Impacts of climate change in Vietnam

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Between 1958 and 2018, the annual average temperature of the whole country increased by about 0.89^{o}C, an equivalent of 0.15^{o}C/decade; the annual average precipitation of the whole country increased by 2.1%, with the most increase in the South Central Coast and decrease in northern and southern parts of Central Highlands; the number of strong typhoons was on the rise; the number of hot days and droughts increased; the number of cold and freezing cold days decreased; extreme rainfall increased; and average sea levels at monitoring stations increased by 2.74 mm/year, and 3.0 mm/year alone during 1993 - 2018.

a) According to the Viet Nam's Climate Change Scenario updated in 2020:

- Temperature: Under the medium scenario (RCP4.5), the annual average temperature of the whole country would increase by 1.2-1.7oC by mid-century and by 1.6-2.4oC by the end of the century. Under the high scenario (RCP8.5), annual average temperature would increase by 1.7-2.3oC by mid-century and 3.2-4.2oC by the end of the century. The temperature in the North would increase higher than that in the South. Extreme temperatures are likely to increase.

- Rainfall: Under the medium scenario, annual rainfall would generally increase by 10-15% by mid-century and 10-20% by the end of the century. Under the high scenario, annual rainfall would increase by 10-15% by mid-century and 10-25% by the end of the century; some regions in the Northeast might witness an increase of over 40%. The average one-day maximum rainfall would rise across the country (10-70%) compared to the base period (1986-2005).

- Extreme weather/climate events: The number of strong to very strong typhoons would increase. The summer monsoon would start earlier and end later. The number of severely cold days in Northern provinces would decrease. The number of hot days would increase. Droughts would be harsher.

- Sea level rise and flooding risks due to sea level rise: Under the high scenario, by the end of the century, the average sea level along the entire coastline could increase by 73 cm (49÷103 cm). If the sea level rises by 100cm, risks of permanent flooding (% of areas) of areas are as follows:

47.3% in the Mekong River Delta, 13.2% in the Red River Delta; 1.9% in Quang Ninh province; 1.5% in Central coastal provinces; 17.2% in Ho Chi Minh City; 4.8% in Ba Ria - Vung Tau province.

b) Impacts of climate change to sectors

1) Natural resources and environment

- *Water resources:* In recent years, water flows of main river basins have been lower than the average for many years. Water flows in the dry season decrease, the water levels reach historic lows in many places, droughts and water shortages happen more frequently, and saline intrusion extends further into the mainland. Under climate change scenarios, in most river basins, flows during the flood season tend to increase; high and extreme floods occur with higher frequency and severity.

- *Land resources:* Prolonged heat and droughts increase the risk of arid soil, reducing soil quality. Increased droughts during the dry season and increased rainfall during the rainy season cause a rise in erosion and landslides in riverside and upland areas. Flooding due to sea level rise is one of the major threats to land resources of the delta and coastal areas.

- *Forest resources:* Increased heat will increase the risk of forest fires. Rising temperature, high humidity, heavy rain, strong wind, degraded land, and other factors create favorable conditions for pests and insects to grow and spread, severely affecting the conservation and development of forest ecosystems. Reduced area due to forest fires, pests and diseases, as well as changes in the growth and development of forest ecosystems will affect the output and value of forest products.

- *Sea and island resources:* Rising sea temperature changes the growing season, increasing the outbreak of phytoplankton, which is detrimental to the growth of seagrasses. Climate change increases ocean acidification; strong storms destroy coral reefs, grasslands, give rise to species modification, and decrease marine fish resources. The islands and island groups will bear the brunt of climate change impact.

- *Mineral resources*: Rising sea level may cause soil, rock and ore to be inundated, contaminated with salt and alum, increasing mining and processing costs. Climate change may also facilitate the formation of new ore bodies. Some types of heavy minerals found in solid rocks (gemstones, gold, titanium, etc.) can easily accumulate over time and form placer deposits and weathered mines.

- *Biodiversity:* Climate change and sea level rise can change the structure and distribution of species and biodiversity of ecosystems. Rising temperature will change the distribution and structure of biomes. Sea level rise and increased storm intensity change the composition of sediments, salinity, and pollute water, degrade and threaten mangroves and species.

