

Environment and Climate Change in the Central Coast of Vietnam

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Abstract: The Central Coast suffers from severe natural conditions, impacted by various natural calamities and disasters. For the past few years, it has been one of the areas that are most influenced by climate change, storms, floods and the sea level rise, which cause negative impacts on local people's life and socio-economic development. Statistic data for 4 decades, from the 1970s to present, shows that the intensity and frequency of natural calamities have been increasingly greater and severer. Storms, floods and the sea level rise have been much more complicated in the Central Coast, due to climate change. The paper describes the actual state of environment and climate change for the past time, based on which the author suggests measures to minimize impacts of environment and climate change on socio-economic development in this region.

Key words: Climate change, environment, socio-economic development, the Central Coast.

1. Actual state of environment and climate change in Central Vietnam

1.1. Climate change

In terms of storms and floods: Flood is one of the natural disasters that cause the most damage to local people in Central Vietnam at present. As the geological structural particularity of this region is that the Annamite Range runs along the coast and sometimes touches directly the sea, rivers and canals are often short with a high slope. In the meanwhile, there are neither flood controlling dikes nor big reservoirs in the upper areas, which can help to accommodate inflows to minimize flood damage in the lower plain areas. Consequently, residence areas in both sides of the rivers are often flooded, when it rains heavily.

Of all regions in Vietnam, the Central Coast suffers the greatest influence of storms. The number of storms slamming

into Central Vietnam accounts for 43.6% of all storms hitting into Vietnam. Statistic data show that in the 1990s, Central Vietnam suffered from over 15 storms, of which an over-12 force storm caused severe damage to human and property. In 2013, storms and floods destroyed 9,035 houses, of which 4,800 ones were located in Quảng Nam Province. The Typhoon Nari (known in Vietnam as the Typhoon No.11) hit many Central provinces such as Quảng Bình, Quảng Trị, Thừa Thiên Huế, Quảng Nam, Đà Nẵng and Quảng Ngãi, killing 20 people (12 ones lived in Quảng Bình; 2 in Thừa Thiên Huế; and 6 in Quảng Nam) and injuring 296 people. In addition, the typhoon caused

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heavy rains afterwards. Some hydroelectric dams had to release water back into rivers, resulting in floods for Central provinces. The total damage was estimated over 2,500 billions VND.

In terms of drought: Droughts have been increasingly severer. According to the Institute of Meteorology, Hydrology and Climate Change, more and more droughts have happened to many areas in the South Central Coast, making tens millions people deprived of water and thousands hectares of fruit and industrial trees dried up. The economic damage was really enormous. Furthermore, the annual rainfall is low, resulting in a greatly decreased inflows in those areas. As a result, the droughts often last for a long time and seawater penetrates further into the land. This causes seriously negative impacts on agricultural production and living water supply for coastal people.

Because of impacts caused by droughts, about 17,277 hectares of cultivated crops in the South Central Coast were deprived of irrigation water or infiltrated with salt water in 2013. They consist of 15,627 hectares of rice, 300 hectares of coffee trees, and 1,350 hectares of other crops. 50 hectares of rice were completely damaged. In Bình Định province, from February to September 2014, the rainfall was very low, making thousands hectares of cultivated crops severely damaged, according to an official assessment. Climate has been getting more and more complicated, which makes it very difficult to have precise forecast and build agricultural production plans.

The sea level rise: The sea level rise and

geo-morphology in the Central Coast are getting more and more complicated. For the past few years, more coastal land have been infiltrated with seawater, threatening to damage coastal infrastructure and residence areas. Climate change has also resulted in serious changes of the natural environment, causing negative impacts on socio-economic development not only for the Central but also for the whole Vietnam.

