Basic Structure of Flood Inundation Model in the Mekong Delta

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Introduction

This study is to develop a flood inundation model in the Mekong Delta that can be used for examining the possibility and effectiveness of semi-control of flood for improvement of agricultural practices in specific areas. The application of hydraulic model can help for analysis the inundation process on the flooding area. In this paper, sub-area based reservoir model is taken into account for the first step before applying hydraulic model. The outcome of this model is expected to be useful for planning of flood control measures and managing the control facilities for irrigated farmland in the Mekong Delta. Temporal and spatial data required for modeling were collected and summarized in Table 1.

Table 1: Data collection

<table>
<thead>
<tr>
<th>No</th>
<th>Data</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DEM of the Mekong Delta</td>
<td>100 meter posting, Map:scale:1:100,000</td>
<td>Mekong River Commission (MRC)</td>
</tr>
<tr>
<td>2</td>
<td>GIS data from MRC</td>
<td>Land cover/Soil/Drainage/Flood map</td>
<td>Mekong River Commission (MRC)</td>
</tr>
<tr>
<td>3</td>
<td>Cambodia’s GIS (phase I&amp;II)</td>
<td>Landuse/Drainage/Geology/ Raod</td>
<td>Min. Public Work and Transportation</td>
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<tr>
<td>4</td>
<td>Water level (2002–03)</td>
<td>20 stations at various point in the floodplain</td>
<td>Min. Water Resources, Phnom Penh</td>
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<tr>
<td>8</td>
<td>CD with PopMap application</td>
<td>Consist of country map/map each 24 prov.</td>
<td>Min. of Planning, Phnom Penh</td>
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<tr>
<td>9</td>
<td>Agricultural statistics</td>
<td>Cropping pattern from 2000–2004</td>
<td>Min. of Agriculture</td>
</tr>
</tbody>
</table>

The Flood Inundation Model

In the previous approach, the whole Cambodia’s floodplain was divided into 4 zones based on the mainstreams network (see Fig.1) and water balance there was analyzed (Sothea. K. et al. 2003). For detail analysis of water movement in the zoned areas, the zones were divided again into a total of 24 sub-areas (SA). In the Mekong Delta, water flow is governed by micro-topography such as natural levees, back-mash, natural or artificial channels and embankments. For instance, a part of water from Mekong and Basac rivers is drawing into the back-mash through Colmatage canals and this water is used for agricultural production in both rainy and dry seasons. The sub-areas were set considering those governing factors. Figure 2 shows sub-divided area in the entire flooding area, and Table 2 presents the size of each divided zone and sub area. For the first step, a simple sub-area based reservoir model is employed. The exchange of flow between sub-area (SA) and the river and neighboring SAs in time step takes place maintaining the mass balance equation:

\[ V_{t+1} = V_t + (Q_{in} - Q_{out}) \Delta t + R - ET_a - Inf \]  

where, \( V_t \) is volume of water in floodplain compartment at time \( t+1 \), \( Q_{in} \) is inflow from the river to SA or from SA to SA, \( Q_{out} \) is return flow between river and SA or neighboring SAs, \( R \) is net rainfall, \( ET_a \) is evapotranspiration, \( Inf \) is infiltration, \( t \) is time.

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The flow into or from of a certain sub-area is determined according to the structures links (Riccardi, 1998) as follows:

1. Flow controlled by wire link

\[ Q_{ki} = \mu \sqrt{2gh_i (h_i - h_k)} \]  

(2) \(-\) if \( h_k > h_w \) and \( h_i > h_k \)

\[ Q_{ki} = \mu b_k \sqrt{2gh_i (h_i - h_k)} \sqrt{(h_i - h_k)} \]  

(3) \(-\) if \( h_i > h_w \) and \( h_i > h_k \)

The equation (2) is used also for the link between river and SA, whereas equation (3) is used for return flow from SA into river.

2. Flow controlled by culvert link

\[ Q_{ki} = \frac{1}{n} A_{ki} R_{ki} \sqrt{(h_k - h_i)} \]  

(4) \(-\) for full flow through culvert

\[ Q_{ki} = A_{ki} \sqrt{\frac{h_k}{B_{ki}}} \]  

(5) \(-\) for critical depth

3. Head loss or control section link

This link is used for flow singularity with head loss due to abrupt changes in cross-section. Two flow conditions are possible (free and submerged).

\[ Q_{ki} = \sqrt{2gh_i (h_i - h_w)} (Cd A_{ki}^2 - A_{ki}^2) \]  

(6)

\[ Q_{ki} = \sqrt{2gh_i (h_i - h_w)} (Cd A_{ki}^2 - A_{ki}^2) \]  

(7)

In the above equations, \( Q_{ki} \) is discharge flow between \( S A_k \) and \( S A_i \); \( h_{ki} \) is water depth between \( S A_k \) and \( S A_i \), \( S \) is slope of the two \( S A_k \) and \( S A_i \); \( h_w \) is crest elevation; \( \mu, \mu_i \) are coefficients; \( h_{Cri} \) is \( A_{ki} \) is cross-section area of \( (SA)_{ki} \); \( R \) is perimeter; \( g \) is acceleration of gravity, \( B_{ki} \) is top width of culvert between \( S A_k \) and \( S A_i \); \( h_{Cri} \) is critical level in control section; \( Cd \) is discharge coefficient in control section; \( A_{Cri} \) is wetted area of control section for critical level; \( A_{Sc} \) is wetted area in control section.

Future Plan

For the next step, a floodplain model based on 1D and 2D hydraulic models (Kazama et al. 2002) together with GIS is to be employed for simulating flood water and the inundation extent in the Delta. This research is partially supported by CREST of the Japan Science and Technology Agency and the Japan Fund for Global Environment (JFGE).

Reference: