Full Report

Determinants of Forest Degradation and Its Impacts on Sustainable Development in Northern Thailand

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EXECUTIVE SUMMARY

This study provides important insights on the current state of forest and forest cover change; the determinants of forest degradation applying a logit model at household level; and the impact of environmental related trade policy on forestry sector and welfare of country.

The total forest areas of Thailand declined from 19549 sq.km. in 1990 to 18972 sq.km. in 2010 indicating the forest area depletion rate of 2.9 percent.. The forest area in Northern Thailand constituted 73057.3 sq.km which is about 56.3% of total forest areas.

This study identifies major determinants of forest degradation based on households survey comprising 719 households living near forests or within forest areas in 28 villages under five Provinces: Chiang Rai, Chiang Mai, Mae Hong Son, Nan and Phayao.

The survey instruments under village questionnaires are classified as 14 categories such as: basic demographic profile, human development profile, property assets, land tenure and use systems, food security, accessibility rights, open asses, livelihood patterns, poverty mapping, environment, migration, management practices, risk and vulnerability profile, and land use situation. The survey instruments used in the household survey contain eight categories: basis demographic profile; human development profile; property type; land tenure and use system; food security, accessibility rights and open access; livelihood patterns; poverty mapping; use of natural resources; and forest management practices.

The model is based on a variant of intertemporal and spatial aspects of deforestation including bioeconomic variables given economic condition. Applying the logit model the findings suggest that the socio-economic variables, biophysical and spatial variables, and households' resource-use patters influence deforestation. In particular, average age of household head, education (years of schooling) of household members, average income of household, land ownership, forest ownership, and agricultural and forestry sector production constitutes major determinants of forest degradation.

The findings under Chiang Rai suggest that households' biological factors do not seem to be important determinant. However, household income, forest ownership, land ownership and commercial production show the significant effects on forest degradation. If land ownership increases by 10%, forest degradation will increase by about 0.1%. In contrast, if forest ownership increases by 10%, degradation will increase by 0.4%. The effect of commercial production has larger effect. A 10% increase in forest production will lead to 5% increase in degradation.

The findings under Phayao that households' biological factors do not seem to influence degradation. However, the coefficients of average age of household head (AGE), education of household members (EDU), average income of household (INCOME), forest ownership (FORO), land ownership (LNDO), agricultural and forestry sector production (FORP), and land and forest ownership (LNDFO) show the significant effects on forest degradation. If forest land increases by 10%, forest degradation will increase by about 0.3%. In contrast if forest ownership increases by 10% degradation will increase by 0.4%. The effect of commercial production has relatively larger effect. A 10% increase in forest production will lead to 3% increase in degradation.

In the case of Chiang Mai shows, the evidence shows that the coefficients of EDU, INCOME, FORP show the significant effects on forest degradation. If forest land increases by 10%, forest degradation will increase by about 0.6%. However, the effect of EDU has a minimal effects. Moreover, if forest and land ownership increases by 10% degradation will increase by 23%. The effect of commercial production has relatively larger effect. A 10% increase in forest production will lead to 3% increase in degradation.

The findings under Nan Province indicate that households' biological factors and income indicate the important determinants of degradation. The coefficients of AGE, EDU and INCOME show the significant effects on forest degradation. The effects of age and education are larger than income effect. The effect of households' income has relatively smaller effect. A 10% increase in forest production will lead to 0.5% increase in degradation.

The research applies a DCGE model to evaluate impact of forest degradation on agriculture and forestry sector and country's welfare. A modified version of intertemporal CGE employed by Morley, Pirneiro and Robinnsion (2011) in the

context of a recursive dynamic model that enables short term adjustment in factors employed in the short run as the economy responds to shocks.

The effect of four policy simulations on agricultural and forestry sector are performed. In simulation-1 (SIM1), the effects of 10% increase in export tax on the macroeconomic performance, while SIM2 examines the effects of the gradual reduction of import tax. In SIM3, the effect of 10% increase in production tax on agriculture and forestry sector production is examined. Finally, in SIM4 we lowered the tax on agricultural and forestry products by 10% per annum to simulate the effect on environment. The summary of findings under four policy shocks can be summarized as follows:

(i) The private consumption of households falls largely under 4 policy alternatives. Secondly, the size of policy effects on consumption differ and the second policy measure: import tariff under SIM2 imposes a larger effect in terms of size effect. The use of tax on environment has led a decline of consumption of urban poor households and rural poor households.

(ii) The public consumption declines under four policy shocks, compared to a base line scenario. In which a large decline was found under SIM2 use of a gradual reduction of import tariff.

(iii) On the effect of each policy shocks on intermediate demand, the import tariff policy has imposed a larger impact under SIM1 compared to SIM3 and SIM4. However, these results lie below the ones under business as usual (BAU) scenario to for the period under study. The environmental tax has led a decline in consumption. This constitutes a largest effect under four policy shocks.

(iv) The effect of policy change on demand for labour, i.e., employment effect indicates a positive effect. SIM1 results in a largest impact on intermediate demand for labour. It lies above the ones under BAU to Year 1 to in Year 10.

(v) On supply effect of these four types policy alternatives, the findings suggest that use of one of four alternatives would result in decline of production under economic sectors under study. The export tax policy shock has larger effect, i.e., a relatively large drop of production under SIM1.

(vi) With respect to impact on export, the findings suggest that use of one of four alternatives results in decline of production in under economic sectors under study. It reveals the effect on production of agriculture sector from Year 1 to Year 10.

The export tax policy shock has a larger effect (a relatively large drop of production) under SIM1.

(vii) On import effects, SIM2 shows a decline of production under economic sectors under study. The export tax policy shock has a large negative effect on GDP.

(viii)The effects of these policies on economic instability in terms of consumer price index (CPI) are reported in the report. The gradual reduction of environment tax has relatively less pressure on CPI. The effect on CPI under 10% export tax cut leads a decline of CPI to 0.992 compared to 1 unit under BAU in Year 1.

Recommendations

1. The findings highlight regional consequences of trade liberalization on households' consumption of resources, income, and the forestry sector. Since these effects vary across provinces, it suggests that the effective policy alternatives should be developed for the need of each province.

2. Since major factors of degradation indicated education, employment and households' income, the forestry management policy should be designed to eradicate rural poverty as suggested by the present study.

3. The forest and land ownership regulations have had a positive effect on degradation and thus in addition to these regulations, the establishment of effective forest management practices are recommended in minimizing risks and the measures for sustainable environment given situations.

4. The commercial production of forestry products influences a relatively large impact on degradation, the introduction of production tax or export tax on forestry products should be exercised to ensure for strategic trade instruments to protect forest and sustainable forest growth by looking at the expected outcomes provided under various policy scenarios as found in the findings of the study.

5. The environmental regulations should be encouraged to enhance regional competitiveness, specialization, industrial redeployment, and trade in forest products through policy coordination among the related ministries.

6. In addition, this method of forest management could productively be used an technical transfer to evaluate protected areas in other GMS countries to evaluate impacts of other large-scale environmental projects.

7. From the welfare aspect, use of policy alternative 1: gradual increase in export tax could provide a more decline in supply of agriculture and forestry products with minimal effects on GDP. In contrast, use of policy alternative 2: gradual reduction of import tariff and alternative 3: a gradual increase in commodity tax have more negative effects on GDP. Thus use of policy alternative 4: gradual increase in agricultural and forest production tax provides a relatively higher GDP compared to policy alternatives 2 and 3.

8. From the perspective of reducing public consumption of forest products, policy alternatives 3 and 4 enable to provide effective policy measures on the control of consumption of forest products in view of sustainable environment, while other things remain constant. Similarly, policy alternative 1 (SIM1) enables to provide gradual increase in investment, in contrast, alternative 4 (SIM4) provides a relatively large employment effect.

9. In addition, in selecting policy alternative to meet simultaneously couples of objectives such as welfare and price stability objectives, suitable policy alternatives can be monitored under this framework. Finally, similar reasoning can be applied in selecting policy alternatives to meet couples of objectives such as export objective and environment objectives at the same time.

In conclusion, this study identifies the linkages between trade, environment and income distribution of Northern Thailand by highlighting policy instruments for intervention policies for sustainable economic development.

ABSTRACT

It has been widely accepted that there exists the impact of nonforestry policies, such as trade liberalization, interest rates, and taxes and subsidies on deforestation and forest degradation. It is also increasing recognition that forestry policies can affect the performance of nonforest sectors through environmental and economic linkages. This research examines the determinations of forest degradation in the wake of trade liberalization based on households survey comprising 719 households living near forests or within forest areas in 28 villages under five Provinces: Chiang Rai, Chiang Mai, Mae Hong Son, Nan and Phayao. The findings enable the policy makers to design the effective environmental management for sustainable development as well as to eradicate rural poverty.

The research contains two parts; Part 1 examines the causes of forest degradation focusing on socio-economic, biophysical and spatial variables in a temporal dynamic and spatial scale household model. The impacts are estimated in the context of survival analysis applying logit model. The findings suggest that average age of household head, education (years of schooling) of household members, average income of household, land ownership, forest ownership, and agricultural and forestry sector production influence significantly forest degradation. Part 2 investigates the impact of trade liberalization in the presence of environmental policy applying a dynamic computational general equilibrium (DCGE) model. This research seeks to elucidate linkages between trade, environment and agriculture and forestry sector policies by highlighting policy instruments for intervention measures for sustainable economic development. The effects of environmental related trade and sector policies on consumption, production, investment, employment, exports, imports, economic stability and country welfare are presented conducting four policy simulations. The study highlighted the different effects of each policy alternative.

The first sets of policy instruments in this study reflects factor affecting forest degradation and provide policy implications. The second set of economic policy instruments includes coordination of trade, environment and macroeconomic policies to ensure the desired outcomes.

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CHAPTER 1
INTRODUCTION

It has been widely accepted that there exists the impact of nonforestry policies, such as trade liberalization, interest rates, and taxes and subsidies on deforestation and forest degradation. It is also increasing recognition that forestry policies can affect the performance of nonforest sectors through environmental and economic linkages. This research aims to examine these policy spillovers for the entire economy analyzing factors affecting degradation and the impacts of trade and environment policies on national welfare.

1.1 Scope of Study

This research focuses primarily on two main areas: (i) the association between forest degradation and bio-economic factors and (ii) the impact of trade policies on the forestry sector. The present research covers the analysis of public policy issues on the impact of economic liberalization on forestry sector as well as the effect of environment policy upon the trade of Thailand. The research attempts to assess the effect of environmental tax policies that on forest outputs. It investigates explicitly the likely effects of trade liberalization on forest products consumption, stumpage markets, international trade in forest products, land use decisions, and efficiency of resource allocation.

The computational general equilibrium (CGE) modeling approach provides its greater comprehensiveness, stronger microeconomic foundations, and ability to accommodate nonlinear relationships and resource constraints. It has been extensively used to simulate macroeconomic policy changes and external shocks in both developed and developing countries. This study provides application of intertemporal dynamic CGE (DCGE) model to forestry issues, impact on all sectors of the economy, in particular, natural resource sectors such as forestry and energy. It summarizes the major policy findings regarding deforestation and forest management and develop framework for deforestation and forest management.

1.2 Objectives

In pursuing trade and investment liberalization policies, trade and environment policies becomes a leading role for sustainable development. The present research develops a framework for detecting forest degradation and developing policy measures using intertemporal special modeling as well as the DCGE model incorporating the nature of change in natural resources due to economic liberalization, which would allow to offer an analytical assessment. It evaluates the impact of trade liberalization upon the forestry sector and income distribution of peoples living in that area. It also seeks to investigate the complementary policy in favor of environment and enhance competitiveness and sustainable development of Northern Thailand.

Specifically, this research investigates changes in regional income, employment, prices of outputs and inputs, demands for inputs, and supply of and demand for output in response to the changes in the use of land and forest resource in Thailand. The research problems in the proposed research are identified as follows:

(i) To examine the trade policies and measures which influence the forest resource of Thailand;

(ii) To examine the simultaneous impact of trade liberalization on forest resources in region;

(iii) To identify the magnitude and direction of the factors determining forest degradation and investigate its impacts on the income distribution in forestry sector in Thailand; and

(iv) To identify the effective forest management policies and practices in this forestry sector.

1.3 Conceptual Framework

The trade liberalisation policies and agreements often involve an assessment of regulatory effects including product and process standards, economic instruments, subsidies, etc. Thus the reconciliation of the conflicting objectives of trade policy and environmental policy for sustainable regional development are crucial. On the basis of such regulatory effect in the forestry sector, complementary mechanisms can be

drawn for the re-enforcement of land and/or forest regulations levying taxes or charges to contribute to an environmental protection fund.

1.4 Research Problems

The research problems in this study are identified as follows:

(i) To identify the trade policies and measures which influence the forest resource of Northern Thailand;

(ii) To examine the simultaneous impact of trade liberalization on forest resources;

(iii) To identify the magnitude and direction of change in factors determining forest degradation and investigate the impacts on the income distribution in forestry sector; and

(iv) To identify the effective forest management policies and practices.

This research begins with baseline environmental conditions focusing on the structural change in the land and forest of GMS countries. Subsequently the broad changes in resource- use due to the trade liberalization are modeled. Finally, the various scenarios are proposed to test the hypotheses that trade affects the environment in positive way and predict the environmental impacts. Moreover, alternative measures are devised to enhance positive environmental effects in the long run and reduce potential negative environmental effects. The findings of an environmental review may advocate different policy responses, including: (i) modification of some aspects of the trade policy; (ii) inclusion of environmental safeguards in the trade liberalization; and (iii) implementation of a complementary environmental mechanism to integrate the trade policy.

