

An Overview of Vietnam Water-city Typology by Quantity of Identification Elements and the Adverse Long-term Effects by Rising Sea-level

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Abstract: Those days, Vietnam water cities are in a state of flux. Nevertheless, it is undeniable that our country being lacking in the quantity of identification elements in order to classify all water-cities through mapping. Therefore, this paper has two primary objectives. Firstly, Vietnam Water-City is conspicuously mapped in terms of four major general identification elements, namely, river density, water terrain, river traffic and sea city. Secondly, that water-city map is employed in forecasting the long-term effects on typical water cities by climate change, especially derived from the scenario of the rising sea level between 2020 and 2050 in two major alluvial plain such as Red River Delta and Mekong Delta. Defining the location of seventy eight water cities, the spatial analysis, generalization and GIS data, evidently, is utilised. Substantially, the adverse long-term effects have been illustrated and hinged on the fundamental indicators including agricultural land area, GDP per capita and population.

Keywords: Vietnam water-city, identification elements, river density, water terrain, river traffic, sea city

1. INTRODUCTION

To commence with, "Urban is a geographic - economic - ecological system in which natural and socio-economic components have a close and balanced relationship that will be harmfully damaged or injured due to terribly unbalanced situation. In other words, nature evidently will be destroyed and seriously polluted, then human life and health are threatened in linked with reducing the effectiveness of manufacture - service - management activities" (Vu Tu Lap, 2005). Furthermore, it is no doubt that there are dominant factors among relationship; hence determining the dominant factors is fundamental to identify Vietnam Water-Cities.

In accordance with Vietnam natural topography in general, and several cities in particular, the river element is an essential factor to identify water cities. The other important factor is terrain: utilise the terrain type of geographic landscape is a synthesis of natural territory, formed from the relationship between geological, topographical, climate, hydrological, soil, organisms and the human impact.

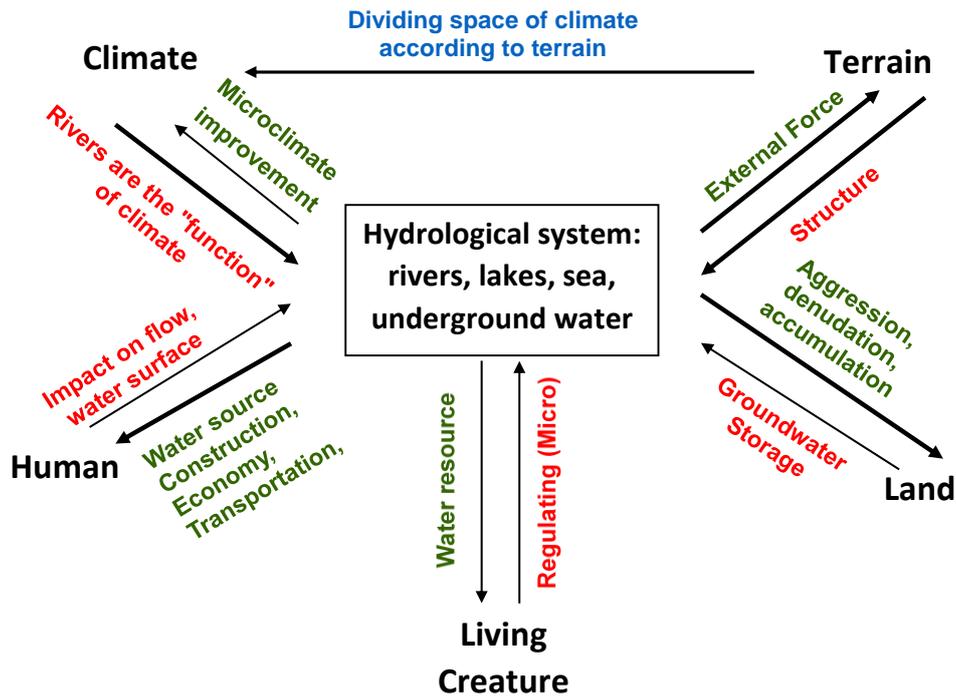


Figure 1. The close relationship between hydrological system and climate, terrain, land, living creature and human

2. METHODS

“Water Urbanism posits that water and cities must be understood within an expanded notion of a constructed ecosystem. How we live with and design for water will be a central, defining element of the next century relative to climate change and urbanis” (Stefanie *et al.*, 2010-2011).

