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Research On Climate Heterogeneity Factors Affecting the Economic Development Through Negative Impacts on The Transport System Along the Coastal Rivers in The Mekong Delta

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ABSTRACT

The Mekong Delta includes 12 provinces and one city with over 7,400km of roads including highways, national highways and provincial roads, excluding district roads, commune roads and 14,826km of inland waterway transport. The phenomenon of sea level rise, in addition to saline intrusion, causes desertification of cultivated land. It also affects riparian and coastal traffic works through issues such as inundation, destabilization of works, subsidence, and ground subsidence, high temperature causing cracking of the road surface, especially asphalt concrete roads, the phenomenon of wheel rutting, large and small potholes causing damage to the road surface, loss of traffic safety. Concrete structures, reinforced concrete, steel structures, rust quickly due to strong oxidation phenomena with high concentrations of Cl^-, SO^{-2}, CO^{-3}, etc. ions in the air, saltwater intrusion is getting deeper and deeper inland. The groundwater exploitation due to lack of fresh water causes land subsidence. According to monitoring data in the Mekong Delta, the annual average subsidence rate is 5-7cm because the Mekong Delta itself is an area with a soft ground geology; so the subsidence will certainly destroy the industrial structures. The content of the article basically assesses the negative impacts of climate change on economic development through the assessment of the deterioration of the quality of traffic works, which is the basis of the special material manufacturing industry. Through the negative impacts of climate change, group of authors suggest timely prevention solutions.

Keywords: Climate change, weather anomalies, temperature rise, sea level rise, intense floods.

I. INTRODUCTION

In Mekong Delta, there are 12 provinces and 1 city which is directly under the Central Government, accounting for about 20% of the country's population. The total area is about 4 million hectares, accounting for 12% of the country's land area, mainly plains and interlaced canals. On the other hand, the Mekong Delta belongs to the lower Mekong River with 9 main river tributaries flowing into the sea and radiating out tributary branches to form a fertile land with great potential for fisheries, agriculture, and fruits (50% of rice production, 60% of aquaculture, 95% of the country's rice exports, 60% of exported aquatic products). It has a coastline of 800km, accounting for 25% of Vietnam's coastline. Therefore, the transportation system makes a great contribution to promoting the economic development of the Mekong Delta.

Regarding transportation in the Mekong Delta, there are 4 modes of transport: road, inland waterway, sea and air. Currently, the total number of roads in 13 southwestern provinces is thousands of kilometers, gradually developing into remote areas, reducing the load for traditional inland waterway transport, making a great contribution to the economic development of the country. However, at present, the transportation infrastructure of the Mekong Delta is facing many challenges due to the increasing negative impacts of nature such as the increasing Earth temperature, the melting of ice in the two poles of the Earth causing sea level rise, increasingly penetration deep into the fields, creating landslides and desertification along the canals due to saline soil and undeveloped crops. Aquatic products of both nature, and farming are also reduced in production, due to the influence of saltwater environment, etc.

Negative impacts also change natural phenomena such as unusual, unpredictable change frequency of rainfall, etc.

From the perspective of natural science, there have been many studies to minimize the negative effects of climate change, but Vietnam in particular has only implemented actions to deal with the negative impacts of climate change, not applying prevention measures that the world has studied and used. This article is an example from the perspective of the transport industry to assess the negative impacts of climate change on the construction system in general, traffic construction works, especially coastal or downstream traffic works in particular. The estuaries flowing into the sea in particular are the works that make great contributions to economic development but suffer greatly from the negative changes of nature and human impacts. There is also a lack of technical precautions for such issues. Examples include anti-corrosion, anti-oxidation materials, alternative materials, application levels of high-strength concrete in the design or measures to prevent corrosion and protect steel and concrete structures, asphalt pavement when the outdoor temperature is up to 38^0C - 40^0C or more, causing the road surface to become brittle, broken, rutted, etc. Other solutions are to repair, renovate and upgrade in the exploitation of the existing system of bridges, roads, traffic tunnels, etc., when they are used at high temperatures, flooded, and salinized; we also need effective management solutions to protect safety, maintain project performance.

On the other hand, the lower Mekong is distributed with 9 major tributaries in the Mekong Delta, which are also affected by human factors such as water reservoir systems, hydroelectric dams (11 dams) built by countries in the Mekong Subregion. Massive construction at upstream to reserve fresh water for domestic use and irrigation, has caused the phenomenon of silt shortage, change of natural flow

regime, polluted freshwater ecosystem, etc. to the people's life and most importantly, change the inherent flow laws of nature (the landslide side, the alluvial side) which has caused the phenomenon of shoreline erosion, illegal flooding. , threatening the lives and lives of 20% of the population of Vietnam who are living stably in the Mekong Delta. Besides, the system of riverside and coastal traffic works that are the basis and premise for economic development is always threatened by inundation.

From the management perspective, the maintenance procedures, maintenance mode, inspection methods, etc., are no longer available, to accommodate the increase of current conditions of natural phenomena (temperature rise, storms, floods, inundation, etc.) and negative human impacts, the state management should pay more attention by setting out the most effective processes and preventive measures in areas vulnerable to climate change impacts.

II. THEORETICAL BASIS

A. Overview of climate change and climate heterogeneity in Vietnam

Climate change occurs due to many causes; it is possible to summarize the factors affecting the regular movement of nature causing climate change as follows:

- The industrial emissions (CO_2 - Carbon dioxide) in large volumes has aggravated the greenhouse effect; the Earth is gradually warming, melting ice at the two poles of the Earth, causing sea level rise and climate changes, rain, heat, drought, storm, and irregular flood. The above phenomena are identified due to many reasons.

- The movement of the Earth itself and the interaction between the Earth and the sun leads to the EI Nino phenomenon, which makes the Earth gradually warmer.

- Human activities affect nature for many different benefits.

+ Humans use more and more energy, mainly from fossil fuel sources, the emissions into the atmosphere are increasing, causing the greenhouse effect, leading to an increase in the temperature of the Earth.

+ Logging and destruction of watershed forests creates the loss in means of water retention, reduced the air-conditioning effect of trees, changed the stratigraphic pressure in the destroyed area, the interaction forces between soil and rock molecules and the vegetation outside the Earth's crust gradually weakened, causing the phenomenon of tube floods, flash floods with great destructive power, threatening the safety and life of people, damaging the long-formed vegetation that produces a large amount of O2 for human consumption.

+ Deforestation affects the absorption of CO2 and release of oxygen (O_2) of trees, etc.

