UNIVERSITI PUTRA MALAYSIA

BIOECONOMIC EVALUATION OF AGROFORESTRY PRACTICES IN THE MOUNTAINOUS REGION OF RIMA'A VALLEY, YEMEN

ABDUL-MOA'AMEN HAMOODSHOGA'A ALDEEN

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By

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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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ALLAH IS THE ALL MIGHTY WHO GIVES US THE POWER TO FIGHT DISHONESTY AND INJUSTICE

To

MY BELOVED HOMELAND YEMEN
THE MARTYRS OF THE HOMELAND AND ARABIAN NATION
MY BELOVED PARENTS A BARRAGE OF LOVE AND COMPASSION
MY BROTHER ABDULKAREEM
MY PRECIOUS FRIEND DR. ADNAN ALSANOY
MY BELOVED WIFE

WITH MY LOVE

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

BIOECONOMIC EVALUATION OF AGROFORESTRY PRACTICES IN THE MOUNTAINOUS REGION OF RIMA'A VALLEY, YEMEN

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ABDULMOAAMEN HAMOOD SHOGAA ALDEEN

February 2009

Chairman: Professor Dato' Nik Muhamad Nik Ab. Majid, PhD

Faculty : Forestry

Yemen encounters serious problems of scarcity of natural resources as well as soil erosion and degradation. Agroforestry system is being promoted as a more appropriate land use system than monocropping practices for smallholders worldwide. Unfortunately, detailed studies on the sustainability of different land use systems are limited and in this region land has started to deteriorate and many farmers turned to traditional agriculture. The general objective of the study was to evaluate the sustainability of agroforestry compared to monocropping systems in terms of soil properties and farmers' perception. The first specific objective of this study was to determine the effects of agroforestry practices on soil properties and compare them with soil properties under monocropping system. The second objective was to simulate the changes over a 20-year period in soil total organic N, total organic P, and organic carbon, and depths which are the most important elements affecting soil productivity. The third objective was to develop a bio-economic model to determine the role of agroforestry and other factors affecting soil

conservation and net farm income. Three different methods were used to achieve the above objectives. First, 72 composite soil samples were collected from two sites (36 from site 1 and 36 from site 2) based on RCBD split plot design (6 systems X 3 replications X 2 depths). Soil N, P, K, organic carbon, and bulk density were determined. Second, the SCUAF model was used to predict the changes in soil properties over a 20-year simulation period. The output was then used in cost benefit analysis. Third, a questionnaire and direct interview with 162 agroforestry farmers and 83 non-agroforestry were conducted to collect data to develop the bio-economic model. The results showed that soil N, P, K and organic carbon were significantly higher under agroforestry practices mixed trees with coffee (S1), and Muringa *(Cordia africana L.)* with coffee (S2) at the two sites as compared to the Arabian jujube (*Ziziphus spina-christi L.*) with maize (S3) and the monocropping systems ($P<0.01$). It was lowest under monocropping maize (S5) in both sites. Other physical soil properties were better under agroforestry practices (S1 and S2) than the monocropping maize (S5). The results of the SCUAF modeling illustrated that soil depth decline was negligible under agroforestry practices (S1 and S2) with soil loss less than 1000 kg/ha/yr even without using chemical fertilizers. The predicted decline of soil depth was highest under S5 followed by S3 which lost 43.1 % and 18 % of the top soil, respectively. Soil organic N and organic P are significantly higher under S1 and S2 systems even without using chemical fertilizers. It declined continuously under other systems at different rates during the simulation period. However adding 55 kg/ha/yr super phosphate (46 % P) and 271 kg/ha/yr urea (46 % N) to the systems (S1, S2, S4, and S6) resulted in maintaining soil fertility and led to sustaining the yield over 20 years of the simulation period. The results of cost benefit analysis showed that by using chemical fertilizers all systems were profitable at this