Moreover, major causes of forest degradation problems are investigated focusing on (a) the existence of forest product production, certain kinds of consumption, and the disposal of waste products, (b) the use of strategic environmental trade policy such as tax on forest product or VAT, and (c) the presence of policy failures due to the subsidies for polluting and resource- degrading activities such as subsidies to agriculture, fishing and energy will be investigated.

The research attempts to estimate the correlation coefficients between increase in income and environmental quality and trade and land and forest degradation. It will attempt to measure the effect of environmental regulations on the competitiveness in

the forestry sector. Finally, it tends to contribute to the effective management model in environment, trade and forest resources in Thailand in the regional perspectives.

1.5 Methodology

The research first constructs the bio-economic models of five provinces in Northern Thailand and second develops an intertemporal CGE model incorporating the change in natural resources due to economic liberalization, which would allows to offer an analytical assessment of impact of trade liberaziation upon the forestry sector and income distribution of peoples living in that area. It also seeks to investigate the complementary policy in favor of environment and enhance competitiveness and sustainable development of Thailand.

The major research activities are as follows: (i) investigating macroeconomic impacts of environmental trade policies and the welfare implications of Thailand; (ii) testing whether trade results in environmental degradation; and (iv) investigating the factors determining deforestation in these countries focusing on the quantitative and qualitative assessments, and (v) encouraging linkages between trade and environmental policies.

1.6 Expected Outcomes and Benefited Organizations

The present research using both the environmental assessment indicators and trade-environment modeling technique, explores the magnitude and sign of effects of trade liberalization on the forestry sector in Thailand.

The research findings tend to contribute to the following areas:

(a) highlighting regional consequences of trade in the forest products of Thailand;

(b) identifying the factor influencing the forest degradation and its impact on the rural poverty;

(c) developing the effectiveness of forest management practices and the measures for sustainable environment;

(d) establishing environmental policy measures for strategic trade instruments to protect forest and sustainable forest growth; and

(e) effects of environmental regulations on regional competitiveness, specialization, industrial redeployment, and trade in forest products.

This research aims to provide insightful information on trade and investment with environmental focus to the following organizations: (a) Office of the National Resources and Environment Policy and Planning, Thailand, (b) Department of Industry and Mineral Resources, (c) Department of Trade Promotion, (d) Environmental Impact Evaluation Bureau and (e) Natural Resources Management Program at Mae Fah Luang University and (f) Others such as NGO (Non-government Organizations) in Thailand.

1.7 Literature Review

The study of Katharine Sims (2008), Barbier and Bergeron (2001) and Barbier, (1998) develop Dynamic Bio-Economic Model focusing on the local socio-economic impacts of protected area: a system level comparison group approach. The model also captures properly the inter-temporal behavior of both ecology and economics. The present research aims to construct the modified version of dynamic bio-economic model for selected individual provinces in northern Thailand.

In analyzing the impact of economic liberalization upon the environment, there exists primarily three main impacts: the natural resource effects, pollution effects, and health and safety affects. The present research focuses extensively on the first issue, in particular, environmental degradation in the forestry sector and its impact on the likelihood of people in that area.

To achieve these goals the various methodologies have been applied recently and these approaches can be summarized as follows: (a) computable general equilibrium (CGE) model, (b) international trade model, (c) input-output model, (d) welfare analysis model, (e) game theoretic model, (f) optimization model, (g) spatial geographic information system (GIS) model, and (h) econometric model.

The issues toward linkages between the change in resource forest and its impact upon income distribution in that area is relatively new area of current research. The research undertaken in this area include the studies of Bergman (2003) and, Hill (2001), Nordhaus (1994), Vennemo (1995), Whalley and Wigle (1992), Conrad, K. (1999), Goulder (1995), Harrison et.al. (1989), Hazilla and Kopp (1990). In addition,

Daly (1993) proposes that trade can induce environmental degradation and that degradation can lead to income losses and these income losses can result in further environmental degradation. Copeland and Taylor (1997, 1999) have employed a theoretic framework for this hypothesis as the "trade-induced degradation hypothesis".

As far as the effect of trade on natural resources are concerned, most theoretical and empirical studies are based on modifications of the Heckscher-Ohlin (H-O) model. These studies include McGuire (1982), Merrifield (1988), Siebert (1992), and Diao and Roe (1997). One modification is to treat environmental damage avoidance as a third good in the model, the output of which competes with the production of other two conventional goods. Another modification introduces the forest resource as factor of production.

Sussangkarn and Kumar (1997) examines the effect of removal of subsidies on natural water and tax on forest benefits on domestic product of Thailand using CGE model. It is based on national level and is lack of the effect of deforestation and its impact on economy. TDRI (1990) tests the hypothesis that poverty, the demand for agricultural land, and the harvest of forest products are major causes of deforestation. This study hypothesize that the area of deforestation or forest loss in province between LANDSAT surveys is determined by the following factors: Population, growth, Income level, Size of forest, Price of cassava, Road network, and Harvest of forest products. These results corroborate an earlier study (Panayotou and Sungsuwan 1989) which identified population, price of forest products, poverty, rural roads, irrigation infrastructure, and crop price as the main causes of deforestation in Northeast Thailand.

This research investigates the socio-economic effects of policy change upon the agricultural land-use and forestry sector in Northern Thailand by constructing a intertemporal computational general equilibrium (CGE) model. Since intertemporal CGE modeling (dynamic modeling) incorporates intersectoral linkages and limit the problem of either overstating or understating the effects of a policy variable on economic sectors. This approach is a convenient way of incorporating the price responsiveness of producers and consumers in regional economic policy analysis especially for natural resource sector.

The present research covers the analysis of public policy issues on the impact of economic liberalization on forestry sector as well as the effect of environment policy upon the trade in forest products. It attempts to assess appropriateness of

environmental tax policies aimed at increasing forest outputs. It investigates explicitly the likely effects of different national value-added tax rates on forest products consumption, stumpage markets, international trade in forest products, land use decisions, and efficiency of resource allocation in these countries.

The analysis contains two parts: the village or household level and regional level studies. The survey/observation data are collected on the basis of available various LANDSAT surveys and household surveys for the former, while the village level information is gathered through surveys in selected five provinces in Northern Thailand. The scheme of this paper is as follows.

This research begins with baseline environmental conditions focus, on the structural change in the land and forest of Greater Mekong Sub-region (GMS) countries. Subsequently changes in resource use due to the trade liberalization are modeled. Finally, the various policy scenarios are proposed to test the hypotheses that trade affects the environment in positive way and predict the environmental impacts.

Moreover, the research attempts to estimate the correlation coefficients between increase in income and environmental quality and trade and land and forest degradation. It measures the effect of environmental regulations on the competitiveness in the forestry sector. Finally, it tends to contribute to the effective management model in environment, trade and forest resources in Thailand in the regional perspectives.

The study by Bye (2000) analyzes the nonenvironmental welfare costs of an environmental tax reform using a numerical dynamic optimization under the intertemporal general equilibrium model for the Norwegian economy. The study, by using existing tax wedges in the labor market and between consumption and saving, finds that the total non-environmental welfare effect of the tax reform is positive. The article also analyzes how imperfect price expectations for the investors in real capital influence the total welfare costs of the tax reform. The welfare effect is the same due to exploitation of initial distortions, but the transitional dynamics are quite different in the two paths. and Keuschigg (1993) examines the effects of trade liberalization under the Tokyo-round as well as complete tariff liberalization using an intertemporal dynamic optimization CGE. It finds a welfare increases under multilateral tariff liberalization.

The recent study of Thurlow (2004) develops a dynamic CGE model incorporating a recursive dynamic in the standard CGE model. In contrast, a study of

Morley, Pirneiro and Robinnsion (2011) investigates intertemporal DCGE in the context of a recursive dynamic model that enable short term adjustment in factors employed in the short run as the economy responds to shocks.

The present research applies an intertemporal DCGE model for Thailand that emphases the trade and forestry sectors. The model is designed to be useful as a development tool for the policymakers in performing trade and environmental issues in particular, trade impact of forestry sector.

In brief, the present research attempts to develop a modified version of intertemporal CGE employed by Thurlow (2004) and Morley, Pirneiro and Robinnsion (2011) in the context of a recursive dynamic model that enables short term adjustment in factors employed in the short run as the economy responds to shocks in an economic system. The other related studies reflect the models developed by Bergman and Henrekson (2003), and Codsi, Person and Wilcoxen (1992).

The presentation of the report is as follows: Chapter 2 provides overview of forestry sector and forestry policies of Thailand, while Chapter 3 examines the determinants of forest degradation in Northern Thailand based on socio-economic, biophysical and spatial variables in a 'temporal dynamic and spatial scale' household model applying a logit model. Modeling determinants of Forest Degradation and its impacts on sustainable development in Northern Thailand is performed in Chapter 4. Chapter 5 investigates the impact of trade liberalization policies emphasizing on environment, in particular, forestry sector on its production, consumption, exports, imports, investment, macroeconomic performance and welfare of Thailand applying a DCGE model. Chapter 6 provides the summary of major findings and recommendations.

CHAPTER 2

OVERVIEW OF FORESTRY SECTOR AND FOREST POLICIES OF THAILAND

This section elaborates the forestry activities, management and its role in Thai economy. Section 2.2 discusses Thailand forestry in brief, while Section 2.3 discusses the forest areas change and the degradation during 1990 and 2010.

2.1 Forestry Situation and Forest Management in Thailand

Thailand is situated in the tropical zone, covering two main types of tropical forest—deciduous and evergreen. The total forest areas comprise 18972 sq.km. in 2010 and thus 37.1 percent of the country area is covered by the forests. As can be seen in Table 2.2 the total forest areas declined annually and indicated 19549 sq.km. in 1990 to 18972 sq.km. in 2010. The forest area depletion rate constituted 2.9 percent during the period 1990-2010, in contrast, it indicated 38 percent for the period 1975-1998[1].

Since 1985, the National Forest Policy attempted to set a more realistic target of 40 % total land areas as forest reserve area, while about 15% was targeted for conservation forest and the remaining 25% was for commercial forest. The Fifth National Economic and Social Development Plan clarified nation's policy regarding land reform project, a landholding ceiling, the establishment of land kind, and land settlements. The Sixth Plan also emphasized land reform- particularly for private land through the establishment of a land bank, improving the land tax system, and carrying land settlement projects on the land already allotted.

The legal framework for both forestry and land reform is found to be closely related and mechanisms for land reform Act started in Thailand since 1975. Under

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[1]One of the studies also stated that between 1950 and 1988, 108 million rai of forest land were cleared, 90 percent of which was converted to agriculture. Thus the amount of cropland tripled between 1950 and 1988, from 52 million rai to 148 million rai. About 40 percent of the 96-million-rai have been transformed into cropland for cash crops such as cassava, maize, and sugarcane; the balance went to rice and tree crop, most notably, rubber. See Tongpan S., T. Panayotou, S. Jetanavanich, K. Faichampa, and C. Mehl, (1990).

this act, land was to be made available by the government or expropriated from private owners who held land in excess of the legally prescribed amount or who were not themselves making proper use of the land. In addition, community forest, forest villages, village woodlots and other forestry projects have been introduced and become leading role in poverty alleviation and reforestation program.

Reforestation activities undertaken in Thailand can be summarized as follows:

(i) Community protected forests are established when a resource (land, forest, or water) is vital to the community;

(ii) The direct link between the threatened resource and the forest, and between the forest and the actions of the community are set;

(iii) Since traditional community institutions alone do not have the power to enforce forest conservation measures, government, NGO and private sectors are allowed to participate in the forest conservation activities; and

(iv) The 'outside' forests serve as a source of fuel wood, construction poles, cash income from charcoal, and land for cultivation. Other available forests are being sought and cleared, that would enable many communities to initiate and implement their own community forests.

(v) The availability and access to off-farm employment opportunities in nearby towns were provided to reduce a heavy dependence on land and forest by poverty-stricken villagers.

2.2 Thailand Forestry in Brief

Thailand is located in the tropical zone and it forest covers about 18,972 thousand hector (37.1%) of which 35.5% (6,726,000ha) is classified as primary forest and is regarded as the most bio-diverse and carbon-dense form of forest. The planted forest covers 3,986,000 ha of total forest areas. Change in forest cover, in particular, loss in forest cover between 1990 and 2010 has been estimated as an average of 28,850 ha or 0.15% per year. Thailand's forest loss indicates 3% of its forest cover, or about 577,000 ha between 1990 and 2010.

It is estimated that Thailand's forests contain 880 million metric tons of carbon in living forest biomass in 2000. On biodiversity and protected Areas: Thailand has

some 1715 known species of amphibians, birds, mammals and reptiles according to figures from the World Conservation Monitoring Centre.

