# Dynamic costs of soil degradation and determinants of adoption of soil conservation technologies by smallholder farmers in Malawi.

by

**Teddie Oliver Nakhumwa**

Submitted in partial fulfillment of the requirements for the degree of

**Ph.D.**

in the

**Department of Agricultural Economics, Extension and Rural Development**
**Faculty of Natural and Agricultural Sciences**
**University of Pretoria**
**South Africa**

**July 2004**

**Dedication**

**To my dear wife Candida and son Joshua-Thanthwe.**

# ACKNOWLEDGEMENTS

I am grateful to many people and institutions for making this thesis possible. Profound thanks and appreciation go to my supervisor, Professor Rashid Mekki Hassan, for his untiring support throughout my PhD program. I would also like to acknowledge with thanks his high intellectual guidance and importantly, patience, throughout the course of my work. His enormous contribution has really shaped this work to what it is.

This study has benefited from the financial support of the Centre for Environmental Economics and Policy in Africa (CEEPA) and the Rockefeller Foundation for which I am very grateful. Particularly, I would like to extend my heartfelt thanks to Dr Akin Adesina, Regional Representative of the Rockefeller Foundations for Southern Africa, Drs Mullugeta Mekuria and Stephen Waddington of CIMMYT (Harare, Zimbabwe) for their significant role in securing the financial support for my research work. I sincerely acknowledge my employers, the University of Malawi (Bunda College-Agricultural Policy Research Unit) for granting me study leave to pursue my post-graduate studies at the University of Pretoria.

I am deeply indebted also to Dr James Appiah Benhin for his invaluable comments and guidance at various stages of this work. My profound appreciation is also due to Dr Ramos Mabugu, Deputy Director of CEEPA, for his useful advice and encouragement. Sincere thanks are due to Dr George Kanyama-Phiri, Principal of Bunda College of Agriculture and Dr MAR Phiri, for their support in securing research funds for this work. Special thanks should also go to Dr A. R. Saka of the Ministry of Agriculture and Irrigation in Malawi and Mr. Vincent Mkandawire of JICA-Malawi for their invaluable contributions to this work. The following people were quite instrumental and provided me with invaluable advice at the planning stage of my research work in Malawi: Dr Todd Benson of IFPRI, Washington, D.C., Drs Julius Mangisoni and Kenneth Wiyo of Bunda College of Agriculture and Mr Mlava (Bunda College). I really appreciate their contributions. I am also thankful to Mr Chirwa (Bunda College, Soil Science Dept), who assisted me with soil analysis.

I have treasured the comfort and encouragement received from fellow PhD students in particular the following: Mampiti Matete, Patrick Birungi, Moses Sichei, James Juana, Rose Emongor, Adelaide Matlanyane, Jethro Zuwarimwe, Oyenuga Oyenike, Glwadyes Gbetibouo, Charles Abukar, Chilot Y. Tizale, and Benjamin Banda.

I have benefited a lot from the wonderful atmosphere in the Department of Agricultural Economics, Extension and Rural Development. Special thanks are due to Professor Johan Kirsten, Head of Department, for his untiring support and profound love. I have also enjoyed the friendship of Ferdinand Meyer and Marnus Gouser, which I acknowledge with gratitude. My thanks and deep appreciation should also go to Mrs Zuna Botha for her untiring efforts in making the department a wonderful place. I am deeply indebted to Dr Simphiwe Ngqanqweni, a true friend who has always been there for me.

Many thanks also go to these dear friends for their support and encouragement: Eric and Alice Mkanda, Denis and Agnes Mwangwela, Timothy and Rose Tieku, John and Grace Muringe, and Prince Kapondamgaga. My two big families in Malawi, the waiting has been too long but you patiently endured. My sister Caroline-Rose has been a reliable source of encouragement for me. The profound love and vision of Abigail has brought me this far. You decorated my life!

