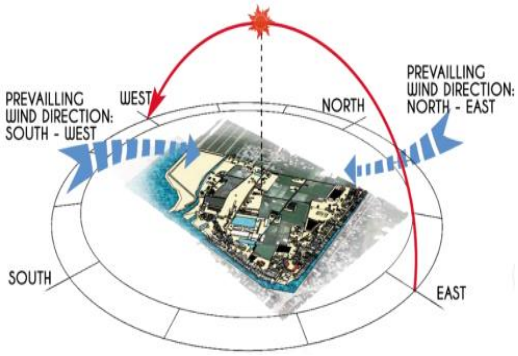


Figure 8: Apparent horizon
(Source: Nguyen & Cao, 2016)

Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	−0.20	0.10	
2	0.10	0.30	
3	0.30	0.40	
4	0.40	0.50	
5	0.50	0.60	
6	0.60	0.70	
7	0.70	0.90	

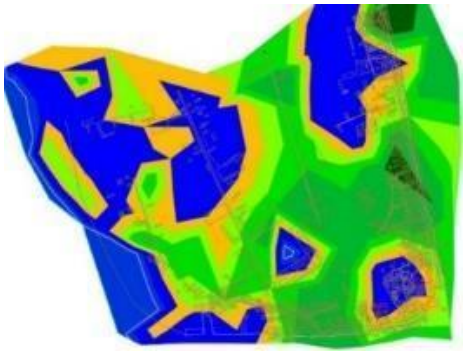


Figure 9: Current topography
(Source: Nguyen & Cao, 2016)

Figure 9 shows the current ground height. It can tell partly why and where a certain area is flooded. The colour represents levels of the flood depth (in 2015) of Nam An Hoa Ward). With the sea level rising, more serious flood situations are projected for the future. These projections can be shown together in a single map.

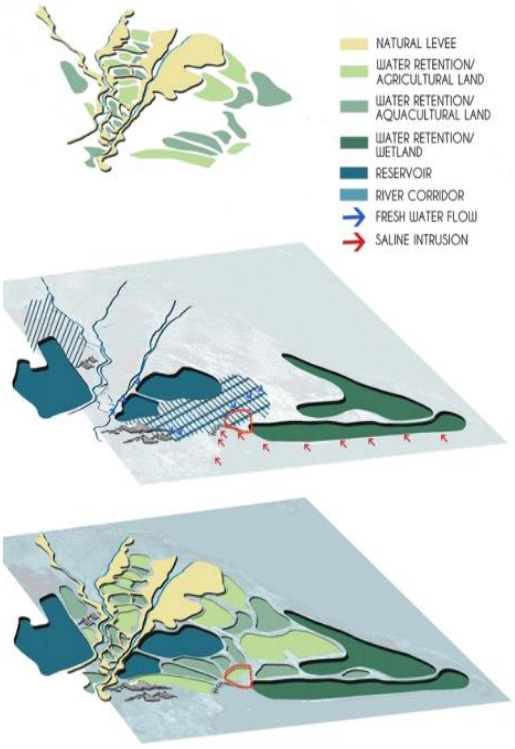


Figure 10: Saline intrusion floods analysis for Nam An Hoa Ward
(Source: Nguyen & Cao, 2016)

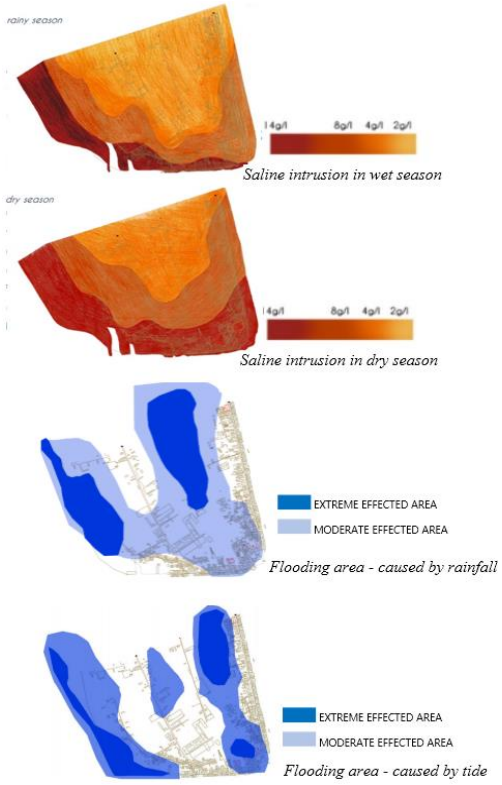


Figure 11: Typologies of water concerned in Mekong delta generally and in the current research particularly
(Source: Nguyen & Cao, 2016)