Pursuant to Vietnam natural terrain, the fundamental factors in order to identify Vietnam water urbanism will be formulated as bellow:

- Density of rivers and streams, the city is situated in high density of rivers and streams consisting in all types of river, namely navigability and innavigability (Urban topology by river density)
- Terrain type, (Urban Topology by water terrain)
 - + Alluvial Plain;
 - + Valley, basin (hilly region);
 - + Coastline (Tidal flats, sand dunes).
- Located along the waterway (Water-city typology by river traffic)
- Adjacent to the sea (Sea City)

2.1. Urban Typology by river Density

To encompass a wide range of 13 large river systems, which cover 10,000 km² in total, Vietnam is considered to have a complex and dense river network with most of the large river systems linked. Other than that, each river system has its own distinctive characteristics, thus environmental management approaches may vary greatly from one river basin to another, depending on socio-economic conditions, land use, environmental factors, and their economical and ecological values, .etc. (Hanh et al., 2008) In truth, Vietnam tropical monsoon climate creates a densely covered network of rivers, consisting in more than 2360 rivers over 10 km; the average annual rainfall is 1,900 mm; the average flow is 26000 m³/s; total water volume is 839 billion m³/year; surface water covers 76% and underground includes 24%; outside flow into Vietnam is 59.7%. In details, the average density is 1km/km². (Hanh et al., 2008)

Admittedly, due to the tropical monsoon climate and distinguished terrains, the density of rivers and streams is unevenly distributed, such as extremely high density (over 2km/km²) and high density (1-2 km/km²) are located in the northern and southern part of Vietnam, meanwhile, the average density is situated in the central part by less than 1km/km².

2.2. Urban Typology by Water Terrain, Namely, Alluvial Plain; Valley, Basin (Hilly Region) and Coastline (Tidal Flats, Sand Dunes)

Amongst those 13 main river systems, 9 have basins which contribute to 90% of total river basin area in the whole country. The 9 main river basins are those of Red, Thai Binh, Bang Giang-Ky Cung, Ma, Ca La, Thu Bon, Ba, Dong Nai, and Cuu Long River. The Red river and the Mekong river systems have the largest basin areas (155,000 and 795,000 km² respectively) as well as the highest total volume of water flow. (Hanh et al., 2008)

Vietnam urban centers have a tradition of building on the "river" terrain. In addition, thousands of rural-urban settlements have been relying on the plain of rice paddies - at local high places inside the plain, or adjacent to the river delta, allowing humans to use water sources for living, production and transportation:

- Particular:

- + Phong Chau at the top of the Red river;
- + Co Loa on the river shelf adjacent to the accumulation plain - RRD;
- + Hoa Lu: Delta edge of Red river, Hoang Long river;
- + Hanoi is in the delta, along the Red River;
- + Pho Hien on the banks of the Red River; Hue along the Huong River Delta;
- + Saigon along the Saigon River.

2.3. Water-City Typology by River Traffic

Because of the natural terrain with long coastline, the waterway is the major driving force behind the construction of urban settlements in Vietnam. Traditionally, the water network has been the first layer to build upon, supporting urbanity, road infrastructure, and agricultural land. Settlements are laid out along rivers and urban centers occur at the confluence of important waterways. Total length of inland waterways: 6658.6km (North: 2663.9km; Central region: 808.4km; South: 3186.3km). The global turnover illustrates the advantage of the seaway: accounting for 69.35% of the volume of circulating goods. Additionally, the river-way is the third, reaching 13.01% based on the data of table 1.

Table 1. The percentage of domestic circulating goods by different transportation type

Transportation Type	Proportion (%)
Railway	1,95
Overland	15,52
River-way	13,01
Seaway	69,35
Airline	0,16
Turnover	100

* Source: Vietnam Inland Waterway Administration (VIWA) – Ministry of Transportation

2.4. Sea City

Combining with a coastline of 3,260km, excluding islands, Vietnam claims 12 nautical miles as the limit of its territorial waters. Thus, a huge number of cities are adjacent to the sea – the fundamental identification element to define the water city. For instance, Ha Long city being situated in Vietnam’s northern coast is likely to have potential source of being a water city in terms of sea tourism, deep-water port, and natural coastline ecosystem. Cam Ranh city is a city in the South Central Coast region of Vietnam also tend to have possible position in order to build up deep-water port and to turn into water city.