+ Changing the natural phenomena that form the Earth's crust by blocking the flow of water. The building of hydroelectric dams and reservoirs has created significantly loss of thousands of hectares of forests; the change of tributary systems which has been distributed in a natural way on the Earth's crust has caused floods with high frequency and destructive power, increasing the extreme phenomena of climate change. All activities contrary to the natural laws of humans have made the Earth warmer, causing the melting of ice at the two poles of the Earth, which inevitably leads to sea level rise.

B. Negative impacts of climate change in Vietnam.

Global warming, sea level rise are the first consequences that countries in general and Vietnam in particular have to suffer due to its 3260km of coastline. The melting ice at the two poles of the

Earth causes sea level rise; large tidal amplitudes easily cause landslides, saltwater intrusion deep into the mainland; and the vegetation and plants are not able to develop normally.

Human construction of hydroelectric dams and reservoirs in the upstream of major rivers flowing through Vietnam (downstream) into the sea has created loss of a large amount of naturally deposited alluvium. Experts and environmental scientists in Vietnam predict that the tendency of landslides and saltwater intrusion will become more serious and it is difficult to take countermeasures, especially the lack of silt pouring into the lower Mekong basin to compensate for the Mekong Delta. It is forecasted that by 2020, the amount of alluvium in the Mekong Delta will decrease by 60 to 65% compared to 2017.

If according to the rate of construction of dams of the countries upstream of the Mekong River, by 2040, the amount of alluvium in the Mekong Delta will only be from 3% to 5%. At that time, the sedimentation phenomenon will be over, landslides will be faster and more complicated due to the deeper river bed, faster water velocity in the flood season, threatening, damaging and subsidence of river and coastal traffic works, greatly affecting the national economic development. Vertical and horizontal salinity intrusion is getting deeper and deeper into the mainland, affecting agriculture and aquaculture (E-Newspaper of the Communist Party of Vietnam 2019). Scientists warn that EI Nino combined with climate change will cause unprecedented heat, estimated global damage is 3 trillion USD. The phenomenon of EI Nino in 1982 ÷ 1983, the global loss was over 4,100 billion USD. In 1997 ÷ 1998, the world lost over 5.7 trillion USD. WMO's accurate forecast that countries with tropical climates will suffer more losses, GDP will decrease by about 10%. Dr. Christopher Callhan at the University of Ddarrtmouth said: "The ocean currents are warming in the Pacific". EI Nino is a kind of test for the green planet being heated by climate change. 90% of EI Nino will appear in 2023, causing the ocean temperature to gradually increase by 1^0C.

C. Assessment of climate change situation in the Mekong Delta region

1) Temperature: According to the average monitoring data for many years (1980 ÷ 2017) at typical meteorological stations (Rach Gia - Moc Hoa - Can Tho - Bac Lieu - Ca Mau) in the Mekong Delta, the tends to increase at an average rate of about 0.0270C/year and tends to increase gradually.

Temperature scenario:
According to the RCP4.5 scenario, at the beginning of the 21st century, the average temperature in the Mekong Delta will increase from 0.6 to 0.80C. By the middle of the 21st century, the average temperature will increase from 1.4 to 1.6^0C. At the end of the 21st century, the average temperature in the region will increase from 1.8 to 2.0^0C.

According to the RCP8.5 scenario, at the beginning of the 21st century, the average temperature of the region will increase from 0.7 to 0.9^0C, by the middle of the 21st century, the average temperature of the Mekong Delta provinces will increase from 1.7 to 2.1^0C, less increase than the coastal area. By the end of the 21st century, the average temperature in the Mekong Delta provinces will increase from 3.3 to 3.5^0C.

2) Rainfall: The average annual rainfall tends to fluctuate in the range from 1250 ÷ 2450 mm, but unevenly distributed, the provinces of Kien Giang - Bac Lieu - Ca Mau have the same yearly high average rainfall, fluctuating in the range of 2050 - 2450mm. Areas with low average annual rainfall such as Dong Thap - Tien Giang - Ben Tre - An Giang - Vinh Long farther from the sea, have an average annual rainfall of 1250 - 1450mm.

Rainfall scenario:

According to the RCP4.5 scenario, at the beginning of the 21st century, the average rainfall in the Mekong Delta provinces will increase from 4.4 to 22.4%. By the middle of the 21st century, the average rainfall of the Mekong Delta provinces will increase from 5.8 to 20.6%. By the end of the 21st century, the average rainfall of the Mekong Delta provinces will increase from 9.6 to 23.8%.

According to the RCP8.5 scenario, at the beginning of the 21st century, the average rainfall in the Mekong Delta provinces will increase from 6.7 to 17.9%. By the middle of the 21st century, the average rainfall of the Mekong Delta provinces will increase from 10.8 to 20.7%. By the end of the 21st century, the average rainfall of the Mekong Delta provinces will increase from 12.6 to 23.7%.

3) Sea level rise: According to the scenario of the Ministry of Natural Resources and Environment (2016) "Scenario of climate change, sea level rise" to the end of the 21st century, if the sea level rises by 1m, the transport system in the Mekong Delta will be affected at the hardest hit with about 27.8% of national highways and 26.8% of provincial roads affected (Table 1).

TABLE 1
IMPACT OF SEA LEVEL RISE ON ROAD TRANSPORT

Water level rise (m)	Flooded area (% area)	Highway length ratio affected (%)	Provincialway length ratio affected (%)
0.50	5.4	4.9	3.3
0.6	9.8	8.2	6.7
0.7	15.8	12.0	11.1
0.8	22.4	14.3	13.4
0.9	29.8	20.2	19.0
1.0	39.0	27.8	26.8
1.2	58.8	45.4	43.6
1.5	78.5	64.0	63.4
2.0	92.1	83.7	80.3

Detailed analysis according to Table 1 shows that if the sea level rises by 50cm, the proportion of national highways will be affected about 4.9%, provincial roads will be affected by 3.3% for the whole Mekong Delta region, which will lead to production stagnation, especially the movement of goods. On the other hand, the area of agricultural land, green land, etc. will be affected by 15%, causing a decrease in production capacity which is difficult to predict.

D. Current status of road transport infrastructure along the river, along the coast of the Mekong Delta

The coastal roads of the Mekong Delta have a length of 750km from Ho Chi Minh City to Kien Giang, and according to the master plan of grade IV, they are still being exploited intermittently on the basis of taking advantage of sections of national highways, calculated roads, and local roads and existing sea dike routes. New sections of the route that coincide with the sea dike are being continued to be invested, upgraded and expanded by the provinces and cities to become two-function roads to prevent water and traffic. However, they still depend on public investment capital and the completion time cannot be confirmed.