In Thừa Thiên Huế province, due to impacts of the global climate change and the sea level rise, storms and tropical low pressure have been taking place very abnormally and have blown off many parts of the seashore. By now, of all 127 kilometers of the provincial seashore, 30 kilometers have crashed down (mainly in Phong Hải of Phong Điền district, Quảng Công, Quảng Ngạn of Quảng Điền district, Hải Dương of Hương Trà district, Thuận An town, Phú Thuận, Phú Hải, and Phú Diên of Phú Vang district, Vinh Hải and Vinh Hiền of Phú Lộc district). Especially, landslides in Thuận An and Tư Hiền seaports have damaged the natural stability of Tam Giang – Cầu Hai lagoon, threatening life and property of more than 1,000 households as well as socio-economic infrastructure in this coastal area of the province. In addition, the coastal sand-bank lying between the coastal plain or the inner lagoons and the East Sea (or the South China Sea) is seen as a direct dyke running for 90 kilometers from the Điền Hương commune (Phong Điền district) to the foot of Hải Vân mountain pass. The sand-bank covers areas of 24 communes and towns of

many districts, including: Phong Điền (6 communes), Quảng Điền (2 communes), Hương Trà (1 commune), Phú Vang (7 communes) and Phú Lộc (8 communes and Phú Lộc town). The sea encroached averagely from 10 to 30 meters on the land every year, causing damage to infrastructural works, making a lighthouse collapse (in 2001), and sweeping away a number of resorts and hotels located in the area of Thuận An beach. This is a really serious menace to life and property of over one thousand households in Hải Dương and Hòa Duân communes.

In Đà Nẵng city, the erosion caused by the sea waves have negatively influenced nearly one hundred households in Nam Ô coastal commune (Liên Chiểu district) for years. The living area and 750 hectares of cultivated crops have been getting smaller and smaller, as the sea has been encroaching more and more on the land. After the storms in late 2007 and 2008, sea water infiltrated far into the area of Hòa Hiệp Nam ward (Liên Chiểu district) and swept away houses as well as shrimp-hatching ponds of 16 households, who lived on hatching seed shrimp. The erosion by the sea waves destroyed tens houses and broke off a 2 km-long part of Cu Đê river dyke (next to Nam Ô bridge, Hòa Hiệp Bắc ward), threatening the security of Nam Ô bridge. The sea water also encroached for 100 meters on the residence area in the North of Nam Ô fall (Trần Văn Minh, 2009).

In Quảng Nam province, climate change and erosion by the sea have been also really severe, depriving of many beautiful beaches;

a large area of protective forest have been swept away; and, sea water has infiltrated more into coastal residence areas, particularly in Núi Thành district and Hội An city. The coastline of Hội An city is 7 kilometers long, but a lot of land has been eroded since 2009, especially in the area of Cửa Đại seaport, where many high-quality resorts such as Golden Sand, SunRise, and Vinpearl are located. Âu Cơ coastal road with a lot of public beaches have been swept away. The coastline of Cửa Đại ward is 3 kilometers long, but more than 1 kilometer has crashed down. Đồng Dương resort with many beautiful apartments is now left unoccupied, since the concrete dyke has been broken off by the sea waves.

For the past 5 years, sea water has infiltrated for 50 meters into many areas in Tam Hải commune (Núi Thành district). As a result, 300 households had to moved away from those areas. During the rainy and stormy season in 2013, the sea waves were so great that they swept away some rows of pine trees, which were deliberately grown to prevent the sea waves; the sea water encroached on the residence areas, making local people always feel insecure.

Lý Sơn island (Quảng Ngãi province) is getting smaller and smaller due to erosion by the sea. Its area has decreased by 1 square kilometer for the past 40 years. Every year, when the raining and stormy season comes, local people feel worried about the risk that houses and property may be swept away by the sea waves. The government, therefore, has decided to spend 10 billions VND on building and rebuilding

dykes against erosion by the sea every year.

Phú Quý district (Bình Thuận province) is one of the areas that have been seriously impacted by what involved with climate change such as sea level rise, droughts, storms, seawater infiltration etc. According to research findings of the Institute of Meteorology, Hydrology and Climate Change, average temperature and rainfall in Phú Quý island have been increasingly higher, compared with those in the 1980 – 1999 period. The average temperature and the average annual rainfall have remained 27.4 degrees Celsius and 1,314 mm for many years. Climate change and the sea level rise have made erosion of the island much severer. According to statistic data, the total area of the island was 32 square kilometers in 1975. In 1988, it was just 28 square kilometers, because of erosion by the sea. By now, there is only 17.82 square kilometers left. In 10 different areas of the island, the erosion has been taking place with a high speed ranging from 3 to 5 meters a year. Some important places have been dangerously eroded for a total length of 1,500 meters (K.V., 2011).