3. RESULTS

3.1 Urban Typology by River Density

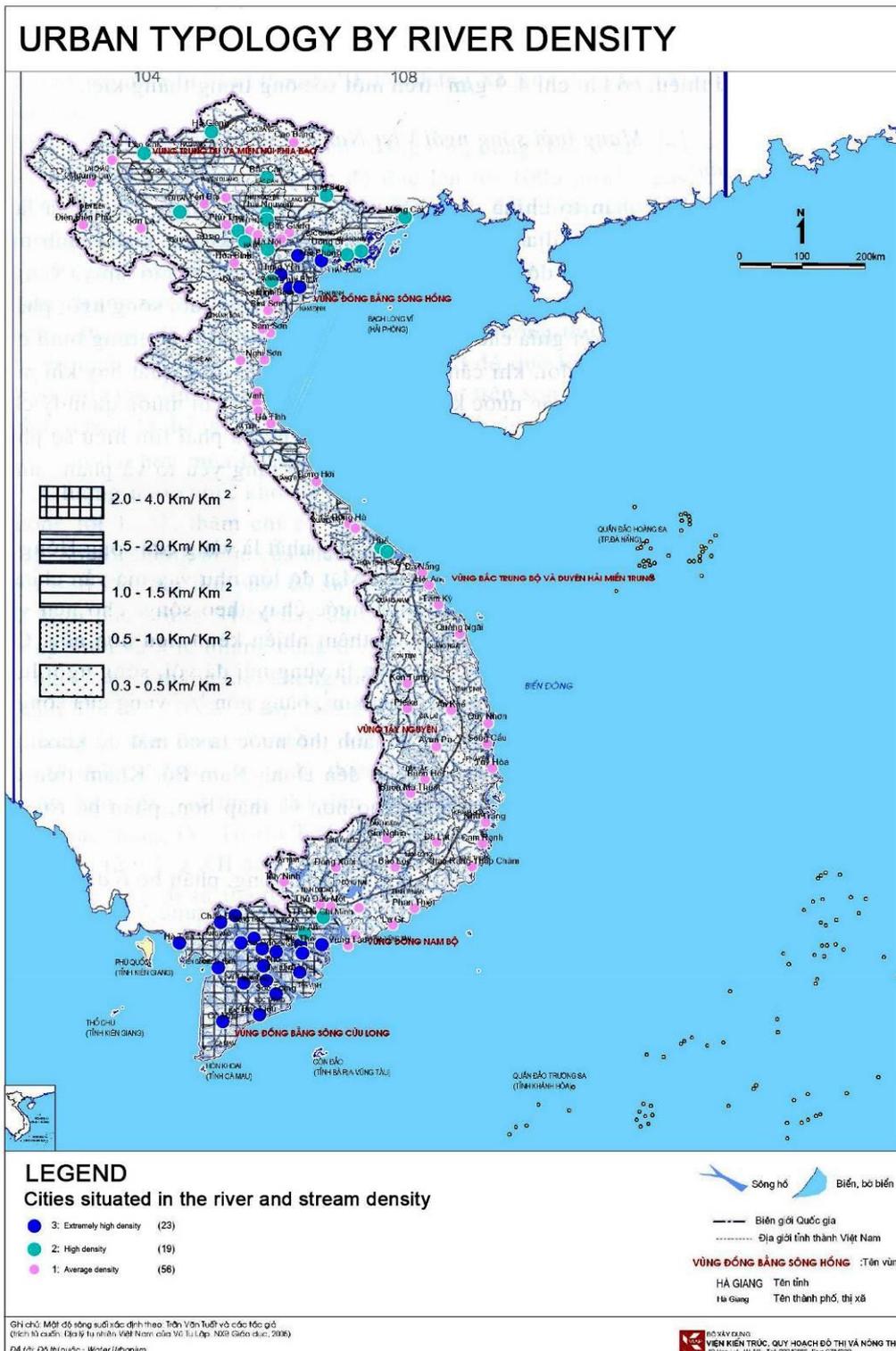


Figure 2. Urban Typology by river density

In total, due to the figure 2 there are 23 cities are located in extremely high density of river and stream. Meanwhile, the number of cities in high density of river is 19, following with 54 cities in average density. In accordance with the meticulous analysing in terms of both river and stream density and annual rainfall(mm) due to the map and GIS data, the total

number of cities being situated in the river and stream density from extremely high to average condition will be illustrated. For example, at the gate of “Red River Delta” has total five water-cities with extreme high density of rivers and streams. Furthermore, unlike the rest of Vietnam, the Mekong delta only has been occupied by Vietnamese for approximately three centuries. As the marshy delta was transformed into productive land for wet paddy cultivation, settlements developed linearly along waterways; hence, the Mekong Delta also has eighteen water-cities with extrem high density of rivers and streams.