The flood, salinity, and water typologies

Similarly, info-graphic maps showing the areas are affected by saline intrusion in wet and dry season, these areas will be concerned to design the suitable water filtration methods and landscapes. The flooding maps is to show the reasons of flooding here and to check the real site condition if these areas are suitable for making "room for river" (Rijkswaterstaat, n.d.).

4. MATERIALS AND METHODS

4.1 The Research Objectives:

According to the problem orientation above, Nam Hoa An in Rach Gia City, Kien Giang province is one of places that are heavily affected by flood and saline intrusion both today and in 30-50 year-projections. While current urbanization and urban developments are taking places without concerns on how people live hoods could be affected and transformed, this research, with an adaptive approach, is to:

- Understand and evaluate the consequences water – related values and issues in Nam Hoa An Ward, focusing on flood and saline intrusion;
- Propose adaptive water management in different scales (whole areas, zones and building/houses) and aspects (economic, social cultural) to fit and support better living conditions and environments in Nam Hoa An Ward. Different land uses for aqua-agriculture, productive landscape and communities' settlements are accordingly proposed based on the characteristics of water solutions and management.

4.2 The research process and methods

The research was carried out in 05 steps as shown in Figure 8. Data relating to water management including fresh water capacity, flood, salinity, traditional water treatments and management, water-based productivities and local aqua-agriculture, development planning, etc. are collected and analyzed using different methods depending on different sources of primary or secondary data. While the primary data was collected by field trip, survey: observing, measuring, and communicating with residents; the secondary data was collected from books, reports, lawful documents, and professional journals. The transformation of the research site was also understood and analyzed using secondary data collected.

The project objective is to maximize its historic, social, cultural values that long ago related to water; while giving priorities to biodiversity, allowing sustainable new urbanization to take place with land use plan, green infrastructure (roads/street network) blended with the blue and green spaces, spatial arrangement, housing design that responsive to the overall context.

The detailed design is to give forms and functions, and meanings to different areas in Nam An Hoa ward: eco water park land that promote not only biodiversity but also sustainable water management for the whole are, but also a new responsive urban development.

Table 1: The process research and method in each step:

Research process	Data / information	Sources of data	Method of collecting	Method of analysis
Data Collection and analysis	History/urban transformation, linkages; Flooding, salinity situation, Water management Water-based productivities. Urban landscape, topography Urban built fabric, street/road, housing, infrastructure and facilities,	Secondary data: books, articles, magazines, reports. map, graphs, figures, etc.) Guidelines, lawful document, statistic information from relevant sectors)	Literature Review, Collecting written document and information from library, authorities, agencies, journal papers	SWOT table. MapInfo, CAD drawing

Research process	Data / information	Sources of data	Method of collecting	Method of analysis
	Climatic issues activities related to water, etc.	Authorities (Construction Department) Primary data: social, cultural and people opinions	Site survey, field trip	Data analysis programme, and excel.
Initial design concept	To develop Vision, strategy and adaptive water management schemes at different scales: region => urban => district / ward/ settlement units.	The government's strategy and visions; Theoretical background on related issues Lessons learnt	Search, reviewing, and analysing	
Urban design coding and guidelines	Design guidelines and coding: for water management, land-use planning, infrastructure development, and landscape planning			
Detailed design for particular area	Detailed design for particular areas: with criteria, principles, and measurable structure and details			

5. RESULTS

According to the analysis, the main water sources that need to be concerned in the Mekong Delta is wastewater (from agro-aquaculture activities and domestic sources), brackish water (from saline intrusion) and stormwater (rain and tide water). The water treatment, therefore, focuses on adaptive solutions for those three sources.