Impacted by the intensive atmospheric circulation after the Typhoon Hagupit (known in Vietnam as the Typhoon No.5 in 13 December 2014), there were heavy rains, resulting in flooding in Phú Yên. The sea waves broke and swept away 100 meters of the dyke and stone embankments. It eroded deep into land, making a hole next to the walls of local residence houses (less than 3 meters far from the walls). In Tuy Hòa city, the sea waves destroyed completely Đình

Tiên Hoàng road, which runs along the coastline. After the waves, many 1 meter-deep holes were formed along the road. Traffic was paralyzed and tens households were isolated. The waves hit the fishing port of Ward No. 6, covering it with a 30 centimeter thick layer of sand. Đà Diên seaport was also covered by sand; the remaining depth was just 1 meters, so boats and ships could not go in and out.

1.2. Influence by exploitation of natural resources on environmental protection

The Central coastline is 2 thousands kilometers long, running from Thanh Hoa to Binh Thuan. Some coastal sand-banks were formed ten thousand years ago, so they contain a lot of mineral deposits, of which the most important is titanium ore. The titanium ore deposited in those coastal banks is the most valuable type of ore in our country at present. It can be exploited industrially. Of the composition of this ore, silicon dioxide (SiO_2) makes up 95 to 99%; the rest consists of heavy materials such as Ilmenite (FeTiO_3), Zircon (ZrSiO_4), Rutile (TiO_2), Leucoxen, Anatase (TiO_2), and Monazite (Ce, La, Th) (PO_4 , SiO_4). In addition, there are other minerals with a very low content such as Xenotime and Manhetit etc (Đặng Trung Tú, 2011).

The reserves of titanium ore in Vietnam amounts to 14.03 millions tons of TiO_2 , making up roughly 0.5% of the total reserves of titanium ore in the world. Titanium ore is distributed widely along Central Vietnam, but it is mostly found in some Central provinces such as Thừa Thiên Huế, Bình Định and Bình Thuận. The

deposits of titanium ore in the coastal sand banks were formed, owing to wind and sea waves. As estimated in 2004, the total reserves of titanium ore in the Central Coast amount to 8.154 millions tons, distributed mainly in mines in some following provinces: Thừa Thiên Huế (4,709,451 tons, making up 57.8%), Bình Định (1,596,763 tons, making up 19.6%), Bình Thuận (967,585 tons, making up 11.9%), Quảng Trị (587,000 tons, making up 7.2%), Khánh Hòa (128,300 tons, making up 1.6%), Phú Yên (110,590 tons, making up 1.4%), and Quảng Nam (54,047 tons, making up 0.67%). The total reserves of accompanying minerals in the mines are 1,305,543 tons of Zircon, 24,526 tons of Rutile and 9,176 tons of Monazite. According to a recent investigation (in 2010), in addition, titanium ore lies densely in the layers of white sand, grey sand, and red sand, but it is most found in the layer of red sand in Bình Thuận and Ninh Thuận provinces, where the reserves of titanium ore is forecast to be around 557 millions tons. The content of Ilmenite in the ore ranges from some kilograms to 195 kilograms per a cubic meter of ore.

In 1993, the Austin Company, an Australian – Vietnamese joint venture, started to carry out industrial exploitation of titanium ore in the area of Kỳ Anh district (Hà Tĩnh province). In 1997, Hà Tĩnh Titanium Exploitation and Processing Company was founded. It mainly conducted exploiting activities in Cẩm Xuyên and Thạch Hà (Hà Tĩnh province).