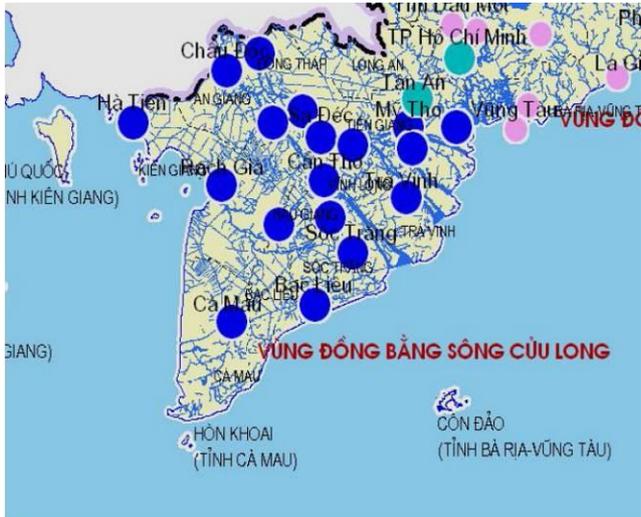


Figure 3-a. Urban with extreme high density of rivers and streams - “Mekong Delta” in total 18 cities

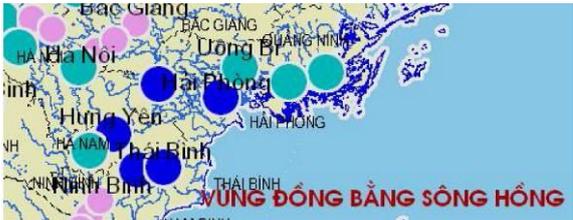


Figure 3-b. Urban with extreme high density of rivers and streams - At the gate of “Red River Delta” in total 5 cities

According to figure 4, the urban with high density of rivers and stream is obviously frequently allocated to the top and edge of the Red River delta in total 15 cities, the valley of the big rivers in northern part including Red River, the upstream of Chay River, Thai Binh River and small river systems of Quang Ninh. Huong River basin, the place with the highest rainfall in Central Vietnam covers Hue water city. In the southern part, Dong Nai is one of the typical water city with high density of rivers and streams.



Figure 4. Urban with high density of rivers and stream

3.2. Urban Typology by Water Terrain, Namely, Alluvial Plain; Valley, Basin (Hilly Region) and Coastline (Tidal Flats, Sand Dunes)

In truth, most of Vietnam cities naturally belong to “water terrain”:

- + There are 69/98 cities and villages (70% of the total) built in topographic features of the river;
- + 47/98 (48%) cities are located in the inland waterway terrain with long-term wet rice agriculture, showing the importance of the relationship between urban and agriculture;
- + The two biggest Northern and Southern triangle alluvial plains have the numerous water cities, such as Hanoi, Ho Chi Minh, Hai Phong, Can Tho;
- + In the Central Coastline the two typical water-cities are Vinh city (constructed in the alluvial plain of Ca river and Lam river – also the major waterway) and Hue city (built up in the alluvial plain of Huong river);
- + Only 2/98 (2%) cities are adjacent to the sea without alluvial plain, especially Cam Pha and Thai Nguyen.



Figure 5. Urban typology by water terrain

3.3. Water-City Typology by River Traffic

Viet Nam has 41,000km of inland waterways, of which only 8,000km are used commercially despite huge potential for freight transport. Despite limited investments, waterway transport capacity and use has increased recently for high-weight low-value goods (e.g. coal, rice, sand, stone, gravel), and personal transport (World Bank, 2014). Transport in the Mekong Delta benefits from an extensive waterway network including rivers and channels, many of which can cater to large vessels.

In order to discern whether the city covers the inland water-way or not, the National Transport Network - figure 6 has been used apparently. Most Vietnam's main urban areas are located in the river and sea routes. Supplementarily, fifty-four cities in total of ninety-eight cities (municipalities granted) located in river routes; furthermore, in fifty-four cities, there are eight urban areas combining with both rivers and sea (Figure 7) - called a river estuary, typically, Da Nang and Cua Lo.

