TECHNOLOGICAL CHANGE AND SCARCITY OF SOIL IN THE TEA SECTOR OF SRI LANKA

Submitted by

Rohan Terrence Jayasuriya

B.Sc. Hons (Agriculture), M.Phil. (Agric. Economics)

A thesis submitted in total fulfilment of
the requirements for the degree of
Doctor of Philosophy

School of Business
Faculty of Law and Management

La Trobe University
Bundoora, Victoria 3083
Australia

March 1998

TABLE OF CONTENTS

List of Tables *vi*
List of Figures *vii*
Abbreviations *viii*
Summary of the Thesis *ix*
Statement of Authorship *xi*
Acknowledgments *xii*

1. INTRODUCTION **1**

1.1 Background 1

1.2 Development of the Issue 3

1.3 The Need and Objectives of the Study 7

1.4 Outline of the Thesis 8

2. MEASUREMENT OF TECHNOLOGICAL CHANGE **10**

2.1 Productivity and Technology: Definitions 10

2.2 Technological Change 11

2.3 Induced Innovation in the Theory of the Firm 14

2.4 Factor Prices and Induced Technical Change in Agriculture 16

2.5 Technical Change and Economic Efficiency 19

2.6 Technical Change and Productivity Measurement 21

2.7 Productivity Measurement and the Need for a 'Total' Productivity Measure 22

2.8 The Growth Accounting Approach to TFP Measurement 25

2.9 The Econometric Approach to Productivity Measurement 27

2.10 Comparison of the Growth Accounting and Econometric Approaches 29

2.11 Overview 31

3. NATURAL RESOURCE SCARCITY **32**

3.1 The Doctrine of Increasing Natural Resource Scarcity 32

3.2 The Unit Cost of Extractive Products 36

3.3 Factors Mitigating Resource Scarcity 38

3.3.1 Exploration and Discovery 38
3.3.2 Technological Progress 39
3.3.3 Resource Substitution 39

3.4 Detecting Resource Scarcity 42

3.4.1 Resource Prices 43
3.4.2 Scarcity Rent 44
3.4.3 Marginal Discovery Cost 45
3.4.4 Marginal Extraction Cost 46

3.5 Conventional Theory: Pollution and Natural Environment 48

3.6 Optimal Pollution Control : Charges Versus Standards 52

3.7 Contemporary View of Natural Resource Scarcity 53

3.8 Overview 59

4. MEASUREMENT OF THE SCARCITY OF SOIL **60**

4.1 The Concept of Land Degradation 60

4.2 Soil Erosion, Mass Movement and Solution 62

4.3 The Costs and Effects of Soil Erosion 63

4.4 The Social Losses from Upland Soil Erosion 66

4.5 Optimal Level of Soil Erosion 68

4.6 Economic Valuation of Soil Erosion 72

4.6.1 Replacement Cost 73
4.6.2 Rehabilitation Cost 74
4.6.3 Contingent Valuation 74

4.6.4 Hedonic Pricing 75
4.6.5 Market Value of Soil 76
4.6.6 Production Value of Soil 76
4.6.7 Opportunity Cost 77

4.7 Contribution of Soil to the Land Value 78

4.8 Economic Scarcity of Soil 78

4.9 Measuring the Scarcity of Soil 80

4.10 Overview 84

5. THE TEA SECTOR IN SRI LANKA 85

5.1 Role of Tea in National Economy 85

5.2 The Crisis in the Tea Sector 88

5.3 Land Degradation in the Tea Plantations 99

5.4 Agricultural Practices Contributing to Soil Erosion in Tea 100

5.5 Empirical Estimates of Soil Erosion in Tea Lands 103

5.6 Overview 106

6. EMPIRICAL ANALYSIS OF THE TOTAL FACTOR PRODUCTIVITY AND COST OF LAND DEGRADATION 107

6.1 Total Factor Productivity 107

6.1.1 Outputs, Inputs and Sources of Data 108
6.1.2 Formulation of a Total Factor Productivity Series 118

6.2 Total Factor Productivity and Land Degradation 131

6.2.1 Specification of Variables and Sources of Data 136
6.2.2 Pretesting of Data for Stationarity, Integrated Series and Cointegration 145
6.2.3 Model Results and Discussion 149

