

Climate Change Impacts on the Mekong Delta

Shigeko Haruyama¹

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Abstract

Climate change impact should be made their great appearance along the flood plain of the large river and coastal plain in Asia and Pacific region because of their hazardous environment in structural factors. Water related natural hazard estimated under climate change, includes rapid flooding and inundation, rapid land slide, glacial lake burst and avalanche flow in mountainous area, sea level rise and coastal erosion along the coastal plain etc. Regarding the several fluvial and coastal plain in Asia and Pacific region, the number of flooding and coastal erosion has been increasing in recent year under the environmental change. The reason why the water related hazard became hugeness, population pressure over low-laying flood plain, prompt land cover change over the whole watershed area, frequent torrential rainfall occurrence under the environmental change and strong storm strengthening running parallel with environmental change of the ocean etc. In recent year, the rapid land cover change has been remarkable in the large river Mekong, especially upper part of China and lower part of Vietnam. After deforestation on the slope land, water resource development in the whole basin, and agricultural development in the middle reaches and floodplain, residential region and agricultural farm land have been suffered by severe flood in every monsoon seasons. The evidence of severe flood can be traced in the long period observation data and remote sensing data analysis in the study area. However, the dimension of flooding is now depending on the floodplain landform and reformation of landform by human activities, thus we should know the exact information of the natural environmental structure, natural environmental change and natural environmental dynamism. When we decide the policy of mitigation and adaptation toward natural hazard, we need more exact estimation, simulation and evaluation for decision making.

¹ Mie University, Graduate School of Bio Resources and The University of Tokyo, Graduate School of Frontier Science)

1. Introduction

2. Geomorphologic Land Classification Map

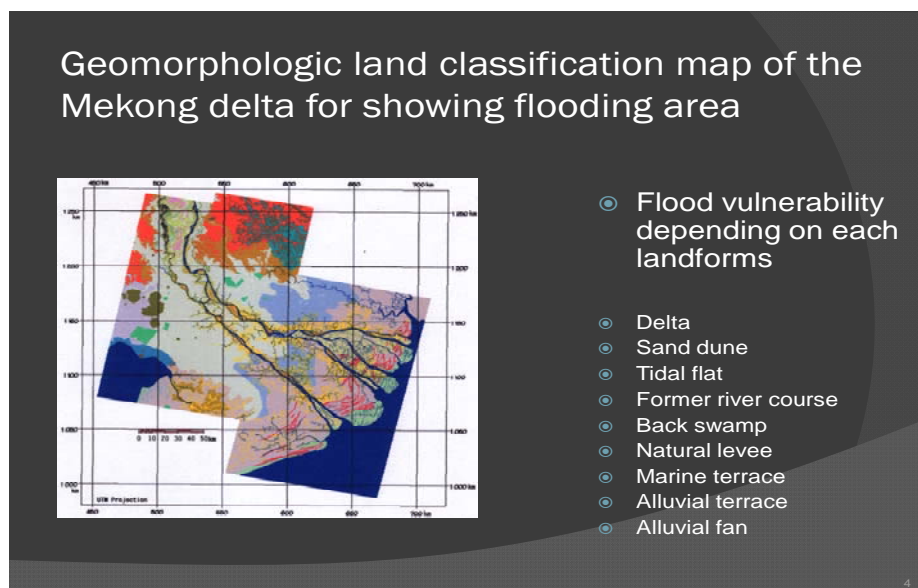


Fig.1: Geomorphologic land classification map of the Mekong Delta

The geomorphologic land classification map reveals the micro landforms and the type of the combination of geomorphologic elements. These expressions on the map are also providing the information of the previous phase of flooding and the state of estimated future flood because the fluvial landforms have been formed by repeated flood. When we would like to make an estimate the future condition of flood on the fluvial plain, geomorphologic land classification map should demonstrate the inundation phase, flood direction, the most vulnerable point for breaking, safety for flood etc. Fig. 1 is geomorphologic land classification map of the Mekong Delta in Vietnamese territory. The typical combination of elements that comprise the geomorphologic landform units in the Mekong Delta is as follows: [Large Natural Levee + Small Natural Levee + Delta + Sand Dune]. Generally, the typical combination of geomorphologic landform units in alluvial and coastal plains is as follows: [Fan + Natural Levee + Delta]; however, the Mekong Delta does not contain an alluvial fan, but it has wide-area network system of rivers and canals on the low relief structure. This is because the landform surface is inclined at a very small angle, 0.01/1000, and the Mekong River does not transport gravels; in fact, it flows through several intermountain basins where it deposits gravels. As a result of the geomorphologic classification, the Mekong River Delta can be classified in detail as follows: lower terrace (alluvial terrace), natural levee, back swamp, delta, subaquatic delta, sand ridge, sand dune with lowlands between sand dunes, and tidal flat.

