

SOME SOLUTIONS TO RESPOND CLIMATE CHANGE FOR THE MEKONG DELTA, VIET NAM

Nguyen Thuy Lan CHI¹, Phan DAO¹, Miroslav KYNCL²

¹ *Trường Đại học Tôn Đức Thắng, Việt Nam
e-mail: nguyenthuylanchi@tdt.edu.vn*

² *Technical University of Ostrava, Czech Republic*

Abstract

In the recent decades, the Mekong River Delta has suffered quite significant impacts of climate change. Fluctuations of weather elements and sea level rises have caused adverse changes, namely: the appearance of unusual high and low levels of annual floods, more and more intense storms, more severe droughts, forest fires, river erosion, cyclones, and tidal surges appear increasingly more dangerous. Traditional adaptation measures to the environmental conditions may be unsuitable in the context of climate change in the Mekong River Delta. This paper summarizes some of the new adaptation measures that scientists and policy planners have proposed for the area to cope with the negative impacts of climate change.

Key words: climate change, mekong delta, flood, accretion and erosion, pollution prevention.

1 MAIN EFFECTS OF CLIMATE CHANGE IN THE MRD

As a coastal plain, located downstream of a large river basin being sensitive to climate change, the Mekong River Delta (MRD) is considered to suffer almost the major consequences of climate change, namely:

- The consequences of sea level rise such as strong waves along the coast, large currents in rivers and estuaries causing narrowing of land and deep inland salinity intrusion.
- The consequences of weather fluctuations in the basin, the most dangerous of which are floods and droughts. Unusual changes in rainfall regimes combined with socio-economic activities in the basin, especially in upstream countries, cause serious effects on the water resources in the Mekong River Delta.
- The dual pressure of climate change can undermine or diminish the inherent advantages of land/water resources and natural ecosystems of the Mekong River Delta. The risk of water shortages for daily life and production, the loss of dwelling and productive land along with the environmental hazards and the loss of biodiversity can have dramatic impacts on both urban and rural areas of the Mekong River Delta.
- Flooding of urban areas degrades or rapidly damages urban, industrial, transportation and energy infrastructures. In rural areas, some settlements may be lost, traditional forms of local livelihoods may be threatened. The ultimate consequence consists in the forced relocation and resettlement caused by environmental hazards [5].

2 OBSERVABLE EFFECTS OF CLIMATE CHANGE IN THE MRD

Over the past 100 years, the Mekong Delta has suffered just three tropical storms, while Typhoon Linda was about 93 years since the 1904's storm, two recent storms were only nine years apart. Climate change has already had observable effects on the MRD [1]. Effects that scientists had previously predicted would result from climate change are now occurring in the area:

- Large floods occurred for three consecutive years, from 2000-2002, during which the flood in the year 2000 was recorded as the largest one in history. The data of water level recorded in Tan Chau from 1924 to present indicate that the flood peak in 2000 was 5.06 m. This flood level, although lower than the flood peak in 1961 (5.12 m), has caused the total water volume to reach 430 billion cubic metres, about 15 billion more than the 1961 ones [6].
- The abnormality is that during seven next consecutive years (from 2003 to 2009), the floods in the MRD are below the average. The flood peak in Tan Chau in 2006 was 4.00 m and in 2008 it reached only 3.65 m, being the lowest in the last 70 years. The main flood flow is small; the total volume is about 80-90% of the average and peculiarly, was less than 70% of it in the years 2003, 2008 and 2009 [3].