level of the capital cost. The results also showed that Muringa coffee system (S2) and monocropping coffee (S4) obtained the highest net present value (NPV) (YR 1,171,077 USD 6163.6/ha) and (YR 1,117,965 USD 5884/ha), respectively. The lowest NPV (YR 55,116 USD 290.1/ha) was obtained under monocropping maize (S5). Consequently, the agroforestry system (S2) using fertilizers predicted the highest annualized net benefits (ANB) (YR 156,783 USD 825.2/ha/year), to the farmers and the lowest ANB (YR 7378 USD 38.8/ha/yr) was from monocropping maize (S5). The results of soil conservation model showed that educational level, number of terraces and channels maintained during the last ten years, geographical location, water efficiency, farmers' experience, and agroforestry index are significantly influenced soil conservation in both models (OLS and SUR). The results of income regression model showed that the net income increased in output price and fixed inputs such as farm size, and decreased in input prices mainly wage of labor, and price of fodder in both models (OLS and SUR). The coefficients of the wage of labor *(PLAB),* fodder price *(PFOD),* are negative and significantly decreased the net income in both models as well. Farm size and price of cows sold are significantly affected the net farm income in models 1 and 2. The model shows that agroforestry can improve soil properties. The calculated values suggest that soil conservation generated productivity benefits in range of 4 to 9 percent of the current farm income. Ii is equivalent to about 23261 YR/yr (US$ 122.4) for an average area of 0.6 ha for each farmer. It can be concluded that agroforestry practices are more profitable and sustainable compared to monocropping systems.

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

PENILAIAN BIO-EKONOMI TENTANG AMALAN PERHUTANAN-TANI DI KAWASAN PERGUNUNGAN LEMBAH RIMA'A, YEMEN

Oleh

ABDULMOAAMEN HAMOOD SHOGAA ALDEEN

Februri 2009

Pengerusi : Profesor Dato' Dr. Nik Muhamad Nik Ab. Majid, PhD

Fakulti : Perhutanan

Yemen menghadapi masalah kekurangan sumber pertanian selain dari-pada kehakisan serta penurunan mutu tanah. Sistem perhutanan-tani telah dipromosikan sebagai sistem guna tanah yang lebih sesuai berbanding dengan amalan tanaman tunggal. Walaubagaimanapun, kajian jangka panjang mengenai kemampanan pelbagai jenis sistem guna tanah tersebut adalah kurang dan pada masa sekarang sistem perhutanan-tani di kawasan tersebut telah menunjukkan kemerosotan di mana petani mula berubah arah kepada sistem pertanian asal. Secara keseluruhannya, kajian ini bertujuan untuk menilai kemampanan sistem perhutanan-tani berbanding dengan amalan tanaman tunggal berdasarkan tanggapan petani serta kesan terhadap ciri-ciri tanah. Objektif pertama adalah untuk menilai kesan amalan tanaman tunggal terhadap ciri-ciri tanah dan membandingkannya dengan amalan perhutanan-tani. Objektif kedua adalah untuk melakukan simulasi selama 20 tahun tentang perubahan pada kandungan N, P, karbon organik dan ke dalaman tanah di mana ini merupakan elemen penting yang mempengaruhi produktiviti tanah tersebut. Objektif ketiga pula

adalah untuk menghasilkan model bio-ekonomi untuk melihat peranan amalan perhutanan-tani serta faktor lain yang mempengaruhi pendapatan para petani serta pemuliharaan tanah. Tiga kaedah telah digunakan untuk mencapai objektif kajian di mana dalam kaedah pertama sebanyak 72 sampel komposit tanah yang diperolehi daripada dua kawasan (36 dari setiap tapak) berdasarkan rekabentuk RCBD split plot (6 sistem x 3 replikat x 2 ke dalaman) telah dianalisa. Pada kaedah kedua, model SCUAF telah digunakan untuk membuat ramalan kepada perubahan dalam sifat tanah untuk jangkamasa simulasi selama 20 tahun yang kemudiannya dikaitkan dengan analisa kos faedah. Seterusnya, soal selidik dan temubual dengan 162 petani yang mengamalkan amalan perhutanan-tani dan 83 daripada kumpulan yang mengamalkan amalan tanaman tunggal telah dijalankan untuk mengumpul data yang digunakan untuk menghasilkan model bio-ekonomi. Hasil daripada kajian telah menunjukkan bahawa amalan perhutanan-tani dengan menggandingkan pokok dengan tanaman kopi (S1) dan Muringa (*Cordia africana Lam*) dengan tanaman kopi (S2) memberikan nilai N, P, K dan kandungan karbon organik yang ketara di kedua-dua tapak ($P<0.01$) jika dibandingkan dengan gandingan Arab jujube (*Ziziphus spina-christi L.*) dengan tanaman jagung serta amalan pertanian tunggal. Kajian juga menunjukkan bahawa amalan S5 memberikan nilai terendah untuk kedua-dua kawasan kajian tersebut. Sifat fizikal tanah lain juga adalah lebih baik dengan amalan perhutanan-tani (S1 dan S2) berbanding dengan amalan tanaman tunggal bijiran (S5). Hasil ramalan menunjukkan pengurangan kedalaman tanah adalah tidak ketara di bawah amalan perhutanan-tani (S1 and S2) di mana kehilangan tanah adalah kurang daripada 1000 kg/hektar/tahun walaupun tanpa penggunaan baja kimia. Pengurangan ke dalaman tanah adalah tinggi untuk S5 dan disusuli oleh S3 di mana kehilangan bahagian permukaan tanah adalah sebanyak 43.1% dan 18%. Kandungan organik N