The typical geomorphologic elements of the study area are as follows: Residual Hills, Marine Terraces and Holocene Terraces, Natural Levees, Back Swamps, Sand Dunes, Sand Ridges with saline lowland dismals, Tidal Flats with ebb and tide levees, Mangrove Forests with Nipa palms, Submerging Forests or Inundation Forests, Former river courses. The relief structure of the Mekong River Delta is monotonous; however, the forefront delta along the East China Sea is occupied by high elevation sand dunes while the western part of the delta is occupied by a tidal flat facing the Gulf of Thailand. A higher natural levee is distributed in the upper delta and the relative height between the natural levee and the back swamp is 4–5 m in the upper delta while a lower natural levee is distributed in the lower delta and the relative height is less than 1 m in the lower delta. These characteristics display the inundation and flooding processes in this delta.

The geomorphologic landforms are related with the following water related hazard; 1) Delta and estuary– storm surge, high tide, Tsunami, web and tide, 2) Back swamp and Back marsh – deep inundation, long period inundation, 3) Former river course – flood water route, 4) Alluvial fan – devastated flood damage with gravels and sands, 5) Sand dune – safety against river flood, but trivial damage under storm surge and Tsunami, 6) Sand ridge – shifting tendency under sever river flood, 7) Natural levee – well drain after flooding, 8) Tidal creek – suffered by web and tide, 9) Alluvial terrace (formed in Holocene) – suffered by severe river flood, 10) Residual hill – gully forming under torrential rainfall, 11) Pleistocene terrace – terrace slope should be suffered by torrential rainfall. In the view of the physical environment, the landform structure has a close connection between the flooding and inundation.

