UNIVERSITI PUTRA MALAYSIA

EFFECT OF LAND USE CHANGE ON WATER BALANCE AND SUSPENDED SEDIMENT YIELD OF TALEGHAN CATCHMENT, IRAN

MAJID HOSSEINI

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By

MAJID HOSSEINI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

Dedicated to:

MY LATE PARENTS, MY WIFE AND MY CHILDREN

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman: **Professor Mohd Amin Mohd Soom, PhD, P. Eng, FLEM.**
Faculty: **Engineering**

The effects of global warming, climate change, and land use changes on catchment water balance and water quality have become the main concern in catchment water management in recent years. Due to rapid population growth upon dam construction, the Taleghan catchment in Iran has undergone rapid land use changes, urbanization, and water resource development for agriculture, industry, and domestic water supply. These changes could potentially cause devastating effects on both water balance and water quality in the catchment. However, there is no known study being conducted to predict the effect of land use changes on water balance and water quality in this area. Therefore there is a need for a physically-based and computationally efficient distributed hydrological model with a simple GIS interface to evaluate the effects of land use changes in Taleghan catchment. The main objective of this research was to examine the effect of land use changes on water balance and suspended sediment yield of the Taleghan catchment in northwest Iran. From a review of various models, a semi-distributed model, Soil and Water Assessment Tools (SWAT) was selected

for this study. The model was applied to the study area and its performance for predicting runoff was evaluated. Two popular programs that are linked into SWAT namely SUFI2 and ParaSol were applied for calibration and validation purposes, respectively.

Comparing the water balance between Joestan (upper part) and Galinak (outlet) stations showed evapotranspiration losses were around 38% and 49% of the precipitation, respectively. Surface runoff was 21% of the precipitation for the upper part of the catchment and 33% at the outlet. Groundwater and lateral flows took place mostly in the mountainous upper part of the catchment. The results of annual suspended sediment yield showed that more sedimentation took place upstream of Galinak with 7.3 t/ha but 5.8 t/ha at Joestan. The water balance at the outlet was predicted for the period between January 1995 and August 2004. The results shows 2.4% increase in surface runoff and 2.04% decrease of interflows. These results indicate the sediment yield increased from 7.3 t/ha to 8.3 t/ha at the outlet during the study period with progressively ascending surface runoff and suspended sediment yield and progressively descending interflows. Sediment yield predictions were compared to the seven land use scenarios. The maximum increase in sediment yields compared to the last observed land use (2007) was 1.6 t/ha (19%) for scenario 7 (all rangeland is bare). Scenario 2 (rangeland to agriculture, 0-20%) and scenario 6 (rangeland to the bare, 0-40%) showed increase of 4% and 12%, respectively. Scenario3 (agriculture to urban 0-20% slope), scenario 4 (agriculture to the urban, 0-40% slope), and scenario 5 (rangeland to the urban, 0-20% slope) showed decreases in sediment yields of 2.5%, 5.7% and 1.2%, respectively. The land use changes in the seven scenarios had varying effects on the water components in relation to slope steepness. These land use scenarios showed increase of 4%, 5.2%, 7.5%, 8%, 10%,

and 15% in surface runoff and decrease of 8.7%, 10%, 12.7%, 30%, 31%, and 45% in groundwater flow for scenarios 2, 3,4,5,6, and 7, respectively. This research has successfully developed a customized SWAT model useful for water engineers and managers in their planning of future land developments of the Taleghan catchment. The database system of the Taleghan catchment, using dispersed datasets in GIS environment could be used not only for modeling purposes but also for decision making. The information on soil erosion sensitivity of a particular area in the catchment will be useful for the government planning of soil and water conservation control measure, such that priority actions on sediment control and restoration budget will be allocated where it is most required. The study has produced a technique with reliable capability and high accuracy for annual and monthly water balance components and suspended sediment yield over different slope classes of the Taleghan catchment. This can pave the way for similar studies in other catchments with the same climatic conditions.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PERUBAHAN PENGGUNAAN TANAH TERHADAP KESEIMBANGAN AIR DAN ENAPAN TERAMPAI DI KAWASAN TADAHAN TALEGHAN, IRAN

Oleh

MAJID HOSSEINI

Disember 2010

Pengerusi: Profesor Mohd Amin Mohd Soom, PhD, P. Eng., FIEM
Fakulti : Kejuruteraan

Kesan pemanasan global, perubahan iklim dan perubahan penggunaan tanah terhadap imbangan air dan kualiti air di kawasan tadahan telah menjadi perhatian utama dalam pengurusan air dalam kawasan tadahan sejak beberapa tahun kebelakangan ini. Disebabkan pertumbuhan populasi yang pesat, pembinaan empangan, kawasan tadahan Taleghan di Iran telah melalui perubahan penggunaan tanah yang pesat, urbanisasi dan pembangunan sumber air untuk pertanian, industri dan bekalan air domestik. Perubahan-perubahan ini berpotensi menyebabkan kesan kemusnahan terhadap kedua-dua imbangan dan kualiti air dalam kawasan tadahan. Walaubagaimanapun, didapati tiada kajian yang dijalankan untuk mengkaji kesan perubahan penggunaan tanah terhadap imbangan dan kualiti air di kawasan ini. Oleh itu, model taburan hidrologi berdasarkan fizikal dan pengkomputeran yang efisien bersama dengan interface GIS yang ringkas diperlukan untuk menilai kesan-kesan perubahan penggunaan tanah di kawasan tadahan Taleghan. Objektif utama kajian ini

adalah untuk menilai kesan perubahan penggunaan tanah terhadap imbangan air dan jumlah sedimen terampai di kawasn tadahan Taleghan, Barat Laut Iran. Daripada ulasan pelbagai model terdahulu, model separa-taburan, Kaedah Penilaian Tanah dan Air (SWAT) telah dipilih untuk kajian ini. Model ini diaplikasi ke atas kawasan kajian dan prestasinya dalam menganggar larian air telah dinilai. Dua program popular yang dihubungkan dengan SWAT dinamakan SUFI2 dan ParaSol, masing-masing telah digunakan untuk tujuan penentukuran dan pengesahan.