The other 14 cities are adjacent to the sea, most of them have deep-water ports such as Ha Long, Nghi Son, Cua Lo, Da Nang, Quy Nhon, Nha Trang, Cam Ranh and Vung Tau. Coastal shipping is very important for medium distance transport in order to connect and to communicate between coastal cities.

Additionally, the river network has a close relationship with the stream network and plain terrain. The favourable river network is the place where there are high density of rivers and streams in association with delta terrain, typically in the North and South. These areas conceal the longest and densest river network. Specifically, the Northern and Southern river transport system are the major driving force behind the proliferation of urban position in territorial organisation.

By using the water transport elements is inclined to reflect the water surface area because of the close correlation between these two factors. Truthfully, most of research projects, sometimes do not take into account the large rivers and sea surfaces because they are not entirely contained in urban areas.

A number of cities do not cover with water terrain; nonetheless, these cities are situated in the fundamental waterway such as Bac Giang located on the plains and adjacent to Thuong river and Bien Hoa situated on the terrain of Dong Nai river.

In Can Tho, the capital of the Mekong Delta, an extended water network has been the main infrastructure for centuries leading to linear settlements along waterways promoting a way of “living with the floods” (Stefanie *et al.* 2010-2011). Hanoi, on the other hand, situated in the heart of the Red River Delta, grew as the dynamic delta conditions (Stefanie *et al.* 2010-2011).

A few number of cities are not likely to embrace “water terrain”; however, those cities are situated in the essential river traffic. For instance, Bac Giang city located in the semi-plain and adjacent to Thuong River and Bien Hoa city abut onto Dong Nai river which is convenient for navigability.



Figure 6-a. National Transport Network: North to Central
(Source: Vietnam National Transport Strategy Study (VITRANSS))

