InfoWorks RS Model as Supporting Tools for Managing Sarawak River Basin

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IN a feature article published in the June 2008 issue of JURUTERA, the authors introduced the concept of integrated hydrosystem approach for managing the Sarawak River Basin [1]. The use of Logical Framework as an integration tool was also demonstrated for managing and developing water supply in the Sarawak River Basin. In this article, the authors will demonstrate how hydraulics modelling could be used as a supporting tool in developing the Logical Framework for Integrated Flood Management in the Sarawak River Basin.

LOGICAL FRAMEWORK FOR INTEGRATED FLOOD MANAGEMENT

The Sarawak River Basin is prone to flooding. Though flooding is a frequent occurrence in the basin (the most severe flood occurred from 25-28 January 1963), major floods seems to be occurring more frequently in recent years with water rising between 1m to 3m for some low lying localities in the basin.

Some examples are the floods from 3-5 February 2003, 23-26 January 2004, 28-29 December 2006, and the most

Table 1: Logical framework for Sarawak river basin integrated flood management

Narrative Summary	Verifiable Indicators	Means of Verification	Important Assumptions
Ultimate Goal To reduce the excessive flood damages at Batu Kitang and Batu Kawa	1.0 Economic growth increase. 2.0 Property and crops value increase. 3.0 Live losses prevented. 4.0 Health and hygenie improved.	1.0 SPU Annual Report. 2.0 DID Sarawak Annual Flood Report.	1.0 Participation of all stakeholders to success integrated Flood Management.
Objectives 1.0 GIS flood map in used by various departments. 2.0 Early flood warning and forecasting center in operation. 3.0 Evacuation centers in operation. 4.0 Community education.	1.0 Information transmits among the departments become faster and precise. 1.1 Stakeholders able to make decision based reliable information 2.0 Less complaint from public. 3.0 The flood victims able to be provided stay, food and medical care. 4.0 Public knowledgeable to evacuate using the right path before flood.	1.0 SPU enforce policy that every related department to use the GIS Flood map and to restrict the development on the Floodplain. 2.0 DID Sarawak Annual Flood Report. Electronic notice board at the main road.	**Objectives to Ultimate Goal** 1.0 Effective law enforcement on floodplain. 2.0 Joint operation rules for Early Flood Warning and Forecasting Center and Evacuation Center. 3.0 Integrated Water Resources Management is enhanced.
Outputs 1.0 Thorough ground information survey been collected. 1.1 Single Geographical information System (GIS) platform for various departments' usage has been developed. 2.0 GIS has been updated from time to time. 3.0 Early flood warning and forecasting center has been setup. 4.0 Evacuation centers are completed. 5.0 Public awareness increase.	1.0 Mapping using GIS can be carried out. 1.1 Information sharing among the departments can be achieved. 1.2 GIS able to trace the latest changes on the ground. 2.0 Land price increase. 2.1 Population growth increase. 2.2 More housing and commercial center been built up. 3.0 Land price increase. 3.1 Population growth increase. 3.2 More housing and commercial center been built up. 4.0 Public able to get information easily, either through mass media or related department webpage.	1.0 Land and survey reports from Land and survey department. 1.1 Coordination among the departments which lead by ICTU. 1.2 Annual report by ICTU. 2.0 Annual report from Land and Survey Department. 2.1 More income for MBKS. 3.0 Annual report from Land and Survey Department. 3.1 More income for MBKS. 3.2 More housing and commercial center been built up. 4.0 Fewer damages and live losses reported. 4.1 Hygiene during flooding period improved.	**Outputs to Objectives** 1.0 Funds are available. 2.0 Each department sharing the single GIS platform. 3.0 Proper operation of Early Flood Warning System and Evacuation Center. 4.0 All Stakeholders concern and participate in the Integrated Flood Management.
Activities 1.0 Thorough ground information survey on topographical and landuse information. 1.1 Set up Single Geographical Information System (GIS) platform for various departments' usage. 1.2 Continuous effort to ensure the GIS has been updated from time to time 2.0 Setup an early flood warning and forecasting center. 2.1 Human resources and community development. 3.0 Construction of evacuation centers. 4.0 Community Education programme.	**Inputs** 2.0 Budgets. 3.0 Other Pre-requirements 4.0 Staff and Technicians. 5.0 Researchers. 6.0 Workshops and Coordination meetings.	**Costs** 1.0 Budgets. 2.0 Other Pre-requirements.	**Activities to Outputs** 1.0 Funds are available. 2.0 Each department has the facilities of GIS. 3.0 Approval for the Early Flood 4.0 All Stakeholders participate in the programme.

