UNIVERSITI PUTRA MALAYSIA

POTENTIAL EFFECTS OF CLIMATE CHANGE ON CARBON STORAGE IN IRAN BASED ON CLIMATE AND SOIL CARBON MODELS

RAHELEH FARZANMANESH

FPAS 2012 4

POTENTIAL EFFECTS OF CLIMATE CHANGE ON CARBON STORAGE IN IRAN BASED ON CLIMATE AND SOIL CARBON MODELS

By

RAHELEH FARZANMANESH

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

May 2012

Specially dedicated to,

To my lovely parents and husband

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

POTENTIAL EFFECTS OF CLIMATE CHANGE ON CARBON STORAGE IN IRAN BASED ON CLIMATE AND SOIL CARBON MODELS

By

RAHELEH FARZANMANESH

May 2012

Chairman: Assoc. Professor Ahmad Makmom Abdullah, PhD

Faculty: Environmental Studies

Soil organic carbon (SOC) is an important carbon pool, with the potential to drive large positive climate feedbacks. Climate change has the potential to alter terrestrial carbon storage since changes in carbon dioxide (CO_2) concentrations, temperature and precipitation could affect carbon inputs to soil, and soil carbon decomposition rates. This study aimed to investigate the potential effect of changes in temperature and precipitation on soil organic carbon in selected parts of Iran. For this aim, 19 climatic stations were chosen across the study area to determine trends in the long-term annual mean temperature and precipitation series. All stations showed increase in mean annual temperature during the 20 year period from 1986 to 2005. Garmsar, ferdous, Ramsar and Birjand with +3.25˚C, 2.1˚C, 1.65˚C and 1.3˚C, respectively had the highest increase. The annual precipitation trend illustrated that the decreasing trends mostly happened in the arid and semi arid regions of the study area such as Mashhad,

Gonabad, Ferdous, Semnan, Sabzevar, Shahroud and Torbat Heydarieh. To assess the influence of soil organic carbon under a changing climate, two climate change scenarios (A2 and B2) were used in the LARS-WG weather generator. The applied climate change scenarios were from the HadCM3 global climate model for the period 2011-2030. The evaluation of LARS-WG model was assessed by comparing between observed data and simulated data and their standard deviation. The evaluation between selected statistics of observed climate data and climate data generated by the model for both scenarios indicates that LARS-WG can predict the daily minimum and maximum temperatures better than daily precipitation. Climate change scenarios from this model indicated that temperature in the future will continue to increase (0.5˚C-1.8˚C). Precipitation is projected to decrease in the future for arid and semi arid regions (11%) but it will increase in northwest of the study area in future.

Prediction of temperature and precipitation for the period 2011-2030 was used as an input for RothC model to show soil organic carbon changes under climate change scenarios (A2 and B2). SOC in the study area accounted for 106.2 t C/ha. The results showed that soil organic carbon will generally decrease during next two decades. Simulations produced the following results: (i) The decrease rate of soil organic carbon in cultivated lands was higher than other biomass under A2 and B2 scenarios. (ii) Soil organic carbon would decrease from 8.45 t C/ha and

13.37 t C/ha by the year 2020 and 2030, respectively, under A2 scenario. It would decrease from 7.34 t C/ha, and 11.77 t C/ha by the year 2020, and 2030, respectively, under B2 scenario. (iii) The rate of SOC changes over time under B2 scenario was minimal during 2005-2030 in comparison with A2 scenario. (iv) This study found an additional released carbon from soil to the atmosphere under A2 scenario than B2 scenario. The results showed that the rate of additional CO_2 released to the atmosphere was highest in cultivated lands in both scenarios. The results also indicated that in the zones where precipitation and temperature have provided a better condition for SOM decomposition, the release of CO_2 to the atmosphere takes place at a higher rate. Modeling results from this study show that changes in temperature and precipitation can influence on soil organic carbon and RothC model can be used to calculate annual carbon inputs and SOC changes in different geographical regions.