Finally, the love and great strength of my "dear wife and best friend" Candida and son Joshua-Thanthwe, really inspired me throughout the period. I really thank you guys for your untiring patience and understanding, but most of all, enduring love.

Many others have contributed in various ways to the completion of this thesis, and although not mentioned by name, you are really appreciated.

Any errors in thinking or omissions are solely my responsibility.

I have treasured the comfort and encouragement received from fellow PhD students in particular the following: Mampiti Matete, Patrick Birungi, Moses Sichei, James Juana, Rose Emongor, Adelaide Matlanyane, Jethro Zuwarimwe, Oyenuga Oyenike, Glwadyes Gbetibouo, Charles Abukar, Chilot Y. Tizale, and Benjamin Banda.

I have benefited a lot from the wonderful atmosphere in the Department of Agricultural Economics, Extension and Rural Development. Special thanks are due to Professor Johan Kirsten, Head of Department, for his untiring support and profound love. I have also enjoyed the friendship of Ferdinand Meyer and Marnus Gouser, which I acknowledge with gratitude. My thanks and deep appreciation should also go to Mrs Zuna Botha for her untiring efforts in making the department a wonderful place. I am deeply indebted to Dr Simphiwe Ngqanqweni, a true friend who has always been there for me.

Many thanks also go to these dear friends for their support and encouragement: Eric and Alice Mkanda, Denis and Agnes Mwangwela, Timothy and Rose Tieku, John and Grace Muringe, and Prince Kapondamgaga. My two big families in Malawi, the waiting has been too long but you patiently endured. My sister Caroline-Rose has been a reliable source of encouragement for me. The profound love and vision of Abigail has brought me this far. You decorated my life!

Finally, the love and great strength of my "dear wife and best friend" Candida and son Joshua-Thanthwe, really inspired me throughout the period. I really thank you guys for your untiring patience and understanding, but most of all, enduring love.

Many others have contributed in various ways to the completion of this thesis, and although not mentioned by name, you are really appreciated.

Any errors in thinking or omissions are solely my responsibility.

# Dynamic costs of soil degradation and determinants of adoption of soil conservation technologies by smallholder farmers in Malawi.

by

**Teddie Oliver Nakhumwa**

Degree: PhD
Department: Agricultural Economics, Extension and Rural Development
Promoter: Professor Rashid Mekki Hassan

Abstract

This thesis aimed at measuring the economic costs of soil degradation and to determine factors that influence the incidence and extent of adoption of soil conservation technologies by smallholder farmers in Malawi. A dynamic optimisation model was used to derive and analyse the optimal conditions for soil resource extraction and use in Malawi, while a selective tobit model was used to simulate the two-step decision-making process of farmers with respect to adoption of soil conservation technologies.

Soil degradation has long-term consequences and static models, which form the bulk of studies that have so far been carried out in Africa on this topic, do not account for the inter-temporal dimension of optimal resource management. To deal with this shortcoming, this thesis used an inter-temporal optimisation framework, which considers soil in a time-dependent resource extraction perspective. This thesis has demonstrated that soil degradation is causing an enormous reduction in the productive value of smallholder land in Malawi. Current user cost of soil quality based on current practices of

smallholder farmers, which [illegible] estimated to be US$21 per hectare. Based on this value and land area under smallholder agriculture in Malawi, economic costs of soil degradation among smallholder farmers were estimated to amount to 14 per cent of the agricultural GDP. If left unabated, soil degradation threatens not only the future of smallholder agriculture but also, economic growth prospects of the nation.

Although not operating on the SS optimal path in terms of soil resource management, current practices show that smallholder farmers in Malawi still consider, to certain degree, the dynamic costs in soil resource use. Hence, there is no strong evidence to suggest that current trends in land degradation are due to an institution failure (i.e., smallholder farmers have private incentives to conserve their soil resource). A result that suggests presence of other factors, most likely market distortions, behind existing deviations of farmers' practices from dynamic optimum. Government's serious support of the input and output market reforms is important not only to make the markets work but also, to make smallholder agriculture a profitable enterprise. It is only when smallholder agriculture becomes profitable that farmers can seriously invest in the soil resource. Agricultural support programs such as "food for work" if extended to include soil conservation, could lead to substantial curtailment of soil erosion since farmers can invest their labour in their own gardens during the critical times of land preparation.