6.3 Overview 156

7. SUMMARY AND CONCLUSION **158**

7.1 Summary of the Study 158

7.2 Policy Implications and Recommendations 162

7.3 Suggestions for Future Research 165

APPENDICES :

1 : Estimating the Quantity of Capital Stocks for the Tea Industry 169
2 : Estimating the Annual User Charge for Capital 170
3 : Input Variables used in Calculating TFP 171
4 : Other Data for TFP Calculation and Model Analysis 172
5 : Partial Productivities of Total Output with respect to Input Groups 175
6 : Cointegration Results 176
7 : Simulation Run when Land Sale Prices Increased by the CPI 186
8 : Simulation Run when Land Sale Prices Increased by the Average of CPI and GDP Indices 188

REFERENCES **190**

LIST OF TABLES

Table 5-1 : Total Tea Land Area According to Administrative Districts 87

Table 5-2 : Cost of Production, Prices and Producer Margins - State Sector 96

Table 5-3 : Estimates of Soil Erosion under Different Land Uses 105

Table 6-1 : Output, Input and TFP Indices 119

Table 6-2 : Contribution of Growth in Total Factor Productivity and Input Use to Growth in Output 122

Table 6-3 : Total Productivity, Prices Received to Prices Paid Ratio and Returns to Costs Ratio Indices 124

Table 6-4 : Fitted Trends in Major Variables 127

Table 6-5 : Partial Productivities of Total Output with respect to Input Groups 129

Table 6-6 : Pre-Testing of Data for Stationarity 148

Table 6-7 : Regression Results for TFP Model 150

Table 6-8 : Sources of Total Factor Productivity Growth 153

LIST OF FIGURES

Fig 2-1 : Rates and Biases of Technical Change 12

Fig 2-2 : Factor Prices and Induced Technical Change 17

Fig 2-3 : Measurement of Economic Efficiency 20

Fig 2-4 : Changes in Technology, Scale, and Technical Efficiency 23

Fig 3-1 : Output Levels and the Possibilities for Input Substitution 40

Fig 3-2 : Optimal Tax on Pollution 49

Fig 3-3 : Determining the Optimal Pollution Tax 51

Fig 4-1 : Divergence Between Private and Social Costs of Upland Tea Production 67

Fig 4-2 : Optimal Level of Soil Quality and Soil Costs 70

Fig 5-1 : Agroclimatic Divisions of Sri Lanka 86

Fig 5-2 : Tea Average Yield by Elevation 90

Fig 5-3 : Tea Average Yield Trends 91

Fig 5-4 : Tea Prices - Nominal 92

Fig 5-5 : Tea Prices - Deflated by CPI 93

Fig 5-6 : Tea Prices - Deflated by GDP 94

Fig 5-7 : Tea Percentage Share of World Production 97

Fig 5-8 : Tea Percentage Share of World Exports 98

Fig 6-1 : Output, Input and TFP Indices 120

Fig 6-2 : Total Productivity, Prices Received to Prices Paid Ratio and Returns to Costs Ratio Movements 125

Fig 6-3 : Partial Productivities of Total Output with respect to Input Groups 130

Fig 6-4 : A Theoretical Relationship of the Impact of Technological Progress and Land Degradation on Tea Production 133

Fig 6-5 : Real Expenditure on Tea Research and Extension 154

ABBREVIATIONS

ADB	Asian Development Bank
GDP	Gross Domestic Product
JEDB	Janatha Estates Development Board
MIRR	Marginal Internal Rate of Return
NARESA	Natural Resources, Energy and Science Authority
NPV	Net Present Value
OLS	Ordinary Least Squares
PIM	Perpetual Inventory Method
SLSPC	Sri Lanka State Plantations Corporation
TFP	Total Factor Productivity
TRI	Tea Research Institute
TSHDA	Tea Small-Holding Development Authority
TVMP	Total Value of Marginal Product
USDA	United States Department of Agriculture
USLE	Universal Soil Loss Equation
VMP	Value of the Marginal Product
VP Tea	Vegetatively Propagated Tea

SUMMARY OF THE THESIS

This study analyses the technological change in the aggregate tea sector of Sri Lanka, by contributing to an understanding of total factor productivity change with assessment of the extent and nature of such changes from 1960/61 to 1994/95. The total factor productivity measures are then used to define a conceptually sound measure of the production cost of land degradation, providing insight into the scarcity of soil in the tea sector.