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

KESAN TERHADAP PERUBAHAN IKLIM ON PENYIMPANAN KARBON DI IRAN BERDASARKAN IKLIM DAN MODEL CARBON TANAH

Oleh

RAHELEH FARZANMANESH

Mei 2012

Pengerusi: Professor Madya Ahmad Makmom Abdullah, PhD

Fakulti: Pengajian Alam Sekitar

Karbon organik tanah (SOC) kolam karbon yang penting, dengan potensi untuk memacu maklumbalas iklim positif yang besar. Perubahan iklim mempunyai potensi untuk mengubah penyimpanan karbon daratan sejak perubahan dalam karbon dioksida (CO_2) kepekatan, suhu dan pemendakan boleh menjejaskan input karbon kepada tanah, dan kadar penguraian karbon tanah. Kajian ini bertujuan untuk mengkaji kesan potensi perubahan dalam suhu dan pemendakan karbon organik tanah di bahagian-bahagian yang dipilih Iran. Untuk tujuan ini, 19 stesen iklim telah dipilih di seluruh kawasan kajian untuk menentukan trend dalam suhu jangka panjang min tahunan dan siri pemendakan. Semua stesen menunjukkan peningkatan dalam suhu purata tahunan dalam tempoh 20 tahun 1986-2005. Garmsar, ferdous, Ramsar dan Birjand dengan 3.25˚C, 2.1˚C, 1.65˚C dan 1.3˚C, masing-masing mempunyai peningkatan tertinggi. Trend pemendakan tahunan digambarkan bahawa trend menurun

kebanyakannya berlaku di kawasan kering dan separa gersang kawasan kajian seperti Mashhad, Gonabad, Ferdous, Semnan, Sabzevar, Shahroud dan Torbat Heydarieh. Untuk menilai pengaruh karbon organik tanah di bawah iklim yang berubah-ubah, dua senario perubahan iklim (A2 dan B2) telah digunakan dalam penjana LARS-WG cuaca. Digunakan senario iklim perubahan adalah dari model HadCM3 iklim global bagi tempoh 2011-2030. Penilaian model LARS-WG dinilai dengan membandingkan antara data yang diperhatikan dan data simulasi dan sisihan piawai mereka. Penilaian antara beberapa statistik terpilih data iklim yang diperhatikan dan data iklim yang dihasilkan oleh model untuk kedua-dua senario menunjukkan bahawa LARS-WG boleh membiak minimum harian dan suhu maksimum yang lebih baik daripada pemendakan harian. Senario perubahan iklim daripada model ini menunjukkan bahawa suhu untuk masa depan akan terus meningkat (0.5˚C-1.8˚C). Pemendakan dijangka menurun pada masa depan dalam kawasan kering dan separa gersang (11%) tetapi ia akan meningkat di barat laut kawasan kajian pada masa akan datang.Ramalan suhu dan pemendakan bagi tempoh 2011-2030 telah digunakan sebagai input bagi model RothC untuk menunjukkan perubahan tanah karbon organik di bawah senario perubahan iklim (A2 dan B2). SOC ini di dalam kawasan kajian menyumbang 106.2 tC/ha. Keputusan menunjukkan bahawa karbon organik tanah secara amnya akan menurun pada dekad akan datang. Simulasi mendapat keputusan berikut: (i) kadar decrese karbon organik