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recent from 10-13 January 2009 and 29-30 January 2009. The floods in the basin usually occur during heavy rainfall which coincides with high tides. A logical framework for integrated flood management was developed by the authors in the hope that this framework would serve as a guide for stakeholders in managing flood for the basin (see Table 1).

INFOWORKS RS FOR FLOOD MODELLING IN THE SARAWAK RIVER BASIN

A hydraulics model for the Sarawak River Basin was developed by the authors using the InfoWorks River Simulation (RS) software. To demonstrate, the model was utilised to have an inundation analysis along the river corridor for the January 2004 flood event (see Figure 1) by incorporating two mitigation structures, *i.e.* the Kuching Barrage and the upcoming flood bypass channel. The river model had computed floodwater level and flood maps at different time steps.

The authors proposed an extraction of those data to have a rate of floodplain submergence from river bankfull level to a depth of 2m. By taking the basis that, (1) a normal adult height is about 1.6m, (2) human settlements were known to be close to the river, (3) most of the village houses outside Kuching were single-storey dwellings, a flood depth of 2m

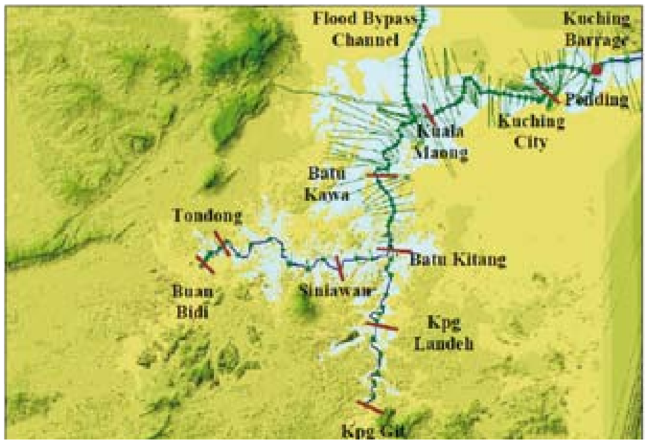

Figure 1: Model simulation of the Sarawak river basin for the January 2004 flood event

was presumably taken as a reference point and beyond 2m would inflict drowning. Some localities such as Batu Kawa had a record flood level of up to 6m.

The rate of floodplain submergence would be a reflection of the river flooding severity. The higher the value of this rate indicates the more vulnerable the location is to fast rising and widespread floodwater. Table 2 has a display of floodwater rising from bankfull level to 0.5m, progressively to 1m, 1.5m and 2m together with its associated time and affected length.

Table 2: Estimation of rise and spread of floodwaters from the Sarawak river

	January 2004 Flood Event Simulation Results Flood Levels from Bankfull												
	1st 0.5 m			2nd 0.5 m			3rd 0.5 m			4th 0.5 m			Remarks
	L^A	t	L/t*	L^A	t	L/t*	L^A	t	L/t*	L^A	t	L/t*	
Lower Sungai Sarawak													
Pending	1.816	0.40	4.541	1.816	0.40	4.541	1.816	0.40	4.541	1.816	0.40	4.541	Rank 1
Kuala Maong	2.005	0.40	5.012	2.005	0.40	5.012	2.005	0.40	5.012	2.005	0.40	5.012	Rank 2
Upper Sungai Sarawak													
Batu Kawa	4.636	2.40	1.932	4.636	2.40	1.932	4.636	2.40	1.932	4.636	2.40	1.932	
Sungai Sarawak Kanan													
Tondong	1.929	7.00	0.275	1.903	4.20	0.451							
Siniawan	2.186	1.20	1.822	2.212	1.55	1.427	2.240	3.05	0.737	2.240	4.40	0.507	
Sungai Sarawak Kiri													
Kampung Landeh	1.531	1.20	1.278	1.613	5.25	0.307							

Notes:

**Rate of floodplain submergence =*

$$\frac{\text{Length of affected area from river bank towards an urban center within the Intended time}}{\text{Time of floodwater reaching the intended level from bankfull level}}$$