Table 2.1 Forest Cover and Forest Policy of Thailand, 2010

Total Land Area (1000 square kilometers)	51089
Total Forest Area (1000 ha)	18972
Percent Forest Cover	37
Primary Forest Cover (1000 ha)	6726
Primary Forest, % total forest	35

Thailand: Forest policy and legal framework National forest policy (year): 2007 Sub-national forest policy: N.A. National forest program (year) - status: 1985 In implementation National forest law (year): Specific forest law (1941) Sub-national forest law

Source: Royal Thai Survey Department

Table 2.2 Trends in Total Net Forest Cover, 1990-2010

TOTAL FOREST COVER (1000 ha)			
1990	2000	2005	2010
19549	19004	18898	18972
ANNUAL CHANGE (1000 ha) *Negative number represents deforestation*			
	1990-2000	2000-2005	2005-2010
	-55	-21	15
ANNUAL CHANGE RATE (percent) *Negative number represents deforestation*			
	1990-2000	2000-2005	2005-2010
	-0.28	-0.11	0.08
CARBON STOCK IN LIVING FOREST BIOMASS (million metric tons)			
1990	2000	2005	2010
908	881	877	880

Source: http://www.mongabay.com

2.3 Deforestation and Forest Cover Change

By definition, deforestation comprises both quantitative and qualitative aspect of changes in forest cover. It includes not only a change in forest cover but also biodiversity change such as changes in species and the health of the forest. This study emphasizes the former and the interaction of forest degradation and socioeconomic effects.

Forest cover in Thailand declined from -.028% of the country's land area for the period: 1990-2000 to -0.11% for the period 2000-05. It has been recognized that deforestation in Thailand was driven primarily by agricultural expansion, which constitutes a basis of country's economic development through increased agricultural production for export. The government sets a target for 40% forest cover in 1980s. To

achieve this they initiated tree planting initiatives and leased some degraded forests to third parties to create logging plantations.

Major land cover types such as forests, croplands, paddy rice (irrigated) and waterbodies were discerned based on the satellite data. Deciduous and evergreen forests were not able to discriminate with reasonable accuracy particularly in the north where a complex of deciduous and evergreen forests exists. Due to various policy measure to combat deforestation, forest area of Thailand is decreasing at the increasing rate.

Woodwell (1993)'s study suggests the desirable maintenance level of forest cover as 75 to 90 percent of country forest cover. It requires well-managed forest landscape mosaics of natural forest, plantation, agroforestry, shelterbelts and other formations to guarantee the health and sustainability of a regional forest ecosystem, including the maintenance of resilience and adaptability. This suggests the need to establish a rational framework for forest land-use policy and planning by taking into account of the use and non-use value of forests.

The knowledge on current trends and patterns of deforestation in Thailand are equally important. These trends result in a stabilization and, conceivably, a net increase in forest cover in some tropical forest countries within one or two decades. In the light of the current high rates of tropical forest loss , it requires a broad-based, rational approach to direct strategic priorities for conservation and sustainable development. This approach should stress the conservation of biodiversity, including the important role of its structural and functional attributes.

The causal relationships between deforestation, ecosystem function and biodiversity highlights that a number of factors are involved in ecosystem degradation and biotic impoverishment. Some of these are dependent as much on the patterns of deforestation and modes of forest utilization as on the total amount of forest habitat loss. Thus, opportunities may often exist to mitigate the worst effects of forest loss through the maintenance of buffers' corridors and large blocks of natural forest as well as through ecological restoration and reforestation. Specific mitigation measures can be described to conserve local, landscape or regional-level structural or functional attributes that are disrupted by forest habitat loss and fragmentation.

The changes in protected forest area of Greater Mekong Sub-region countries: Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam and Yunnan Province of China are provided in Table 2.3. Thailand's protected forest area constituted as 7% of total

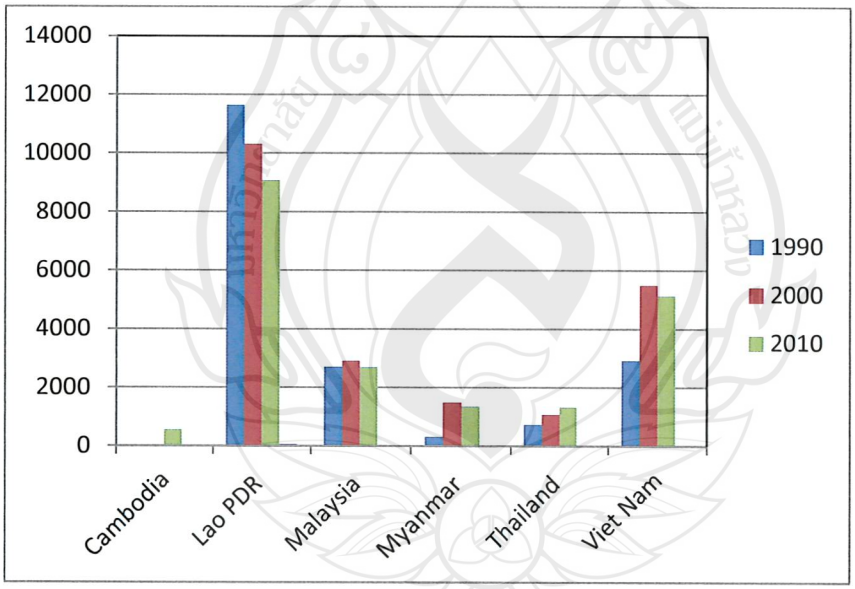
forest area, which is lower that her neighboring GMS countries where 58% in Lao PDR, 37% in Viet Nam.

Table 2.3 Change in Protected Forest Area in GMS

	Area (000 hectare)			% forest
	1990	2000	2010	area 2010
Cambodia	-	6	551	5
Lao PDR	11634	10310	9074	58
Myanmar	312	1499	1352	4
Thailand	727	1081	1332	7
Viet Nam	2925	5502	5131	37
Yunnan-China	-	-	-	-

Source: Food and Agriculture Organization (FAO) of the United Nations (2010)

Figure 2.1 Change in Protected Forest Area in GMS (000'hectare)



The forest degradation level and rates of GMS countries are shown in Table 2.4. It shows that Thailand's forest cover change has been increased from -21.2 thousand hector for the period 2005-2010 compared to 14.8 thousand hectors for the period 2000-2005. The forest cover has declined in Cambodia, Lao PDR and Myanmar for the period 2000-2005.

Protected areas in Thailand are relatively well protected by law from encroachment, logging and collecting and hunting in the park. The law enforcement is, stated weak in some cases. Thailand's first national park was established in 1962 and the growth of national parks reached 77 national parks and 36 wildlife sanctuaries. Land cover change in Thailand is mainly characterised by the change of forest areas to non-forest areas, in which forest areas are largely converted to agricultural lands.

It has been widely accepted that major causes of the forest degradation are encroachment, shifting cultivation, commercial logging and forest fire. The reason for the mangrove forest destruction is due to shrimp farming, salt farming, expansion of agriculture lands and mining. Other forces responsible for forest loss in Thailand are land development for tourism and real estate, agricultural clearing, hydroelectric projects, and forest fires. It has been observed widely that Thailand's recent economic development has been achieved at the expense of the environment and the country's natural resources.

Table 2.4 Deforestation and Degradation Rates in GMS

	Forest cover change (000ha/yr)		Growing stock change (million m3/yr)		Carbon stock in forest (tonnes)*
	2000-2005	2005-2010	2000-2005	2005-2010	2010
Cambodia	-163	-127.4	-16.8	-13.2	464
Lao PDR	-78	-78.2	-4.6	-5.6	1074
Myanmar	-309.4	-309.6	-14	-13.8	1654
Thailand	-21.2	14.8	-0.8	0.6	880
Viet Nam	270.4	144	12.2	3.0	992
Indonesia	-310.4	-685	-154	-223.2	13017
Malaysia	-140.2	-86.8	-52	-39.4	3212
Philippines	54.8	54.8	1.8	1.3	663
SE Asia	-709.8	-1086.4	-228.6	-290.8	22028

Source: FAO (2010)

Figure 2.2 Deforestation and Degradation Rates in GMS

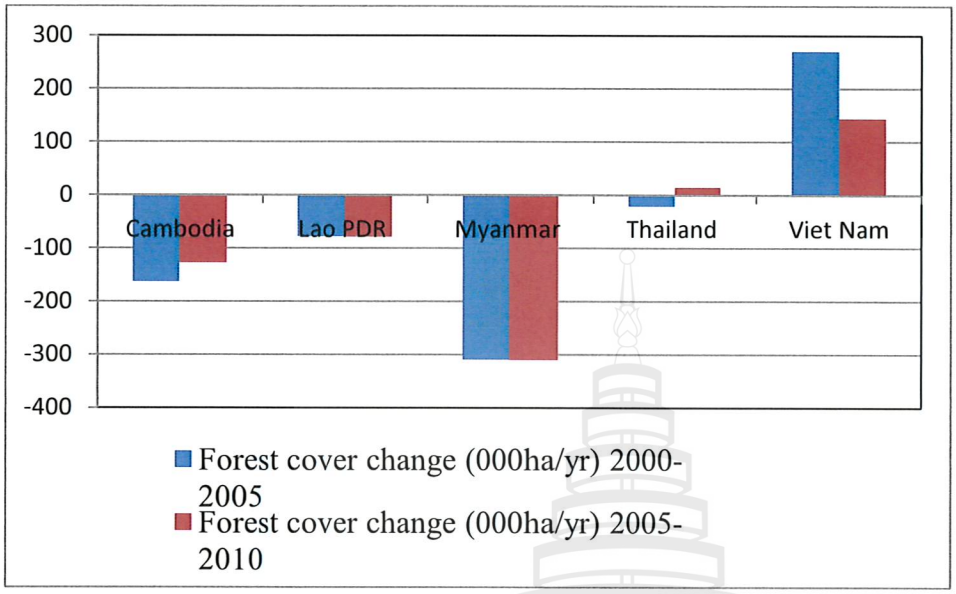


Table 2.5 Forest Cover Trends in GMS (000 hectare)

	Forest cover 2010 (%)	Annual change 2005-2010 (%)	Forest cover target
Cambodia	57.2	-1.2	Maintain 60% through 2015
Lao PDR	68.2	-0.5	70% by 2020
Myanmar	48.3	-0.9	50% (35% closed forest, 15% open forest)
Thailand	37.1	0.1	40% (25% conservation forests, 15% economic forests); not less than 33% (18% conservation area)
Yunnan/China	-	-	-

Source: *Ibid.*

On the basis of FAO (2010), the conceptual and methodological approaches to assessing forest degradation can be summarized as follows: i) conserving the relative values and benefits of different attributes and elements of biodiversity; ii) enhancing the role of biodiversity in ecosystem function; iii) encouraging relationships between

elements and critical structural and functional aspects of biodiversity; iv) ecosystem patterns and processes at different spatial and temporal scales that influence biodiversity; and v) modes and patterns of land and forest-use in consistent with the conservation and sustainable management of tropical forest biodiversity.

CHAPTER 3

DETERMINANTS OF FOREST DEGRADATION IN NORTHERNTHAILAND

By definition, deforestation reflects a decrease in the area covered by forest. However, it cannot be so defined without taking into account the forest utilization and priority objectives of forest management. This is the case of clear cutting of areas where forest will regenerate itself or be regenerated, or of the final cut in an even-aged forest sylvicultural treatment once natural regeneration has been assured. Thus there is no deforestation if there is a guarantee of continuity in maintaining the forest cover. In contrast, forest degradation does not involve a reduction of the forest area, but rather a quality decrease in its condition. It is related to one or a number of different forest ecosystem components (vegetation layer, fauna, soil, and etc.) to the interactions between these components, and more generally to its functioning. The estimation of degradation can be hampered by a number of difficulties that are notably caused by two main factors biophysical and economic factors such as (i) the different choices of the initial state of reference: "climax" or its numerous substitutes, the forest condition (ii) the criteria with their indicators on health and vitality, species diversity, the production capacity of market or non-market goods and services; and (iii) the present state is only transitory and leads to a satisfactory, or even improved, later state and (iv) economics of forest dwellers.

3.1 The Causes of Deforestation

The major causes of deforestation in Thailand are recorded in the previous studies as follows: (i) timber and fuel wood extraction, including wood for charcoal, (ii) clearing for farming by an ever-increasing rural population, (iii) the conversion of forests into croplands, (iv) imperfection of markets, and (v) poverty, or poorly defined property rights.

3.2 The Effects of Deforestation

The impacts of the loss of forests in Thailand are primarily concerns with the detrimental effects center around increasing carbon dioxide and methane in the atmosphere, increasing runoff, decreasing rainfall, loss of genetic diversity, and loss of soil fertility.

In fact, the current rate of deforestation is likely to continue at an accelerated rate unless appropriate policy interventions are undertaken. Of such causes and effects of deforestation, the present research attempts to explore the effect of above-mentioned three environmental policies under three scenarios upon the prices, unemployment and income distribution of different household groups in Thailand.

3.3 Methodology

Rural people in the country are assumed to maximize their utility given the resource endowment and other constraints. Since the different areas (districts) of the economy are interdependent on each other and that all depend on the same resources, the temporal dynamic and spatial scale model major sectors of the economy is applied in this chapter.

3.4 Changes in Forest Area

Table 3.1 provides changes in forest area of provinces under the Northern Thailand for the period: 2004 – 2006. A large decline in forest areas was found in Lamphun, Tak, Chiang Mai, Mae Hong Sorn, and Nan Provinces indicating forest area loss of 3700 thousand hectares in Northern Thailand.

In terms of geographical distribution of the forest, 56.3 percent were located in the North followed by the North-East; 16.2 percent, the Central; 12.4 percent, the East; 5.8 percent, and the South; 9.3 percent.

Table 3.2 provides total land area and forest areas of Thailand for 2009. The forest area in Northern Thailand constituted 73057.3 sq.km which is about 56.3% of total forest area in Thailand. Land area of Northern Thailand covered 33% of total land area. The changes in forest cover in historical perspectives are illustrated in Figures 3.1 and 3.2.

