UNIVERSITI PUTRA MALAYSIA

LANDSLIDE SUSCEPTIBILITY ANALYSIS USING SINMAP IN FRASER'S HILL,MALAYSIA

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FPAS 2012 10

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

January 2012

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

LANDSLIDE SUSCEPTIBILITY ANALYSIS USING SINMAP IN FRASER'S HILL, MALAYSIA

By

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January 2012

Chair : Assoc. Prof. Wan Nor Azmin Sulaiman, PhD

Faculty : Faculty of Environmental Studies

Shallow landslide is normally occurred between 1 to 2 meter depth and it also normally occurs in highly and completely weathered rocks (Grades IV to VI) or known as residual soil. It can be very active and widespread in occurrence especially during rainy seasons where the soil moisture is saturated or nearly saturated. Due to spatial variability in rainfall and runoff, soil depths, land use and topographic characteristics, it is often difficult to predict and thus control the landslides occurrences at the catchment level. In this study an attempt has been made to evaluate the applicability of a slope stability model (SINMAP) to simulate shallow landslide in tropical environment. The study was carried out in Fraser Hill Catchment, a popular hill resort area in Peninsular Malaysia. Model input parameters include soil bulk density, friction angle, cohesion and hydraulic conductivity were gathered through *in situ* and laboratory analysis. Landslides locations were recorded using GPS as well as image interpretation of SPOT 5 satellite imagery to establish landslide source areas inventory. The historical landslide inventory was used to assess

the model output performance. To evaluate the accuracy of the landslide susceptibility map produced by the model, two approaches were taken which are Success Rate (SR) and Modified Success Rate (MSR). Comparison between simulated model output and the historical landslide inventoried map were done through overlay analysis. The results indicated that 68% of the actual landslide inventoried fall within the unstable area predicted by the model. The model also indicated 70.5% of the catchment area is naturally unstable that most of the upper and middle part of the catchment is susceptible to shallow landslide, particularly areas where slopes are steep and lack of vegetation. When simulated using a 70 mm/hr of precipitation and estimated soil depth at 2.64 m, 89% of the catchment area is in saturated zone when the event occurred. Prior to that, 87% of the landslide inventory fall into that saturated zone and this indicate that hydrologic factors might triggered the landslide incidence in Fraser Hill. DEM spatial resolution effect on the landslide susceptibility map was assessed by aggregating the DEM into 20, 30, 40, 60 and 80 m resolution sizes. Result shows that using coarser DEM resolution, the accuracy of prediction decreased gradually. However, at 20 and 30 m DEM resolution the result doesn't significantly change. Perfect DEM might not be available but choosing the right resolution for specific project is more important. Sensitivity analysis was done to evaluate model input parameters which are soil bulk density, friction angle, cohesion and ratio of transmissivity over recharge (T/R). Results from sensitivity analysis shows that the most significant parameter that gave the highest impact on total predicted susceptible landslide area is soil cohesion. By manipulating the mean soil cohesion value at ±0.5 Std. Dev (SD), ±1.0 SD and ± 2.0 SD, the changes in predicted unstable zone varies from 0.3% (+2.0SD) to 89.0% km^2 (-2.0SD). Friction angle, bulk density and T/R input come second, third and fourth respectively. The simulated result was considered to be reasonably accurate taking into the consideration of constraint in the accuracy of the DEM constructed from 1: 50,000 topographic map. These findings may suggest that the model can be used as a decision support tool in many environmental impact analysis projects on catchment wide basis in this country.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ANALISIS PEMETAAN KAWASAN BERPOTENSI MENGALAMI TANAH RUNTUH MENGGUNAKAN SINMAP DI BUKIT FRASER, MALAYSIA

Oleh

MOHD. HAFIZ BIN ROSLI

Januari 2012

Pengerusi : Prof. Madya Wan Nor Azmin Sulaiman, PhD

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Tanah runtuh cetek biasanya berlaku pada kedalaman satu hingga dua meter dan selalunya berlaku pada tanih yang berada di Gred IV hingga VI. Tanah runtuh cetek boleh jadi sangat aktif dan merebak terutamanya semasa musim hujan di mana lembapan tanah adalah penuh atau hamper dipenuhi. Disebabkan oleh faktor kebolehubahan ruang hujan dan larian air, kedalaman tanah, guna tanah dan ciri-ciri topografi, tanah runtuh cetek sering kali sukar untuk diramal dan faktor-faktor ini dijangka akan mengawal kejadian tanah runtuh di sesuatu kawasan tadahan. Dalam kajian ini, satu kajian telah dibuat untuk menguji kebolehgunaan model kestabilan cerun (SINMAP) untuk mensimulasikan tanah runtuh cetek dalam persekitaran tropika. Kajian telah dijalankan dalam di kawasan tadahan Bukit Fraser, kawasan peranginan yang popular di Semenanjung Malaysia. Parameter yang digunakan sebagai input adalah ketumpatan pukal tanah, sudut geseran tanih, kepaduan tanih dan keberkonduksian hidraulik. Parameter ini telah dikumpul melalui data lapangan dan analisis di makmal. Lokasi tanah runtuh direkodkan