The sensitivity analysis indicated that increasing the discount rate to 5%, SS solutions were close to current practice solutions. This suggests that one reason smallholder farmers are exploiting the soil resource is because they have a higher time preference. The high levels of poverty, especially among the smallholder subsistence farmers in Malawi, entail that farming households are more concerned with their survival now than their future well being.

The study estimated an optimal output of 1.5ton/ha and nitrogen fertiliser rate of 49 kg/ha at SS. The fertiliser estimates are based on smallholder farming system that incorporates soil conservation. In one of the most detailed studies on nitrogen use efficiency in

Malawi, Itimu (1997) indicated that with the incorporation of manure, nitrogen fertiliser use dropped from 60 to 30 kg/ha to produce about 2.5 tons of maize. Malawi uses area specific recommendations for fertiliser application. However, using "best bet" technologies, at least 35kgN/ha is recommended for smallholder farmers on average. The SS optimum fertiliser estimated in the current study was somehow higher due to the fact that an inter-temporal framework, which considered the dynamic costs of soil nutrient extraction, was used. Results from fertiliser recommendation trials may be reinforced if researchers consider the inter-temporal nature and dynamic costs associated with the use of soil.

The selective tobit model results indicate that factors that influence smallholder farmers' decisions to adopt soil conservation technologies may not necessarily be the same factors that influence subsequent decision on levels of adoption. The implication of this finding is that different policy prescriptions on soil conservation should strictly be guided by the goals the government wants to achieve. With fertiliser prices being out of the reach of most smallholder farmers in Malawi, soil conservation is one of the reliable options available to reduce soil degradation. However, any policy aimed at improving adoption of soil conservation technologies among smallholder farmers would succeed only if the various needs of smallholder farmers at the two decision stages are properly identified and addressed.

# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ADD | Agricultural Development Division |
| ADMARC | Agricultural Development and Marketing Corporation |
| ALDSAP | Agriculture and Livestock Development Strategy &Action Plan |
| CD | Cobb Douglas |
| CEC | Cation Exchange Capacity |
| DFID | Department for International Development (Previously ODA) |
| EPA | Extension Planning Area |
| EPIC | Erosion Productivity Impact Calculator |
| FAO | Food and Agriculture Organisation |
| FEWS | Farming Early Warning System |
| GDP | Gross Domestic Product |
| GIS | Geographical Information System |
| GoM | Government of Malawi |
| IFDC | International Fertiliser Development Centre |
| IITA | International Institute for Tropical Agriculture |
| LUPMAP | Land Use Policy &Management Action Plan |
| MoAI | Ministry of Agriculture and Irrigation |
| MK | Malawian Kwacha |
| MLE | Maximum Likelihood Estimation |
| MPTF | Maize Productivity Task Force |
| NEAP | National Environmental Action Plan |
| NEC | National Economic Council |
| NGO | Non Governmental Organisation |
| NRI | Natural Resources Institute |
| NTRM | Nitrogen Tillage Residue Management |
| OLS | Ordinary Least Squares |
| PI | Productivity Index |
| PLCE | Presidential Land Commission of Enquiry |
| RDP | Rural Development Project |

| | |
|---|---|
| RUSLE | Revised Universal Soil Loss Equation |
| SLEMSA | Soil Loss Estimation Model for Southern Africa |
| SNA | System of National Accounts |
| SOC | Soil Organic Carbon |
| SOM | Soil Organic Matter |
| SSA | Sub-Saharan Africa |
| TIP | Targeted Input Program |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environmental Programme |
| UNO | United Nations Organisation |
| USAID | United States Agency for International Development |
| US$ | United States Dollar |
| USLE | Universal Soil Loss Equation |