In the meanwhile, BIMAL (Vietnam Malaysia Minerals Joint Venture) was

founded in Bình Định to carry out exploitation of titanium ore in Đền Gi mine (Phù Cát district). It processed minerals from the ore to be exported. Another company, Bình Định mineral company, also made exploitation of titanium ore in Cát Hải mine (Phù Cát district) to be carried to Quy Nhơn city for processing. Since the year of 2000, exploitation of titanium ore has been carried out widely all over the Central coastal sand-banks, from Hải Thủy district (Quảng Bình province) across Phú Diên district (Thừa Thiên Huế province), Duy Xuyên district (Quảng Nam province) to Hàm Thuận Nam district (Bình Thuận province) and many other areas.

Exploitation and processing of titanium ore in the coastal sand-banks have been causing a lot of negative impacts on the natural environment, the coastal landscape, the agricultural ecology as well as socio-economic development. This has been also making a part towards the reduction in other natural resources and resulting in pressing issues for residence community, as described below:

Firstly, the topography of the coastal sand-banks has changed. The Central coastal sand-banks can be seen as dykes to prevent wind, sand and seawater. Exploitation of titanium ore has changed the original topography and the structure of sand layers in the sand banks. A lot of round and hollow holes, of which the depth ranges from 5 to 20 meters, were dug in the inherently stable surface of the sand banks. At the same time, new sand dunes, of which the height ranges from 6 to 10 meters, were

formed in the surrounding areas of the holes. The dunes consist of dry and spongy sand, which is easily blown by wind.

Secondly, the vegetation cover and protective forest have been damaged. In the Central Coast, the coastal forests and the vegetation cover have been seen for a long time as a protective belt against wind and storms. To carry out exploitation of titanium ore, ones cut down the forest; whereas, it is not easy to do reforestation, because the filling sand cannot provide enough fertility and water for trees.

In order to do exploitation of titanium ore, ones have also cut down the casuarina (she-oak) forests, which existed for tens years along the Central coastal sand banks (in Quảng Bình, Quảng Trị, and Bình Định etc.) without any regret. As a result, the wind and storm preventive belt has been destroyed completely; the vegetation cover has been seriously damaged; sources of underground water have been depleted; sand hills have been formed, resulting in a convexo-concave surface in the Central Coast.

In Quảng Trị province, the casuarina forests, of which the age ranges from some tens to a hundred years, in Vĩnh Thái commune (Vĩnh Linh district), Trung Giang commune and Gio Mỹ commune (Gio Linh district) have been destroyed severely due to exploitation of titanium ore during the past 15 years. There are hundreds of poisonous impurities left by sand blasting machines in the sand. In the fierce “black whirlwind”, local people’s life has been seriously influenced by desertification and exhaustion of fresh water. Crossing Vĩnh

Linh, Gio Linh and Hải Lăng districts (Quảng Trị province), we can see easily hundreds of screw-shaped sand blasting machines digging into beaches and villages to get titanium ore.

In Vĩnh Thái, a coastal commune of Vĩnh Linh district, digging and sandblasting activities are carried out the same fiercely as those in coastal communes of Gio Linh district. The 3 kilometer long coastline running from Mạch Nước village to Tân Hòa village is now desolate and destitute, because of this “black gold”. The sand preventive dyke running for over 300 meters in Tân Thuận village was removed completely by titanium exploiting companies. Although it has been rebuilt, there are often depressions; plants can not be grown to protect the dyke, as they do not get enough water to live.

Bình Định is one of the “granaries of black gold” of Vietnam. When exploitations of titanium ore was the most animated in 2008 – 2009, the amount of titanium ore exploited in Bình Định was more or less 800 thousands tons, excluding the illegally exploited amount. In 2012, the productivity of titanium exploitation in Bình Định was 450 thousands tons. The corresponding figure in 2013 is estimated not less than 400 thousands tons. For the period from 2010 up to now, the productivity of titanium ore exploited in Bình Định accounts for 70% of the total national productivity.

As a result, the exploitation of titanium ore from the layer of grey sand has made many beaches in the Central Coast completely devastated. Since the preventive forests

have been removed, local people have to face sand winds and sand drifts, which cause environmental pollution and encroach on cultivating land. This has led to a lot of pressing issues for residence communities.