Water Management Objective: to optimize the natural levee along Bassac River by building the settlement area to avoid flooding. Low land reserved the location of freshwater, brackish and saltwater:

- *Urban wetland:* water retention, stormwater biofiltration to enhance biodiversity. Besides, building a wetland system to filtrate water along the coastal area.
- *Water reservoir:* to store fresh water in wet season and artificial canals/ channels is to discharge fresh and saltwater in the dry season.
- *Urban orchard:* use local grey water recycling (for irrigation) to grow agriculture, aquaculture.
- With storm water, there will be design of permeable ground surface that allows water run-off then becoming groundwater and be able to be released into the nature;
- With grey water (or black water), depending on the waste level from daily use or from public use (public hygiene, industrial activities, etc.), different treatments are applied to reuse domestically, or be transferred to the upper level treatment point/factories before discharging to the natural system.

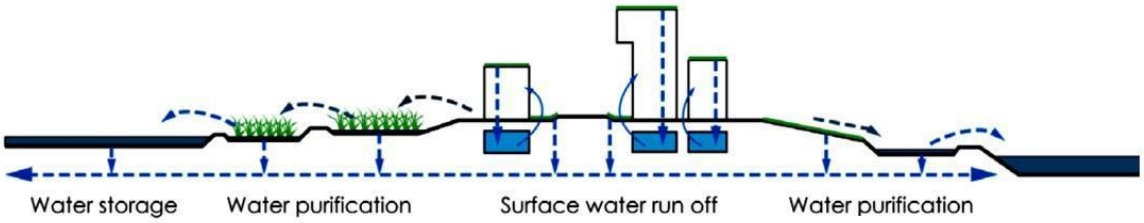


Figure 12: Water management strategic section in Rach Gia City – Kien Giang Province (Source: Nguyen & Cao, 2016)

Cut and fill concept: Land was cut and fill following the arrows

Hierarchical circulation concept: some roads are also hard dikes with gates to protect from flood and salinization

Different zones and landmarks are proposed based on the analysis and support water management concept

Figure 13: Spatial zoning and circulations based on cut-and fill principles and adaptive water management for Nam An Hoa Ward, Rach Gia city (Source: Nguyen & Cao, 2016)

a. Nam An Hoa Ward – Overall Ecological Spatial Design Concept

Based on the analysis, it is clear that saline intrusion in both wet and dry season to form the areas are affected by the sea following seasons, and the level of brackish/ salt/ fresh water. Therefore, the research suggested to respect the current conditions and local traditional "cut and fill" method:

- Digging the low land: for water storage and reservoir; depending on the depths at different sections, natural processes of purifying and salinization are managed. At some
- And fill ground to the higher land: To adapt to climate change by the most natural methods, knowing the topography of the site is also necessary in creating high land for living areas, for locating the vulnerable buildings such as hospitals, schools, police stations, etc.

Then based on the new "cut and fill" topography, the hierarchical circulation was proposed with both vertical and horizontal axes to ensure the connection for the area. Different urban functions are also suggested:

- New residential area of Phu Cuong approved project was kept with modifications of building design guidelines to fit to overall proposed ecological landscape context;
- The industrial area is based on the existing ship making and repairing factory, with certain distances (covered with blue and green areas) to both existing communities on the left side and new development on the right side. There are exes to connect both via wetland and the industrial zone;
- Due to the eviction of around 1 0 0 households (Nguyen & Cao, 2016), resettlement site next to the existing communities is suggested with guided housing typologies and morphologies;
- As local social cultural characters are preserved, the existing market place is preserved, expanded to serve the need of local people and tourist;
- Several landmarks are also designated in places following the analysis to create legible images of the place according to Kevin Lynch ideas of Path, Edge, District, Nodes and Landmarks.

b. Nam An Hoa Ward – Ecological Water Management Concept

A Flood map is to show the areas affected by flood and the reason for flooding, flood by rainy season and flood by tide in daily life. With the flooding map, it is necessary to create 3 reservoirs to store fresh water in the rainy season. The new roads also are used as dams to discharge water when salt water occupies deeply inland. Besides, determining the flooding area with many levels can help choose to transform the most vulnerable into the reservoir or to change it to agricultural and aqua cultural land.