Total factor productivity in the tea sector, increased at an estimated annual rate of 1.82 percent during the study period. This resulted from an estimated annual rate of increase of 0.01 percent in total output and a considerably larger rate of 1.81 percent annual decrease in total input. Thus, the reason for total factor productivity growth was largely due to cost savings associated with decreased use of inputs rather than increased output. Land and capital inputs showed significant negative growth trends, confirming a lack of long-term investment in the tea sector. As expected, all the partial factor productivities showed increases over the study period due to lower use of those individual inputs; the most significant changes occurring in the partial productivities of land and capital inputs. The terms of trade and the returns to costs ratio, exhibited an annual rate of decrease of around 3.7 percent and 1.9 percent, respectively. The producer terms of trade growth rate of -3.7 percent, has been brought about by an estimated annual rate of increase in prices received of 10.6 percent compared with an increase of 14.3 percent in prices paid.

The Sri Lankan tea industry, once pre-eminent in the world, has been going through intermittent crises for a long time due to problems related to low productivity and the high cost of production. The management of the nationalised plantations proved inadequate to meet the task of adjusting to the new challenges of raising productivity and remaining competitive. The contribution of the tea industry to the economy declined. Among other causes, stagnating crop productivity was found to be an important factor. Land degradation in the form of soil erosion, was found to be a serious problem for the entire tea sector.

Careless and ecologically unbalanced agricultural practices, have over the years, led to varying degrees of degradation of the tea soils. However, these physical measures of land degradation do not necessarily reveal an economic or social problem.

In the second part of the study, an attempt is made to quantify the impact that land degradation has on tea production. Based on the theoretical relationship of the impact of technological progress and land degradation on tea production, a regression model was fitted to deconstruct the total factor productivity variable. The objective of this approach is to find an economic value for land degradation by quantifying the extent of this impact on aggregate tea production in Sri Lanka. One of the key points to come out of this estimation exercise, is the difficulty of isolating the impact of individual factors on measured total factor productivity. On the basis of available data and the chosen model, it could be concluded that the impact of technological progress has outweighed the negative effect of land degradation in the tea sector, over the study period. Considering the fact that investment in tea research is mainly on developing varieties of vegetatively propagated clonal tea, and the associated very long gestation periods involved, a much larger lag length of the order of 25-35 years is recommended for the research investment variable, to enable calculation of the marginal internal rate of return to public investment in tea. Importantly, a larger set of data will become available over the next decade or so which will enable appropriate lags to be incorporated in future research on productivity in the tea industry.

STATEMENT OF AUTHORSHIP

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma.

No other person's work has been used without due acknowledgement in the main text of the thesis.

This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

Signature : ----------

Date : _____/_____/_____

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to La Trobe University for awarding me a Postgraduate Research Scholarship which enabled me undertake the research for this thesis. I also extend my thanks to the ACIAR Project No. 9212 for offering me a research assistantship that enabled me to complete the last few months of my study.

I am deeply indebted to my supervisors, Professor Anthony H. Chisholm and Dr. Sisira K.W. Jayasuriya of the School of Business at La Trobe University, for their constructive advice and support throughout the conduct of this thesis. I thankfully acknowledge the valuable comments by Dr. Anura Ekanayake of the Ministry of Plantation Industries in Sri Lanka, on an earlier draft of the dissertation.

I wish to express my appreciation to the School of Agriculture and the School of Business, at La Trobe University, for the facilities and conducive research environment which I enjoyed during the course of this study. Grateful acknowledgments are due to Dr. Anandacoomaraswami and Ms. Deepa Pallemulla of the Tea Research Institute of Sri Lanka and Mr. Sumedha De Silva all of whom helped by providing important data. A special word of thanks is extended to Mr. Rabiul Beg for helping me in the cointegration analysis. I am thankful to Marie Fenton for helping me in administrative matters and Kristen Chisholm for editing this thesis.

Finally, my sincere appreciation and gratitude are offered to my family. My wife Madara and daughter Michelle made considerable sacrifices throughout the period of this study. They shared my moments of joy as well as frustration which are the inevitable concomitants of research of this nature. My father gracefully accepted a long period of absence. To my family and my father who profoundly influenced my life, I dedicate this piece of work.