Table 3.1 Changes in Forest Area (Thousand hectare)

Province / Region	Province	2004		2005		2006		2004-2006	
			% of Area		% of Area		% of Area	Changes	% of changes
Kamphaeng Phet	8,607.49	1,970.92	22.90	1,902.83	22.11	1,899.85	22.07	-71.07	0.02
Chiang Mai	20,107.06	15,690.71	78.04	15,385.19	76.52	15,243.98	75.81	-446.73	0.12
Chiang Rai	11,678.37	5,101.46	43.68	4,964.79	42.51	4,918.56	42.12	-182.90	0.05
Tak	16,406.65	12,669.78	77.22	12,292.52	74.92	12,180.80	74.24	-488.98	0.13
Nakhon Sawan	9,597.68	848.25	8.84	818.13	8.52	817.85	8.52	-30.40	0.01
Nan	11,472.07	8,497.28	74.07	8,261.57	72.01	8,095.10	70.56	-402.18	0.11
Phetchabun	12,668.42	3,650.56	28.82	3,623.69	28.60	3,616.16	28.54	-34.40	0.01
Phrae	6,538.60	4,263.65	65.21	4,142.56	63.36	4,095.07	62.63	-168.58	0.05
Phayao	6,335.06	3,189.20	50.34	3,082.16	48.65	3,012.32	47.55	-176.88	0.05
Phichit	4,531.01	13.33	0.29	13.22	0.29	13.18	0.29	-0.15	0.00
Phitsanulok	10,815.85	3,940.14	36.43	3,875.54	35.83	3,820.79	35.33	-119.35	0.03
Mae Hong Son	12,681.26	11,128.22	87.75	10,785.45	85.05	10,642.99	83.93	-485.23	0.13
Lampang	12,533.96	8,600.52	68.62	8,096.11	64.59	7,926.24	63.24	-674.28	0.18
Lamphun	4,505.88	2,605.98	57.84	2,581.10	57.28	2,575.53	57.16	-30.45	0.01
Sukhothai	6,596.09	2,133.41	32.34	2,097.96	31.81	2,091.30	31.71	-42.11	0.01
Uttaradit	7,838.59	4,442.67	56.68	4,339.09	55.36	4,303.64	54.90	-139.03	0.04
Uthai Thani	6,730.25	3,322.34	49.36	3,119.08	46.34	3,114.75	46.28	-207.59	0.06
North	**169,644.29**	**92,068.42**	**54.27**	**89,380.99**	**47.31**	**88,368.11**	**52.09**	**-3,700.31**	1.00

1/ Royal Thai Survey Department, 2010.
2/ Management and Restore Forest Conservation Office, National Park, Wildlife and Plant Conservation Department
1. Forest area acquired from LANDSAT 5 (TM), interpretation imageries at the scale of 1 : 50,000
2. Existing forest area in this table means forest of all types such as evergreen, pine, mangrove, mixed deciduous, dry dipterocarp, scrub, swamp, mangrove and beach forest etc., either in the national forest reserves, national parks, wildlife sanctuaries, forest working plan with an area of 5 hectares (3.125 rai) or more with tree taller than 5 metre or more and with canopy covering more than 10% of the ground area.
Source: Royal Survey Department, Thailand.

Figure 3.1 Forest Land cover of Thailand

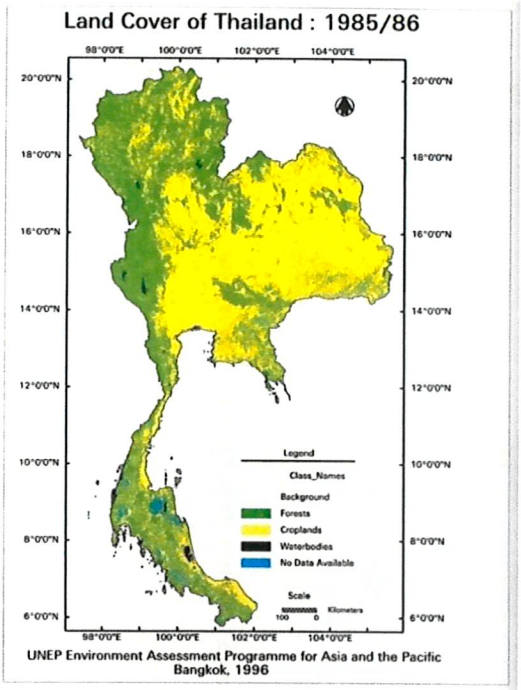


Figure 3.2 Forest land cover change of Thailand

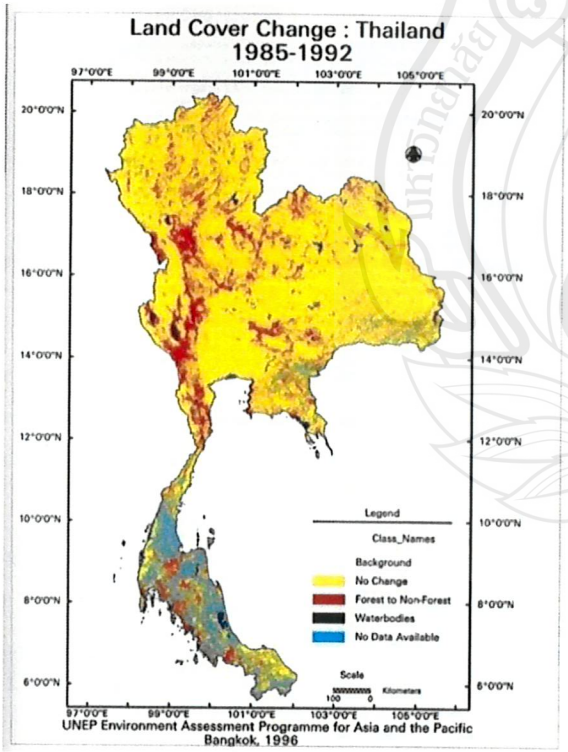


Table 3.2 Total Land and Land-Use by Province, 2009

	Total Land		Total	
Province/Region	Area		Forest Area	
	sq.km.	%	sq.km.	%
North	169,644.3	33.1	73,057.3	56.3
North-east	168,854.3	32.9	20,983.9	16.2
Central	67,398.7	3.1	16,048.5	12.4
East	36,502.5	7.1	7,507.4	5.8
South	70,715.2	13.8	12,125.1	9.3
Whole Kingdom	513115.02	100	129722.28	100

Source: Royal Survey Department, Thailand.

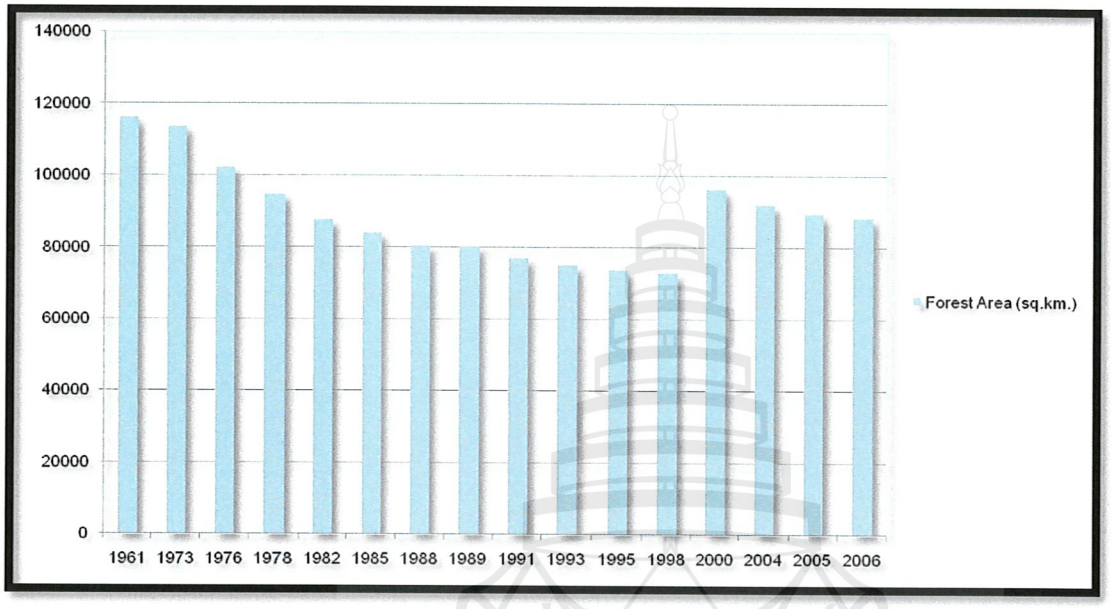
The trade liberalization policies and agreements often involve an assessment of regulatory effects including product and process standards, economic instruments, and subsidies, etc. Thus the reconciliation of the conflicting objectives of trade policy and environmental policy for sustainable regional development are crucial. On the basis of such regulatory effect in the forestry sector, complementary mechanisms can be drawn for the re-enforcement of land and/or forest regulations levying taxes or charges to contribute to an environmental protection fund.

This research begins with baseline environmental conditions focusing, on the structural change in the land and forest of Northern Thailand. Subsequently it predicts broad changes in resource use due to the trade liberalization will be modeled. The trade effects of the environment in positive way should be devised to enhance positive environmental effects in the long run and reduce potential negative environmental effects. These includes an environmental review that advocates different policy responses, including: (i) modification of some aspects of the trade policy; (ii) inclusion of environmental safeguards in the trade liberalization; and (iii) implementation of a complementary environmental mechanism to integrate the trade policy.

Thus major causes of forest degradation in Thailand should be adjusted based on (a) revising the existing forest product production, certain kinds of consumption, and the disposal of waste products, (b) establishing use of strategic environmental

trade policy such as tax on forest product, and (c) revising the policy failures due to the subsidies for polluting and resource-degrading activities such as subsidies to agriculture, fishing and energy.

Figure 3.3 The Status of Forest Areas in Northern Thailand: 1961-2006



It has been widely accepted that a change in the use of land resource may impact on all sectors in the economy, in particular natural resources such as forestry and energy. Land use change, in particular deforestation is pervasive in Northern Thailand where resources are the mainstay of the region. In addition, it is crucial to identify the causes of forest degradation in the wake of trade liberalization and their impact on local income distribution. Identification of determinants will enable effective environmental management and eradicate rural poverty.

CHAPTER 4
MODELING DETERMINANTS OF FOREST DEGRADATION AND ITS IMPACTS ON SUSTAINABLE DEVELOPMENT IN NORTHERN THAILAND

4.1 The Survey Design, Method and Instruments

This study provides important insights on the impacts of forest area including protected and un-protected areas based on household survey comprising 719 households living near forests or within forest areas in 28 villages under five Provinces of Northern Thailand. To investigate the socio-economic impacts experienced by each province, the present research attempts to contribute the broader issue of the socioeconomic impacts of forest area systems. To assess impacts, the approach relies on evaluating differences between communities in the these province or with a similar likelihood of protection and similar pre-protection development potential.

The section provides evidence from household survey data. The households are clustered on the basis of levels of income earned during the year and hence changes in use of natural resources and impacts on the forestry sector; policy initiatives for each income group are suggested. The evidence based on household survey data analysis suggests that the socio-economic variables incorporating biophysical and spatial variables influence reforestation.

Material and methods

Various LANDSAT and house hold survey of Thailand are used for the period: 1991-2009. To obtain the require parameter for calibration of the model, surveys will be conducted in selected areas in the selected countries. Survey includes 719 households from 28 villages under 5 provinces: Chiang Rai, Chiang Mai, Mae Hong Son, Nan and Phayao. The total numbers of villages in each province under survey reflect 4 villages in Chiang Rai, 7 villages in Chiang Mai, 6 villages in Mae

Hong Song, 7 villages in Nan and 3 villages in Phayao. The detailed sample villages are provided in Table 4.1. The survey instruments are discussed in the following section.

This study examines the linkages among rural household demographics, livelihoods and the environment applying the livelihood approach as an organizing framework. It links environmental, demographic and economic variables in the spatial and intertemporal model. The evidence suggests that dependence on natural resources intensifies when households lose human and social capital.

The survey instruments used in the household survey contain eight categories: basis demographic profile; human development profile; property type; land tenure and use system; food security, accessibility rights and open access; livelihood patterns; poverty mapping; use of natural resources; and forest management practices. The details can be summarized below.