Figure 14: Adaptive water management concept for Nam An Hoa Ward, Rach Gai City (Source: Nguyen & Cao, 2016)

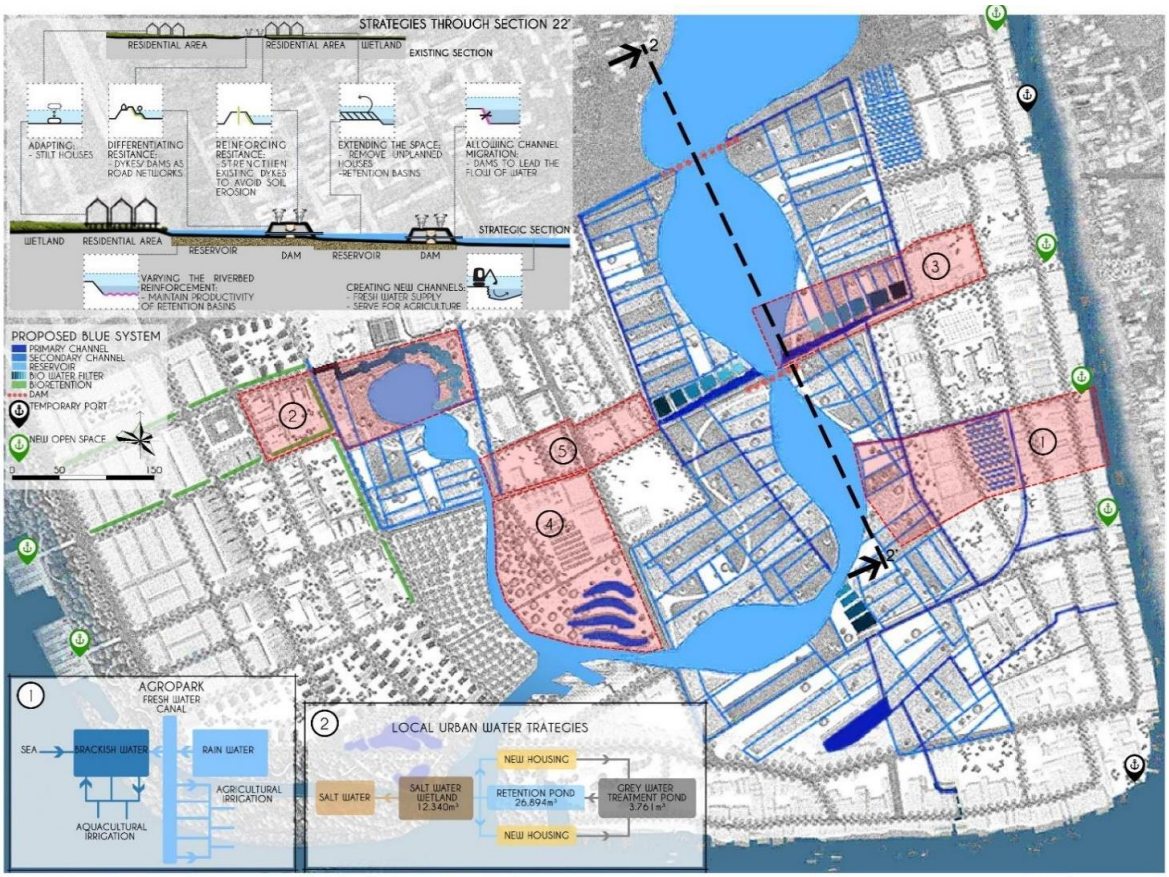


Figure 15: Master plan of water management and supporting conceptual design areas in Nam An Hoa Ward (Source: Nguyen & Cao, 2016)

The main aim is to construct an area with great ecological value, which combines the human activities with new greenery and new water surface. Therefore, with the new concept design, the area transforms into 5 main unique characterized areas:

No.1 : New apartment +old - poor residents and the agricultural waterscape:

Apart from contributing to the urban metabolism by cleaning surface water, they also form good habitats. The open character of the ponds can balance the enclosed urban spaces and make up views to the agricultural landscape. Besides, a suitable water management section in domestic use also helps limit waste water to nature and plan for retreating grey/black water in daily use.