Thirdly, it has been more favorable for desertification. Exploitation of titanium ore has caused extremely negative impacts on the sand banks along the Central Coast. They are now too dry, lacking moisture. Salt is more deposited in soil. Fertility is lower. The vegetation cover is smaller; some varieties have changed. Sand area is getting larger and larger. In some places, mobile sand banks is encroaching more and more on land. As impacts caused by man is getting severer and severer, the cover of drought resistant lawn grown in the sand banks is getting obviously smaller and smaller. Consequently, it is possible that desertification will develop rapidly and become a disaster. This is a really pressing matter for coastal communities.

Fourthly, the vegetation cover is damaged; sand hills are formed, resulting in a convexo-concave surface along the Central Coast. Due to impending benefits, companies as well as local governments and communities have been trying to exploit titanium ore. The excessive exploitation has caused unforeseen consequences: deprivation of forest and natural resources; negative impacts on the environment and life of people; disappearance of a hundreds-kilometer long coastline and hundred-year old forests. Many villages, which were inherently peaceful for years, have been disordered due to exploitation of titanium ore. Activities of

titanium exploitation and processing have made soil and underground water in many places of the Central Coast infiltrated with seawater; many hectares of coastal land and sand banks have been dug for titanium ore; the casuarina forests against wind and sand have been destroyed; the coastal landscape has much worsened; fresh water inside the sand banks has been polluted and infiltrated with seawater; the rural roads has deteriorated much due to transport of ore etc. Obviously, these corollaries cannot be solved overnight.

Fifthly, the coastline is eroded. Exploitation of titanium ore takes place in the sand banks located just 80 to 100 meters far from the sea. The coastline has been therefore broken down, because of storms, high tides and the sea level rise. Phenomena of the coastal dynamic earthquake have happened to the areas, where titanium ore is exploited, such as distortion of the coastline, dyke crash, sand wind and sand drifts etc.

Sixthly, underground water has decreased. Rain water is the only supply for underground water of the sand banks. The amount of underground water is, therefore, limited. In the meanwhile, it is the major supply of water for local people, who live in the sandy areas and do agricultural cultivation in the western areas of the sand banks. Exploitation and washing of titanium ore require a lot of water. At the same time, the amount of water evaporating from the exploitation sites is very great. As a result, the amount of underground water in the sand banks drops down, especially in the dry season. This directly influences the

households, who use underground water from the sand banks. Once a company, which exploited titanium ore next to the seashore, secretly used pipes to pump seawater to do washing of ore. This made seawater infiltrate into underground water in the sand banks.

Seventhly, radioactive substances are scattered all around. Activities involved with exploitation, processing and transport of titanium ore scatter radioactive substances, harming community health. The data of radioactivity measured at the areas of exploitation and processing of titanium ore in Bình Định and Bình Thuận provinces show that the level of radioactivity in heaps of wet ore is relatively high. Especially, the level of radioactivity in the ore screening workshops as well as in the heaps of screened ore and waste sand is very high, exceeding the standard of radioactive safety (in Bình Thuận, the level of radioactivity is from 6 to 15 times higher than the standard; the corresponding figure in Bình Định is from 4 to 70 times; at the heaps of Monazite ore, the level of radioactivity is 100 times higher than the standard). It is very dangerous, as a high level of radioactivity may cause lung cancer for those who are affected.

Eighthly, to recover the environment by filling sand and land back is just a temporary coping measure. Based on the law on minerals and license for titanium exploitation, after doing exploitation work, it is necessary to fill back the excavation holes and recover the vegetation cover. This requires a lot of time and funding, so titanium exploitation companies often do it

very cursorily. Although some titanium exploitation companies have leveled the surface and re-grow the casuriana forest, most of the sand banks have been left bare. This potentially results in desertification and reduces the amount of underground water in the coastal sand banks.

Ninthly, social contradictions have occurred. It is inevitable that exploitation of titanium ore in the sand banks will lead to social contradictions, because interests are not equal and transparent between the parties involved. Consequently, local people in the areas of exploitation demonstrate against exploitation activities; they even come in titanium exploitation companies, destroying the company facilities and machines. Such an event happened in Bình Định province. Similarly, local people in Bình Thuận often submit complaints and lawsuits against titanium exploitation companies, since they cause bad impacts on their life and environment.