- There were two strong typhoons that hit and severely affected the MRD: Linda in 1997 and Durian in 2006.
- Droughts occurred in 8 consecutive years in the Mekong Delta. Particularly, droughts combined with low flows of the Mekong River have caused deep salinity intrusion in 2004, 2008, 2010. Droughts in the area are projected to become more intense [9].
- Thunderstorms, cyclones appear more than before and cause serious consequences.
- Forest fires have been occurred in many places; particularly the fire in the U Minh Thuong National Park in the year 2002 caused serious damage.
- The frequency, with which the number of locations and intensity of coastal erosion have increased in the Tien Giang, Soc Trang, Bac Lieu, and Ca Mau provinces.
- River bank erosion in Tan Chau, Hong Ngu, Sa Dec, Vinh Long (along the Tien River), Chau Doc and on National Road 91 (along the Hau River) have occurred with high intensity recently.
- Sea level rise is observable. High tides due to sea level rise increasingly threaten the low-lying areas, including the cities such as Can Tho, Ca Mau, Vinh Long.

Impacts on water resources in the MRD are considered by scientists to be the most serious. These impacts are no longer predictions but they have been actually observed in the South East Asia (Table 1)

Tab. 1: Summary of the observed impacts of climate change on the water resources in Southeast Asia.

Climate change	Observed impacts
1. Temperature rise	Increasing evaporation and transpiration in river basins and on the surface of reservoirs and other water bodies, resulting in reducing water supply for daily life, irrigation and electricity generation.
2. Changes in precipitation patterns	<ul style="list-style-type: none"> - Decreased river flows and water level in many dams and water reservoirs, particularly during El Nino years, leading to decreased water availability; increased stress on water supply; - Increased river flow, especially during La Nina appearances, leads to flooding in some areas; - Increased runoff, erosion and flooding, affecting the quality of surface and groundwater.
3. Sea level rise	Salt water penetrates deeper into rivers and freshwater aquifers, leading to reduced fresh water source.

Source: The Economics of Climate Change in Southeast Asia: A Regional Review (2009) [1]

3 PROJECTED SCENARIOS FOR THE MRD

3.1 Increased inundation

In accordance with the research by the Vietnam Institute of Meteorology, Hydrology and Environment [2], the climate change in the Mekong basin strongly influences the flow into Vietnam. The largest monthly flow tends to increase, leading to increasing floods in the MRD. By 2050, the maximum flooded area with a level greater than 0.5 m will reach 68% of the total area of the MRD, nearly 30% of the area compared to the flood situation in 2000. The flood season shall come earlier and may be ended later. This will greatly affect the production of food, fisheries, environment and livelihoods of the people in the MRD.

By 2050, the flooded area may reach up to 3,514,400 hectares, accounting for 89% of the MRD's total natural area of 3,336,000 hectares, an increase of about 20% compared to the 2000 historic flood. The largest flooded area by over 0.5 m is projected up to 2,666,750 hectares, an increase of about 1,160,650 hectares compared to the flood of 2000.

The largest flooded area by over 1.0 m is predicted up to 1.522.700 hectares, accounting for 89% of the MRD's area, an increase of about 503.600 ha in comparison with the year 2000. Flooding intensity in the Plain of Reeds and Long Xuyen Quadrangle, especially in the area between the Tien and Hau rivers, will be more serious [9].

In addition to the current flood-prone cities such as Chau Doc, Long Xuyen and Cao Lanh, there will be others such as Sa Dec, Vinh Long, Tan An, My Tho, Can Tho, Vi Thanh, Soc Trang, Rach Gia and Ha Tien

submerged more than 1.0 m. The increase in flood level in 2011 due to the effects of higher tides may be a sign of the impact of rising sea levels on the MRD [6].

3.2 Accretion and erosion

Fluctuations in the geomorphology of the MRD's coastal zone are complex [4] and are likely unpredictable under the impacts of sea level rise and the changes in the flow regime from the inland. Accretion and erosion processes occur more regularly, creating large mudflats in many places and causing also serious erosion in other ones.

The areas include: Ba Lai River mouth (Ben Tre Province), North of Dinh An estuary (Tra Vinh Province). Coastal erosion occurs in many places such as Go Cong (Tien Giang Province), Thanh Phu (Ben Tre Province), Hiep Thanh (Tra Vinh Province), Vinh Chau (Soc Trang Province), Ganh Hao (Bac Lieu Province), and in Ca Mau Cape. The extent of erosion is quite serious, which directly threatens the safety of sea dykes that are seen as effective shields against adverse impacts from the sea.