Perbandingan imbangan air di antara stesen Joestan (bahagian atas) dan Galinak (laluan keluar), masing-masing menunjukkan kehilangan evapotranspirasi daripada hujan adalah sekitar 38% dan 49%. Larian air permukaan daripada hujan untuk bahagian atas kawasan tadahan adalah 21% dan sebanyak 33% di laluan keluar. Kebanyakan aliran air bawah tanah dan sisi adalah di bahagian atas kawasan tadahan, di atas puncak gunung. Keputusan jumlah sedimen terampai menunjukkan lebih banyak sedimen di bahagian hulu, Galinak dengan jumlah 7.3 t/ha manakala sebanyak 5.8 t/ha di Joestan. Imbangan air di laluan keluar untuk jangkamasa antara Januari 1995 dan Ogos 2004 telahpun diramal. Keputusan menunjukkan kenaikan sebanyak 2.4% untuk larian permukaan dan penurunan sebanyak 2.4% untuk aliran antara. Keputusan ni menunjukkan hasil sedimen meningkat dari 7.3 t/a kepada 8.3 t/ha di laluan keluar dalam tempoh kajian dengan peningkatan larian permukaan dan hasil sedimen terampai secara progresif serta penurunan progresif unutk aliran antara. Ramalan hasil sedimen telah dibandingkan dengan tujuh senario penggunaan tanah. Kenaikan hasil sedimen yang maksimum dibandingkan dengan pemerhatian ke atas guna tanah terbaru (2007) adalah sebanyak 1.6 t/ha (19%) untuk senario 7 (semua kawasan ragut adalah terbuka). Senario 2 (kawasan ragut kepada pertanian, 0-20%) dan senario 6 (kawasan ragut kepada terbuka, 0-40%) masing-masing

enunjukkan kenaikan sebanyak 4% dan 12%. Senario 3 (pertanian kepada bandar, 0-20% kecerunan), senario 4 (pertanian kepada bandar, 0-40% kecerunan) dan senario 5 (kawasan terbuka kepada bandar, 0-20% kecerunan) masing-masing menunjukkan penurunan jumlah sedimen iaitu 2.5%, 5.7% dan 1.2%. Perubahan penggunaan tanah di ketujuh-tujuh senario yang disebutkan telah mempelbagaikan kesan-kesan terhadap komponen air berkaitan dengan kedalaman kecerunan. Kesemua senario penggunaan tanah masing-masing menunjukkan peningkatan larian permukaan sebanyak 4, 5.2, 7.5, 8, 10 dan 15% serta penurunan dalam aliran air bawah tanah untuk senario 2,3,4,5,6 dan 7, masing-masing sebanyak 8.7, 10, 12.7, 30, 31 dan 45%. Kajian ini telah berjaya membangunkan model SWAT bersesuaian yang berguna untuk jurutera-jurutera air dan para pengurus untuk merancang pembangunan tanah pada masa hadapan di kawasan tadahan Taleghan. Sistem pangkalan data kawasan tadahan Taleghan yang menggunakan dataset taburan dalam persekitaran GIS bukan sahaja boleh digunakan untuk tujuan pemodelan, tetapi juga untuk membantu dalam membuat keputusan. Maklumat mengenai sensitiviti hakisan tanah akan berguna dalam perancangan kerajaan untuk pemuliharaan tanah dan air, sedemikian tindakan utama terhadap kawalan sedimen serta bajet pemulihan akan diperuntukkan dimana ia lebih dikehendaki. Ini dapat membuka jalan untuk kajian yang serupa dalam kawasan tadahan lain dengan keadaan iklim yang sama. Kajian ini telah menghasilkan teknik dengan kebolehan yang boleh dipercayai dan kejituan yang tinggi untuk komponen keseimbangan air tahunan dan bulanan serta jumlah sedimen terampai untuk kelas-kelas kecerunan yang berbeza di kawasan tadahan Taleghan.

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Majid Hosseini

I certify that and Examination Committee has met on date of viva to conduct the final examination of Majid Hosseini on his PhD thesis entitled "Effect of Land use Changes on Water Balance and Suspended Sediment Yield of Taleghan Catchment, Iran" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Chairman, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

EXAMINER 1, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Examiner 2, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Independent Examiner, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Independent Examiner)

BUJANG KIM HUAN, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia
Date:

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

Mohd Amin Mohd Soom, PhD, P.Eng., FIEM
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Supervisor)

Mohammad Ghafouri, PhD, P. Eng.
Associate Professor
Research Institute for Water Scarcity and Drought, Tehran-Iran
(Joint Supervisor)

Abdul Halim Ghazali, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Abdul Rashid Mohd Sharif, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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