2. Measures to overcome impacts of the environment and climate change on socio-economic development in the Central Coast

2.1. Measures to minimize damage caused by climate change

Practical experience shows that it is very difficult to make precise forecasts about climate change. Thus, it is very essential to carry out preventive and coping activities against impacts of climate change.

For particular characteristics of the Central Coast, there are two issues that need solving: How to prevent disasters and minimize damage caused by climate

change; and, how to adapt to climate change and the sea level rise. In order to solve the two issues, we suggest that we should focus on some following measures:

- *In terms of policy:* It is necessary to promulgate appropriate policies to cope with global climate change, based on which we can design specific plans that are practically suitable for local conditions. To minimize damage of climate change, it is firstly essential to see how to take control over industrial carbon dioxide and to make an assessment of the current state of preventive forests in the upper areas and coastal areas as well. This will help to reduce climate change in the Central Vietnam, as forests play an important role in reducing the greenhouse gasses. It is necessary to have long-term protective measures for the Central Coast, from the national as well as global perspective. Due to impacts of climate change, local people encounter disasters and they become more vulnerable. It is, therefore, urgently necessary to build coping plans for adaptation to climate change. To get high effectiveness, however, policies must be practically suitable for local specific conditions.

- *In terms of technique.* It is important to have measures to improve effectiveness of irrigation works. Irrigation planning and irrigation projects should be carried out practically for future. It is necessary to strengthen programs on protecting and planting upper forests and coastal protective ones as well. Investments must be made into protection and improvement of river and seashore dykes. The geo-morphological factors and the sea level rise must be taken

into account specifically, when carrying out planning activities and designing projects for coastal and estuary areas. Seashore dykes must be solidified, especially in most important parts, aiming at ensuring living safety for local people. It is also necessary to build some public works, such as multi-purpose shelters, so that local people can stay in, when a storm or a flood comes. Provincial comprehensive socio-economic development plans as well as action plans of all sectors involved must be reviewed and revised properly, in order to cope with floods, storms and the sea level rise. Particularly, it is necessary to estimate the number of households and people in the Central coastal areas that are potentially infiltrated with seawater, in order to make a plan to move them to new safe residence areas of an appropriate altitude; productive forces must be also re-allocated. The forecasting technology must be improved; management must be carried out more effectively; and, protective forests must be maintained. All of these will help to reduce damage of climate change and the sea level rise. Crops should be re-arranged and structure of cultivated plants should be revised properly, in order to avoid damage to crops. To protect crops and residence areas, it is necessary to do protection of casuriana and coconut forests along the coastline of Central provinces, as they are very helpful to prevent storms, waves and the sea rise. In swampy and alluvial areas, we should plant salt-marsh forests with appropriate kinds of trees, such as: avicennia, mangrove, sonneratia, black mangroves (aegiceras corniculatum, and bruguiera

gymnorhiza). The width of the forests should range from 300 to 1,000 meters; next to the forests, there should be a dyke and a road. Some kinds of trees, such as casuriana, bamboo, and dipterocarpaceae, should be planted along both sides of the dyke and the road to prevent wind, storm, tsunami, and landslide etc.

For coastal cities, such as Hà Tĩnh, Huế, Đà Nẵng, Tuy Hòa, and Nha Trang etc., they are impacted a lot by natural calamities, climate change and the sea level rise. Urban flooding is getting more frequent and more serious. It is, therefore, very important to grow more trees for the urban landscape greenization. Urban projects must have more green spaces and enterprises, communities and urban people should be encouraged to do urban greenization (e.g. to grow grass to cover grounds; to plant trees in construction works, in the inner courtyards, and in the terraces etc). In terms of planning, it is necessary to have more water containing spaces so that water can penetrate into urban areas under control, instead of building technical obstacles against floods. This will help to improve urban climate, urban landscape, water quality and minimize the cost of flooding preventive and sewerage works. In riverside cities, it is necessary to build a lot of reservoirs, as they will improve the urban ecological landscape and sub-climate conditions. At the same time, they will keep water, when rains and floods come as well as when the sea level rises.

