

DEVELOPMENT OF FLOOD DEPTH-
DAMAGE CURVE FOR URBAN AREA IN
KUANTAN, PAHANG

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MASTER OF SCIENCE

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We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Banjir merupakan bencana alam yang sering berlaku di seluruh dunia yang mendatangkan impak kerugian ketara. Oleh itu, penilaian kerosakan banjir telah menjadi elemen penting yang perlu dipertimbangkan dalam pengurusan risiko banjir yang efisien. Lengkung kerosakan banjir merupakan kaedah yang paling diterima untuk menganggarkan kerosakan banjir di seluruh dunia. Walau bagaimanapun, kaedah ini hanya mengambil kira faktor kedalaman banjir, manakala faktor keadaan banjir yang lain iaitu faktor impak dan kerentanan biasanya diabaikan. Seharusnya, penilaian risiko banjir perlu mengambilkira semua aspek yang mempengaruhi tahap kerosakan bagi mendapat gambaran sebenar kerosakan banjir yang berlaku. Di Malaysia, penilaian risiko banjir sukar dilakukan kerana kekurangan data, maka terdapat penilaian yang menggunakan model kerosakan dari negara-negara maju yang lain. Oleh itu, kajian ini menyediakan rangka kerja bagi menganggarkan nilai kerosakan banjir yang memfokuskan penghasilan model kerosakan banjir multivariat dan lengkung kedalaman-kerosakan banjir setempat bagi kategori kediaman dan komersial. Data empirikal banjir pada tahun 2013 di Lembangan Sungai Kuantan digunakan untuk mengenalpasti pengaruh impak dan kerentanan terhadap tahap kerosakan banjir menggunakan beberapa kaedah regresi multivariat iaitu Regresi Linear Berbilang (MLR), Regresi Pokok (RT) dan Regresi Hutan Rawak (RF). Model regresi multivariat tersebut telah digunakan untuk menjana data kerosakan sintetik yang mana data daripada model regresi RF telah dipilih kerana keputusan validasi yang memuaskan. Lengkung kerosakan banjir telah dibina dengan memplot peratusan kerosakan banjir dengan kedalaman banjir menggunakan kombinasi data sintetik dan empirikal. Jumlah anggaran kerosakan banjir pada tahun 2013 dan bagi pelbagai kala kembali purata (ARI) telah dikira dengan mengambilkira hubungan keterdedahan, bahaya, dan kerentanan. Hasil kajian menunjukkan bahawa ciri sosio-ekonomi dan harta benda mempunyai korelasi yang signifikan dengan tahap kerosakan banjir. Faktor kedalaman banjir didapati mempunyai kesan yang ketara kepada semua kategori kerosakan, diikuti oleh tempoh banjir, nilai bangunan, jenis bangunan dan pendapatan isi rumah/perniagaan. Lengkung kedalaman-kerosakan banjir setempat yang dibangunkan dalam kajian ini adalah boleh diterima jika dibandingkan dengan kajian-kajian terdahulu di mana pekali korelasi, R^2 , yang diperolehi adalah lebih besar daripada 0.8 untuk kategori kediaman dan komersial. Anggaran purata kerosakan seunit bagi kawasan kediaman di Permatang Badak adalah paling tinggi (RM13,053) dan premis perniagaan di Sungai Isap mengalami kerosakan paling teruk (RM37,153). Anggaran kerosakan banjir yang dikira bagi ARI 10 tahun, 20 tahun, 50 tahun dan 100 tahun menunjukkan kerosakan bertambah teruk dengan peningkatan ARI. Validasi bagi model kerosakan banjir multivariat, lengkung kerosakan banjir serta anggaran kerosakan banjir telah diuji dengan data empirikal tahun 2013 dan indikator ralat piawai. Keputusan validasi adalah bagus jika dibandingkan dengan kajian terdahulu yang mana nilai Ralat Min Mutlak (MAE), Min Punca Kuasa Dua (RMSE), Ralat Min Pincang (MBE), Pekali Variasi (CV) yang diperolehi menghampiri nilai 0 dan Kadar Ketepatan (HR) adalah hampir kepada 0.9. Walaupun kajian ini merupakan kajian khusus setempat, namun rangka kerja yang dihasilkan ini boleh digunakan bagi penilaian kerosakan banjir di kawasan lain yang mengalami masalah kekangan data. Di samping itu, kajian ini juga boleh dijadikan garis panduan dalam membantu kerja-kerja penilaian kerosakan banjir pada masa hadapan di Malaysia, serta dapat membantu pembuat-pembuat dasar pembangunan dalam menguruskan strategi yang berkaitan dengan risiko banjir.

ABSTRACT

Flood is a frequent natural hazard worldwide that has significant financial consequences. Therefore, flood damage assessment has become a crucial element to be considered in the implementation of efficient flood risk management. The flood damage curve is a commonly accepted approach for the estimation of flood damages worldwide. However, this method usually considers only the flood depth while the effect of other flooding conditions such as the impact and resistance parameters to the degree of flood damages are normally neglected. In fact, the flood risk assessment should cover all damage dimensions to obtain an extensive description of flood damages. In Malaysia, conducting the assessment of flood damages is challenging due to data scarcity, thus, there are assessments that adopt damage models from other developed countries. Hence, this study provides flood damage estimation framework with limited data focusing on the derivation of a multivariate flood damage model and site-specific flood depth–damage curves for the residential and commercial areas. The empirical dataset collected from the 2013 flood in the Kuantan River Basin (KRB) was used to investigate the influence of impact and resistance variables on the level of flood damages using the multivariate regression approach including Multiple Linear Regression (MLR), Regression Tree (RT) and Random Forest (RF) techniques. The multivariate analysis was utilized to generate synthetic damage data where RF regression model was selected due to its satisfactory results. The damage curve was established by plotting the damage percentages against the observed flood depth using a combination of the synthetic and empirical data. The total direct tangible flood damage for Kuantan during year 2013 flood and various Average Recurrence Intervals (ARIs) was calculated using the combination of hazard, vulnerability, and exposure. The study's findings revealed that socio-economy and property characteristics have shown a significant correlation to the degree of flood damage. Flood depth was found to have a significant effect in all damages categories followed by flood duration, property value, building type and household/business income. The developed site-specific flood depth–damage curve in this study was acceptable compared with other studies where the correlation coefficient, R^2 , was greater than 0.8 for residential and commercial categories. The average damage per unit to residential area in Permatang Badak was the highest (RM13,053) and the business premises in Sungai Isap suffered the worst damage (RM37,153). The estimation of flood damage for the return period of 10 years, 20 years, 50 years, and 100 years shows that damage worsens with increasing ARI to residential and commercial categories. The multivariate flood damage model, flood damage curve, as well as estimation of flood damage were tested by comparison to empirical 2013 data and calculation of statistical error indicators. The validations results were good compared to previous studies where the values of Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Mean Bias Error (MBE), Coefficient of Variation (CV) obtained were closer to 0 and HR was close to 0.9. Although it is a site-specific study, the framework can be applied to assess the potential flood damages to other data-scarce areas. In addition, this study may serve as guidelines to assist in future damage assessment works in Malaysia, as well as offer decision-makers with an indispensable tool for managing strategies related to flood risk.

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