Basic road routes run along river routes.

Crossroads axis 1: National Highway 30 and National Highway 57 running along the north bank of Tien River.

- National Highway 30 is 119.5km long, from Dinh Ha international border gate (Dong Thap) to An Huu (Tien Giang).

- National Highway 57 is 103.28km long from Vinh Long to Thanh Phu, Ben Tre.

The two National Highways connect with each other to form the north horizontal axis of the Tien River.

The horizontal axis 2 running along the south bank of the Tien River is the national highway 53 (167.6km) from Vinh Long to Long Toan, Tra Vinh. Many sections of the road from the design scale to the later maintenance and repair work have not been given due attention and so the quality is degraded.

The 3rd horizontal axis running along the north bank of Hau River is National Highway 54 (152km) from Binh Thanh, Dong Thap to Tra Vinh City, many sections have been deteriorated.

Horizontal axis 4: Including National Highway 91 (143.63km) from Chau Doc to Can Tho:

National Highway 91C (35.5km) from Tinh Bien to Chau Doc runs along the south bank of Hau River and the South Song Hau road from Can Tho to Soc Trang. In which, the South Song Hau route and National Highway 91 have been upgraded. Particularly, National Highway 91C has roadbeds and small road surfaces with high risk of landslides.

Horizontal axis 5 includes 2 national highways.

+ National Highway 80 (78.96km) from Ha Tien (Kien Giang) to My Thuan (Vinh Long).

+ National Highway 63 (114.63km) from Chau Thanh, Kien Giang to Ca Mau City.

Above are some basic national highways running along major tributaries (Tien River, Hau River) of the Mekong River running through the Mekong Delta at risk of being affected by flooding.

TABLE 2.

NATIONAL HIGHWAYS AT RISK OF FLOODING IN THE MEKONG DELTA IN 2019

N.	Province	Road	Milepost	Length (m)	Depth (m)	Impact of flooding on roads
1	An Giang	National highway 91	Km56 – Km60	4,000	0.3	Very low
2	Bac Lieu	National highway 1	Km2194+100 – Km2196+300	2,200	0.3	Very low
3	Bac Lieu	National highway 1	Km2197+800 – Km2199+800	2,000	0.3	Very low
4	Bac Lieu	National highway 1	Km2200+100 – Km2201+200	1,100	0.3	Very low
5	Bac Lieu	National highway 1	Km2201+500 – Km2205+100	3,600	0.3	Very low
6	Bac Lieu	National highway 1	Km2205+700 – Km2211+310	5,610	0.3	Very low
7	Bac Lieu	National highway 1	Km2212+900 – Km2217+380	4,480	0.5	Medium
8	Bac Lieu	National highway 1	Km2227+170 – Km2227+330	160	0.2	Very low
9	Bac Lieu	National highway 1	Km2229+300 – Km2231+000	1,700	0.5	Medium
10	Bac Lieu	National highway 1	Km2231+500 – Km2232+850	1,350	0.2	Very low
11	Ca Mau	National highway 1A	Km2232+850 - Km 2234+450	1,600	0.2	Very low
12	Ca Mau	National highway 1A	Km2291+040 - Km2291+400	360	0.2	Very low
13	Ca Mau	National highway 1A	Km2291+840 - Km2291+870	30	0.2	Very low
14	Ca Mau	National highway 63	Km110+040 – Km110+140	100	0.3	Very low
15	Can Tho	National highway Nam Song Hau	Km2 – Km2+200 (intersection IC3)	200	0.3	Very low

N.	Province	Road	Milepost	Length (m)	Depth (m)	Impact of flooding on roads
16	Tien Giang	National highway 1	Km1967 – Km1967+800	800	0.7	High
17	Tra Vinh	National highway 53	Km106+500 – Km106+550	50	0.125	Very low
18	Tra Vinh	National highway 53	Km106+920 – Km107+050	130	0.2	Very low
19	Tra Vinh	National highway 53	Km108+600 – Km108+850	250	0.2	Very low
20	Vinh Long	National highway 53	Km12+800 – Km13+260	460	0.125	Very low
21	Vinh Long	National highway 53	Km13+460 – Km13+640	180	0.125	Very low
22	Vinh Long	National highway 53	Km14+740 – Km14+790	50	0.125	Very low
23	Vinh Long	National highway 53	Km7+860 – Km8+208	348	0.15	Very low
24	Vinh Long	National highway 53	Km8+408 – Km8+745	337	0.15	Very low
25	Vinh Long	National highway 54	Km47+200 – Km47+500	300	0.372	Low
26	Vinh Long	National highway 1	Km2042 – Km2042+800 (right)	800	0.4	Low
27	Vinh Long	National highway 1	Km2047+200–Km2047+600 (left)	400	0.3	Very low
28	Vinh Long	National highway 1	Km2053+200–Km2053+400 (left)	200	0.45	Medium
29	Vinh Long	National highway 1	Km2053+200–Km2053+550 (right)	350	0.4	Low
30	Vinh Long	National highway 1	Km2057+200–Km2058+200 (left)	1,000	0.45	Medium
31	Vinh Long	National highway 1	Km2057+400–Km2058+200 (right)	800	0.45	Medium
32	Vinh Long	National highway 1	Km2059+200–Km2061+150 (left)	1,950	0.45	Medium
33	Vinh Long	National highway 1	Km2059+500–Km2061+150 (right)	1,650	0.45	Medium
34	Vinh Long	National highway 1	Km2062+200 – Km2062+700	500	0.45	Medium

Source: Website of the Ministry of Transport

Table 2 shows that some localities affected by flooding are Bac Lieu, Vinh Long, Ca Mau. Sea level rise, rain and floods have caused flooding, landslides of the shoreline leading to the collapse of houses, riverside works and the immediate threat is that the riverside traffic system will sink, or collapse into the river, causing traffic disruptions to riverside corridors that play a key role in connecting land and water transport.

E. Assessment of landslides that threaten the transport infrastructure of the Mekong Delta

The Mekong Delta has low-lying terrain, the land is mostly soft alluvium with many organic impurities, very vulnerable to floods and landslides. According to data summarizing the entire Mekong Delta, there are currently 526 areas of riverbank and coastal erosion with a total length of 800km. Of which, 57

areas with extremely dangerous landslides with a total length of 164km need to be handled immediately to ensure the safety for people and goods.