dan P pada tanah juga didapati meningkat di bawah sistem perhutanan-tani S1 dan S2 yang tidak menggunakan baja kimia. Pada sistem lain, ianya telah menunjukkan penurunan secara berterusan dalam tempoh simulasi tersebut. Walau bagaimanapun, penambahan super phosphate (46% P) sebanyak 55 kg/hektar/tahun dan 271 kg/hektar/tahun urea (46% N) kepada sistem S1, S2, S4 dan S6 telah mengekalkan kesuburan tanah serta memberikan hasil berkekalan selama 20 tahun simulasi. Hasil daripada kos faedah telah menunjukkan bahawa penggunaan baja pada tahap modal kos tersebut telah memberikan keuntungan kepada kesemua sistem. Hasil kajian juga telah mendapati bahawa sistem amalan berdasarkan tanaman kopi Muringa (S2) dan penanaman kopi secara tunggal (S4) memberikan nilai bersih terkini yang tertinggi iaitu (YR 1,171,077 USD 6163.6)/hektar dan (YR 1,117,96 USD 5884)/hektar. Nilai NPV terendah (YR 55,116 USD 290.1)/hektar pula didapati daripada sistem yang mengamalkan tanaman tunggal bijiran (S5). Selain itu, ramalan yang diperolehi daripada sistem amalan perhutanan-tani dengan pembajaan (S2) menunjukkan faedah tahunan bersih faedah tahunan yang tertinggi (YR 156,783 USD 825.2)/hektar/tahun kepada petani manakala S5 memberikan faedah tahunan yang terendah (YR 7378 USD 38.8)/hektar/tahun. Hasil daripada model pemuliharaan tanah, menunjukkan bahawa tahap pendidikan, jumlah terusan serta tali air yang diselenggara dalam tempoh sepuluh (10) tahun, lokasi geografik, keberkesanan pengairan, pengalaman petani, dan indek perhutanan-tani sangat mempengaruhi pemuliharaan tanah pada kedua model (OLS dan SUR) tersebut. Koefisen harga buruh, harga makanan ternakan, adalah bersifat negatif dan berkurangan dengan ketara terhadap pendapatan bersih pada kedua-dua model tersebut. Keluasan ladang, dan harga jualan lembu, adalah ketara dalam Model 1 dan 2. Model tersebut juga menunjukkan bahawa perhutanan-tani boleh memperbaiki keadaan sifat tanah di mana produktiviti

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I certify that an Examination Committee met on 27th February 2009 to conduct the final examination of Abdul-Moa'amen Shoga'a Al-Deen on his Doctoral thesis entitled "Bio-economic Evaluation of Agroforestry Practices in the Mountainous Region of Rima'a Valley, Yemen" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (higher Degree) regulation 1981. The Committee recommends that the candidate be awarded the relevant degree.

Members of the Examination Committee are as follows:

Ahmad Ainuddin Nuruddin, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Azmy Mohamed, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Mohd. Zaki Hamzah, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Babiker Idris Babiker, PhD
Professor
Faculty of Agriculture
University of Khartoum
Sudan
(External Examiner)

_____
Bujang Kim Huat, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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

Nik Muhamad Nik Ab. Majid, Ph.D
Professor
Faculty of Forestry
Universiti Purta Malaysia
(Chairman**)**

Awang Noor Abd. Ghani, Ph.D
Associate Professor
Dean of Faculty of Forestry
Universiti Purta Malaysia
(Member**)**

Mohamed Azani Alias, Ph.D
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Member**)**

Shukri Bin Mohamed, Ph.D
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Member)

Christopher Teh Boon Sung, PhD
Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

_____
HASANAH MOHD. GHAZALI, PhD
Professor/ Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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 or concurrently submitted for any other degree at UPM or any other institutions.

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ABDUL-MOA'AMEN SHOGA'A ALDEEN

Date:

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