2) Agriculture and rural development

- *Cultivation:* Viet Nam's rice and corn yields could decline by 8.8% and 18.7% in 2030, and 15.1% and 32.9% in 2050 respectively. If the sea level rises by 100cm, 32.2% of agricultural land is at risk of flooding. Under the climate change scenario, if rice yield and cultivation area remain unchanged with no adaptation measures, Viet Nam will run the risk of losing 21.4% of rice production by 2100.

- *Husbandry:* Impacts of climate change on husbandry include changes in the production and quality of animal feed, and increase in disease outbreaks. Pig farming is expected to decrease by about 8.2% in terms of headcount.

- *Forestry:* Climate change and extreme weather events will increase the risk of forest fires, especially in the Northwest, North Central and Central Highlands; affect the distribution of biodiversity in sensitive forests such as dipterocarp forests, mangroves, evergreen broadleaf forests; increase the risk of developing forest pests and diseases; affect the productivity and suitability of planted forests; change the distribution and risk of biodiversity loss, especially for species with narrow ecological distribution.

- *Aquaculture:* Saline intrusion will significantly reduce areas of freshwater aquaculture, affecting the ecological environment, and changing biodiversity.

3) Transportation infrastructure

Storms and heavy rains cause flooding and erosion, damaging traffic works and equipment in ports and wharves; sea level rise and spring tide may cause flooding of roads, coastal stations, port and wharves infrastructure; storms, fog and heavy rain affect aviation activities; saline intrusion causes structural corrosion and damage equipment. The roadways sector is heavily affected by climate change, followed by railways and inland waterways. The maritime and aviation sectors are insignificantly affected. Mountainous areas in the North, Central Coast and Central Highlands are at risk of erosion and landslides. The Red River Delta and the Mekong River Delta regions are at risk of flooding due to sea level rise. Central coastal provinces face risks of inundation and erosion caused by rain and floods. All of these risks have an impact on transport infrastructure.

4) Urban development and housing

Sea level rise may cause the inundation of metropolises such as Ho Chi Minh City as well as cities in the Mekong River Delta and along the Central Coastal regions. Municipalities in the Northern mountainous, hilly region and the Central regions are often affected by extreme rain and post-storm circulation, causing floods, flash floods and landslides. Climate change also affects water resources and water supply systems.

5) Tourism

Climate change has direct impacts on tourism resources, infrastructure and travel activities. Tourism service facilities, accommodations and entertainment facilities are damaged or degraded under the impact of typhoons and floods. Climate change also indirectly affects tourism activities through its effects on other sectors, such as transport, energy, water management, and land-use, etc.

6) Public health

Climate change will adversely affect human health, especially that of the elderly, women, children, and people with chronic illnesses. According to statistics, an average temperature increase of 1°C results in a 3.8% increase of hospitalisation rate for children aged under 5 due to respiratory infections. Climate change facilitates the development of vector-borne diseases, increasing the likelihood of outbreaks and spread of diseases, such as influenza A, diarrhea, cholera, dysentery, malaria, dengue fever, yellow fever, typhoid, viral encephalitis, severe acute respiratory syndrome, plague, and zika.

7) Industry and trade

- *Industry:* Rising temperatures lead to increases in energy consumption in industries as well as costs of ventilation and cooling for mines and reduce the efficiency and output of power plants. Rain, storms and sea level rise will affect the operating process, increasing the cost of maintenance and repair works; affect the supply and consumption of energy; increase the risk of inundation in industrial zones. If the sea level rises by about 100 cm, most coastal industrial zones will suffer from flooding of between 10% and 67% of their total areas.

- *Energy:* Increased temperatures increase the energy demand due to the use of cooling equipment. Unusual rainfall and water flows affect the supply capacity and production plan of hydroelectricity, damage the electricity supply infrastructure, increase the cost of new investment, renovation, repair and upgrading of equipment and electricity distribution network. Sea level rise has negative impacts on power plants, power transmission systems, substations, fuel systems, mines, coal yards and other energy-related facilities in coastal areas.