In recent years, due to human reclamation activities that have caused an increase in climate change, riverbank and coastal erosion has become more and more serious. Every year, the Mekong Delta loses 300 to 500 hectares of land because of riverbank and coastal erosion, but structural and non-structural solutions have only been able to reduce it. Because, in addition to the problem of awareness, the capital resources, the negative human impacts on hydropower development, freshwater reservoirs in the upper Mekong River, exploitation of sand and gravel, groundwater and surface water in the Mekong Delta continues to increase, causing the largest increase in settlement are provinces such as Bac Lieu, Soc Trang, and Ho Chi Minh City.

It is possible to mention the situation of landslides threatening and unsafe for traffic on some national highways, provincial roads, district roads, riverside, sea mouths, etc..

An Giang: An Giang is a locality in the Mekong Delta and is the most severely affected province by landslides. On August 1, 2019, National Highway 91, the section through Binh Tan Hamlet, Binh My Commune, Chau Phu District, suffered a serious landslide, more than half of the road surface of National Highway 91 with a length of 85m collapsed completely into the Hau River. The People's Committee of An Giang province has declared a state of emergency. The Directorate for Roads of Vietnam had to urgently complete the bypass to ensure uninterrupted traffic.

Can Tho: At dawn on July 29, 2019 at the Rach Soi - Hau Giang canal along National Highway 80, the section passing Vinh Lan Hamlet, Vinh Thinh Commune, Vinh Thanh District, a landslide happened to the canal with a length of more than 40m, affecting the canal. Both high voltage power stations had to be relocated urgently.

Dong Thap: On the night of July 15, a landslide with a length of 100m at Nha Man canal, Tan Nhuan commune, Chau Thanh district, the landslide section went deep into the bank 4m, causing 5 households to collapse into the canal completely, threatening many neighboring households; traffic in the area was completely cut off. According to the report of Dong Thap Province, there are 123km of the main stream of the Tien River, 101km of the riverbank is eroded. Only from 2015 to 2018, Dong Thap lost 322ha of land that was swept away by water. In the immediate future, the province has had to relocate more than 8,000 households and currently thousands of households are located in the belt with high risk of landslides, seriously threatening the riverside traffic corridors and people's lives, livestock and plant, etc...

Tien Giang: Currently, there are 120km of the main stream of the Tien River. In the past 10 years, there have been hundreds of large and small landslides threatening the lives of thousands of households.

On the other hand, the inter-district, inter-commune and inter-hamlet roads along the Tien River on both the North and South banks are at high risk of landslides. However, localities still face many difficulties in handling due to reasons such as: funding, technology, and procedures due to slow administrative reform, causing confusion when handling.

F. Identify the causes of increased harm by climate change

1) Assessment of adverse factors caused by climate change

Climate change causes the phenomena including:

- Temperature rise

+ Temperature increases when exceeding 38oC and in a prolonged time will potentially risk further rutting of wheel tracks, asphalt will quickly become brittle and break easily. The reason is that the road surface is absorbed by solar energy and the influence of air radiation, so the actual pavement temperature is much higher than the air temperature, the concrete pavement can be up to 60oC.
+ Melting ice at the Earth's poles causes sea level rise
+ Natural disasters, unusual floods with great intensity

Consequences for the Mekong Delta: 1) Saltwater intrusion deep into the field; 2) Lack of fresh water; 3) Flooding, tidal water level has a large amplitude (highest water level and lowest water level is large) causing landslides, loss of living and production land, destruction of riverside and coastal road works.

Currently, there have been many studies evaluating the vulnerability of road structures due to flooding.
- Decreasing the strength of the ground and road surface
- Roughness and rutting values increase significantly after rain and flood events.
+ In light level, the road surface has small cracks and local peeling.
+ If the level is severe, the foundation will be eroded, the road surface will be broken into large pieces.
+ Bridge works are eroded in foundation, abutment areas. The concrete of the bridge deck, railings, and corridors quickly became brittle and broken due to the rapid rusting of the reinforcement due to the increased ion content of Ion Cl^-, SO^{-2}, CO^{-3}, etc.

2) Evaluation from the perspective of transportation

Water transport was formerly a long-standing traditional mode of transportation of the Mekong Delta provinces. But now, this mode has gradually been replaced by road transport due to the recent 15 years of consolidating and perfecting rural areas. The new roads have contributed to perfecting the land transport system, changing the face of rural Vietnam. Land transport vehicles with a tonnage of 3.5 tons to 5 tons due to their high mobility have been able to enter remote areas, reducing the pressure on waterway traffic that is dependent on a heterogeneous inland port system, with small capacity, and increased shoreline erosion.

According to the scenarios RCP4.5 and RCP8.5, if sea level rises by 0.5, the proportion of national highways will be affected 4.9%, provincial roads will be affected by 3.3%. Due to the dependence on terrain and capital, the affected rate is not less than 10%. Therefore, in the middle of the 21st century, the rate of flooded traffic routes is also approximately 20%, requiring immediate solutions.

According to the above scenarios, at the end of the dry season and the beginning of the rainy season (from May to October), when the Mekong River's lowest water level encounters the phenomenon of heavy rain, changing seasons and high velocity, the landslides of the transport routes will be affected and very likely to occur.

3) Assessing Vietnam's response to climate change

Climate change and timely prevention measures are important factors. Vietnam has recognized and synthesized data demonstrating the phenomena caused by climate change including high temperature, prolonged hot weather, high intensity flood water.

Sea level rise will cause land loss on the mainland along major rivers and fertile islets that have been formed for generations, especially the Mekong Delta and then the Red River Delta. At sea, submerged islands have a great impact on production, fishing, storm shelter, etc. People are also aware and have constructions and non-constructions solutions but still they are still very fragmentary, lacking of fundamental and systematic solutions.

The Mekong River Delta has a relatively low construction altitude, 80% of the area is lower than the altitude of +2.5m, so it is easy to be flooded when the sea level rises or storms and floods have great intensity. As a result, the areas for crops, and aquaculture could be completely flooded, threatening Vietnam's main source of income and food security.

The core problem is to prevent water surge, erosion, flooding, salinization of cultivated land, livestock and prevent erosion, loss of soil, crop death, etc. Afterthat, issues about supply industry, technical infrastructure such as water supply and drainage, electric power, infrastructure systems, and traffic are also heavily affected by inundation, flooding, storm surge, sea level rise, etc.

The riverine and coastal transportation systems, which are important works that make great contributions to economic development, are the ones that are heavily affected by climate change phenomena; so the prevention measures need to be paid attention to at a high level, but there are currently no specific solutions.

