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EFFECTS OF TOPOGRAPHICAL FACTORS AND SOIL CHARACTERISTICS ON GULLY PROPERTIES IN KOHGILOYE AND BOYER AHMAD PROVINCES, IRAN

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By

ABDAL SHAHRIVAR

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

June 2013

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Dedicated to my father's soul

my precious mother

and

my wife

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirements of the degree of Doctor of Philosophy

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June 2013

Chairman: Christopher Teh Boon Sung, PhD

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Gully erosion is unequivocally an important form of soil erosion in the arid and semi-arid regions of Iran. These lands, which are the main sources of income for farmers, are being rapidly decimated. Moreover, nomadic livestock grazing in such regions is heavily dependent on these lands. Sediments resulting from gully erosion can engender a plethora of environmental problems, such as water quality problems in waterways, rivers and lakes as well as decrease fertility of farmland. This study focuses on the basic implications of the roles of gully watershed and certain physico-chemical soil properties upon gully erosion in a semi-arid region of 210 km^2. In this particular study, the Abgendi watershed, which has the largest number of gullies, was selected. In this area, all the gullies (53 gullies) were coded and 35 gullies were chosen randomly (using random numbers in Excel, function of random between) and studied. Each of these gullies has a small watershed, whose properties such as gully volume, gully length, slope above gully, distance between head-cut and borderline, altitude difference, gully watershed area and soil cover were determined. From the main waterway of the gully, soil sampling from head-cut and two walls in two depths (0-30 cm and 30 cm to bottom

of gully) was carried out. Physical characteristics of the soil, such as aggregate stability (AS), mean weight diameter (MWD), clay, sand and silt, and soil chemical properties such as electrical conductivity (EC), sodium adsorption ratio (SAR), organic carbon (OC), cation exchange capacity (CEC), calcium (Ca), magnesium (Mg) and sodium (Na) were determined. Moreover, in order to identify the main factors responsible for the development of gully erosion, the gullies were classified according to gully volume in three sizes: big, medium, and small gullies. The three gully volume groups were compared to one another on the basis of their topographical factors such as gully watershed areas, distance between head-cut and borderline, altitude difference of gully watershed area, slope above head-cut and gully bottom slope and then they were compared with the area without gullies (the control group) in terms of their soil's physico-chemical properties and soil cover such as percentages of vegetation cover, stubble and gravel. The results of the investigation of the soil texture in the gully and control areas indicated that the occurrence probability of gullies is low in soils which tend to have high amount of sand. Soils with silt clay loam texture are the most susceptible types of soils, while sandy loam and loam are the most resistant types to gully erosion in the study area. The soil texture groups and mean values of gully volume and length in soil texture groups in the top and sub-layer of gully head-cut and walls showed that the occurrence probability of gullies in the soil with silt loam and silt clay loam in the top layer, and clay loam and silt clay loam in the sub-layer is high. In contrast, the occurrence probability of gullies in the soil with loam texture is low. In other words, if a gully is formed in soils with clay loam and silt clay loam in the top layer, the gully can be very large and long.

The results of the comparison between the gully volume groups and control area indicated that some soil physical properties such as sand and proportion of sand / silt

+ clay in both top and sub-layers of head-cut (at least one of the gully volume groups), and sand, and proportion of sand / silt + clay in both top and sub-layers of the gully walls (all three volume groups), were significantly lower than those of the same depths in the control area. Furthermore, there was a positive correlation between the percentage of clay in the top and sub-layers of the head-cut and gully volume at the 5% level (2-tailed). Likewise, the proportions of clay / (sand + silt) in the top -layers of the head-cut were correlated positively with the volume and length of gully.

A comparison between the gully volume groups and the control area in terms of soil chemical properties showed that, except for EC in the sub-layer of the gully walls (big gully group) that was significantly higher than that in the same depth of the control area, none of the chemical factors was significant. However, there was a significant positive correlation between the volume and/or length of gully and Ca, Mg, EC in the head-cut top layer, EC in the head-cut sub-layer, Mg in the gully walls top layer, and EC and Ca in the gully walls sub-layer at the 5% level (2-tailed). However, comparison between the gully volume groups in terms of soil chemical properties indicated that soil chemical properties of the gully area were approximately uniform.

The result of the comparison between gully volume groups in terms of gully watershed properties demonstrated that some topographical factors such as distance between head-cut and borderlines, altitude difference and gully watershed area could explain the different sizes among gully volume groups. The correlation between these topographical factors and gully volume and length was strongly significant at 1% level. The statistical analysis of gully watershed properties not only explained the gully

volume and length but also explained the differences among the volume groups in the gully area.