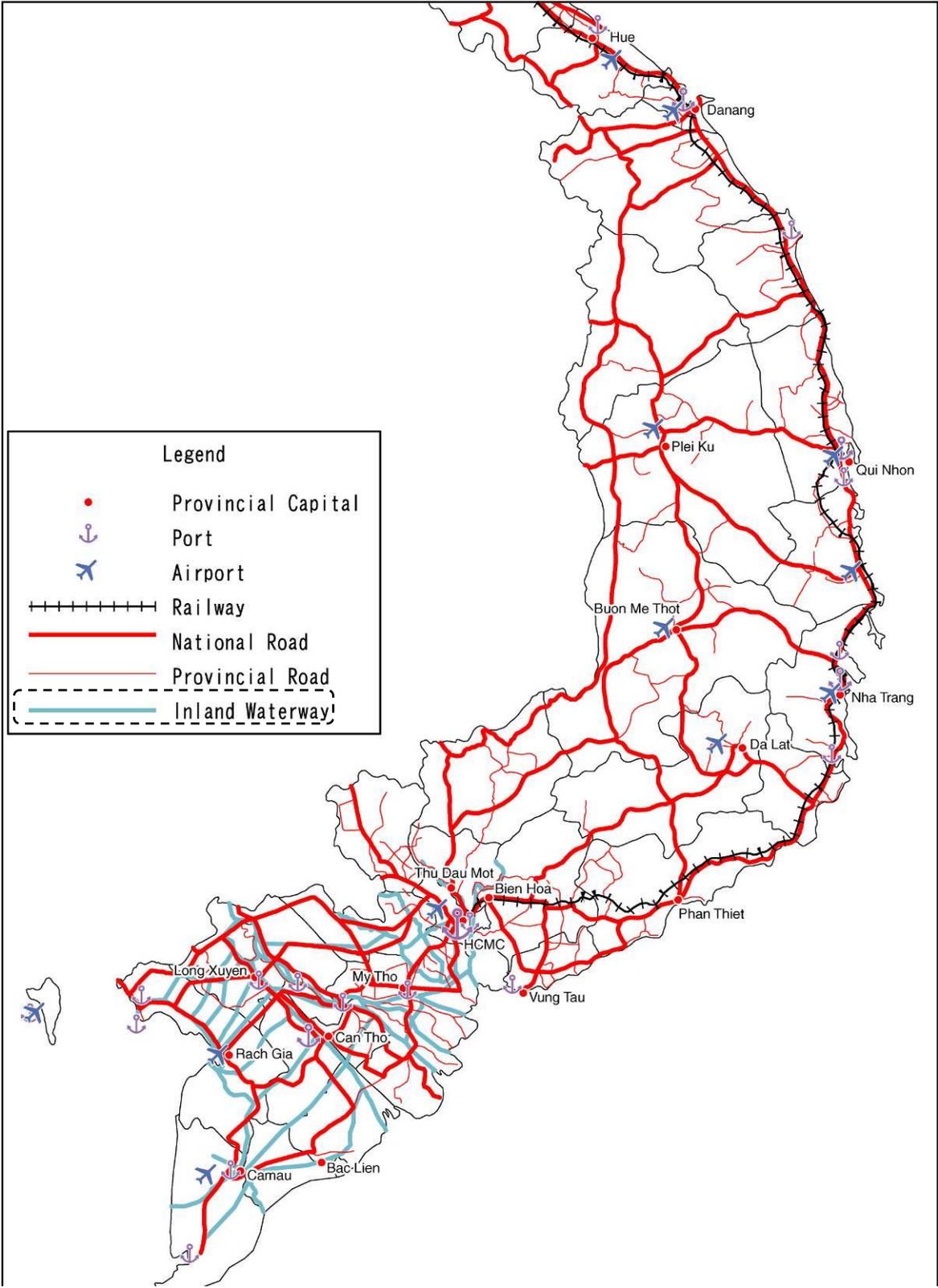


Figure 6-b. National Transport Network: Central to South

(Source: Vietnam National Transport Strategy Study (VITRANSS))

The North and the South have the longest and densest river network. In other words, the river transport system is a fundamental factor to develop urban position in territorial organization. For instance, Bien Hoa City landed along the Dong Nai River has a low density of rivers and streams but is adjacent to the river, thus has convenient river-way. Nga Bay Town, the typical urban area for the delta triangle group with dense waterways is the main transport route for a long time. Up to now, there has always been an important urban and external transport route.