3. Mekong Delta and Changing Flood

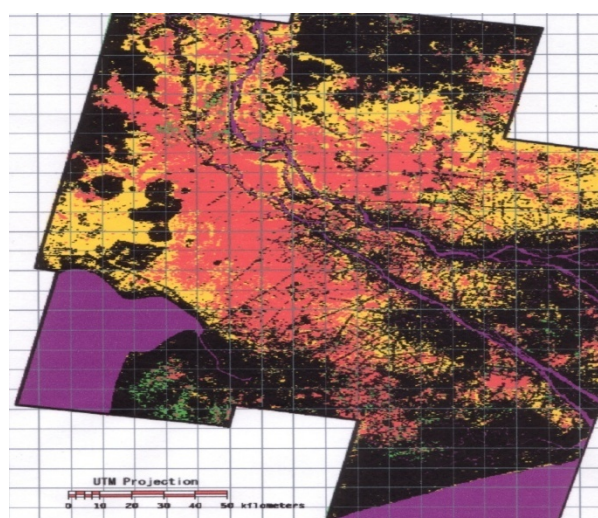


Fig.2: Flood inundation area of the Mekong River Delta

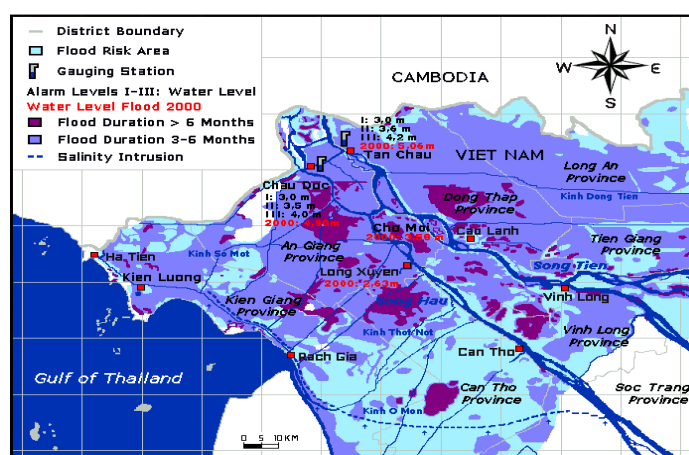


Fig.3: 2000 flood and inundation area of the Mekong River Delta

The Mekong Delta has been suffered by severe flood in the last decade and 1996 flood and 2000 flood were the memorial and historical records of the flooding damage. After 1996 flood, several infrastructures were settled on the flood plain in Vietnamese side and after that the condition of flood has been changed because of the hydro condition transformed. Conducting for damage analysis in the last ten years, three types of flooding damage were evaluated: 1) overflow type: in the upper reaches—the inundation depth is the greatest and diffusion speed is high, 2) land side water inundation type: in the middle reaches—the flooding is gentle and exhibits long stagnation, 3) tidal effect and saline intrusion type: in the lowest reaches—flooding cases such as typhoons and high tides, and the flood depth is low; however, they are unaffected by river flooding in the Mekong Delta. Comparing the time series of JERS 1 SAR images with the geomorphologic land classification map, the flooding propagation can be monitored. When the flood usually begins on the flood plain in June, it is distributed in the depths of the back swamps, and the flood flowing from Cambodia propagates to the lower reaches around the natural levee in August. The flood spreads and covers the surface of delta, and it overflows the natural levee in September; however, roads and artificial piled lands remain safe. The delta front and the sand dune complex zone are unaffected by the river flood in September. The river flood stops at the central part of the floodplain because the above point is located on a significant boundary that connects the sand dune complex zone and the delta.

The relationship between the geomorphology and the flooding features is as follows: 1) the longest inundation flood zone exists for more than 3 months in the deeper back swamp, namely, back swamp I; 2) the shallow depth inundation area lies in back swamp II and here, the inundation period is less than 1 month; 3) natural levee I and II experience overflow but exhibit rapidly reducing flooding in the monsoon season; 4) the coastal plain with the sand dunes and the lowland between the sand ridges is unaffected by the overflowing from the main Mekong River; however, it experiences tidal effects, storm surges, and typhoons; 5) the length of the inundation period in the lowlands between the sand ridges is less than 1 month, and the inundation depth is less than 50 cm; 6) the eastern part of the Mekong River Delta, which is a former river course, is a flood flow course in the rainy season; 7) the urbanized area experiences flooding; however, the inundation depth is less than 50 cm; 8) back swamp II, located in the central part of the delta, experiences inundation for 1 month; however, the suburban areas.

In the contrast, human activities such as infrastructure construction have transformed the flood characteristics in this delta. The hard infrastructures development is making convenient facility for living, agriculture and industrial place for activities, in contrast, flooding characteristics are transformed by infrastructure construction under enormous flooding. The flood flow trend in Mekong Delta undergoes profound variations. An increasing tendency is found in maximum water level, especially accelerated toward the downstream but maximum water level at main observation stations of the Mekong River have decreased. The infrastructure development in the lower Mekong is a reason that causes variation in the lower Mekong. The higher embankments and strengthening of dikes and roads have become obstructions to flood drainage, increasing flood peaks. Man-made activities have also influenced the inflow to and outflow from the Mekong River Delta, by 1) decreasing the amount of overbank flow and across the border between Cambodia and Vietnam, but 2) increasing flow in canals, and 3) decreasing drainage to the West Mekong region while the amount drained to the Gulf of Thailand increases.

In order to understand in greater detail the mechanism of flood propagation and inundation, numerical models should be applied to simulate flood propagation, and comparisons among scenarios must be carried out (Fig.4).