- *Trade:* Climate change can affect commercial infrastructure through local flooding, impacting the storage and circulation of goods. Sea level rise will affect seaports, river ports as well as trade and logistics centres in coastal areas. Different climate change responses in different countries could also affect global, regional and domestic trade.

c) Impacts of climate change to delta, coastal and mountainous areas

- *Delta areas:* The delta areas will face risks of inundation due to sea level rise. Increased saline intrusion and droughts bear serious impacts on freshwater supply, reducing water quality; rice yield may decrease between 8% and 15% by 2030, and possibly 30% by 2050. Other threats are also on the rise, such as lack of water for domestic use, negative effects on the aquaculture and fishing environments, increased crop

diseases, degradation of soil, and the loss of biodiversity and rare genetic resources.

- *Coastal areas:* Coastal areas of Viet Nam are severely affected by sea level rise and such climate-related hazards as typhoons and tropical depressions, floods, and landslides. Sea level rise will increase the risk of inundation in coastal areas. Climate change accelerates soil degradation processes, increases saline intrusion area, reduces rice production and creates many other environmental consequences; degrades biodiversity in coastal areas, changes the ecosystems of lowland areas; shrinks the area of forests and natural vegetation.

- *Mountainous areas:* Rising temperatures will affect agriculture, biodiversity, energy production and consumption, and public health. Floods will affect agriculture, water resources, transportation, people's health and lives. The heavily affected groups are mainly people in mountainous areas, especially ethnic minorities and the elderly, women and children. Under the impact of heavy rains caused climate change, the intensity of flash floods tends to increase, causing greater impacts on people's lives.

d) Loss and damage of climate change

- *Historical loss and damage:* Between 2011 and 2020, extreme climate events have caused severe economic damage, with total losses estimated at VND 229,958 billion (an equivalent of USD 10 billion at 2022 exchange rates). On average, Viet Nam suffers about USD 2.4 billion worth of direct damage in public and private property (equivalent to 0.8% of GDP) due to extreme weather events. Moreover, taking into account the overall costs of environmental degradation, for 2020, climate-induced losses are estimated to be at around USD 10 billion, equivalent to 3.2% of GDP. In 2011, 2012, 2018 and 2020, there were 5,929 classrooms and functional buildings destroyed and damaged, and 2,723 school sites affected. More than 204,000 hectares of forest were damaged in 2012, 2018, and between 2020 and 2021.

Between 2011 and 2020, 2,153 people died, 316 people went missing, and 4,117 people were injured due to natural disasters. Post-disaster losses also include disease outbreaks caused by contaminated drinking water and mental health problems caused by trauma, anxiety, and stress. Climate change is also one of the reasons for increasing migration and forcing tens of thousands of households to permanently relocate, risking the loss of cultural identity and local knowledge.

- *Future loss and damage:* Climate change will be one of the factors impeding Viet Nam"s growth. Without effective adaptation measures, a temperature increase of 1.0^0C and 1.5^0C could cause losses of about 1.8% of GDP and 4.5% of GDP respectively; as well as economic losses of about USD 4.3 billion in the next 10 years. If the sea level rises and temperature increases as in the worst case scenario, it is estimated that 3.1 million Vietnamese people will have to migrate internally by 2050.

Under the high climate change scenario, the flood risk level of urban areas is expected to increase to 7%. It is estimated that by 2050, the loss of houses due to climate-induced storms and floods in the Mekong River Delta will be at USD 2.1 billion, an increase of 11% compared to current level. Increased rainfall can create risks of landslides and flooding for about 20% of the total length of the national highway network, and 20% of the total length of the railway network. If the sea level rises by 100 cm, about 4% of the railway system, over 9% of the national highway system and about 12% of the provincial roadway system would be affected. Disruption of railway lines can lead to economic losses of USD 2.3-2.6 million/day. Rising sea levels could cost agriculture USD 43 billion. The Mekong Delta is the area that suffers the most, followed by the Red River Delta. About 1.1 million tons of farmed aquaculture, or USD 935 million, are at risk of loss from flooding every year. If the sea level rises from 75 to 100 cm, then 78 out of 286 "critical natural habitats" (27%), 46 conservation areas (33%), 9 biodiversity areas of national and international importance (23%) and 23 other biodiversity areas will be severely impacted. The majority of the coastal industrial zones will be flooded. It is estimated that up to 35% of construction works in coastal areas will be eroded; 42% of coastal hotels are located near landslide areas; and 2/3 of the dike system (over 2,659 km) may not meet safety standards.