- *In terms of management.* It is essential to strengthen propaganda and disseminate knowledge, aiming at helping local officials and people realize measures to minimize

calamities and take control over the coastline effectively. The whole society should be equipped with full understanding of the necessity to cope with climate change and its impacts on natural, economic, and social conditions as well as national defense. Authorities, specialized institutions and social organizations should collaborate with each other in holding training courses on storm prevention for local people and fishermen in the coastal areas. At present, a project titled “To strengthen resistance to climate change in Đà Nẵng city” funded by the Rockefeller Foundation with a funding of 200 thousands US dollars is carried out in Đà Nẵng city. The project initially aims at evaluating impacts caused by climate change on two districts of Đà Nẵng, including Liên Chiểu and Sơn Trà, enhancing policy-makers’ awareness of climate change, and building strategies to cope with climate change and calamities via conferences with participants from various State institutions and social organizations. At the same time, the project has helped to improve understanding of local people in Liên Chiểu and Sơn Trà about consequences, impacts of climate change and provide them with measures for adaptation to calamities caused by climate change. In addition, the project has also mobilized aids for a follow-up that will deploy research activities to make an assessment of influence caused by climate change at the city level. This is an effective model to be expanded widely in other areas of the Central Coast.

It is essential to strengthen inter-regional cooperation, in order to update information and data relating to climate change and the

sea level rise in Vietnam, including also the Central Coast. Cooperation in human resource training and research on regional issues must be also intensified. In the short term, it is necessary to carry out surveys and measurements, aiming at designing a topographical map of coastal as well as plain areas, based on which a map of flooding forecast concretized at different levels can be made. This will enable us to build proper protective measures.

It is important to pay more attention to human resource training and capacity improvement for universities in the region, including Vinh university, Huế university, Đà Nẵng university, Quy Nhơn university, and Nha Trang university. Cooperation and linkage between those universities should be also strengthened, in order to provide technicians, who can make analysis and forecast. These will help to build proper measures to cope with climate change and the sea level rise in the Central Coast.

All the above-mentioned measures must be applied synchronously and appropriately with economic conditions of our country. It is also necessary to promote international cooperation. At that time, we can determine the extent, to which coping measures should be implemented to overcome climate change in each specific period.

2.2. Combination of the sea – island economic development and protection of natural resources and environment

On the basis of the Party's and the State's guidelines on strengthening the sea economic activities to make the most of natural conditions, local potential and advantage for socio-economic development,

coastal provinces in Central Vietnam have built sea economic development strategies. For the past 20 years, many coastal industrial zones and economic parks have been founded according to the following pattern: Seaport + Economic or Industrial Zone + Coastal Urban Area.

It is important to develop offshore fishing. Economic potential of various islands (such as Hòn Mê, Hòn Mát, Hòn La, Cồn Cỏ, Chàm, Lý Sơn islands, and the sea of the Paracel islands, the Spratly islands, and Phú Quý island) should be thoroughly exploited.

In the current context of international economic integration, it is necessary to exploit effectively the Central Coastal economic potential by two ways as described below, in order to solve employment for laborers as well as stabilize and improve living standards of people:

- To build a strategy of the sea economic exploitation, using the sea economy as a foundation to strengthen development of the whole region, creating more jobs to attract laborers and promoting development of aquaculture. The Central provinces have focused on exploitation of the sea economic potential. Yet, they just paid attention to visible products. A lot of invisible interests, for example, the geographical advantage of seaports and islands that can play the role as a bridge for economic linkage between different regions of our country and other countries in the world, haven't been exploited yet. To achieve the targets, it is necessary to re-evaluate our resources to see whether an impulse for development can be created and whether resources of development can be aroused and promoted.

Appropriate economic leverage and promotion of internal resources as well as external investments will enable us to realize successfully our potential in practice. Thus, it is essential to build economic zones towards the regional as well as the world markets. A multi-sector economy must be developed. More investments must be made into infrastructural works, especially those in coastal urban areas. It is also important to have proper policies to encourage linkage and cooperation in occupational restructuring and labor division between different areas.

