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EXTENDED ABSTRACT

Evaluating the Performance of Collection and Disposal of Surface Runoff Network Using SWMM Model (Case Study: the City of Likak, Kohgiluyeh and Boyer Ahmad Province)

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Introduction

Flood is one of the most dangerous and destructive phenomena which endangers people's lives and properties all around the world. According to statistics of a 30-year period (1974-2003), about 2162 major floods have occurred which constitute 34% of the world's disasters (Tajbakhsh and Khodashenas, 2012). Floods are frequent and ruinous in Iran due to severe weather condition. Several factors intensify the risk of flood in urban areas including urbanization, land use changes, inappropriate drainage systems, and impermeable area development (Sabeti, 2011).

Likak has faced numerous floods due to high rain density, high rate of urban development, unsafe and unproductive urban development, ignoring safety criteria in developing urban areas, road watering issues, inefficient drainage systems, and inefficacious water channels. Water channels and drainage issues have never been evaluated in this town. Applying an effective runoff management plan is the ultimate solution for the problem of flood in Likak. Storm Water Management Model (SWMM) is one of the most reliable and prevailing models for evaluating and managing the urban runoff issue. SWMM is a dynamic rainfall-runoff simulator which can be used for simulating the quantity and quality of the run-off for a single raining event or continuous long-term rains (Gironas et al, 2010). Yu et al. (2014) adapted and calibrated SWMM to Jinan, a typical piedmont city in China. Fourteen storms were used for model calibration and validation, finally verifying large-scale applicability of the model to piedmont cities. Results of this study verified that SWMM is applicable to large-scale cities.

Methodology

In this study, the performance of run-off channels in Likak was evaluated using SWMM model. In order to determine the basin boundary, the land use map with the 1/5000 scale was applied. The TIN (Triangulated Irregular Networks) and flow path layers were combined to determine the outlet on the basin boundary. The basin boundary was determined and divided into 52 sub-basins using the combination of slope map, the land-use map, and the results of on-site visits. After determining the basin boundary and the sub-basins, the performance of the model was evaluated. The Manning

Coefficient of roughness and surface storage in permeable and impenetrable areas was calculated using the combination of land-use maps, survey data in Arc GIS software, and the SWMM manual tables. In this study, five flood events with their corresponding runoffs were selected for the evaluation and calibration of the model. The flow rate generated after several storms in the outlet of the channels was determined by estimating the runoff height using a ruler. The model was calibrated and validated using two and three rainfall data sets, respectively. Three performance indexes were used for model validation including Nash-Sutcliff (CNS), sum of squares errors (RMSE), and Bias. The formulas for these indicators are as follows.

$$CNS = 1 - \sum_{i=1}^{n} \frac{(Q_{si} - Q_{oi})^2}{\sum_{i=1}^{n}(Q_{oi} - Q_{avo})^2}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Q_{si} - Q_{oi})^2}$$

$$BIAS = \frac{\sum_{i=1}^{n}(Q_{si} - Q_{oi})^2}{\sum_{i=1}^{n} Q_{oi}} \times 100$$

Results and Discussion

The results of computational and observed hydrographs showed that the observed peak, the volume of flow, the simulated peak, and the volume of flow values were in good agreement with each other (Table 1).

Table1- Amounts of simulated and observed peak flow and flow volume

	Discharge (m^3/s)			Volume (m^3)		
event	Simulated	Observed	Error (%)	Simulated	Observed	Error (%)
2015/10/30	0.44	0.37	7	6.32	3.65	42
2015/11/11	0.78	0.59	19	9.49	6.88	27
2015/12/16	0.57	0.53	4	7.06	5.1	28

Calibration results showed that the simulated peak flow rate and flow volume had a good correlation with the observed values. Calibration results were applied to estimate the values of model parameters. To evaluate and validate the model, two rainfall events were used. The calibration results validate the performance and accuracy of the developed model (Table 2).

Table2- Values of model performance indicators in calibration and validation periods of the SWMM model

event rainfall	parameter	step	NS	BIAS%	RMSE
2015/10/30	discharge	calibration	0.71	6.32	0.0032
2015/11/11	discharge	calibration	0.74	9.33	0.0052
2015/12/16	discharge	calibration	0.78	15.8	0.0073
2015/12/28	discharge	validation	0.57	11.33	0.0021
2015/12/31	discharge	validation	0.59	10.57	0.00034

The run-off results showed that the SWMM model had a good performance in simulating the peak flow and the flow volume. Studies by Rostami Khalaj (2011), Veisipanah (2013) and Donquan et al. (2009) have also confirmed the good performance of SWMM. Flood hydrographs were calculated for 2-, 5- and 10-year return periods, and the regions with the highest runoff depth were determined. The critical areas for the collecting network of surface runoff during the occurrence of the flood were identified. Also, results showed that the water channels were not efficient in conveying water, especially in continuous rainfalls, which may cause flooding. In order to determine the optimal hydraulic dimensions of the surface drainage system channels, parts of the system of collecting surface runoff in the area that were not able to pass the design flood with the current conditions were identified after simulation and their optimal dimensions were suggested. To solve this issue, the channel cross-section area and slope should be increased.

Conclusion

Results of model validation show that the predicted maximum flow rate and the flow volume have a good correlation with the observed values (or the experimental data). The validation results were used to estimate the optimal parameter values. The validation results confirm the efficiency and accuracy of the model, which is acceptable for all events in this study. Results of calibration show that the model can accurately predict the observed values. As computer simulation methods significantly decrease the study expenses and save time, they can be used to improve water management performance.The method applied in this study can be used to improve drainage and water channel design in urban basins.

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