3.3 Drought and salinisation

As predicted by the Vietnam Academy for Water Resources, by the end of the 21st century, the inland depth of penetration with a salinity of one-thousandth can rise to over 20 km on the Tien and Hau rivers. Over the next 50 years, the salinity intrusion area over 4 g/l in the MRD will account for about 45% of the natural area, an increase of nearly 400,000 hectares over the 1990-1999 average. The area affected by salinity of 1g/l occupies about 60% of the natural area, an increase of about 450,000 hectares compared to today. Nearly four-fifths of the Ca Mau peninsula will be intruded by saltwater [5].

The highest salinity recorded in all three major rivers (Vam Co, Tien and Hau rivers) and in the West Coast showed a continuous upward trend in 2006-2010 (*Figure 1*). Particularly, the severe drought in the dry season from 2015 to 2016 has led to a sudden increase in salinity intrusion (*Table 2*).

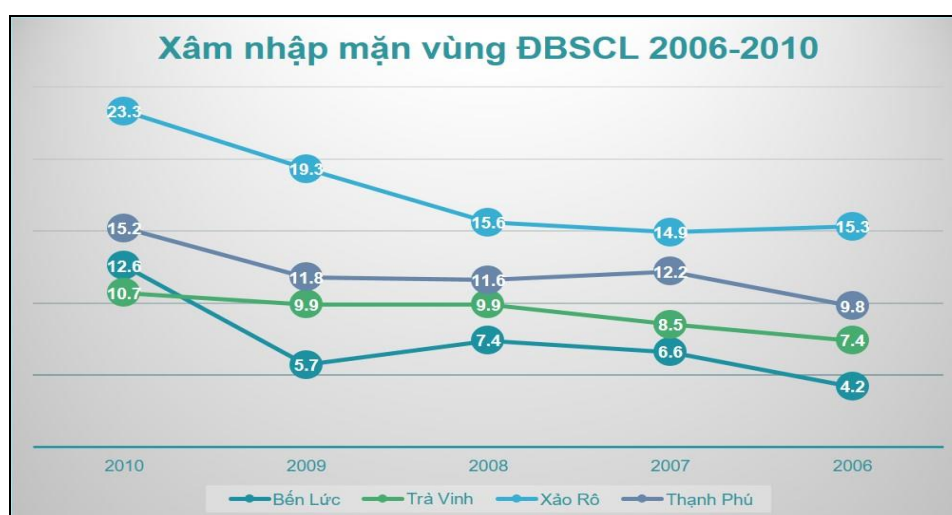


Fig. 1: The highest salinity in the dry season of five years (2006-2010) in the MRD (‰)

Source: Southern Institute for Water Resources [5]

Tab. 2: Comparison of salinity intrusion from the beginning of the dry season to 25/4/2016 with the same period of 2014-2015.

Area	Rise of highest salinity (g/l)	Penetration depth by 4g/l (km)	Rise of the penetration by 4g/l (km)
Vam Co River	2.6 -3.5	100-120	10-30
Tien River	0.2-10.4	50-73	3-21
Hau River	3.2-6.4	55-60	15-20
The Western Coast	2.2-7.4	68	8-10

Source: Southern Institute for Water Resources [6]

The increased salinity intrusion has the potential to disrupt irrigation projects that have been previously implemented. Impacts on specific projects are as follows: When salinity by over 4g/l penetrates the Mang Thit River mouth, the South Mang Thit freshwater-transform project (the benefit area of 225,682 ha in Vinh Long) will no longer guarantee its “freshwater retaining function”; the Quan Lo - Phung Hiep project (with a benefit area of 263,743 ha in the Soc Trang, Bac Lieu and Ca Mau provinces) designed to transfer fresh water from the Hau River will not achieve the goal of bringing freshwater to the Ca Mau Peninsula.