Vietnam has been aware all of the above issues but the response is too slow. On the other hand, due to lack of capital, the proactive prevention is limited and currently, there is no official solution for localities.

Summarizing the causes in the form of qualitative comments, it is possible to draw out 6 groups of basic factors affecting the economic development of the Mekong Delta. (1) The group of factors on increasing climate change; (2) Group of factors on human perception; (3) Group of capital factors to respond to climate change; (4) Group of factors on scientific information and technology application; (5) Group of factors on the influence of industrial production and transport industries; (6) Group of factors on national topography and neighboring countries.

III. FACTORS AFFECTING INVESTMENT FOR ECONOMIC DEVELOPMENT IN THE MEKONG DELTA

A. Groups of influencing factors

After analyzing and matching factors of the same nature and arrangement, there are 6 groups of basic factors that inhibit economic development in the Mekong Delta (Table 3).

TABLE 3.

FACTORS AFFECTING THE ECONOMIC DEVELOPMENT OF THE MEKONG DELTA

No.	Factors
1	***Group of factors on increasing climate change causes changes in the economic development environment***
1.1	Rising temperature, low humidity, prolonged hot sun over a large area
1.2	Prolonged drought affects crops, livestock, and vegetation on the earth's crust.
1.3	Industrial production decreased due to slow adaptation of humans to high temperature and low humidity. (eliminated in phase Cronback Alpha)
1.4	Unusual floods with great intensity, causing flooding, eroding the foundation of works, disrupting the circulation of goods and passengers.
1.5	Sea level rise, saline intrusion causes shortage of fresh water to ensure stable production and living.
1.6	Saltwater intrusion causes rust and corrosion of steel structures, reinforced concrete structures,

	shortens the life of the works, and easily causes problems.
1.7	Non-structural and structural solutions to limit landslides and saltwater intrusion
2	***Group of factors on human perception***
2.1	The determination of the whole political system to reduce the negative impacts of climate change
2.2	Completing climate change response apparatus at all levels of government
2.3	Training management team with knowledge, expertise and responsibility on climate change
2.4	Develop a process for managing and exploiting rivers and streams, protecting freshwater sources and natural vegetation, exploiting, and protecting forests.
2.5	The design and construction of works must consider the factors of climate change
3	***Group of capital factors to respond to climate change***
3.1	The initiative in allocating central and local budget
3.2	Funding from world organizations
3.3	The allocation of capital by target and geographical region of the country
3.4	Mobilizing capital from domestic organizations and private individuals
3.5	Capital allocation by industry, field and localities
4	***Group of factors on scientific information and technology application***
4.1	The reception and processing of information by the management authorities
4.2	Actively conduct deep and extensive scientific research at the central and local levels
4.3	Urgently deploy the application of advanced science and technology in the country and in the world by governments at all levels
4.4	Experiment in localities heavily affected by climate change, adjustment – application
4.5	Extensive propaganda, increasing people's awareness about the harmful effects of climate change
4.6	Participation and commitment to share responsibility, experience, science and technology of global countries
5	***Group of factors on the influence of industrial production and transport industries***
5.1	Fossil emissions and noise from mechanical operations, smoke, industrial emissions, chemical industry, etc.
5.2	The phenomenon of self-ignition at high temperature of some compounds (P_2O_5, C_6H_6, NO_x, C_nH_{2n}, etc...), high molecular rubber dust, etc... (eliminated in phase Cronback Alpha)
5.3	Thermal radiation of the system of construction works in general, traffic works in particular
5.4	Methods of treating solid waste, dust and industrial wastewater
5.5	Foundations, and loads of construction works disrupt the system of surface flow, underground flow and natural flow of rivers, and canals.
6	***Group of factors on national topography and neighboring countries***
6.1	The length of the country's coastline
6.2	Length of local coastline
6.3	Coverage density of the river system, length and slope of the river bed facing the sea
6.4	The support of the world and neighboring, watershed countries.

B. Research method

1) Research model and research hypotheses

From the above analysis results, it is shown that there are many factors affecting the ability to attract investment in road transport infrastructure. Through primary and secondary survey methods and combined with expert consultation, in order to eliminate duplicate factors, it can be summarized into 06 groups of factors as in Figure 1.

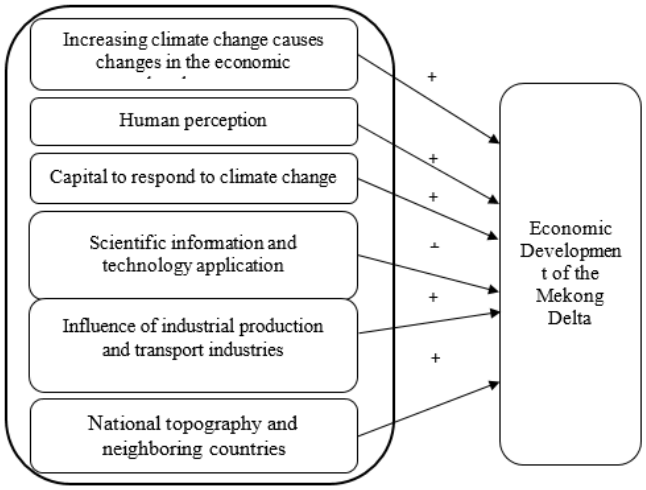

Figure 1. Research model of factors affecting ability to attract investment in road transport infrastructure

"+": Show groups of factors according to the proposed hypothesis, which have positive impacts on the ability to attract investment in road transport infrastructure.

follows: Group 1: The group of factors on increasing climate change; Group 2: Group of factors on human perception

Group 3: Group of capital factors to respond to climate change; Group 4: Group of factors on scientific information and technology application; Group 5: Group of factors on the influence of industrial production and transport industries; Group 6: Group of factors on national topography and neighboring countries.

2) Questionnaire, scale

2.1) Questionnaire

The questionnaire was built on the following basis:

Refer to previous studies on factors affecting the ability to attract investment in road transport infrastructure.

Consult experts with experience in the field of investment economics. The official questionnaire consists of 32 observed variables (Table 4), including: Increasing climate change causes changes in the economic development environment (7 variables); Human perception (5 variables); Capital sources to respond to climate change (5 variables); Scientific information and technology application (6 variables); Influence of industrial production and transport industries (5 variables); Topography of neighboring countries and localities (4 variables) (Table 4).

TABLE 4.