With the new topography, the area of residents, public spaces and buildings such as hospitals, schools, police stations, etc. are located in highland (the filled) help avoid floods in extreme weather, and the 'cut' lands are prepared for flood and other nature-related circumstances. Conversely, people learn how to live with flood, appreciate its benefits and enjoy the seasonal changing landscape.

Together with permeable materials, this area works as a flood protection buffer zone that creates more room for floodwater and accelerates storm water drainage and storage in the rainy season. Moreover, the terrace design of this area alleviates the height difference between the city and the river, reconnecting people to the waterfront with a variety of public activities.

No.2 + 3 : New residential areas and saltwater-biofilter water scape:

Applying building water storage tanks (for rainwater harvesting and recycling of greywater). There was a small calculation:

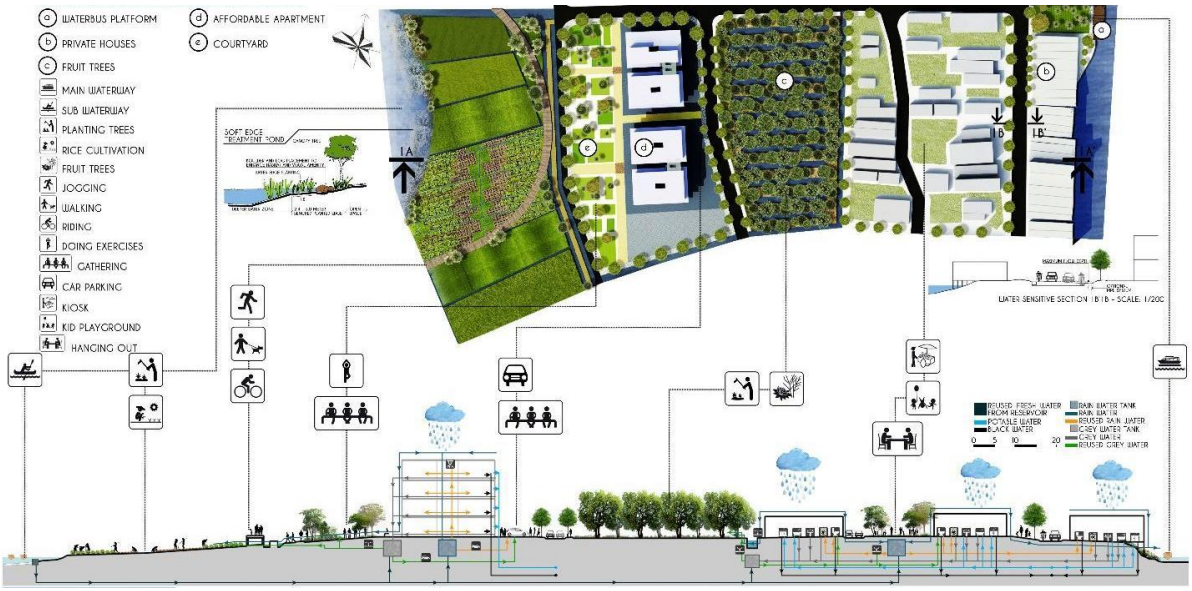


Figure 16: Plan and section of water management in area No.1
(Source: Nguyen & Cao, 2016)