Part I Survey Instruments under Household Questionnaires

Number of Family

A. Basis Demographic Profile

Member sex

Member age

Employment/working status

Education

Other data

B. Human development Profile

Health access

Social fund

School studying

Campus studying

Receive scholarship

4.1 Survey Sample under Five Provinces in Northern Thailand

Province	District	Sub-district	Moo	Village	Household Sample Size
Chiang Rai	Chiang San	Mae Ngern	2	Pa Ka	26
Chiang Rai	Chiang San	Mae Ngern	5	San Ton Pao	62
Chiang Rai	Chiang San	Mae Ngern	7	Mae Khom	56
Chiang Rai	Chiang San	Ban Saew	4	Pa Teang	36
Total				**4 Villages**	**180**
Chiang Mai	San Kum Pang	On Tai	11	Pa Pao Ngam	11
Chiang Mai	San Kum Pang	On Tai	10	Ban Phae	27
Chiang Mai	Chom Thong	Mae Soi	8	Hui Fang	25
Chiang Mai	Chom Thong	Ban Luang	10	Mae Hom	12
Chiang Mai	Chom Thong	Ban Luang	11	Maung Kan	28
Chiang Mai	Chom Thong	Sod Tea	3	Cheng Doi	37
Chiang Mai	Hod	Hang Dong	1	Op Lung	8
Total				**8 Villages**	**148**
Mae Hong Son	Pang Ma Pha	Sod Pong	2	Nam Rin	19
Mae Hong Son	Mae sa Reang	Ban Kad	4	Mae Harn	30
Mae Hong Son	Mae sa Reang	Ban Kad	9	Pa Mo Lo	28
Mae Hong Son	Maung	Hui Pha	6	Mae Su Ya	24
Mae Hong Son	Kun Yume	Maung Pond	1	Pond	17
Mae Hong Son	Mae La Noi	San Ke Ree	1	Mae Pang	48
Total				**6 Villages**	**166**
Nan	Pua	Si La Phet	1	Na Khum	21
Nan	Pua	Own	1	Rai Sa Mak Kee	23
Nan	Pua	Own	3	Nam Yao	21
Nan	Maung	Boo	1	Wang Mor	43
Nan	Ban Luang	Ban Pee	4	Pee Near	25
Nan	Tha Wang Pha	Pha Tor	6	Sob Pead	13
Nan	Tha Wang Pha	Pha Tor	4	Num Phu	8
Total				**7 Villages**	**154**
Phayao	Dok Kum Tai		5	Ronghai	22
Phayao			7	Yaopangpulor	28
Phayao	Sri Toi		13	Ban Mai	21
Total				**3 Villages**	**71**
Grand Total				**28 Villages**	**719**

Source: Compilation based on survey data.

C. Property Type

Land area

Forest area

Land property right

Residence property right

Number of car

Number of truck

Number of motorcycle

Number of bicycle

Number of cow

Number of Buffalo

Number of chicken

Number of duck

Number of goat

Number of duck

Other animal

D. Land Tenure and use system

Other property

Land tenure

Land rent

Forest rent

Land property rent

Resident property

Other rent

Community area

Agriculture area

Yearly crop

Flat area

High area

Outside area plant

Garden plant

Specific plant

Animal feed area

Fishery area

Forestry area

Natural forest

Forest production

Forest protection

Special use

Forest protection

Forest production

Forest protection

Special use

Forest nursery

Special area

Resident area

E. Food security, accessibility rights and open access

Property right

Food spending

F. Livelihood Patterns

Gov occupation

Occupation

Non wage

Self employ

Wage

Others

Stream Use

Area use

River use

Irrigation use

Other use

Ecological system use

G. Poverty Mapping

Income monthly

Ratio of income per expense

Village average

Household income average

Level of poverty

H. Use of Natural resources

I. Forest Management Practices

Part II Survey Instruments under Village Questionnaires

The survey instruments under village questionnaires are classified as 14 categories as follows:

A. Basic demographic profile

B. Human development profile

C. Property assets

D. Land tenure and use systems

E. Food security, accessibility rights, open asses

F. Livelihood patterns

G. Poverty mapping

H. Questions on environment

I. Migration

J. Management practices

K. Impact and risk assessment

L. Anticipated Impacts

M. Risk and Vulnerability Profile

(Life Cycle, Economics, Environment, Social/Governance)

N. Land under crops

1. Annual Crops, (upland fields and other annual crops)

2. Home Garden

3. Perennial Crops, (Perennial Industrial, ruit Trees, Other perennial, Nurseries)

4. Pasture (Planted Pasture, Natural Pasture)

5.Pond (Fish Pond, Shrimp Pond, Other aquaculture)

The survey results on socioeconomic likelihood condition and resource use in these villages in five provinces and the expected impacts are discussed in the following section.

4.2 Summary of Socioeconomic and Natural Resource-Use of Households

Household Characteristics

The household characteristics comprise gender of household head and household members, average age of household, their employment current status, health access and education attachment. These are presented in Table 4.2.

Table 4.2 Household Characteristics (Percent)

Privince	Village	Gender of Leader		Number of Family	Gender of Member		Age Average	Work		Health		Education
		Male	Female		Male	Female		Yes	No	Access Yes	Access No	average year
Chiang Rai	Pa Ka , Moo 2	72	28	n.a	57	43	n.a	57	21	66	1	n.a
	San Ton Pao , Moo 5	72	28	n.a	51	49	n.a	104	69	157	4	n.a
	Mae Khom, Moo 7	85	15	n.a	52	48	n.a	106	66	163	9	n.a
	Pa Teang, Moo 4	18	82	n.a	53	47	n.a	59	49	117	0	n.a
Phayao	Ban Rong Hai Moo5	70	30	22	51	49	n.a	61	39	99	1	n.a
	Yaopangpulor, Moo7	76	24	28	39	61	n.a	53	47	80	20	n.a
	Ban Mai, Moo 13	86	14	21	56	44	n.a	66	34	94	6	n.a
Chiang Mai	Ban Pa Pao Ngam, Moo 11	10	1	11	19	25	32	28	16	42	2	8
	Ban Phae	22	5	27	52	46	35.29	62	33	82	21	5.04
	Ban Hui Fang, Moo 8,	20	5	25	45*	53*	34.42	63	35	101	1	5.01
	Ban Mae Hom, Moo 10	10	2	12	24	28	34	39	13	50	2	6
	Ban Maung Kan, Moo 11	22	6	28	52	48	44.39	69	31	96	7	4.34
	Ban Cheng Doi, Moo 3	27	10	37	72	67	38.3	101	38	120	19	5.05
	Ban Op Luang, Moo 1,	7	1	8	12	13	31.6	17	8	18	7	4
Mae Hong Som	Ban Nam Rin, Moo 2	15	3	18	40	35	30.3	59	15	73	2	3.6
	Ban Mae Ham, Moo 4	24	5	29	42	43	36.6	49	30	94	20	6.07
	Ban Pa Mo Lo Moo 9	23	5	98	51	39	33.1	53	37	77	13	5.26
	Ban Mae Su Ya, Moo 6	17	7	89	40	46	31.5	49	37	73	13	3.69
	Ban Pond, Moo 1	12	5	65	34	27	36.3	43	18	52	9	6.5
	Ban Mae Pang, Moo 1	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Nan	Ban Na Khum	16	5	21	36	43	34.93	50	29	79	0	6.2
	Ban Rai Sa Mak Kee	15	6	21	32	37	42	40	29	56	13	4.86
	Ban Nam Yao	18	3	21	38	29	37.22	42	24	59	7	5.09
	Ban Wang Mor	37	6	43	89	81	35.13	112	54	161	9	4.11
	Ban Pee Near	18	8	26	39	51	39.57	64	26	83	4	6.01
	Ban Sob Pead	10	1	12	32	21	31.94	38	15	58	2	4.15
	Ban Num Phu	3	4	7	15	11	49	15	8	25	2	1.25
Average by Province												
Chiang Rai		61.9	38.1	n.a	53.4	46.6	n.a	62.4	37.6	97.7	2.3	n.a
Phayao		77.3	22.7	22.0	48.7	51.3	n.a	60.0	40.0	91.0	9.0	n.a
Chiang Mai		16.9	4.3	21.1	38.5	37.8	35.7	54.1	24.9	72.7	8.4	5.3
Mae Hong Som		18.2	5.0	59.8	41.4	38.0	33.6	50.6	27.4	73.8	11.4	5.0
Nan		16.7	4.7	21.6	40.1	39.0	38.5	51.6	26.4	74.4	5.3	4.5

Source: Compilation based on survey data.

Table 4.2 reports the household characteristics comprising gender of household head and member of household, average of household, their current status, health access and education attachment. In Chiang Rai Province, 62% of household head under survey were male and 38% were female. About 62.4% had employment and 97.7% had health access. In Phayao Province, 77% of household head under survey were male and 22.7% were female. About 60% were employed and 91% had health access. About 18% of household head were male and 22.7% were female in Chiang Mai Province. Gender composition of male and female in a household indicated 38% and 37% respectively.

Table 4.3 Land-Use of Household (Rai)

Province	Village	Agriculture	Forestry	Property	Housing	Total Area
Chiang Rai	Pa Ka , Moo 2	158.7	0.0	113.0	0.0	271.7
	San Ton Pao , Moo 5	605.0	0.0	389.0	0.0	994.0
	Mae Khom, Moo 7	456.6	39.0	363.9	0.0	859.5
	Pa Teang, Moo 4	960.2	195.0	761.6	0.0	1,916.8
Phayao	Ban Rong Hai Moo5	209.5	28.0	59.0	11.3	307.8
	Yaopangpulor, Moo7	126.0	31.0	58.0	19.1	234.1
	Ban Mai, Moo 13	175.0	18.0	42.5	7.8	243.3
Chiang Mai	Ban Pa Pao Ngam, Moo 11	33.8	5.6	0.0	2.8	7.5
	Ban Phae	152.2	63.8	0.0	32.0	19.5
	Ban Hui Fang, Moo 8,	230.8	113.8	8.0	68.8	11.4
	Ban Mae Hom, Moo 10	56.9	17.8	3.0	9.0	11.1
	Ban Maung Kan, Moo 11	140.4	64.5	7.0	31.0	16.8
	Ban Cheng Doi, Moo 3	2995.7	654.0	2020.0	237.0	84.7
	Ban Op Luang, Moo 1	0.0	0.0	0.0	1.0	1.5
Mae Hong Sorn	Ban Nam Rin, Moo 2	340.3	322.0	4.0	0.0	14.3
	Ban Mae Harn, Moo 4	150.3	74.5	22.0	41.0	12.8
	Ban Pa Mo Lo Moo 9	1728.5	225.5	1426.8	0.3	76.0
	Ban Mae Su Ya, Moo 6	158.8	76.0	17.0	44.5	21.3
	Ban Pond, Moo 1	198.8	98.0	21.0	74.0	5.8
	Ban Mae Pang, Moo 1	n/a	n/a	n/a	n/a	n/a
Nan	Ban Na Khum	64.8	37.5	2.0	16.5	8.8
	Ban Rai Sa Mak Kee	190.0	105.0	31.0	42.0	12.0
	Ban Nam Yao	270.1	101.0	40.0	111.0	18.3
	Ban Wang Mor	1450.3	753.0	386.0	260.0	51.3
	Ban Pee Near	296.5	214.8	41.0	33.3	7.5
	Ban Sob Pead	181.1	104.0	16.0	57.0	4.1
	Ban Num Phu	141.3	91.5	0.0	46.0	3.8
Average by Province						
Chiang Rai		545.1	58.5	406.9	0.0	1010.5
Phayao		170.2	25.7	53.2	12.7	261.7
Chiang Mai		515.7	131.3	291.1	54.5	21.8
Mae Hong Sorn		515.3	159.2	298.2	32.0	26.0
Nan		370.6	201.0	73.7	80.8	15.1

Source: Compilation based on survey data.

As shown in Table 4.3, about 54% of households engaged in employment and 72% had health access. The average schooling age was 5 years (i.e. junior secondary school). In Mae Hong Sorn Province, about 18% of household head was male and 22.7% was female. Gender composition of male and female in a household showed 41% and 38% respectively. About half of them had employment and 73% had health access. The average schooling age was 5 years. In contrast, about 16% of household head was male and 22.7% was female in Nan Province. Gender composition of male and female in a household reflected 16% and 4.7% respectively. About 51.6% had employment and 74% had health access. The average schooling age under survey was 4.5 years (i.e. primary education).

One of the major areas of population pressure on environment research in the past decade has focused on household-level population dynamics and their relationship, through livelihood strategies, to environmental change. Studies also have sought to investigate the relationships among population variables (household size, age and sex composition, fertility, on-farm population density, migration, and mortality), biophysical variables (forest cover, coastal mangroves, and soil quality), and natural resources (firewood, timber, non-timber forest products, bush meat and water. This study applies the relevant studies with fruitful future directions in this large and growing body of research.

In this study, the livelihood approach is used as an organizing framework to focus on demographic and environmental changes as they play a critical role. In most rural areas the household is the basic unit of production and reproduction in which most rural smallholders made these. Within the livelihood approach, a "household" has been described as "a site in which particularly intense social and economic interdependencies occur between a group of individuals" .

Table 4.4 Vehicle Ownership of Household

Province	Village	Car	Motorcycle	Truck	other
Phayao	Ban Rong Hai Moo5	9	14	n.a	n.a
	Yaopangpulor, Moo7	7	15	n.a	n.a
	Ban Mai, Moo 13	7	17	n.a	n.a
Chiang Mai	Ban Pa Pao Ngam, Moo 11	8	10	n.a	n.a
	Ban Phae	8	8	n.a	n.a
	Ban Hui Fang, Moo 8	8	19	2	n.a
	Ban Mae Hom, Moo 10	16	16	0	n.a
	Ban Maung Kan, Moo 11	8	13	0	n.a
	Ban Cheng Doi, Moo 3	14	23	1	n.a
	Ban Op Luang, Moo 1	0	4	0	n.a
Mae Hong Sorn	Ban Nam Rin, Moo 2	4	9	0	n.a
	Ban Mae Harn, Moo 4	2	14	0	n.a
	Ban Pa Mo Lo Moo 9	11	13	0	2
	Ban Mae Su Ya, Moo 6	2	16	0	0
	Ban Pond, Moo 1	9	14	0	0
	Ban Mae Pang, Moo 1	n.a	n.a	n.a	n.a
Nan	Ban Na Khum	3	0	14	0
	Ban Rai Sa Mak Kee	6	12	1	0
	Ban Nam Yao	6	15	1	0
	Ban Wang Mor	11	35	0	2
	Ban Pee Near	6	12	0	1
	Ban Sob Pead	4	5	0	1
	Ban Num Phu	0	4	0	0
Average by Province					
Phayao		7.7	15.3	n.a	n.a
Chiang Mai		8.9	13.3	0.6	n.a
Mae Hong Sorn		5.6	13.2	0.0	0.7
Nan		5.1	11.9	2.3	0.6
Total		6.8	13.4	1.0	0.6

Source: Compilation based on survey data.