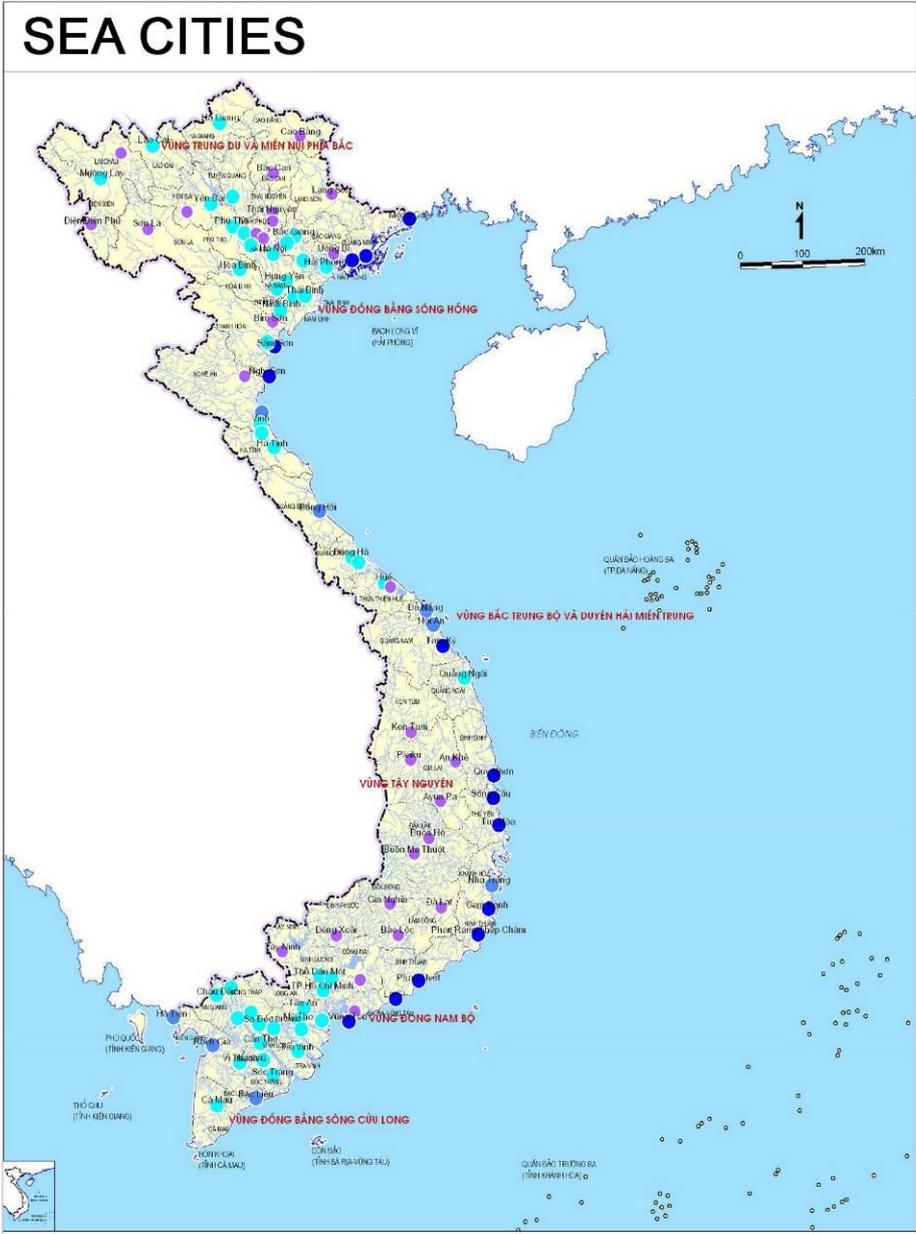
SEA AND RIVER CITY



Figure 7. Water city typology by river traffic

3.4. Sea City

Due to the natural long coastline, Vietnam has total 22 cities being adjacent to the sea.



LEGEND

CITIES ARE ADJACENT TO THE SEA

●	SEA CITY	(22)
●	OTHERS	(76)

Figure 8. Sea City

3.5. Water City Typology by Quantity Of Identification Element

In accordance with four major general identification elements of water city, namely, (1) urban typology by river density; (2) urban typology by water terrain, such as alluvial plain; valley, basin (hilly region) and coastline (Tidal flats, sand dunes); (3) Water-city typology by river traffic; and (4) Sea city, the two triangle alluvial plain of the South and North have combined apparently numerous importance water cities, meanwhile, there are rare or none of these water-cities are located in the Northern mountain, Central Highland and the North of the South-East. To sum up, Vietnam has totally 78 water-cities consisting in between four and only one identification elements as mentioned above.



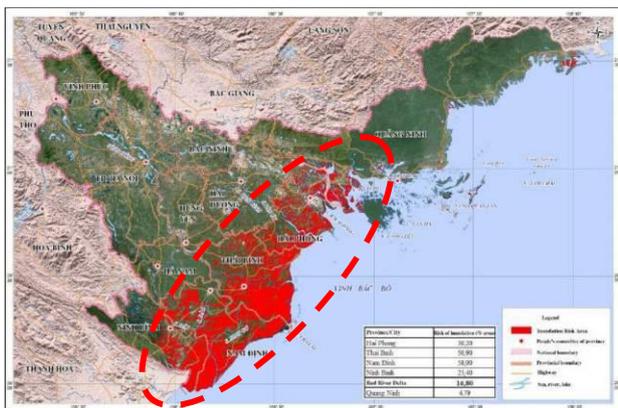
Figure 9. Water city typology by quantity of identification element

4. THE ADVERSE LONG-TERM EFFECTS BY RISING SEA LEVEL

In fact, 84 coastal developing countries investigated in terms of sea level rise, Vietnam ranks first in terms of impact on population, wetlands, urban extend and agriculture. (Dasgupta et al., 2007)

Pursuant to the analysis above most of the potential and indispensable water-cities in Vietnam are situated in the two vast majority of Northern and Southern triangle alluvial plain (Red River Delta and Mekong Delta), for instance, Ha Noi, Hai Phong, Ha Long, Da Nang, Ho Chi Minh, Can Tho, Dong Nai. In addition, the Red River Delta is the second most important rice-producing area in Vietnam, accounting for approximately 20 percent of the national crop and also hosts other important economic activities such as fisheries, aquaculture, land reclamation for agriculture, harbor construction, mangrove forestry, etc.

Meanwhile, Mekong Delta, a rice-growing region that spans southern Vietnam, not only is home to 18 million people but also is produced more than half of Vietnam's rice in that delta, as well as 60 percent of its fish and shrimp. Flooding, a major issue in the Mekong Delta is predicted to become more severe as rainfall increases and seawater level is rising. Furthermore, those two delta triangles, namely, Red River Delta and Mekong Delta have numerous water-cities which will confront with terrible and hazardous effect on climate change, especially rising sea level (according to the scenario of rising sea level in Mekong Delta from 2020 to 2050, Vietnam Remote Sensing Center).