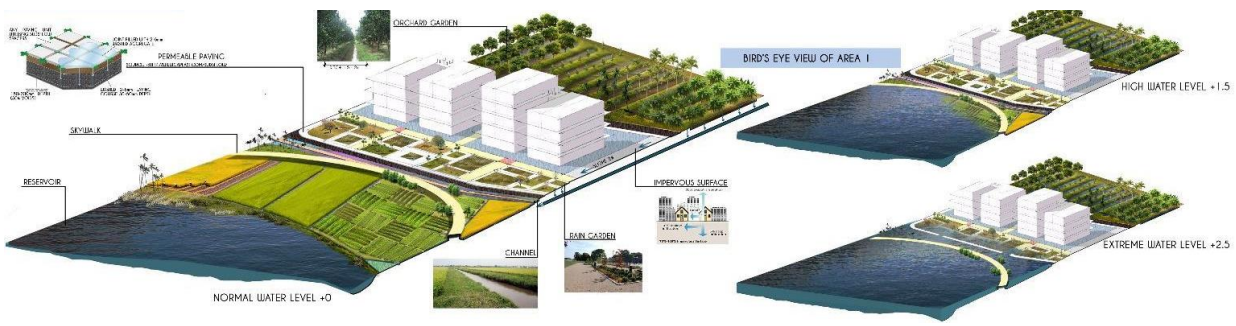


Figure 17: Bird's eye view of area No.1
(Source: Nguyen & Cao, 2016)

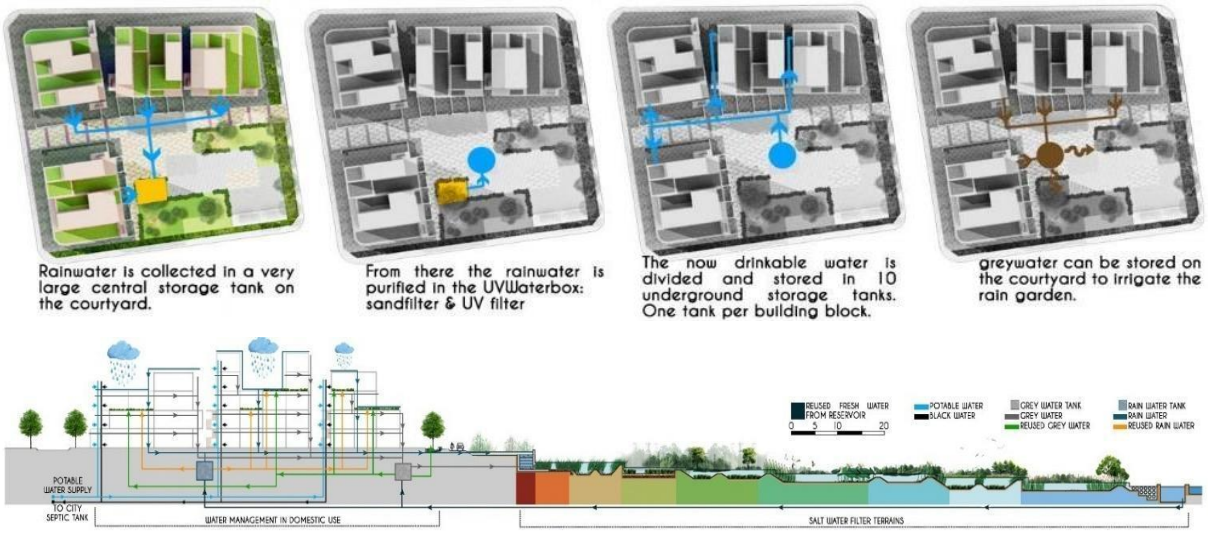


Figure 18: Plan and section of water management in area No.2 and No.3
(Source: Nguyen & Cao, 2016)

Annual rainfall in the Mekong Delta is approximately 2000 mm. As the rainy season lasts from May to November, it is needed to store water from November to April. If every day each Vietnamese person needs 5l rainwater for drinking and cooking, annual rainwater use for a four people household in Mekong Delta is: 5 L/day/person x 4 person/household x 365 days/year = 7.300L/household/year. Therefore, a 3.700L water storage box is enough for each household in the dry season. Public water uses require bigger water storages, such as: lake, water retention, etc.

At a bigger scale for the whole new residential area, people can apply bio-swale and green surface water runoff, permeable paving. These elements are designed to remove silt and pollution from surface runoff water in urban areas. Besides, having a filter terrain can help deal with saline intrusion issues in dry season, which was shown in the strategy section. In the filter terrain, people can grow the local plants that can help absorb the saline water to bring it back to the brackish and freshwater. Besides, brackish water still can be used for another agri – aquaculture activity such as growing shrimps, fishes, and rice cultivation.