Table 4.5 Ownership in Animal (Number)

Province	Village	Cow	Buffalo	Chicken	Duck	Goats	Bird	Other
Chaing Rai	Ban Sobyod, Moo 2	35	18	720	0	0	0	0
	Ban Pong Kong, Moo 10	66	1	14	911	5	15	0
	Ban Maengern, Moo 12	80	158	45	956	2	0	0
	Ban Saew, Moo 4	40	0	6	192	0	0	0
Phayao	Ban Rong Hai Moo5	59	7	95	0	0	0	15
	Yaopangpulor, Moo7	16	10	109	0	0	0	2
	Ban Mai, Moo 13	6	0	415	0	0	0	0
Chiang Mai	Ban Pa Pao Ngam, Moo 11	34	0	0	0	0	0	0
	Ban Phae	48	30	4	0	0	0	5
	Ban Hui Fang, Moo 8	1	0	218	0	0	0	0
	Ban Mae Hom, Moo 10	97	22	75	0	0	0	0
	Ban Maung Kan, Moo 11	13	3	180	0	0	0	23
	Ban Cheng Doi, Moo 3	320	0	873	0	0	0	2
	Ban Op Luang, Moo 1	23	0	10	0	0	0	0
Mae Hong Sorn	Ban Nam Rin, Moo 2	0	0	163	0	0	0	0
	Ban Mae Harn, Moo 4	18	10	36	15	0	0	10
	Ban Pa Mo Lo Moo 9	146	5	475	0	0	0	19
	Ban Mae Su Ya, Moo 6	0	3	160	0	0	0	3
	Ban Pond, Moo 1	0	0	98	0	0	0	0
	Ban Mae Pang, Moo 1	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Nan	Ban Na Khum	24	0	148	37	0	0	4
	Ban Rai Sa Mak Kee	0	0	53	0	0	0	0
	Ban Nam Yao	0	0	132	0	0	0	0
	Ban Wang Mor	4	2	134	0	0	0	0
	Ban Pee Near	30	0	128	6	0	0	3
	Ban Sob Pead	0	0	95	0	0	0	2
	Ban Num Phu	0	0	0	0	0	0	0
Average								
Chaing Rai		221	177	785	2,059	7	-	-
Phayao		27.0	5.7	206.3	0.0	0.0	0.0	5.7
Chiang Mai		76.6	7.9	194.3	0.0	0.0	0.0	4.3
Mae Hong Sorn		32.8	3.6	186.4	3.0	0.0	0.0	6.4
Nan		8.3	0.3	98.6	6.1	0.0	0.0	1.3

Source: Compilation based on survey data.

Land-Use Condition of Household

Table 4.3 provides the average land-use condition of household under survey in Northern Thailand. The agriculture area constituted 545 rai and forestry area showed 58.5 rai under survey in Chiang Rai. The property area was about 406 rai. In Phayao, average agriculture land area covered 170.2 rai, while forest area indicated 131.3 rai. Property land and housing land indicated 291.1% and 54.5% respectively. In Chiang Mai, average agriculture rai showed 515.7 rai, while forestry area indicated 25.7 rai. The property and housing land indicated 291.1 rai and 54.5 rai respectively. Mae Hon Son also have larger portion of agriculture land use (515.3 rai) while forestry land showed 159 rai. The property land and housing land constituted 32 rai and 26 rai respectively.

In general, rural households pursues a 'livelihood strategy' that may comprise a number of different activities such as farming, herding, fishing, off-farm employment and the exploitation of natural resources through hunting and gathering. In order to engage in these activities, households mobilize the following assets (Sherbinin et. al., 2009):

Natural capital: the natural resource stock, or local environmental endowment including water, wind, soil, forest resources;

Social capital: social resources, such as interpersonal networks, membership in groups, relationships of trust, access to wider institutions of society;

Human capital: formal and informal education, local ecological knowledge, the ability to work, and good health;

Physical capital: productive assets held by the household (land, tools, oxen) as well as communal assets to which they have access (roads, communication infrastructure such as radio broadcasts);

Financial capital: cash savings, supplies of credit, or regular remittances and pensions.

Households' wealth is comprised of some combination of these assets. The type and amount of each that a household holds is dependent on past investment and economic opportunities and constraints.

Table 4.6 Type of Occupation (Percent)

Province	Village	Government	Private	Farmer
Chiang Rai	Pa Ka , Moo 2	0	33	57
	San Ton Pao , Moo 5	50	33	21
	Mae Khom, Moo 7	50	33	21
Phayao	Ban Rong Hai Moo5	1	5	15
	Yaopangpulor, Moo7	2	1	19
	Ban Mai, Moo 13	0	0	19
Chiang Mai	Ban Pa Pao Ngam, Moo 11,	n/a	n/a	n/a
	Ban Phae	9	1	8
	Ban Hui Fang, Moo 8,	4	0	19
	Ban Mae Hom, Moo 10	n/a	n/a	n/a
	Ban Maung Kan, Moo 11,	2	0	26
	Ban Cheng Doi, Moo 3,	2	0	46
	Ban Op Luang, Moo 1,	2	0	7
Mae Hong Sorn	Ban Nam Rin, Moo 2	1	0	18
	Ban Mae Harn, Moo 4	1	0	3
	Ban Pa Mo Lo Moo 9	1	1	28
	Ban Mae Su Ya, Moo 6	3	4	15
	Ban Pond, Moo 1	3	1	15
	Ban Mae Pang, Moo 1	n/a	n/a	n/a
Nan	Ban Na Khum	0	0	23
	Ban Rai Sa Mak Kee	4	4	14
	Ban Nam Yao	4	0	16
	Ban Wang Mor	3	2	41
	Ban Pee Near	3	2	22
	Ban Sob Pead	1	1	11
	Ban Num Phu	2	0	6
Average by Province				
Phayao		1.0	2.0	17.7
Chiang Mai		3.8	0.2	21.2
Mae Hong Sorn		1.8	1.2	15.8
Nan		2.4	1.3	19.0
Total		2.3	1.2	18.4

Source: Compilation based on survey data.

Table 4.7 Water and Irrigation –Use

Province	Village	Cannel	River	Irrigation	Other
Chiarn Rai	Pa Ka , Moo 2	46	47	42	4
	San Ton Pao , Moo 5	55	53	48	9
	Mae Khom, Moo 7	44	44	22	12
	Pa Teang, Moo 4	47	48	24	13
Phayao	Ban Rong Hai Moo5	10	n/a	4	6
	Yaopangpulor, Moo7	11	9	5	3
	Ban Mai, Moo 13	10	7	3	3
Chiang Mai	Ban Pa Pao Ngam, Moo 11	7	7	0	3
	Ban Phae	7	2	11	4
	Ban Hui Fang, Moo 8,	3	5	12	10
	Ban Mae Hom, Moo 10	12	8	5	2
	Ban Maung Kan, Moo 11	18	11	5	0
	Ban Cheng Doi, Moo 3,	13	11	10	11
	Ban Op Luang, Moo 1,	1	2	1	1
Mae Hong Sorn	Ban Nam Rin, Moo 2	6	6	3	10
	Ban Mae Harn, Moo 4	17	11	5	5
	Ban Pa Mo Lo Moo 9	10	4	9	6
	Ban Mae Su Ya, Moo 6	13	8	3	5
	Ban Pond, Moo 1	10	7	0	7
	Ban Mae Pang, Moo 1	n/a	n/a	n/a	n/a
Nan	Ban Na Khum	12	2	2	11
	Ban Rai Sa Mak Kee	8	8	1	6
	Ban Nam Yao	6	5	1	12
	Ban Wang Mor	21	16	2	14
	Ban Pee Near	15	5	1	6
	Ban Sob Pead	5	5	0	8
	Ban Num Phu	4	1	1	2
Average by Province					
Chiang Rai		48	48	34	10
Phayao		10.3	5.3	4.0	4.0
Chiang Mai		8.7	6.6	6.3	4.4
Mae Hong Sorn		9.3	6.0	3.3	5.5
Nan		10.1	6.0	1.1	8.4

Source: Compilation based on survey data.

In brief, household population dynamics, environment and natural resources, farm size and farm tenure are key indicators of the physical capital of households.

Vehicle ownership

Average number of use of car and motorcycle in households under survey in Phayao and Chiang Mai are quite similar, in which both provinces have more use of cars compared to Mae Hong Sorn and Nan. Such data is not available for Chiang Rai. The details can be seen in Table 4.3.

Animal ownership

The animal ownership of household under survey is provided in Table 4.5. The average ownership of household showed 221 units of cow, 177 units of buffalo, 785 units of chicken, 2059 units of duck and 7 units of goats in Chiang Rai. Use of cow in agriculture and forestry production was higher in Chain Rai (221 unit) followed by Chiang Mai (76 units) Mae Hong Sorn (32.8 units), Phayao (27 units) and Nan (8.3 units).

Cattles are second only to land as an important form of physical capital for rural families worldwide. But unlike land, cattles are portable assets that are easily transported and traded. They also provide a stream of income from dairy products. Cattle grazing requires little labor and they can be sustained on land that is too poor for crops. Thus, it could be considered as a factor into fertility decision making.

There is the potential for this line of research to yield important insights into the feedbacks between demographic change and environmental change by joining it with microlevel research on specific health impacts of environmental change. There is a growing literature on the health impacts of land-use transformations resulting from frontier migration.

Figure 4.1 Survey Area 1 in Chiang Mai

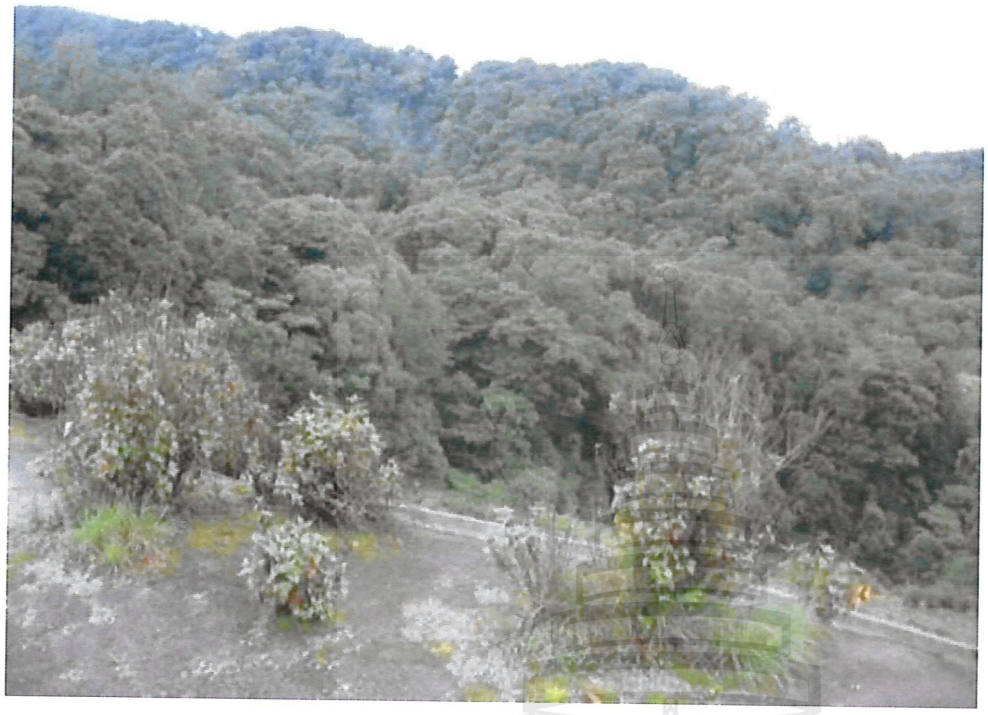


Figure 4.2 Survey Area 2 in Chiang Mai

Occupational structure

Occupational structure of households under survey in terms of farmer, private and government sectors are provided in Table 4.6. As an can be seen in this table, about 15% to 20% of households under survey worked as farmers in these provinces. The about 3.8 % in Chiang Mai worked in government sector followed by Nan (2.4%), Mae Hong Sorn (1.8%) and Phayao (91%).