In the context of the sea level rise, the ability to get fresh water from the Hau River to coastal areas becomes more difficult. Other freshwater retaining projects in the Tien Giang and Ben Tre provinces will also face the risk of shortage of the same freshwater source.

4 ORIENTATION OF SOME SOLUTIONS

4.1 Rational planning

Human understanding of global and regional climate systems, and also the process of thawing is not yet comprehensive. Furthermore, climate change scenarios depend on the reliability of greenhouse gas emission scenarios and the method of scenario building, so these make it difficult to assure the certainty of those scenarios. Due to the uncertainty of climate change scenarios and sea level rise, the planning of climate change adaptation projects, especially for long-term planning, is quite complicated and difficult.

In order to cope with the uncertainty, it is necessary to use meteorological and hydrological parameters in a realistic manner in light of weather trends in the planning and design of climate change response projects. The recommended input parameters are as follows:

- The parameters recorded over the past decades for basic design purposes to mobilize favourable conditions and control the adverse factors of the inherent natural environment.
- The results of CC research in the past two decades and the trend of the changes projected over the next two decades to adjust the planning in line with the changing trend of weather factors (for the 10- 20 years duration).
- Refer to CC scenarios to integrate climate change elements into long-term planning, especially for key projects such as key urban and industrial areas, important transport and energy infrastructures, and residential areas in country sides (for the 30-50 years duration).

For short-term and medium-term planning, the attention should be paid to options and solutions that allow for quick and easy upgrading of infrastructures in case that changes (especially in extreme weather elements) appear earlier or more unusual than expected trends or predicted CC scenarios.

4.2 Flood prevention

Dykes and embankments in the Mekong Delta are multi-purpose structures that aim to protect people's safety, infrastructures, and to maintain the production activities. At the same time, these flood control facilities play a role of alluvium retaining and field hygiene.

Hydrological and hydrological modelling results verified by measured data [7] show that these structures do not raise the water level significantly. However, the elevation of dykes designed according to the previous flood frequency may have to be changed to suit both socio-economic development in the flood-prone areas and the requirement for the climate change adaptation. Therefore, the elevation of dykes and reasonable structure solutions should be considered in the supplemental irrigation planning [7].

Soft dyke structures, such as geotextile sand-filled tubes and plastic coated water-filled tubes can be combined dynamically to protect residential areas, urban and industrial buildings (*Figure 2*). These solutions also are suitable for the weak land and flood regime in the MRD.

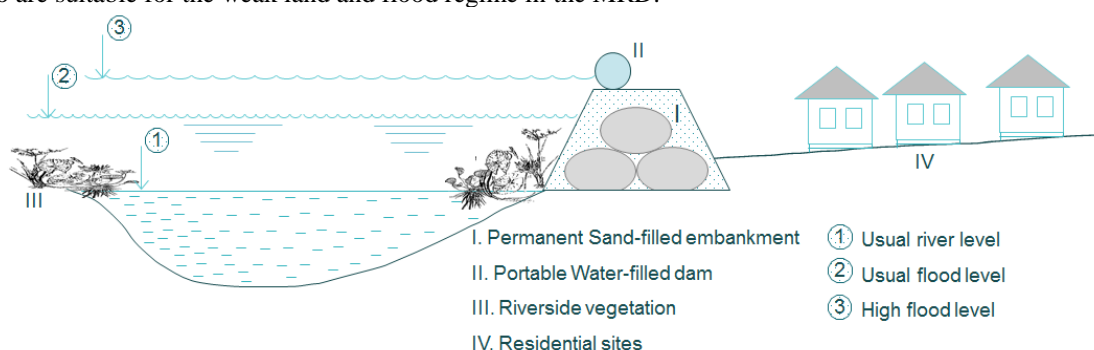


Fig. 2: Combination of a soft embankment and a dam to protect residential areas.

The permanent embankment made of geotextile tubes combined with riverside vegetation will be designed for the prevention of regular floods. Wherever needed to control high flood, portable dams filled with onsite water can be installed [7].