No.4 +5: New factories with wastewater treatments:

Followed appendix No.3 - TCVN 4449:1987 of urban designing and planning standard, the hazardous level of factories in this area is 4, which has the minimum safe and hygiene distance from industrial areas to residential areas and public constructions is 100 m, making these kinds of products:

a. Mechanical manufacturing and metal processing:
   Iron and steel metalworking industrial enterprises (with output of less than 1,000 tons / year) and nonferrous castings (with output of less than 100t / year). Small casting workshop of manufacturing machinery and equipment for the electronics industry (generators, transformers, lamps, etc.)
b. Wood producing and processing: Wood saw and veneer mill. Wood - shipbuilding factories.
c. Manufacturing and processing products from animals: Enterprise of forages from the food scraps. Forages grinding mills. Freezing meat plant. Meat storages in a day. Canned fish factories, complex fish factories.

The conventional sewage treatment should be concerned to filtrate the black water in industrial areas (including mechanism and organism waste water) to the grey water, which can be easily released to the natural source. Then, there will be a sewage pipe to lead the grey water to filter ponds: The wetland with 4 ponds. The first pond is for primary treatment, which is subsurface treatment. The second pond will remove the remaining heavy metal.

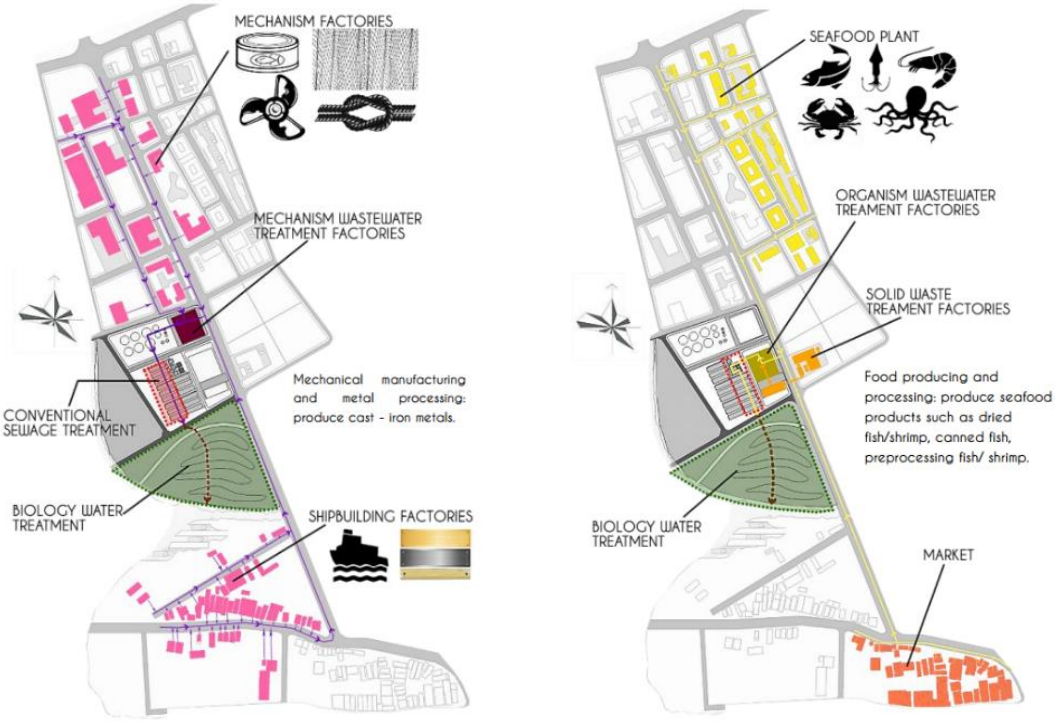


Figure 19: Purify organism (left) and mechanism (right) waste water system (Source: Nguyen & Cao, 2016)

Two last ponds will purify the water again 2 more times before releasing it to nature. The water is no longer a separating element in the neighborhood scale, the infrastructure pattern forms a unity with the natural water structure (culvert/pipeline takes rainwater from bioswale and rain garden).