Table 4.8 Income and Expenditure

Province	Village	Monthly Expenditure*	Monthly Income**
Chiang Rai	Pa Ka , Moo 2	2126	3617
	San Ton Pao , Moo 5	0	3074
	Mae Khom, Moo 7	218	4490
	Pa Teang, Moo 4	0	3552
Phayao	Ban Rong Hai Moo5	10,323	30,982
	Yaopangpulor, Moo7	7,447	4,000
	Ban Mai, Moo 13	6,266	6,284
Chiang Mai	Ban Pa Pao Ngam, Moo 11,	n.a	n.a
	Ban Phae	n.a	161,500
	Ban Hui Fang, Moo 8,	n.a	138,500
	Ban Mae Hom, Moo 10	n.a	n.a
	Ban Maung Kan, Moo 11,	n.a	101,500
	Ban Cheng Doi, Moo 3,	n.a	134,400
	Ban Op Luang, Moo 1,	n.a	45,500
Mae Hong Sorn	Ban Nam Rin, Moo 2	3,444	4,313
	Ban Mae Harn, Moo 4	2,969	3,771
	Ban Pa Mo Lo Moo 9	3,807	1,892
	Ban Mae Su Ya, Moo 6	3,243	2,256
	Ban Pond, Moo 1	4,558	2,717
	Ban Mae Pang, Moo 1	n.a	n.a
Nan	Ban Na Khum	3,361	4,080
	Ban Rai Sa Mak Kee	3,785	3,133
	Ban Nam Yao	4,952	5,547
	Ban Wang Mor	3,783	4,175
	Ban Pee Near	4,325	6,961
	Ban Sob Pead	2,796	2,580
	Ban Num Phu	7,700	8,900
Average by Province			
Phayao		8,012.0	13,755.3
Chiang Mai		n.a	116,280.0
Mae Hong Sorn		3,604.2	2,989.8
Nan		4,386.0	5,053.7
Total		5,334.1	34,519.7

Source: Compilation based on survey data.

*monthly average expenditure on food; **monthly average income per household

Source: Compilation of survey data.

Table 4.9 Resources Use Condition

Province	Village	Nature Resource			Water			Soil			Soil Erosion		
		Unchanged	Decreased	Increased	Unchanged	Decreased	Increased	Unchanged	Decreased	Increased	Unchanged	Decreased	Increased
Phayao	Ban Rong Hai Moo5	n.a	n.a	n.a	24	14	0.62	n.a	n.a	n.a	n.a	n.a	n.a
	Yaopangpulor, Moo7	n.a	n.a	n.a	35	17	48	n.a	n.a	n.a	n.a	n.a	n.a
	Ban Mai, Moo 13	n.a	n.a	n.a	53	14	33	n.a	n.a	n.a	n.a	n.a	n.a
Chiang Mai	Ban Pa Pao Ngam, Moo 11	0	50	50	27	46	27	55	27	18	82	18	0
	Ban Phae	9	64	27	8	17	75	40	0	60	82	18	0
	Ban Hui Fang, Moo 8,	8	72	20	28	28	44	21	29	50	5	86	9
	Ban Mae Hom, Moo 10	9	64	27	8	17	75	40	0	60	82	18	0
	Ban Maung Kan, Moo 11,	n.a	n.a	n.a	74	4	22	32	9	59	4	76	20
	Ban Cheng Doi, Moo 3,	6	79	15	0	92	8	17	77	6	15	32	53
	Ban Op Luang, Moo 1,	14	86	0	37.5	25	37.5	17	0	83	14	86	0
Mae Hong Sorn	Ban Nam Rin, Moo 2	0	20	80	0	83	17	80	20	0	11	44	44
	Ban Mae Harn, Moo 4	0	86	14	31	17	52	41	18	41	54	21	17
	Ban Pa Mo Lo Moo 9	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	Ban Mae Su Ya, Moo 6	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	Ban Pond, Moo 1	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	Ban Mae Pang, Moo 1	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Nan	Ban Na Khum	86	14	0	52	0	48	42	11	47	0	83	14
	Ban Rai Sa Mak Kee	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	Ban Nam Yao	n.a	n.a	n.a	50	20	30	25	19	56	18	64	18
	Ban Wang Mor	60	5	35	34	6	60	22	62	16	25	72	2
	Ban Pee Near	64	36	0	52	20	28	23	32	45	38	62	0
	Ban Sob Pead	83	17	0	54	8	38	12.5	12.5	75	18	73	9
	Ban Num Phu	57	43	0	57	0	43	40	0	60	0	83	17
Average by Province													
Phayao		n.a	n.a	n.a	44.0	15.5	27.2	n.a	n.a	n.a	n.a	n.a	n.a
Chiang Mai		7.7	69.2	n.a	26.1	n/a	41.2	n/a	20.3	n.a	n.a	n.a	11.7
Mae Hong Sorn		0.0	53.0	47.0	15.5	50.0	34.5	60.5	19.0	20.5	32.5	32.5	30.5
Nan		70.0	23.0	7.0	49.8	9.0	41.2	27.4	22.8	49.8	16.5	72.8	10.0
Total		25.9	48.4	27.0	33.9	24.8	36.0	44.0	20.7	35.2	24.5	52.7	17.4

Source: Compilation of survey data.

Table 4.10 Resources Related Problems

Province	Village	Drought		Flood		Forest Fire		Soil Collapse	
		Yes	No	Yes	No	Yes	No	Yes	No
Chiang Rai	Pa Ka , Moo 2	91.1	8.9	37.5	62.5	55.4	42.9	30.4	67.9
	San Ton Pao , Moo 5	84.1	15.9	65.2	34.8	50.7	49.3	30.4	69.6
	Mae Khom, Moo 7	93.2	6.8	66.1	33.9	8.5	91.5	15.3	83.1
	Pa Teang, Moo 4	92.1	7.9	66.7	33.3	12.7	87.3	17.5	81.0
Phayao	Ban Rong Hai, Moo5	58.0	42.0	68.0	32.0	74.0	26.0	74.0	26.0
	Yaopangpulor, Moo7	56.0	44.0	36.0	64.0	69.0	31.0	20.0	80.0
	Ban Mai, Moo 13	19.0	21.0	n/a	n/a	29.0	71.0	81.0	19.0
Chiang Mai	Ban Pa Pao Ngam, Moo 11,	18.0	82.0	100.0	0.0	18.0	82.0	73.0	27.0
	Ban Mae Hom, Moo 10	75.0	25.0	58.0	42.0	50.0	50.0	82.0	18.0
	Ban Hui Fang, Moo 8,	80.0	20.0	48.0	52.0	52.0	48.0	12.0	88.0
	Ban Mae Hom, Moo 10	75.0	25.0	58.0	42.0	50.0	50.0	82.0	18.0
	Ban Maung Kan, Moo 11,	46.0	54.0	46.0	53.0	46.0	53.0	11.0	80.0
	Ban Cheng Doi, Moo 3,	86.0	14.0	51.0	49.0	68.0	32.0	16.0	84.0
	Ban Op Luang, Moo 1,	75.0	25.0	25.0	75.0	88.0	13.0	25.0	75.0
Mae Hong Sorn	Ban Nam Rin, Moo 2	60.0	40.0	50.0	50.0	33.0	67.0	25.0	75.0
	Ban Mae Harn, Moo 4	41.0	59.0	31.0	69.0	17.0	83.0	62.0	21.0
	Ban Pa Mo Lo Moo 9	46.0	54.0	79.0	21.0	79.0	21.0	21.0	79.0
	Ban Mae Su Ya, Moo 6	50.0	50.0	21.0	79.0	75.0	25.0	50.0	50.0
	Ban Pond, Moo 1	29.0	71.0	35.0	65.0	24.0	76.0	82.0	18.0
	Ban Mae Pang, Moo 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nan	Ban Na Khum	43.0	57.0	10.0	90.0	24.0	76.0	0.0	100.0
	Ban Rai Sa Mak Kee	43.0	57.0	100.0	90.0	24.0	76.0	0.0	100.0
	Ban Nam Yao	57.0	43.0	38.0	62.0	19.0	81.0	19.0	81.0
	Ban Wang Mor	71.0	29.0	51.0	49.0	21.0	79.0	21.0	79.0
	Ban Pee Near	60.0	40.0	23.0	77.0	8.0	92.0	4.0	96.0
	Ban Sob Pead	38.0	62.0	54.0	46.0	38.0	61.0	8.0	97.0
	Ban Num Phu	86.0	14.0	0.0	100.0	43.0	57.0	17.0	83.0
Average by Province									
Chiang Rai		90.1	9.9	58.9	41.1	31.8	67.7	23.4	75.4
Phayao		n/a	n/a	n/a	48.0	57.3	42.7	n/a	n/a
Chiang Mai		65.0	35.0	n/a	44.7	n/a	46.9	n/a	55.7
Mae Hong Sorn		45.2	54.8	43.2	56.8	45.6	54.4	48.0	48.6
Nan		56.9	43.1	39.4	73.4	25.3	74.6	9.9	90.9

Source: Compilation of survey data.

The water-use system

Table 4.7 provides the water-use system in the form of cannel, river, irrigation and other sources. About 11% of households in these provinces used cannel and about 7% used river. Use of irrigation showed about 4% to 6% in Phayao, Chiang Mai and Mae Hong Sorn provinces. Use of irrigation in Nan indicated about 1.1%.

Average monthly income and expenditure of household

The average monthly income and expenditure of household under survey are shown in Table 4.8. In Chiang Mai, Households received highest average annual income 116280 baht followed by Pahyao (913755 baht), Nan (5053 baht) and Mae Hong Sorn (2989 Baht). There exist average net savings in household since average monthly income exceeded month expenditure.

Change in natural resource-use condition

The opinion on change in natural resource-use condition and the expected problems in resource-use in the forms of natural resource-forest, water soil and soil erosion are provided in Tables 4.9 and 4.10 respectively. These are examined on the basis of the opinion of households. About 69% of household in Chiang Mai and about 53% of household in Mae Hong Song agreed that the condition of natural resource has been declined. In Nan, 23% of household reported a decline in forest resources. With respect to water, 15% of households in Phayao, 50% of household in Mae Hong Sorn and 9% of household expressed a decline in available water condition. About 20% of respondents al revealed the decreased in soil quality. In Chiang Mai about 32% indicated the soil erosion problem and it showed about 72% in Nan indicating the effect on soil erosion.

Figure 4.3 Survey Area in Phayao

Figure 4.4 Survey Area 1 in Nan

Figure 4.5 Survey Area 2 in Nan

4.3 Temporal Dynamic and Spatial Scale Model[2]

4.3.1 Dynamic Bio-Economic Model

The model is based on a variant of Vance and Geoghegan (2002), Barbier and Bergeron (2001) and Barbier, (1998) focusing on temporal and spatial aspects of possible determinants of deforestation given economic condition. In addition, the prediction on the effects of degradation is made in this study applying the survival analysis to identify the effect of household level explanatory variables including

[2] The section is presented in the regional workshop at the National Resource Center, Mae Fah Luang University in November 2009. The comments and suggestions from participants are greatly appreciated.

bioeconomic variables on the probability of deforestation. Thus the model captures property the inter-temporal behavior of both ecology and economics. There exists two types of modeling deforestation such as location of land-use change and irreversible land conversion due to urban fringe development. The latter has led habitat degradation.

4.3.2 Model Specification

The empirical model is summarized in the following section. The model is based on two conditions. The first condition requires that forest clearing decision is made in the presence of net benefit under this framework. In the second condition, in addition to positive net benefits there exist benefits from waiting because of the potential for higher benefit in future. The net benefits to agriculture use for each time period is summarized as follows:

Let X(i) : the characteristics of a small plot so-called 'pixel i' in forest

A (i, t) : the net benefits to famer for current living

F (i, t) : the one-time clearing costs

C (i, T) : optimal time for clearing the pixel in the first time period

$$A(X(i), T) - F(X(i), T) - \delta C(X(i), T+1) - \varepsilon(i) \geq 0 \quad \text{..... (1)}$$

The hazard rate which is the probability of pixel i will be deforested in period T can be expressed as:

$$h(i,T) = \frac{G[W(i,T+1)] - G[W(i,T)]}{1 - G[W(i,T]} \quad \text{..... (2)}$$

where G is the cumulative distribution function for the error term.

$$W(i, T+1) = A(X(i), T) - F(X(i), T) - \delta C(X(i), T+1) \quad \text{..... (3)}$$

$$W(i, T+1) = A(X(i), T) - F(X(i), T) - \delta C(X(i), T+2) \quad \text{..... (4)}$$

Next, to test the effect of explanatory variables X(i) on the hazard rate, the survival model is applied. This model has been used in the literature, in particular, in engineering and biomedical sciences to examine the processes as the length of time until component failure or the survival times of patients diagnosed with certain disesses. In the model of Vance and Geoghegan, the length of time indicates an individual pixel remains forest before being converted to cropland or pasture.

The likelihoodfunction of the n pixels that are to be deforested is given below.

$$\prod_{i=1}^{n} Pi, t1\ (1 - P\text{i, ti} - 2) \qquad \text{..... (5)}$$

The complementary log-log likelihood function is can be expressed as follows:

$\log[-\log(1-Pit)] = \beta' X(i,T)$, where

$$X(i,t) = A(X(i), T) - F(X(i), T) - \delta C(X(i),T+1) \qquad \text{..... (6)}$$

X(i) are the exogenous variables and α and β vector of parameters to be estimated using maximum likelihood methods. The complementary log-log model is silimar to logit and probit model in such way that the predicted probabilities lies in [0,1] intervals, the logit model specification is used in the present study as follows:

$$\text{logit}(p) = \ln(p/(1-p)) = \beta 0 + \Sigma\ \beta j\ Xi \qquad \text{..... (7)}$$

The households are clustered on the basis of average income of household head, age of households, education, resource-use of households, land ownership, forest ownership, and agricultural and forestry sector production. The evidence based on household survey data analysis suggests that the socio-economic variables incorporating biophysical and spatial variables, and households' resource use patterns influence deforestation.

The research using both the environmental assessment indicators and trade-environment modeling technique explores the magnitude and sign of effects of trade liberalization on the forestry sector in Thailand.