GROUP OF FACTORS AFFECTING INVESTMENT OF TRANSPORTATION INFRASTRUCTURE

No.	Code	Factors
1	*KH*	***Group of factors on increasing climate change causes changes in the economic development environment***
1.1	KH1	Rising temperature, low humidity, prolonged hot sun over a large area
1.2	KH2	Prolonged drought affects crops, livestock, and vegetation on the earth's crust.
1.3	KH3	Industrial production decreased due to slow adaptation of humans to high

		temperature and low humidity. (eliminated in phase Cronback Alpha)
1.4	KH4	Unusual floods with great intensity, causing flooding, eroding the foundation of works, disrupting the circulation of goods and passengers.
1.5	KH5	Sea level rise, saline intrusion causes shortage of fresh water to ensure stable production and living.
1.6	KH6	Saltwater intrusion causes rust and corrosion of steel structures, reinforced concrete structures, shortens the life of the works, and easily causes problems.
1.7	KH7	Non-structural and structural solutions to limit landslides and saltwater intrusion
2	***NT***	***Group of factors on human perception***
2.1	NT1	The determination of the whole political system to reduce the negative impacts of climate change
2.2	NT2	Completing climate change response apparatus at all levels of government
2.3	NT3	Training management team with knowledge, expertise and responsibility on climate change
2.4	NT4	Develop a process for managing and exploiting rivers and streams, protecting freshwater sources and natural vegetation, exploiting, and protecting forests.
2.5	NT5	The design and construction of works must consider the factors of climate change
3	***NV***	***Group of capital factors to respond to climate change***
3.1	NV1	The initiative in allocating central and local budget
3.2	NV2	Funding from world organizations
3.3	NV3	The allocation of capital by target and geographical region of the country
3.4	NV4	Mobilizing capital from domestic organizations and private individuals
3.5	NV5	Capital allocation by industry, field and localities
4	***CN***	***Group of factors on scientific information and technology application***
4.1	CN1	The reception and processing of information by the management authorities
4.2	CN2	Actively conduct deep and extensive scientific research at the central and local levels
4.3	CN3	Urgently deploy the application of advanced science and technology in the country and in the world by governments at all levels
4.4	CN4	Experiment in localities heavily affected by climate change, adjustment – application
4.5	CN5	Extensive propaganda, increasing people's awareness about the harmful effects of climate change
4.6	CN6	Participation and commitment to share responsibility, experience, science and technology of global countries
5	***SX***	***Group of factors on the influence of industrial production and transport industries***

5.1	SX1	Fossil emissions and noise from mechanical operations, smoke, industrial emissions, chemical industry, etc.
5.2	SX2	The phenomenon of self-ignition at high temperature of some compounds (P_2O_5, C_6H_6, NO_x, C_nH_{2n}, etc...), high molecular rubber dust, etc... (eliminated in phase Cronback Alpha)
5.3	SX3	Thermal radiation of the system of construction works in general, traffic works in particular
5.4	SX4	Methods of treating solid waste, dust and industrial wastewater
5.5	SX5	Foundations, and loads of construction works disrupt the system of surface flow, underground flow and natural flow of rivers, and canals.
6	***CK***	***Group of factors on national topography and neighboring countries***
6.1	CK1	The length of the country's coastline
6.2	CK2	Length of local coastline
6.3	CK3	Coverage density of the river system, length and slope of the river bed facing the sea
6.4	CK4	The support of the world and neighboring, watershed countries.

Source: Research proposal of the author's team

2.2) Scale

A Likert scale of 1 to 5 was used to measure these variables, in which:

(1) Not affected; (2) Very little effect; (3) Medium; (4) High influence; (5) Very high influence.

2.3) Order of processing survey results

To build a multivariate regression equation showing the influence of factors on the ability to attract investment in road transport infrastructure, the authors conducted a survey for subjects who had experience in the field of road transport, road traffic infrastructure management, project management, economic investment, etc.

Data were collected through the distribution of 250 questionnaires. After re-collection, there are 250 valid questionnaires. The encrypted data is processed using SPSS24 software. Procedure includes:

Step 1: Evaluate the reliability of the scale through Cronbach's Alpha coefficient. To measure the internal consistency of variables in the same group, thereby eliminating the intrinsically inconsistent variables of the variables in the same group.

Step 2: Exploratory factor analysis EFA.

To reduce a set of many interdependent measurement variables into a smaller set of variables so that the results will be more meaningful but still contain most of the information of the original set of variables.

Step 3: Analyze Pearson correlation

Check the close linear correlation between the dependent variable and the independent variables and identify the problem of multicollinearity early when the independent variables are also strongly correlated with each other.

Step 4: Multivariate regression analysis

In order to evaluate the influence of different groups of variables on the ability to attract investment in SCC in Vietnam, at the time of the survey.

Through the process of processing using SPSS24 software, following the above steps, the results of multivariable regression analysis (tables 3-5), show the groups of factors affecting the ability to attract investment in road transport infrastructure.

TABLE 5. ANOVA TESTING

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	56.055	6	9.343	82.819	.000[b]
	Residual	27.412	243	.113		
	Total	83.467	249			
a. Dependent Variable: HTGT						
b. Predictors: (Constant), CK, NV, NT, SX, KH, CN						

>> Sig test F = 0.000 < 0.05, so the regression model is significant.

TABLE 6. MODEL TESTING

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.820[a]	.672	.663	.33587	2.105
a. Predictors: (Constant), CK, NV, NT, SX, KH, CN					
b. Dependent Variable: HTGT					

The adjusted R squared is 0.663 = 66.3%. Thus, the independent variables included in the regression affect 66.3% of the change of the dependent variable.

TABLE 7. MULTIVARIATE REGRESSION ANALYSIS RESULTS

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-.240	.188		-1.273	.204		
	KH	.317	.035	.372	9.141	.000	.817	1.224
	NT	.398	.035	.452	11.344	.000	.850	1.176
	NV	.148	.034	.172	4.356	.000	.872	1.147
	CN	.085	.035	.105	2.440	.015	.732	1.366
	SX	.073	.034	.090	2.116	.035	.755	1.324
	CK	.034	.036	.039	.950	.343	.805	1.243
a. Dependent Variable: HTGT								

Multivariate regression results (Table 7), show that:

- Regression results show that the variable CK is not significant in the model because the sig t-test is greater than 0.05. The remaining variables all have an impact on the dependent variable because the sig t-test of each independent variable is less than 0.05.

- VIF coefficients of independent variables are all less than 10, no multicollinearity occurs.