4.3 Pollution prevention in concentrated residential sites

The relocation and resettlement of people in the locations vulnerable to flooding may be inevitable. In fact, the “over flood“ residential clusters/routes – the key resettlement solution in the “living with flood“ strategy have proved its rationality.

Residential cluster is an area where houses are built adjacent to the land with foundations higher than the flood level or surrounded by an anti-flood dyke. As stipulated by the government, a cluster must have its size from 2 to 3 ha with its population size about 100 to 200 households. These residential sites are close to a farm, convenient for livelihood purposes, and enable to access to public services (clean water, schools and health facilities).

Residential routes are smaller than clusters, but the land chain near the anti-flood dykes is very advantageous for farming and livestock production. Although there is a safe place to live, these new types of settlement are densely populated and difficult to meet essential standardized environmental services such as water supply, sanitation and solid waste management. In fact, there are no resettlement sites that are full of these services. The diagrams given in Figures 3 and 4 describe the solution for the implementation of essential environmental facilities using appropriate onsite natural resources (water, soil, natural ecosystems).

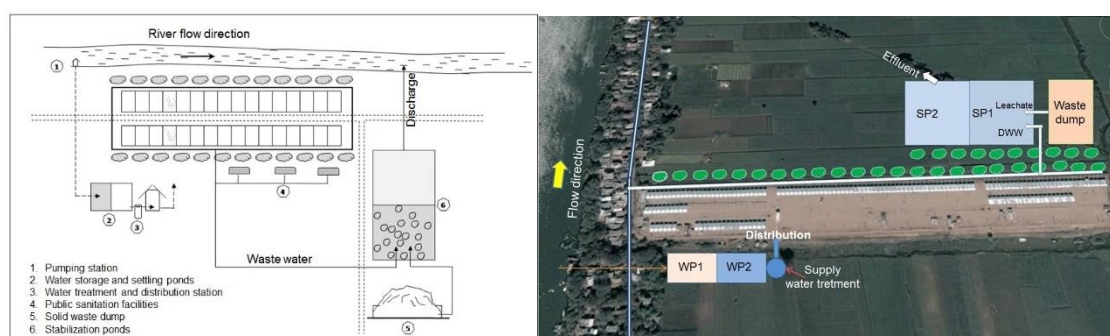


Fig. 3: Proposed overall scheme for essential environmental facilities at concentrated residential sites.

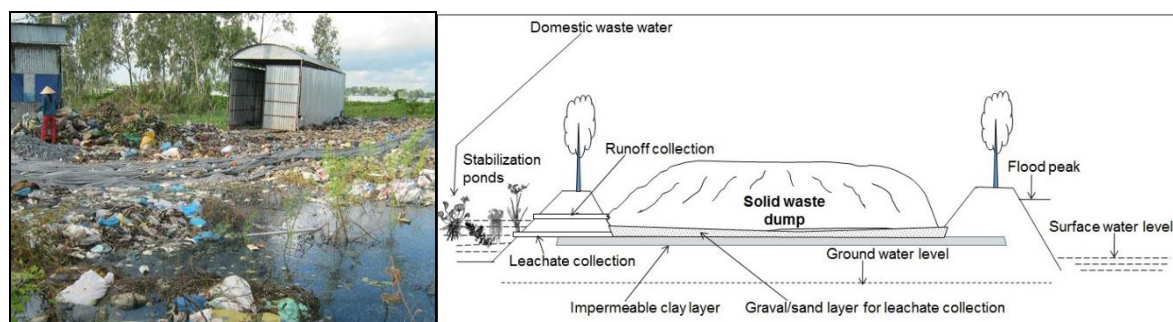


Fig. 4: Solid waste dump proposed for flood-prone areas.