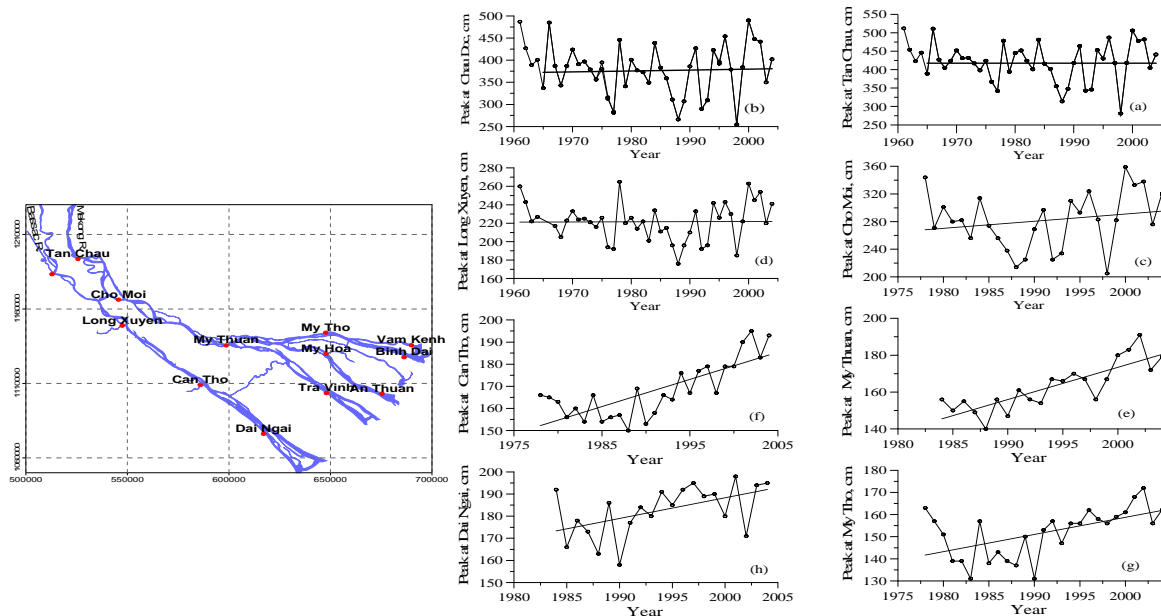


Fig.4: Variation of maximum water level of the Mekong River

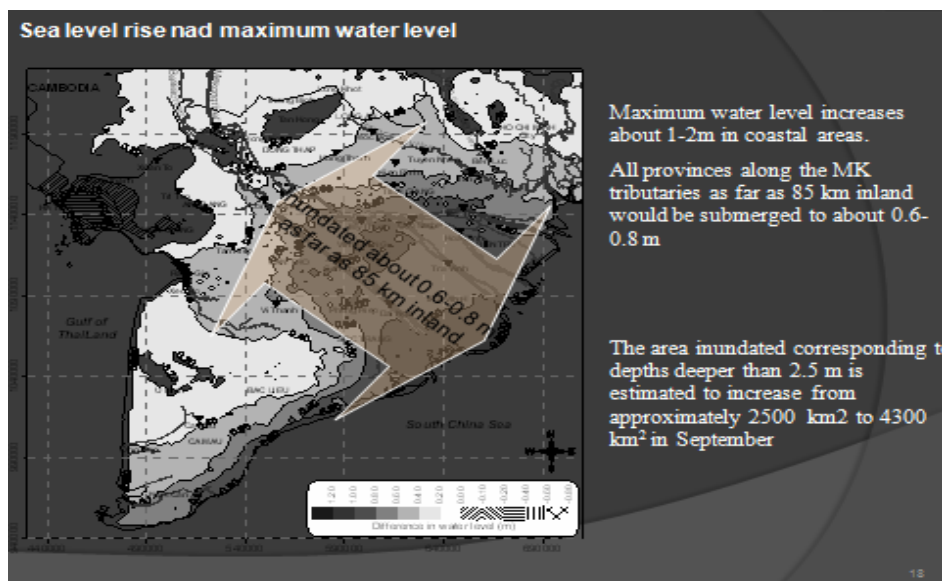


Fig.5: Simulation of the flood phase under the sea level rise in future

We simulated the flood phase of the Mekong River delta in future environmental change (Fig.5). The low laying fluvial plain should be affected by deep inundation and sea water intrusion in more inland.

4. Adaptation and Mitigation

What kind of technology should be needed for mitigation in the huge low relief fluvial plain and thus international river basin. The Mekong River Commission now discusses the following programs of the Mekong river basin such as development, water utilization and conservation of natural environment. The Flood management and mitigation are the most important programs in the lower Mekong River Basin Country (Fig.6).