menggunakan GPS serta tafsiran imej satelit SPOT 5 untuk mendapatkan inventori lokasi kawasan tanah runtuh. Inventori tanah runtuh digunakan untuk menilai prestasi dan ketepatan hasil permodelan. Untuk menilai ketepatan peta kawasan potensi tanah runtuh yang dihasilkan oleh SINMAP, dua pendekatan telah diambil iaitu Kadar Kejayaan (SR) and Kadar Kejayaan Diubahsuai (MSR). Perbandingan antara hasil model simulasi dan inventori tanah runtuh peta dibuat melalui analisis pertindihan data reruang. Keputusan menunjukkan 68% daripada jumlah inventori tanah runtuh sebenar termasuk ke dalam kawasan tidak stabil yang diramal oleh model. Model juga menunjukkan 70.5% daripada keuasan kawasan tadahan secara adalah semula jadi tidak stabil di mana kebanyakan daripada bahagian tengah dan atas kawasan tadahan berpotensi untuk mengalami tanah runtuh cetek, terutama kawasan lereng-lereng yang curam dan kekurangan tumbuhan. Menggunakan 70 mm / jam data hujan dan anggaran kedalaman tanah adalah 2.64 m, 89% daripada keluasan kawasan tadahan berada dalam zon tepu air apabila hujan tersebut turun. Rentetan dengan itu, 87% daripada inventori tanah runtuh terletak di zon kelembapan tepu yang tinggi dan ini menunjukkan yang faktor hidrologi mungkin mencetuskan insiden tanah runtuh di Fraser Hill. Kesan resolusi DEM pada peta kawasan potensi tanah runtuh adalah ditaksirkan dengan membahagikan DEM kepada saiz resolusi yang berbeza iaitu 20, 30, 40, 60 dan 80 meter saiz resolusi. Keputusan menunjukkan dengan penggunaan resolusi DEM lebih kasar, ketepatan hasil permodelan menurun beransur-ansur. Bagaimanapun, menggunakan 20 dan 30 meter resolusi, keputusan DEM tidak menunjukkan perbezaan yang ketara. Resolusi DEM yang sempurna mungkin tidak terdapat tetapi faktor pemilihan resolusi yang betul untuk projek tertentu adalah lebih mustahak. Analisis kepekaan dilakukan kepada parameter yang digunakan sebagai input kepada model seperti ketumpatan pukal tanah, sudut geseran tanih, kepaduan dan ratio antara keberkonduksian elektrik dan imbuh (T/R). Keputusan dari analisis kepekaan menunjukkan bahawa parameter yang paling penting yang memberi kesan tertinggi mengenai jumlah meramalkan kawasan potensi tanah runtuh ialah kepaduan tanih. Dengan memanipulasi nilai kepaduan tanih menggunakan ±0.5 SD, ±1.0 SD and ± 2.0 SD, julat perubahan adalah dari 0.3% (+2.0SD) dan 89.0% km2 (-2.0SD) dalam meramalkan kawasan yang tidak stabil dalam kawasan tadahan Bukit Fraser. Sudut geseran, ketumpatan pukal dan input T/R masing-masing menduduki tempat kedua, ketiga dan keempat Hasil simulasi dianggap agak tepat dengan mengambil kira pertimbangan kekangan dalam ketepatan penghasilan DEM yang dibina dari 1: 50,000 peta topografi. Hasil daripada kajian ini mencadangkan yang model boleh digunakan sebagai alat bantuan untuk membuat keputusan dalam banyak projek analisis kesan alam sekitar terutamanya yang dilakukan di kawasan yang seluas kawasan tadahan.

ACKNOWLEDGEMENTS

Praise to Allah Almighty for blessing and strength which enable me to complete this thesis. I would like to thank my supervisor, Assoc. Prof. Dr.Wan Nor Azmin Sulaiman for giving me valuable suggestions and continuous encouragement during the preparation of this thesis. Sincere thanks also to the guidance and encouragement by my co-supervisor, Dr. Taher Buyong whom gave consultation in spatial analysis. I am also very thankful to Mr. Othman Deris and Mr. Awie from Department of Forestry Raub for giving the required assistance during the field data collection. To my friend, Dr.Benni from Austria, thanks so much for your constructive suggestion.

Many thanks also to IKRAM to provide me with the unpublished technical report and constructive suggestion. Special thanks also to the Slope Team of the SBESA 09, UKM members whom help me with the shallow landslide inventory collection and soil sampling collection. Sincere thanks to my colleagues in the Faculty of Environmental Studies and Faculty of Engineering, UPM for their guidance and support throughout the entire program.

Lastly, to my family, wife and son, thanks for being patience and understanding.

I certify that an Examination Committee has met on 30 January 2012 to conduct the final examination of Mohd. Hafiz bin Rosli on his Master of Science thesis entitled "Landslide Susceptibility Analysis Using SINMAP In Fraser Hill, Malaysia" in accordance with Universiti Putra Malaysia (Higher Degree) Act 1980 and Universiti Putra Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the degree in Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledge. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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(MOHD HAFIZ BIN ROSLI)

Date: 30 January 2012

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