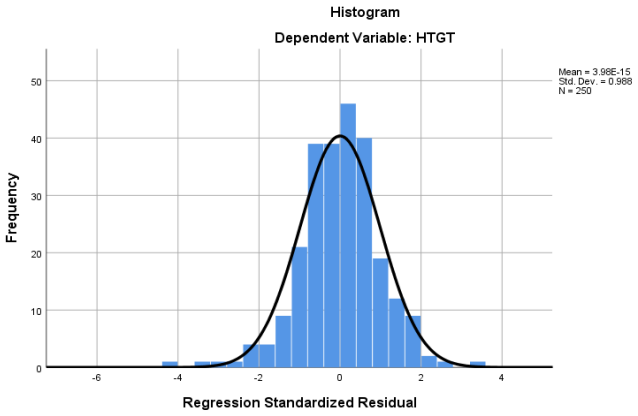

FIGURE 2. HISTOGRAM OF THE NORMAL DISTRIBUTION OF THE RESIDUALS

The results in Figure 2 show that the mean is close to 0, the standard deviation is 0.988, which is close to 1, so the residual distribution is approximately standard.

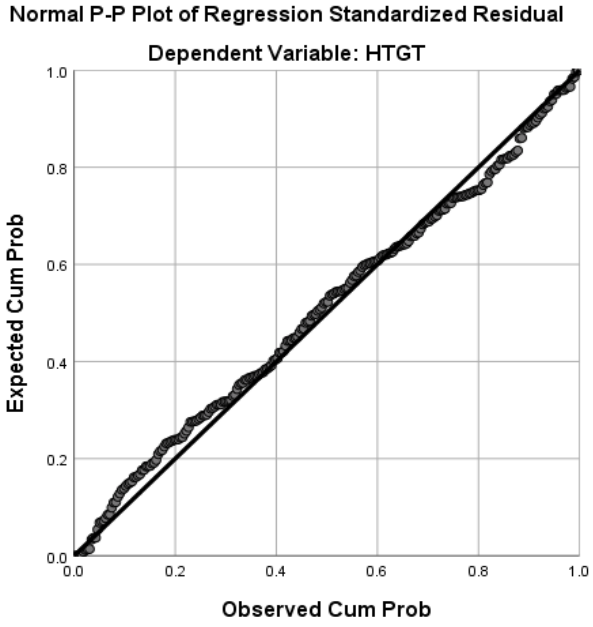

FIGURE 3. NORMAL P-P PLOT SCATTER CHART

The distributed data points are centered around the diagonal. There is no large deviation from the diagonal, so the residuals are approximately standard (Figure 3).

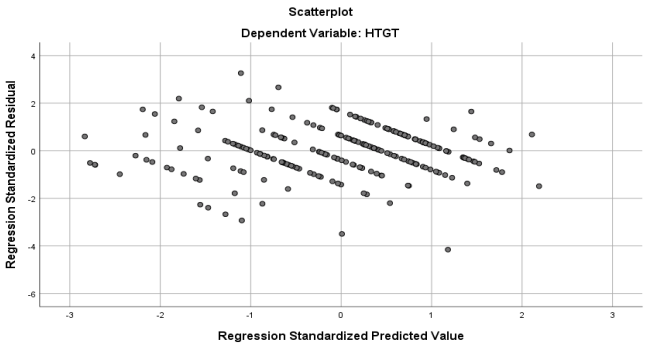

FIGURE 4. SCATTERPLOT

It can be easily seen that the data points are distributed around the zero coordinate line and tend to form a straight line, assuming the linear relationship is not violated (Figure 4).

So, the multivariable regression equation, the remaining 5 variables have the form (according to the standardized Beta coefficient), which is represented by formula (1) as follows:

HTGT=0.452NT+0.372*KH+0.172*NV+0.105*CN +0.09*SX (1)

In which:

NT: Human perception

KH: Increasing climate change

NV: Capital sources to respond to climate change

CN: Scientific information and technology application

SX: Influence of industrial production and transport industries.

IV. SOLUTION SYSTEM

A. Orientation of the solution system

At the end of the 20th century, scientists in advanced countries in the world made comments on the increase of climate change through the phenomena of global warming, resource depletion along with the increase in population and resource exploitation will lead to increasingly difficult life as well as industrial and agricultural production in an increasingly harsh climate.

British physicist Stephen Hawking said at the University of Cambridge (2016): "I am not optimistic

about the long-term prospects for the mankind who wish to maintain stability on Earth". He thinks that the above scenario is partly due to climate change and the destruction of the environment of mankind and the solution to deal with it, he humorously said that this scenario is to learn new worlds to move home from the Earth. Next is the development of AI, he predicts this modern technology can threaten people. We need to develop artificial intelligence, but also be aware of its real dangers: "AI can completely replace humans", programmers or criminals can create computer viruses. AI is also capable of doing that. This is a life form that surpasses humans and becomes a danger to humanity. Therefore, the application of AI in forecasting the negative impacts of climate change should also be studied to find effective solutions.

The above comments have provided a system of solutions on a macro basis that is an environmentally friendly solution and starts from increasing human awareness, identifying potential dangers for countries to depend on geographical conditions, giving specific studies. At the micro level, it aims to direct the production to improve products with two criteria (1) being environmentally friendly and (2) radically reducing the negative impacts of climate change.

B. Solution system

1) Solution system at macro level

- The unity and determination of the whole political system is a prerequisite and top priority, so the Government needs to establish an organizational system equivalent to ministries and branches from central to local levels, directly directed by the Government. and assigned to ministries - branches to implement with the following contents:
- Develop policies, action tools... on the negative impacts caused by climate change to the world and the effects that the country is suffering in the long and short term.
- Build a legal corridor for localities to actively implement solutions.
- Requesting localities to strictly implement and report periodically and unexpectedly, incidents, negative impacts of climate change and solutions to be handled.
- The Government proactively arranges medium-term and regular capital sources to promptly support localities.
- Localities must also actively allocate annual budget capital depending on the specific situation of climate change, and consider this as the top task in the annual investment capital allocation.
- Establishing a fund for disaster prevention and climate change to proactively allocate capital to localities every year.
- Develop a program to reduce the use of fossil fuels.
- Develop action programs in scientific research for timely application to localities heavily affected by climate change and must be set by specific targets with detailed and clear tasks.
- Implement extensive and systematic propaganda to agencies, organizations and people.
- Strengthen the inspection and examination of the implementation of documents and action programs on climate change in localities. Organization of the inspection force must have the participation of specialized ministries and sectors and consider this as an annual task of inspection and examination.