It is necessary to keep sustainable development of the aquaculture towards industrialization and modernization. It should be viewed as a key economic sector that will bring a major breakthrough in economic development for coastal provinces. Economic transformation should be made step by step, accelerating growth of aquaculture, especially the breeding of shrimp, crabs, and other sea food to be used for tourism and export. Local fish farming should be developed together with economic transformation and rural labor re-division in coastal areas. In addition, we have to intensify other activities relating to fishery encouragement as well as application of scientific – technical achievements, in order to increase productivity and quality of fishery products.

It is important to strengthen aquaculture development towards the multi-component commodity economy. In the fishing and sea exploitation sector, the boat owner should be seen as a basic unit of production (the boat owner can be a household or a group of households); in the processing sector, the economic unit should be the household or

the private enterprise. The State-run and collective enterprises should play a major role in processing and service, owing to which the aquaculture can be further encouraged and promoted. It is significant to develop various careers of aquaculture, aiming at achieving rural economic transformation in coastal areas properly and sustainably. Offshore fishing and exploitation should be strengthened; high quality aquaculture should be promoted to meet an increasingly higher demand of tourism and export. In addition, we have to expand effectively domestic processing and export activities, which will help to create jobs for laborers and improve the standards of living in the Central Coast.

More motives should be created for aquaculture production and trading. Aquaculture must develop in linkage with agriculture, forestry, salt-making work, and craft industry. A practical and promising way is to combine aquaculture development projects with employment provision and establishment of coastal new economic areas. This will help to realize rapidly and effectively potentials.

Exploitation must go together with protection of sea resources; economic development must be combined with national defense and sovereignty over the territorial waters. All of these combinations will contribute a major part into the sea environmental protection and security.

Exploitation of economic potentials of islands is also one of the greatest advantages for the sea economy of Central Vietnam. Domestic and international cooperation must be strengthened and markets of consumption must be expanded both

domestically and internationally.

- *To combine the sea economic development with environmental protection.* Economic development is the key measure to help the Central Coast to overcome poverty and to get human comprehensive development. It is also seen as a foundation for civilized and modern social development. Since economic development has relied heavily on over-exploitation of natural resources regardless of environmental protection and a great bulk of poisonous substances have been discharged into the environment, environmental pollution and climate change are surely inevitable. This has caused a lot of negative impacts on social development and living quality of people in coastal areas. To attach economic growth with environmental protection, it is necessary to carry out strictly following measures: The task of environmental protection is obligatory; it cannot be separated from economic development; it is not allowable to make economic development by all means, disregarding environmental protection. It is essential to pay more attention to research and forecasting work. Only when the measures to cope with climate change, natural calamities as well as to protect the environment are actually appropriate for characteristics of the Central provinces, can they minimize damage to people and society. Enterprises and individuals that cause serious environmental pollution must be strictly punished. Activities of environmental improvement must be encouraged; the State should play a more effective role in management of the environmental protection, especially in the field of exploitation and

use of land, water, minerals and other natural resources.

Conclusion

The territorial waters and coastal areas of our country generally and the Central Coast specifically play a strategically significant role in economic development and national defense. A lot of advantages can be exploited in the Central Coast. This region can be seen as a widely open door to attract foreign investments and international cooperation. It is, therefore, necessary to exploit potential and advantage of the sea and coastal areas to the maximum. In addition, socio-economic development activities must be combined with those of national defense and security, in order to protect the sovereignty over the territorial waters of our country.

Realizing the significance and the great economic potential of the sea and islands, the Party has built socio-economic development guidelines appropriate to the particular conditions of this region, aiming at accelerating the national development generally and improving the living standards of people specifically. Those viewpoints must be taken into account thoroughly in building orientations and measures for the sea and island economic development in the Central Coast.

In the process of development, however, apart from the above-mentioned advantages, the Central coastal area generally and the Central sea area specifically have to encounter a lot of unfavorable impacts from the environment and natural conditions; furthermore, it also faces disadvantageous factors caused by men, such as territorial conflicts, as well as negative impacts from

the national, regional and the world situation. All the objective and subjective factors have been affecting socio-economic development and social management in the Central Coast.

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