In addition to the already identified economic losses, Viet Nam is also at a high risk of non-economic losses, which include loss of human lives, negative impacts on people's health or loss of opportunities due to the relocation of economic zones. Non-economic losses also include loss of land due to erosion, loss of cultural heritage and local knowledge, and loss of biodiversity and ecosystem services.

e) Efforts in climate change adaptation

Viet Nam has implemented many programs and projects to adapt to climate change.

1) Climate monitoring, early warning of natural disasters

The monitoring system for climate change and sea level rise has been developed and operated. Developing hydrometeorological forecasting technology; enhancing the accuracy in typhoon and tropical depression forecasts. Establishing the earthquake and tsunami warning system, warning of geological hazards and natural environmental disasters; establishing a set of zoning maps to provide warnings for different natural disasters.

2) Natural disaster response, flood prevention for major cities, reinforcement of river dikes, sea dikes, and the safety of reservoirs

- Consolidating irrigation infrastructure; developing and expanding clean water supply systems in rural areas; supporting residents in areas that are prone to floods and landslides; formulating plans to relocate and resettle residents in areas frequently hit by floods, typhoons, flash floods

and landslides; adjusting production plans and infrastructure to adapt to and limit the negative impacts of climate change;

- Proactively undertaking natural disaster prevention, focusing on areas vulnerable to natural disasters; improving the capacity of search, rescue and disease prevention; implementing flood prevention planning in the Day and Red - Thai Binh River systems; protecting flood drainage spaces in the river basins like the Red - Thai Binh River, Mekong, Cau, Nhue - Day, Dong Nai, and Saigon Rivers and other major rivers; constructing drainage works;

- Repairing and improving dam safety in the North, Central Coastal regions and Central Highlands; building new large reservoirs in the Central Northern, Central Southern Coastal regions and Central Highlands; building new small reservoirs and spillway clusters in the Northern mountainous regions; repairing and upgrading irrigation systems in the Red River Delta; completing and finalizing the irrigation systems, expanding flood drainage canals and regulating sewers in the Mekong River Delta; continuing the investment program to reinforce, protect and upgrade sea dikes from Quang Ninh to Quang Nam and from Quang Ngai to Kien Giang provinces;

- Promoting measures to prevent and mitigate impacts of high tides, inundation, and saline intrusion; developing flood risk maps based on sea level rise scenarios at the commune level; implementing flood prevention schemes for Ho Chi Minh City, Can Tho, Ca Mau and other coastal cities, especially those in the Mekong River Delta;

3) Ensuring food security

Transforming crop structure, developing large-scale agricultural production; researching, selecting, creating and applying new plant and animal species adaptable to climate change; constructing irrigation works for production restructuring; restructuring public investment, significantly directing investment capital into irrigation to serve multiple purposes; prioritizing capital for implementation of irrigation for upland crops, high-value industrial plants and for aquaculture; facilitating and ensuring the interests of the parties involved in agricultural insurance and risk-sharing.

4) Ensuring water security

Formulating and implementing the national master plan on water resources and the consolidated master plan for river basins, integrated with climate change; implementing solutions to ensure water security in the context of climate change; determining the minimum flow on rivers, streams and downstream of reservoirs and dams; promulgating legal documents on incentives for thrifty use of water and restriction of underground water exploitation; developing criteria for products, equipment and technologies for economical use of water.

5) Building climate-resilient communities

Enhancing community capability and participation in climate change response; focusing on local response experiences and the role of governments at all levels and community organisations; developing sustainable livelihood; improving public health and access to basic healthcare and education services; promoting the use of local knowledge in responding to climate change

6) Protecting and sustainably developing forests and preservation of biodiversities

Conserving and improving forest carbon stocks; protecting and restoring forests, planting mangroves and coastal protection forests; protection of ecosystems and conservation of biodiversity achieved a number of important results.

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