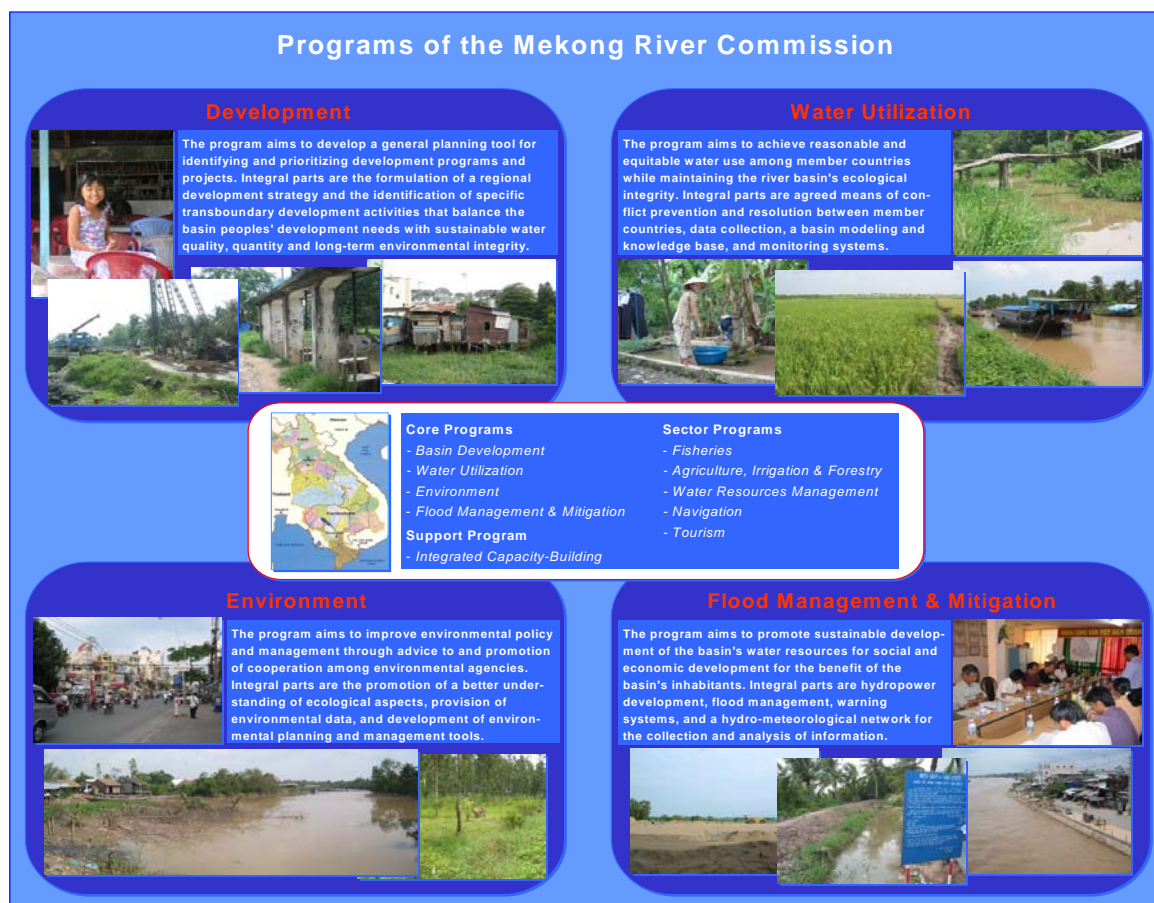


Fig.6: Programs for Mekong River Delta

However, there is very few of flood observation data and now need more exactly evidence for adaptation and mitigation, 1) transnational sharing of catchment-related information and data, 2) guidance on methods of collecting and analyzing data for monitoring and evaluating risk reduction activities, 3) identification of appropriate indicators for the many different forms that flood reduction can take, 4) implementation of a disaster information system where all relevant data obtained from remote sensing, at gauging stations, in the field, from statistics or maps is entered, 5) ensuring that agricultural practices are in harmony with the geophysical systems in order to avoid aggravate flood hazards, 6) preparation of more reliable flood probability information.

5. Conclusion

We should consider the future as for new project for flood monitoring of Monsoon Asia, evaluation of nature and extent of risks and vulnerability, well organizing the knowledge networking, supportive policies, standards, regulations, and design guidance. The rapid land cover change has been remarkable in the large river Mekong, especially upper part of China and lower part of Vietnam. After deforestation on the slope land, water resource development in the whole basin, and agricultural development in the middle reaches and floodplain, residential region and agricultural farm land have been suffered by severe flood in every monsoon seasons. The evidence of severe flood can be traced in the long period observation data and remote sensing data analysis in the study area. However, the dimension of flooding is now depending on the floodplain landform and reformation of landform by human activities, thus we should know the exact information of the natural environmental structure, natural environmental change and natural environmental dynamism. When we decide the policy of mitigation and adaptation toward natural hazard, we need more exact estimation, simulation and evaluation for decision making.