

Development of Numerical Models for Water Resources Management of Dong Nai – Saigon River Basin in Context of Climate Change and Rural Development

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(気候変動と地域開発に伴うドンナイ–サイゴン川流域の水資源管理のための数理モデルの開発)

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論 文 内 容 の 要 旨

The downstream of the Dong Nai - Saigon River Basin spreads over a wide area, including Ho Chi Minh City (HCMC) and six provinces: Binh Duong, Dong Nai, Tay Ninh, Long An, Dong Thap and Tien Giang, with a total area of 10,805.2 km². This area is a low-lying land, adjacent to the East Vietnam Sea and about 15% of this area has been often an intertidal area (1,593.6 km²). In general, this low-lying area is strongly influenced by the variation of two factors: river flow and tidal current.

In recent years, many large reservoirs have been constructed in the upstream area for multiple purposes of flood control, hydropower generation, irrigation and industrial usages. However, failure of equipment or mishandling of reservoir operation caused a huge disaster in the downstream of the Dong Nai – Saigon River Basin. Moreover, the impact of tidal current considerably increases, and salt water intrusion problems and lack of fresh water have been seriously happening on the Saigon River. Furthermore, climate change - rising sea level is also an important factor which governs increase of salinity intrusion, flooding, and hamper flood drainage in the Plain of Reeds (Dong Thap Muoi area, a part of Mekong Delta) and HCMC. Extreme rainfall on the Dong Nai - Saigon River Basin combining the high tides and rising sea levels will progressively put pressure on the drainage system and increased flooding in HCMC in the near future.

The objectives of this research are to develop numerical models for optimal water resources management of Dong Nai – Saigon River Basin in context of climate change and rural development and to propose several countermeasures for mitigating flooding, salinity intrusion and river ecosystem.

Firstly, numerical models for rainfall-runoff process using the Tank model and the NAM model incorporated with a parameter-optimization technique of Genetic Algorithm (GA) for the Dautieng Reservoir Basin. The simulated runoff results of two optimized hydrological models achieved a good performance as compared to observed data through two indicators of correlation coefficients and Nash-Sutcliffe coefficients which were 0.90 and 0.82 in the GA–Tank model and 0.90 and 0.80 in the GA–NAM model respectively.

Next, the model of optimal reservoir operation using a constrained genetic algorithm (CGA) was also constructed for multi-use reservoir management of Dautieng Reservoir and the scenario analyses were conducted from the viewpoints of river ecosystem conservation and salt water intrusion from a river mouth. The optimal reservoir management simulated by the proposed CGA-optimization model showed the effective performance in comparison with the current operation in simulated 20 years (1999-2008). In addition to that, the results also indicated that water deficits in the scenarios reduced significantly in spite of ensuring adequate amount of environment base flow.

Then, a tool of vulnerability assessment using a GIS-based hydraulic model, a depth-damage function and flood loss model was developed to estimate flood damage and discriminate land areas from the

viewpoint of flood inundation damage in the downstream of the Dong Nai-Saigon River Basin. The obtained results of flood loss estimation showed the land areas with high/low vulnerability if extreme flood events would occur. This approach gained an important outcome in contribution of urban management and disaster risk mitigation measures to decision makers.

Lastly, the two-dimensional model (MIKE 21/3 Coupled FM) was applied to simulate the effect of sea level rise on the sedimentation of the Mekong River Estuaries based on the sea level rise (SLR) scenarios that Vietnamese Government has been employing for every national land development projects. The results indicated that the erosion of river bed was very serious with a lowering of 0.5m every year. Influenced by sea level rise, the velocity increased slightly within the range 5–7% in the low-SLR scenario but increased considerably up to 21% in the high-SLR scenario. In the two simulated SLR scenarios, suspended sediment became to be much higher in the estuarial area and led to consequent aggradation of the coastline in the Mekong River Estuaries, while the bathymetry of the coastal zone became steeper.

In this dissertation, the deterministic approaches were proposed for modeling and solving urgent problems in water resources management for the Dong Nai - Saigon River Basin. The empirical results indicated the applicable potential of numerical models for the water resources management. The results also showed that the SLR and development strategy are not only significantly impact on operation of reservoirs and inundation in the downstream of the Dong Nai – Saigon River Basin, but also influence to sedimentation of the Mekong Delta Estuaries. The aforesaid outcomes highlighted that the Dong Nai – Saigon River Basin is dramatically affected by climate change and rural development. This study is the key contribution to avoid the mistakes of past and building resilience into managing water sensitive cities, and improve decision-making process to guide HCMC towards aspired benefits in the coming decades.