[L in km]
[t in hour]

Pending, Tondong and Kampung Landeh have peak flood depth less than 2 m

Table 3: Sub-logical framework for Sarawak river basin flood management

<table>
<tr><td>Goal
This would relate to the dedication to Flood Disaster Risk Reduction and Emergency Response at the Sarawak River basin level.</td><td>Objective Verifiable Indicators (OVI)
Smilarly, this would relate to the measurement of reducing injuries, deaths and properties damage caused by floods at the basin level.</td></tr>
<tr><td>Popular
• Practicing of an automatic (realtime) flood early warning system
• Community-based cooperation</td><td>This would relate to the achievement of the impact indicators set out below and the merging realisation of strengthening local authorities and communities capacities in flood preparedness. This is an exercise for the stakeholders of the Sarawak River basin management.</td></tr>
<tr><td>Outputs
• Timely evacuation of community in the identified areas
• Timely decision to minimise damages to properties</td><td>• Identified area from modelling outputs:
<table>
<tr><th>Priority</th><th>Location</th><th>Rate of Submergence</th></tr>
<tr><td>1</td><td>Kuala Maong</td><td>5.8</td></tr>
<tr><td>2</td><td>Pending</td><td>4.5</td></tr>
<tr><td>3</td><td>Batu Kawa</td><td>1.9</td></tr>
<tr><td>4</td><td>Siniawan</td><td>1.8</td></tr>
<tr><td>5</td><td>Kpg Landeh</td><td>1.3</td></tr>
<tr><td>6</td><td>Tondong</td><td>0.4</td></tr>
</table>
Lower Sarawak River is found to be the most critical to river flooding.</td></tr>
<tr><td>Activities
• Test against time to evacuate</td><td>• Estimated time factor from modelling outputs:
<table>
<tr><th>Location with more than 2m flood depth</th><th>Time to reach 2m flood depth from bankfull</th></tr>
<tr><td>Kuala Maong</td><td>1 hour 25 min</td></tr>
<tr><td>Batu Kawa</td><td>16 hours 25 min</td></tr>
<tr><td>Siniawan</td><td>11 hours</td></tr>
</table>
Taking the most critical time, evacuation should be carried out within one and half hour.</td></tr>
<tr><td>• Test against route to evacuate</td><td>• Estimated effected length of flooded area from river bank from modelling outputs:
<table>
<tr><th>Location with more than 2m flood depth</th><th>Time to reach 2m flood depth from bankfull</th></tr>
<tr><td>Kuala Maong</td><td>2.091 km</td></tr>
<tr><td>Batu Kawa</td><td>4.785 km</td></tr>
<tr><td>Siniawan</td><td>2.240 km</td></tr>
</table>
Route to evacuate should be outside the flood zone.</td></tr>
<tr><td>• Test against when to warn
• Test against mechanism to warn etc.</td><td>• Need to link up with Meteorological Department.
• Need to link up with Rivers Board as authority in Operation Plans.</td></tr>
</table>

SUB-LOGICAL FRAMEWORK FOR FLOOD EARLY WARNING SYSTEM

As mentioned earlier in this article, a wider picture of the framework in descriptive nature has been provided; this section attempts to demonstrate an analytical in nature flood management framework inferred from the Sarawak River Basin modelling outputs. In this study, a flood early warning system guided by hydro-informatics is described – logical framework efforts that showed logic sequences and impact indicators for improved flood relief activities in Kuching city which is located in the basin. The significance of this section is, therefore, to portray river modelling outputs in influencing the decision making processes. This section concentrated on a smaller sub-framework (Table 3) which identifies the priority areas most likely in need of emergency notification, critical time for evacuation and most effective route for relief.

CONCLUSION

Hydraulics modelling, when used together with Logical Framework, is an excellent tool to support the decisions on flood management measures. This article has shown the utilisation of river basin modelling incorporated into the development of a sub-logical framework which is part of the bigger logical framework.

ACKNOWLEDGEMENT

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REFERENCE

[1] Bong, C.H.J. and Putuhena, F.J. (2008). "Logical Framework for Managing Sarawak River Basin through Integrated Hydrosystem Approach". *Bulletin of The Institution of Engineers, Malaysia, ISSN*: 0126-9909, Bil. 2008, No.6, pp. 16 -19.