tanah di tanah yang ditanam adalah lebih tinggi daripada biojisim lain di bawah senario A2 dan B2. (ii) karbon Tanah organik akan berkurangan dari 8.45 t C/ha dan 13.37 t C/ha menjelang tahun 2020 dan 2030, masing-masing, di bawah senario A2. Ia akan berkurangan dari 7.34 t C/ha, dan 11.77 t C/ha pada tahun 2020, dan 2030, masing-masing, di bawah senario B2. (iii) kadar perubahan SOC dari masa ke masa di bawah senario B2 adalah kecil sepanjang 2005-2030 berbanding dengan senario A2. (iv) Kajian ini mendapati karbon tambahan dilepaskan dari tanah ke atmosfera, di bawah senario A2 daripada senario B2. Keputusan menunjukkan bahawa kadar CO_2 tambahan yang dilepaskan ke atmosfera adalah tertinggi di tanah yang ditanam di kedua-dua senario. Keputusan juga menunjukkan bahawa dalam zon di mana pemendakan dan suhu telah menyediakan suatu keadaan yang lebih baik bagi penguraian SOM, pelepasan CO_2 ke atmosfera berlaku pada kadar yang lebih tinggi. Hasil pemodelan dari kajian ini menunjukkan bahawa perubahan suhu dan pengaruh pemendakan karbon organik tanah dan RothC model boleh digunakan untuk mengira input karbon tahunan dan perubahan SOC di kawasan-kawasan geografi yang berbeza.

ACKNOWLEDGEMENTS

In the name of God, the Most Gracious and the Most Merciful,

It would not have been possible to write this thesis without the help and support of the kind people around me, to only some of whom it is possible to give particular mention here.

This thesis would not have been possible without the help, support and patience of my supervisor, Assoc. Prof. Dr. Ahmad Makmom, not to mention his advice and unsurpassed knowledge. The good advice, support and friendship of my external supervisor, Dr. Alireza Shakiba, has been invaluable on both an academic and a personal level, for which I am extremely grateful.

Special appreciation goes to my supervisory committee members, Assoc. Prof. Dr. Mohd Talib Latif and Assoc. Prof. Dr. Wan Nor Azmi, for their supervision and constant support. Their help of constructive comments and suggestions throughout the study have contributed to the success of this research. Not forgotten, my appreciation to Dr. Amin Hosseinasl for his invaluable support and knowledge regarding this topic.

I would like to acknowledge the academic and technical support of the UPM and Shahid Beheshti University of Iran and their staff, particularly in the Postgraduate division for supporting this research.

Last, but by no means least, I thank Dr. Majid Nokhandan, Dr. Iman Babaeian, Ms. Sharareh Malbousi and my friends in Faculty of Environmental Studies, Dr. Jamil, John and elsewhere for their support and encouragement throughout, some of whom have already been named.

Above all, I would like to thank my husband Mahdi for his unconditional personal support and great patience at all times. My beloved parents, brother and sisters have given me their unequivocal support throughout, as always, for which my mere expression of thanks likewise does not suffice.

I certify that an Examination Committee has met on 30 May 2012 to conduct the final examination of Raheleh Farzanmanesh on her Doctor of Philosophy thesis entitled "Potential Effects of Climate Change on Carbon Storage in Iran Based on Climate and Soil Carbon Models" in accordance with the Universiti Pertanian Malaysia (Higher degree) Act 1980 and Universtiti pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the student be award the Doctor of Philosophy.

Member of the Thesis Examination Committee were as follows:

Name of Chairperson, PhD
Prof. Madya Dr Mohammad Firuz Ramli
Faculty of Environmnetal Studies
Universiti Putra Malaysia
(Chairman)

Name of Examiner 1, PhD
Prof. Madya Dr. Osumanu Haruna Ahmed
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
(Internal Examiner)

Name of Examiner 2, PhD
Y.Bhg. Prof. Dato' Dr. Nik Muhamad bin Nik Majid
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Name of External Examiner, PhD
Associate Prof. Dr. Nathsuda Pumijumnong
Faculty of Environment and Resource Studies
University of Mahidol
Thiland
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date 2012

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

Ahmad Makmom Bin Abdullah, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Wan Nor Azmin B Sulaiman, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

Mohd Talib Latif, PhD
Associate Professor
Faculty of Science and Technology
Universiti Kebangsaan Malaysia (UKM)
(Member)

Alireza Shakiba, PhD
Associate Professor
Faculty of Earth Science
Shahid Beheshti University
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for equations 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 other institutions.

RAHELEH FARZANMANESH

Date: 30 May 2012

TABLE OF CONTENTS