4.4 Prevention of accretion and erosion

Anti-erosion and coastal protection solutions are usually divided into two groups: hard and soft [8]. The hard structures include: sea embankment, jetties, breakwater, artificial “cape”... Soft solutions include field rearing, mangrove planting, and sand dunes. The disadvantages of hard structures involve self-erosion (at the foot or the bottom of the structure), unexpected accretion and high costs. On the other hand, soft solutions usually require a long period of time (five to ten years) to be effective. In addition, soft solutions such as afforestation are risky because they depend on the environment, soil type, and sedimentation rate [9].

The failure of forest plantation on the coast of Trung Binh Commune (Long Phu District, Soc Trang Province) and Tan Thanh Commune (Go Cong District, Tien Giang Province) is an evidence of such risks in the use of single soft solutions. Therefore, the combination of hard and soft structures will be the solution that is usually chosen.

Developing mangroves, maintaining riverine ecosystems to prevent erosion is a positive solution. However, implementing them takes a long time and there must be supporting works. Normally, in order to protect the sea dykes, there should be a strip of mangrove forest with a width of at least 200-300m. To create this forest in places where sea waves and winds are strong and mudflats are not stable, it is necessary to build temporary structures to reduce the waves before planting [8].

The optimal solution for the coastal protection of landslide areas in the South Coast can only be a combination of hard and soft ones, namely, to develop mangrove forests on the basis of the support of hard structures that reduce waves and increase accretion. In addition to protecting the coast, the long term governing purpose is to take advantages of the alluvium from the rivers to enlarge to the sea. The research team from the Vietnam Academy for Water Resources propose the following way [4]:

- Creating accretion and afforestation in a manner of gradual encroachment in different phases from the inside to outside.
- Building simple temporary breakwater using local materials or lightweight structures that can be reused and easily dismantled, moved and installed.
- The hard structures must ensure a moderate sedimentation rate and the deposited alluvium have enough nutrition so that mangroves can grow. The embankment and jetties system in Can Gio, Ho Chi Minh City is a good example of the success of combining hard solutions and afforestation to prevent shore erosion.

4.5 Responding to salinity intrusion

In order to prevent salinity intrusion, scientists have proposed two ways including: maintaining sufficient fresh water to prevent salinity in dry season and building salinity prevention structures (sluices and/or river barriers) in places where it is really effective [10].

- For the first solution group, it is proposed to build some big reservoirs at deep depression areas such as the Plain of Reeds, Long Xuyen Quadrangle, and U Minh Forest where the agricultural productivity is relatively low. In these depression areas, it is possible to create reservoirs up to several billion cubic metres of water that can both reduce the intensity of flood flow and regulate the flow during dry season to prevent salinization in case of prolonged drought. In addition, these large lakes can be used to develop aquaculture and diversify sustainable livelihood forms for humans.
- The second set of recommended solutions is the construction of medium-sized river barriers. In fact, in the coastal zone of the Mekong Delta, many sluices and river barriers were built with the purpose of retaining fresh water and preventing salinity intrusion for different areas. The current irrigation structures have blocked some small and medium branches. Large rivers are still forced to open in order to escape floods and therefore must accept saline intrusion. These structures can only work well under normal hydrological conditions.

In the event that a shortage of freshwater from the upstream occurs at the same time of the higher tide due to sea level rise, current “hard“ salinity prevention works are at risk of losing their effect. Therefore, in order to proactively respond to increased salinity intrusion in the context of CC, the application of those groups of solutions should be considered thoroughly.

5 CONCLUSION

The experience in exploration of and adaptation to natural conditions in the MRD has formed a system of proper responding solutions to the changes of the environment. Particularly, the “living with floods” strategy and its corresponding structure solutions have effectively worked.

Abnormalities and severity of weather are increasing. Floods and droughts are the visible consequences of CC and sea level rise in the MRD. To minimize these consequences, structure solutions should be imperative. “Design with nature”, synchronically combining “hard” with “soft” solutions could be a suitable and necessary way for this area.

“Hard“ structure solutions should be designed flexibly and realistically according to planning phases. In addition, priority should be given to the application of “soft“ solutions capable of coping with sudden changes or being able to adjust to gradual changes due to climate change.

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