6. CONCLUSION AND DISCUSSION

Current natural condition reflects the large picture of general consequences of climate change, especially in Vietnam, and its most severe affected Mekong Delta. Flood, saline intrusion, shortages of freshwater are projected to have big negative impacts upon people and habitats in the Mekong region. Therefore, dealing with water is the main focus in planning and management of natural resources and human settlements.

Regarding water treatment, every case study learnt has its own advantages to apply in Vietnam – Kien Giang Province contexts. As is shown, "Rooms for river" program in Netherland can be best applied by guiding the methods of maximize rooms for water storage

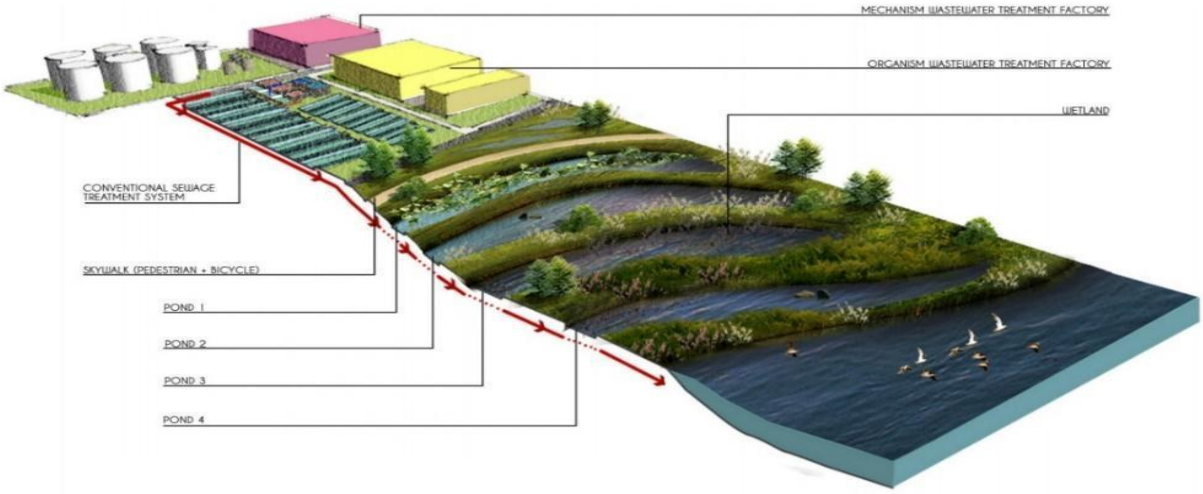


Figure 20: Bird's eye view and section of water management in area No.4 and No.5 (Source: Nguyen & Cao, 2016)

(such as wetland, basin, and ponds) lower the floodplain area to enhance the topography of higher land, and build dykes which can control the water releasing in both rainy and dry season.

In the local context, Vinh Te canal built in the early 19th century has always shown effective adaptive water control and treatment of Vietnamese people. Located in the border of Vietnam – Cambodia, it was built for taking sediment and fresh water from upstream of the Mekong Delta to Kien Giang Province in the far West of the region. This canal helps store fresh water for agri–aquaculture activities/ productivities and fight off the saline intrusion for a long time ago in Kien Giang. Today, people still take advantage of the canals like Vinh Te canal in adapting with saline intrusion and flooding in the rainy season. Those canals are naturally characterized by the local nature plantation such as mangrove and melaleuca.

In preventing the flood risks and salinity caused by sea level rise and climate change, more in-depth research and analysis are required; to allow the contextualization of the solutions. There is neither such a direct applicable model nor single method. At big scales (city, region, national levels): strategic policies regarding adaptive planning, city spatial design, land-use planning, urban design and building design principles are initial; with priorities given to people, their water-based living environment and livelihoods. At a smaller scale, Vietnamese people have traditionally considered making rain gardens, treatment ponds, permeable materials, green roof, bioswale, etc. in years. In current context, the more systematic and hierarchical adaptive water treatment such as local reservoirs, basin, ponds; cut and fill terrains, roads as the dykes, etc. to save fresh water in rainy season (for usage in dry season), and treat salinity caused by tides and sea level rise. The upcoming shortages of water flow from upstream caused by many water power stations along the Mekong River also issues that need to be addressed as causes of salinity and drought in the lower Mekong River Basin.

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