The percentage of the vegetation cover in the study area showed that, under these circumstances, not only runoff generation is quickly formed, but raindrops can be quickly dispersed throughout the soil particles as well. This process is attributed to scarcity of soil cover. The result of comparison between control and gully area also showed that the soil covers in the different sizes of gully were uniform, but the vegetation cover of the control area was significantly higher than that in the gully area.

In order to develop a model, regressions between the gully length as a dependent variable and other measured factors as independent variables were performed using a stepwise method through SPSS. It should be mentioned that the same process was carried out for the gully volume as the dependent variable and all the measured factors as dependent variable. The gully length model indicated that gully length was affected by the percentages of clay in the top layer of the gully head-cut and walls, gully watershed area and distance between head-cut and borderline. Therefore, these three factors turn out have the greatest impact on gully erosion. Among these effective factors, the most important factor was distance between head-cut and borderline, with a β coefficient of 0.517,whereas the least important factor was clay percentage of the gully walls' top layer, with a β coefficient of 0.246. On the other hand, the gully volume model indicated that the gully volume was affected by distance between head-cut and borderline and clay of the head-cut top-layer. Comparison of the two models revealed that the gully length model could better explain the gully erosion development

than the gully volume model for the simple reason that it had stronger R, R^2 and adjusted R^2.

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

CIRI-CIRI PEMBENTUKAN KESAN HAKISAN PEPARITAN KAWASAN TADAHAN AIR DAN TANAH DI WILAYAH KOHGILUYEH BOYERAHMAD, IRAN

Oleh

ABDAL SHAHRIVAR

Jun 2013

Pengerusi: Christopher Teh Boon Sung, PhD

Fackulti: Pertanian

Hakisan peparitan merupakan bentuk hakisan di kawasan kering dan separa-gersang di negara Iran.Tanah, merupakan sumber pendapatan utama bagi petani sedang menghadapi masalah kemusnahan.Sumber makanan ternakan nomad di kawasan-kawasan tersebut sangat bergantung kepada tanah ini. Sedimen yang terhasil daripada hakisan peparitan ini menyebabkan begitu banyak mencemarkan alam sekitar, seperti masalah kualiti air pengairan, sungai dan tasik serta memusnahkan kesuburan tanah ladang. Kajian ini memberi tumpuan kepada implikasi asas kesan hakisan peparitan terhadap kawasan tadahan air dan keadaan fiziko-kimia tanah selepas dilanda hakisan peparitan di kawasan kering dan separa gersang seluas 210 km^2. Dalam konteks kajian ini, kawasan tadahan air Abgendi, yang mempunyai bilangan terbesar galur peparitan, telah dipilih. Dalam kawasan ini, 35 galur peparitan telah dipilih secara rawak dan dikaji. Setiap galur ini mempunyai satu titik kecil, keadaan tanah (seperti jumlah sampah, parit panjang, cerun parit, jarak antara tahad tarahan tanah dan pinggiran, perbezaan ketebalan sampah, kawasan tadahan air dan pelitub bumi) telah ditentukan. Dari parit laluan air utama, sampel tanah daripada tahad tarahan dan dua tebing dalam

dua kedalaman (0-30 cm dan 30 cm ke bawah dari peparitan) telah dijalankan. Ciri-ciri fizikal tanah, seperti kestabilan agregat (AS), min diameter berat (MWD), tanah liat, pasir dan kelodak, dan sifat-sifat kimia tanah seperti kekonduksian elektrik (EC), nisbah penyerapan natrium (SAR), karbon organik (OC), keupayaan pertukaran kation (CEC), kalsium (Ca), magnesium (Mg) dan natrium (Na), telah ditentukan. Selain itu, untuk mengenal pasti faktor utama yang bertanggungjawab terhadap hakisan peparitan, galur-galurnya dikelaskan mengikut saiz isi padu peparitan: iaitu galur besar, galur sederhana, dan galur kecil. Kumpulan isipadu peparitan dikelaskan mengikut saiz yang berbeza daripada galur dan kawasan tanpa galur (kumpulan kawalan) dibandingkan daripada segi sifat-sifat fizik-kimia tanah, dan tanah litup seperti peratusan tumbuhan pelindung, tunggul dan batu kelikir. Selain itu, kumpulan isi padu glur peparitan dibandingkan dari segi kandungan galur kawasan tadahan air, seperti peparitan kawasan tadahan air, jarak antara tahad tarahan dan sempadan, perbezaan ketinggian tebing peparitan kawasan tadahan air, cerun tarahan dan cerun bahagian bawah peparitan. Hasil daripada perbandingan antara kumpulan isipadu peparitan dari segi keadaan kawasan tadahan air menunjukkan bahawa beberapa faktor topografi seperti jarak antara tahad tarahan dan batas, perbezaan ketinggian dan peparitan kawasan tadahan air menunjukkan saiz yang berbeza di kalangan kumpulan isipadu peparitan. Korelasi antara faktor-faktor topografi dan isipadu galur dan panjang galur adalah amat penting pada peringkat 1% (2-hujung).Hasil korelasi antara jenis litup bumi (seperti tumbuhan perlindungan, tunggul dan batu kelikir) dan isipadu galur peparitan dan panjang peparitan tidak signifikan.Walau bagaimanapun, peratusan tumbuhan litup bumi dan tunggul kawasan kawalan berbanding dengan kawasan peparitan adalah lebih tinggi. Satu perbandingan antara kumpulan isi padu galur dan kawasan kawalan dari segi sifat-sifat kimia tanah menunjukkan bahawa,