Rising Sea Level: 0.1 m
Flooding area: 16.8% of the Red River Delta



Figure 10. The three important water cities of Red River Delta including Ha Noi, Hai Phong and Ha Long will face with rising sea level: 0,74m (2050)

The landscape of Mekong delta was characterised by patterns of dispersion and dissipation with intensified nodes of which Cantho has always been the most important one” (Shannon, 2004) Because of its central position in the delta, Can Tho gained importance and grew up as a regional central for cultural and economic exchanges.

In addition, Can Tho strategically situated at the confluence of the Can Tho and the Hau Rivers became an important colonial market town. The city developed following a few principleavenues laid out in the direction of the prevailing monsoon winds with a large market structure oriented towards the waterway as the focal point of the plan (Shannon, 2004). Unfortunately, due to the scenario of rising sea level from 2020 to 2050, Can Tho is likely to confront with terrible flooding situation in 2050 because of 1,0m rising sea level.

Furthermore as so-called climate refugees may migrate from surrounding flooded areas, safe land in Can Tho could be under high pressure. Particularly, the two densely populated delta regions will be affected: it is predicted that a 1m sea level rise will flood more than 20000km² of the Mekong Delta (IPCC 2007:59). Concerning the Mekong Delta, investigations of the Global Change System for Analysis, Research and Training (START) centre of Chulalongkorn University predicts a rising water level that could be twice as high as the estimated sea level rise as it combines 5 important elements: upstream flood, local rainfall, sea level rise, north-east wind and the spin from the equator. (DeNijs, 2010)



Figure 11. The important water-city of Mekong Delta, namely Can Tho will be disappeared in 2050 due to rising sea level: 1,0m (2050)

Table 2. A list of Vietnam water-cities strongly suffering from rising sea-level between 2020 and 2050

Water city	Agricultural land area (ha)	GDP per capita US\$	Population in 2017	Number of factors
Ho Chi Minh	118,052	5,428	8,426,100	4
Can Tho	81,688	2,980	1,237,300	4
Da Nang	69,989	2,506	1,046,876	4
Ha Noi	174,429	3,425	7,587,800	3
Hai Phong	83,310	2,857	2,103,500	3
Bien Hoa	-	3,300	1,104,495	3
Quy Nhon	110,972	1,625	537,320	3
Rach Gia	-	266	245,328	3
Ha Long	9,544.86	3,718	227,000	3
Nha Trang	-	3,184	420,521	2

In accordance with my analysis, it is obviously that the rank of four factors, namely, river density, water terrain, river traffic and sea city need to be established in order to evidently demonstrate the certain degree of “sea-rise” effects on each water-cities. In details, not all four factors are stay the same level for all water cities; hence, it is infrequently that four-factors cities will be harder hit by rising sea. For instance, Hai Phong and Ca Mau covering only two factors such as sea city and River Traffic. Nevertheless, those two factors stand on the first and second ranks of four factors, they also face with wider impact and implications of rising sea-level.

Table 3. The ranks of four factors

	Rank	Factor
Most Effective	1	Sea City
↓	2	River Traffic
↓	3	River Density
Less Effective	4	Water Terrain

Table 4. Typical Northern and Southern Water-cities and their factors

Water City	Factor 1 (River Density)	Factor 2 (Water Terrain)	Factor 3 (River Traffic)	Factor 4 (Sea City)
Ho Chi Minh	✓	✓	✓	✓
Can Tho	✓	✓	✓	✓
Da Nang	✓	✓	✓	✓
Bien Hoa	✓	✓	✓	
Quy Nhon	✓	✓	✓	
Rach Gia	✓	✓	✓	
Ha Long		✓	✓	✓
Nha Trang			✓	✓
Hai Phong			✓	✓
Ca Mau			✓	✓

5. CONCLUSION

To recapitulate briefly, it is no doubt that Vietnam is inclined to suffer the terrible consequences of climate change, especially huge numbers of water cities tend to be the direct victims in the near future. Hence, by accurately identifying all 78 water cities, the urban administrator is able to analyse and investigate the advantages and disadvantages of four mentioned identification elements in order to build up the urban center, to take into account the water element and also to preserve the water resources from climate change, especially the rising sea level.

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