2) Solution system at micro level

a) Non-structural solutions

- Localities are proactive in responding to climate change through various tasks.
- Strictly implement the sub-law documents promulgated by the Government and Ministries.
- Extensive propaganda to agencies - enterprises under their local jurisdiction on the phenomena and negative impacts of climate change so that people can join hands with the State in dealing with climate change, environmental protection.

- Implement the conservation and development of the green environment by proposing the planning of vegetation, planting green trees on the corridors of rivers and canals, islets and islands, in areas sensitive to natural disasters. These trees have the effect of regulating the air, preventing heat, protecting against erosion of the shorelines and preventing the transverse saline intrusion.

Create natural lungs: Forest protection to maintain the existence of forests is a long-term and mandatory problem. However, many countries are not fully aware, so the exploitation of forests by both the state and the private sector is still for immediate benefits. The long-term consequences for the whole society are huge due to global climate change. This is an important task of the state management to green the bare hills but also cover the forest on the rocks.

- Land and planning management, etc., more specifically, the conversion of land use purposes is arbitrary mainly due to two main reasons: 1) The capacity, qualifications and responsibilities of the contingent of state management officials are still weak; and 2) Interest groups avoiding responsibility have become common and become a national problem that solutions to prevent are not timely, synchronous and ineffective.

- Change the production structure in the direction of expanding environmentally friendly production and service industries, on the basis of improving land use efficiency, taking advantage of water surface and underdeveloped remote areas.

- Research on shifting the type of transport by consolidating and organizing the development of small waterways suitable for river and water characteristics, in order to share with road traffic as one of the causes of reducing environmental pollution.

- Strengthening appropriate tree strips along the shore to reduce wave pressure acting on shorelines, minimizing landslides due to wave kinetic energy.

- There is a roadmap to gradually replace the use of fossil fuels with electric motors.

b) Structural solutions

The current construction solution has high costs. On the other hand, Vietnam's natural materials are increasingly scarce, leading to higher costs, in which the cost reduction by alternative materials has not been invested in extensive research and development.

Currently, measures to make hard embankments against landslides, as a premise for the development of navigation, are being applied in Vietnam. The main materials are still reinforced concrete, in which stone and sand are natural materials and increasingly scarce. The method of replacing river sand with fine sand exploited at sea has not been boldly applied. It is still a theoretical problem on the basis of not daring to take the initiative to make breakthroughs. This causes high costs while public investment capital is increasingly limited. Therefore, the immediate solutions are proposed as follows:

- Focus on research on river sections to come up with solutions to correct the flow by embankment, soft embankment if it is a wide river section to ensure navigation and low construction cost due to the utilization of many natural rocks. when exploiting in the sea and islands.

- For small river sections, it is mandatory to apply hard embankment measures, which can be mixed with soft embankment solutions or green tree solutions to reduce the kinetic energy of the water and prevent salinity. This shows that it is necessary to allocate capital to invest in comprehensive research on major river routes of the Mekong Delta so that

solutions are implemented synchronously on these routes.

- The reduction of alluvium in the Mekong Delta will lead to deeper river beds, so the study to offset this amount of silt requires a sustainable solution to prevent sediment from flowing into the sea but still have to ensure water traffic.

- Research on the transport of sea sand back to the river in the estuary areas. This has the effect of washing salt for sand and after a certain time, this amount of sand will be exploited as a material for leveling and compensating settlements in the Mekong Delta. This Delta is sinking due to groundwater exploitation. And in the immediate future, it has the effect of limiting shoreline erosion due to the deepening of the river bed.

- Develop a research strategy for large-scale quarrying with 2 main purposes: 1) Making embankments to prevent erosion; and 2) Making rock mud as a component to make CO2 absorbers

c) Applying science and technology

The research and application of the world's increasingly advanced science and technology as well as the practical studies of Vietnam on the basis of traditional methods are very important but have not been given due attention. Humans increasingly tend to go to the sea, towards the two poles of the Earth, towards harsh climates, etc. Therefore, the research and application of new and advanced technologies must be regularly enhanced. Specifically (1) High strength concrete against salt water intrusion, (2) Protective coatings for metal structures, (3) Types of glue for bearing, waterproof, anti-corrosion metal, (4) Alternative materials for sand, natural stone, (5) Fireproof, anti-corrosion materials, etc.

- Reinforcing the riverbed near the shoreline with bamboo or poles of melaleuca, mangrove, nipa, etc. They are long-life water-resistant materials that will reduce shoreline erosion along large rivers by reducing the phenomenon of creating clefts along the banks of large rivers and canals.

- Exploiting reefs in submerged islands and shoals used as aggregates for the construction of sea dykes, welding mine embankments, and processing rock mud (mineral mud) as a filler when producing chemical fertilizers for green plants and with ability to absorb CO_2.

- Research and calculate solutions for sea encroachment on the basis of the sea encroachment model of Rach Gia city, Kien Giang province on the basis of sustainable development. This model must be accompanied by legal regulations such as in $1km^2$, how many trees must be planted, etc.

- Most importantly, the high density coastal and riverside green trees are expected to reduce negative impacts of climate change and break waves, windbreaks, prevent erosion, reduce temperature, reduce environmental pollution, etc.

According to research conducted by Professor Mimik Rosing of the University of Copenhagen, "The simpler the solution, the more effective it is," he said, adding that rock powder (rock mud, mineral mud) created under glaciers in Greenland absorbs CO_2. According to the ERV, for 1 ton of rock powder, 250kg of CO_2 can be absorbed and the amount of rock powder collected under the glaciers will absorb all of the CO_2 globally. However, in Vietnam, there is no experimental studies on mining to produce rock powder (mineral mud) on islands and shoals in the sea.

V. CONCLUSIONS

The article summarizes the anomalous phenomena of the climate change and the negative effects of the climate change such as: high temperature, sea level rise, ice melting at the two poles of the Earth, saltwater intrusion into the mainland, large tidal amplitudes cause flooding, pollution of vegetation habitats, freshwater aquatic products and light pollution. In addition to the fact that people are not fully aware of the the hazards caused by climate change, there are negative factors such as deforestration, exploitation of ground water without planning, lack of planning, lack of breakthrough in industrial and agricultural production, consuming more and more energy from fossil fuels, creating emissions to cause the greenhouse effect to increase the earth's temperature.

The above phenomena are always a permanent threat to human life and tend to increase significantly. The Mekong Delta is a soft land of Vietnam, surrounded by nearly 800km of coastline, so it is greatly affected by the increase of climate change. Therefore, the article develops a solution system with the desire to minimize the negative impacts of climate change on the economic development of Vietnam in particular and the world in general.

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