kecuali SPR dalam sub-lapisan tebing peparitan (kumpulan peparitan besar) yang jauh lebih tinggi daripada itu dari segi kedalaman yang sama kawasan kawalan, tiada faktor-faktor kimia (seperti SAR, OC, CEC, Na, Ca dan Mg) yang signifikan. Walau bagaimanapun, terdapat korelasi positif yang signifikan antara isipadu galur atau panjang peparitan (atau kedua-dua jumlah dan panjang) dan Ca, Mg, EC di lapisan atas had tarahan, sub lapisan EC had tarahan, Mg di tebing atas lapisan peparitan, dan EC serta Ca dalam lapisan tebing peparitan kecil di peringkat 5% (2-tialed). Keputusan perbandingan antara kumpulan isi padu galur dan kawasan kawalan menunjukkan bahawa beberapa sifat fizikal tanah, seperti pasir dan kadar pasir / kelodak + tanah liat di atas dan lapisan sub-tahad tarahan (sekurang-kurangnya satu daripada jumlah kumpulan isipadu galur), dan pasir, serta kadar pasir / kelodak + tanah liat dalam kedua-dua lapisan atas sub-lapisan di bahagian tebing peparitan (kesemua tiga kumpulan isipadu), adalah jauh lebih rendah daripada kedalaman yang sama di kawasan kawalan. Selain itu, terdapat hubungan yang positif antara peratusan tanah liat di atas dan sub-lapisan tahad tarahan dan isipadu pada tahap 5% (2-tialed). Begitu juga, peratusan pasir dan kadar pasir / (tanah liat + kelodak) ada berkorelasi negatif dengan isipadu dan panjang galur. Kurang bilangan galur jika tanahnya gembur dan kelodak tekstur gembur di lapisan atas tahad tarahan, manakala bilangan yang paling banyak peparitan mempunyai kelodak tanah liat gembur dan tanah liat gembur dalam lapisan sub-tahad tarahan. Keputusan tekstur tanah dalam perbandingan dengan kumpulan tekstur tanah menunjukkan bahawa panjang peparitan dan isipadu meningkat dari tanah gembur kepada tanah liat gembur. Dalam kajian ini, menunjukkan sebagai usaha untuk menyediakan model, regresi antara panjang peparitan sebagai pembolehubah bersandar dan faktor ukuran lain sebagai pembolehubah tak bersandar telah dijalankan menggunakan kaedah langkah demi

langkah menggunakan SPSS. Model ini menunjukkan bahawa panjang peparitan terjejas oleh peratusan tanah liat pada lapisan atas tahad tarahan dan tebing, peparitan kawasan tadahan air dan jarak antara tahad tarahan dan pinggiran. Faktor yang paling penting ialah jarak antara tahad tarahan dan pinggiran, dengan β pekali sama dengan 0,517, manakala faktor yang paling kurang penting ialah peratusan tanah liat lapisan tebing peparitan, dengan pekali β sama dengan 0.246.

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I certify that a Thesis Examination Committee has met on 4 June 2013 to conduct the final examination of Abdal Shahrivar on his thesis entitled "Effects of Topographical Factors and Soil Characteristics on Gully Properties in Kohgiloye and Boyer Ahmad Provinces, Iran" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy.

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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 doctor of philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I hereby declare that the 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, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

ABDAL SHAHRIVAR

Date: 4 June 2013

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