Data and variables of the Model

The survey data includes household demographic composition (household family size, age of household head, education attainment, socioeconomic variables (income); forest regulatory variables (ownership, re-plantation) and trade policy variables as follows:

Y_1	Dummy with value 1, forest degradation exists and zero otherwise
Y_2	Dummy with value 1 if tree re-plantation exists and zero otherwise
FAML	Family size of household
AGE	Age of household head
EDU	Education level attainment
LNDO	Land owned
FORO	Forest owned
FORP	Forest production
FORPOP	Dummy with value 1 if the area is under projected area and zero otherwise
INCOME	Average income of household
LNDFO	Land and forest ownership LNDFO = LNDO + FORO (land ownership and forest ownership)

4.4 Model Results and Discussions

This case study examines the socioeconomic impacts of Northern Thailand using a quasi-experimental approach to provide estimates of the aggregate social impacts of forest areas. It seeks to answer the question on the effect of this forest area on economic outcomes within provinces by applying logit model as mentioned above. These effects are examined based on two set of dependent variables Y_1 and Y_2. On the use of Y_2, it is postulated that tree replantation in same pixel is associated directly with forest degradation. Thus Y_2 is used as an proxy or alternative of Y_1.

In contrast to the results indicated above, those conventional methods erroneously implied that protection had negative impacts on the livelihoods of local communities. These findings suggest that the case study demonstrates the specific value delivered by applying an impact evaluation approach, which carefully identifies suitable counterfactuals for measuring the social impacts of protected areas.

The logit model is estimated for individual provinces under survey since the impacts of forest degradation varies across provinces. The model results for Chiang Rai, Phayao, Chiang Mai, Mae Hong Sorn, and Nan are reported in Tables 4.11 through 4.15.

Table 4.11 Socio-Economic Impact of Degradation
Model Result- Chiang Rai Province

Model	Dependent Variable		LNDO	FORO	INCOME	FOR_P	LNDFO
1	Y_1	β	0.018***	0.042***			n/a
		t	3.751	1.645			
		ρ	0.000	0.102			
2	Y_2	β	0.03***	0.039***			n/a
		t	8.598	2.113			
		ρ	0.000	0.036			
3	Y_2	β				0.505***	0.010***
		t				8.832	2.840
		ρ				0.000	0.005
4	Y_2	β			5.65E***		0.017
		t			5.150		4.192
		ρ			0.000		0.000

*** $\rho < 0.01$, ** $\rho < 0.05$, * $\rho < 0.1$

In general, the coefficients of variables: AGE, FAMILY, EDU, INCOME, FORO, LNDO, FORP, LNDFO turn out to be positive as expected. The surprising result, however, is the significant and positive estimate for the stringency of environmental regulation variables. It means that apparently a more stringent forestry policy would give rise to less degradation. The results reveal the strong view on the

link between forest degradation and its determinants: socioeconomic and trade policies.

The findings under Chiang Rai suggest that households' biological factors do not seem to be important factors of degradation, in contrast, household income, forest ownership, land ownership and commercial production show the significant effects on forest degradation. Based on model 1 of Table 4.11, if forest area increases by 10%, forest degradation will increase by about 0.1%. In contrast, if forest area increases by 10% degradation will increase by 0.4%. The effect of commercial production has larger effect. A 10% increase in forest production will lead to 5% increase in degradation. The results also are significant at 1% level.

Table 4.12 Socio-Economic Impact of Degradation
Model Result- Phayao Province

model	Dependent Variable		LNDO	FORO	FORPOP	FORP
1	Y_1	β	0.032***	0.048**		
		t	5.082	2.345		
		ρ	0.000	0.022		
2	Y_2	β			0.05***	0.312***
		t			1.319	5.382
		ρ			0.092	0.000

*** $\rho < 0.01$, ** $\rho < 0.01$, * $\rho < 0.1$

The findings under Phayao showt that households' biological factors do not seem to influence degradation. However, the coefficients of AGE, FAMILY, EDU, INCOME, FORO, LNDO, FORP, LNDFO show the significant effects on forest degradation. Based on model 1Table 4.12, if forest land increases by 10%, forest degradation will increase by about 0.3%. In contrast if forest ownership increases by 10% degradation will increase by 0.4%. The effect of commercial production has relatively larger effect. A 10% increase in forest production will lead to 3% increase in degradation. The results also denote significant at 1% level. Similar conclusion can be drawn from model 2 of this table.

Table 4.13 Socio-Economic Impact of Degradation

Model Result- Chiang Mai Province

Model	Dependent Variable		EDU	INCOME	FORP
1	Y_1	β t ρ	0.060** 2.4490.024	2.32E-05** 2.251 0.036	
2	Y_1	β t ρ	0.0602.34*** 20.030		
3	Y_2	β t ρ	0.047* 1.816. 0.085		0.321** 1.002 0.328

*** $\rho < 0.01$, ** $\rho < 0.05$, * $\rho < 0.1$

The findings under Chiang Mai indicate that the coefficients of EDU, INCOME, FORP show the significant effects on forest degradation. Based on model 1 of Table 4.13, if forest land increases by 10%, forest degradation will increase by about 0.6%. However, the effect of EDU has a minimal effects. If forest and land ownership increases by 10% degradation will increase by 23% based on model 3. The effect of commercial production has relatively larger effect. A 10% increase in forest production will lead to 3% increase in degradation. The results also show significance at 1% level. Similar conclusion can be drawn from model 2 of this table.

The findings under Nan Province reflect that households' biological factors and income indicate the important determinants of degradation. The coefficients of AGE, EDU and INCOME show the significant effects on forest degradation. The effects of age and education are larger than income effect. Based on model 1 in Table 4.15, if AGE factor increases by 10%, forest degradation will increase by about 6%. In contrast, if education factor (schooling) increases by 10% degradation will increase by 19%. The effect of households' income has relatively smaller effect. A 10% increase in forest production will lead to 0.5% increase in degradation. The results also denote significant at 1% level for AGE and EDU. Similar conclusion can be drawn from the various specification of models shown in Table 4.15.

Table 4.14 Socio-Economic Impact of Degradation

Model Result- Mae Hong Sorn Province

model	Dependent Variable		FAMILY	LNDO	INCOME	LNDFO
1		β	0.100***	-0.015***	9.82E-05	n/a
	Y_1	t	3.597	-2.349	3.485	
		ρ	0.001	0.024	0.001	
		β	0.100***		9.77E-05***	0.014***\
2	Y_2	t	3.505		3.427	-2.134
		ρ	0.001		0.002	0.039
		β	0.075***		8.63E-05***	
		t	2.771		2.963	-
3	Y_1	ρ	0.008		0.005	

*** $\rho < 0.01$, ** $\rho < 0.01$, * $\rho < 0.1$

In brief, the significant and positive estimates for the stringency of environmental regulations variable are found indicating a more stringent forestry policy measures are needed to give rise to less degradation. The results reveal the strong view on the link between forest degradation and its determinants: socioeconomic, resource use and trade policies.

Three concluding remarks can be drawn from this results. First, the restrictive forestry regulation has contributed to lower impact on degradation. Second other non- socio-economic factors and resource-use condition in the community have positive associations with forest degradation. Finally the commercial production of forest are associated with degradation. The estimations for the non-environmental policy variables are in line with those suggested by logit models.

Table 4.15 Socio-Economic Impact of Degradation

Model Result- Nan Province

Model	Dependent Variable		β_0	AGE	EDU	INCOME
1	Y_1	β	-0.183***	0.063***	0.198***	0.005**
		t	(-0.098)	(0.166)	(0.939)	(0.042)
		ρ	0.005	0.028	0.0056	0.0967
2	Y_1	β	-	0.031	0.188	0.0001
		t		(0.166)	(1.036)	(0.001)
		ρ		0.0081	0.0069	0.0088
3	Y_1	β	0.0282*	0.049***	-	-
		t	(0.05)	(0.340)		
		ρ	0.0901	0.0338		
4	Y_1	β	-	0.056	-	-
		t		(5.870)		
		ρ		0.0000		
5	Y_1	β	-0.1482*	-	0.1892***	-
		t	(0.8909)		(0.8909)	
		ρ	0.0758		0.0651	
6	Y_1	β	-	-	0.1019***	-
		t			(4.1485)	
		ρ			0.0001	

*** $\rho < 0.01$, ** $\rho < 0.05$, * $\rho < 0.1$

This research addresses an issue of great significance to trade and environment policy and practice- the socioeconomic impacts of forest degradation. The conclusions from this analysis show that the most effective evaluative perspective is gained by combining methodological approaches to ensure that both macro- and local-level impacts are accurately assessed. The research findings contribute to the following areas:

(a) highlighting regional consequences of trade liberalization, in particular in forestry sector of Thailand;

(b) identifying the factors influencing the forest degradation and its impact on the rural poverty based on the results suggested by the present study;

(c) developing the effectiveness of forest management practices in minimizing risks and the measures for sustainable environment;

(d) establishing environmental policy measures for strategic trade instruments to protect forest and sustainable forest growth as suggested by the model; and

(e) developing environmental regulations on regional competitiveness, specialization, industrial redeployment, and trade in forest products as found in this study.

This findings under this study can be summarized as follows:

(i) Villages surrounding forest areas in Thailand experienced forest degradation in varying degree depending on age structure, education, foreign ownership, land ownership, and commercial production of forest:

(ii) Forest ownership, land ownership, and commercial production have had a larger effects on households' income as well as forest degradation ; and

(iii) Income inequality exists among households living near forest and within forest areas under study depending on the existing opportunities given in the community.

This approach presented in this chapter analyzes a forest area system in Northern Thailand with respect to socioeconomic and environmental impacts at the community level. To measure socioeconomic outcomes, data are used from our surveys conducted in 28 villages in five provinces in Northern Thailand.

In addition, this method of forest management could productively be used to evaluate protected areas in other GMS countries to evaluate impacts of other large-scale environmental projects. It would complement existing studies, including case comparisons or household survey work, by providing a broader overview of impacts across a larger number of sites. The effective mechanism for the positive economic effect of national parks indicated the increased income from tourist visits in and near the parks and forest due to Thai Government policy initiatives.

CHAPTER 5

THE IMPACT OF FOREST DEGRADATION ON TRADE AND WELFARE OF NORTHERN THAILAND: A DYNAMIC INTERTEMPORAL CGE MODEL

The effects of sectoral and macroeconomic policies on deforestation and forest management are investigated in this chapter using intertemporal dynamic computable general equilibrium (DCGE) model. The presentation is made in four main sections. Section 5.1 summarizes a DCGE model, while Section 5.2 presents the results under the applied model. Section 5.3 discusses implications and policy framework for deforestation and forest management.

5.1 Specification of A Dynamic Intertemporal CGE Model

The research applies a DCGE model for evaluation on impact assessment of forest degradation in Northern Thailand that emphases the trade and forestry sectors. The model is designed to be useful as a development tool for the policymakers in performing trade and environmental issues, in particular, trade impact of forestry sector. A modified version of intertemporal CGE employed by Morley, Pirneiro and Robinnsion (2011) in the context of a recursive dynamic model that enables short term adjustment in factors employed in the short run as the economy responds to shocks.

The model is recursive dynamic and is solved in two stages. First, the model determines a within-period equilibrium, given parameters and exogenous variables. Second, some parameters and exogenous variables change over time. The model is solved forward in a dynamically recursive fashion, with each static solution depending on current and past values of variables and parameters implying that the behavior of agents is based on historical information and adaptive expectations. The variables and parameters used as linkages between periods are aggregate capital stock, population, domestic labor force, working capital supply, factor productivity, export and import prices, export demand, tariff rates, and transfers to and from the rest of the world.

Producers are assumed to maximize profits under constant returns to scale and perfect competition. There are two primary factors of production: labor (skilled and unskilled), location (rural and urban), and sector type (formal and informal); and capital. In addition, working capital is required and is assumed to be complementary with physical capital. Production is related to factor inputs through a constant elasticity of substitution (CES) production function, which allows producers to substitute among primary inputs so that the marginal revenue product of each factor equals its wage or rental rate (for capital). Producers demand intermediate inputs assuming fixed input–output coefficients (Leontief technology). In addition to input costs, producers also consider relevant taxes and subsidies.

The model includes the flow of single commodity from producers to final demand. First, producers use factor inputs according to a CES production function to produce output. This output is sold domestically or internationally. Producers allocate supply between domestic sales and exports using a constant elasticity of transformation (CET) function, which assumes imperfect transformability between exports and domestic sales. The share of production for domestic and export markets depends on relative prices. The domestic price of an export is the international price times the exchange rate plus any export taxes or subsidies. The goods sold on the domestic market is, in turn, assumed to be an imperfect substitute for an imported goods of the same commodity classification, assuming a CES aggregation function—the Armington specification.

There are four institutions in the model—households, enterprises, government, and the rest of the world—which do three things: (1) produce, (2) consume, and (3) accumulate capital. Households save a constant share of their disposable income and buy consumption goods. They own the enterprises and work in those enterprises. Household income is the sum of salaries, profits, net government transfers, and rest-of-the-world transfers. Household consumption of goods and services is determined by a linear expenditure system. Enterprises buy intermediate goods, hire factors of production, produce commodities and services, and sell them in the market. The government receives taxes, consumes goods and services, and makes transfers to households. The capital account acts as a loanable funds market, collecting savings from households, firms, government, and the rest of the world and making investment.

In this model each sector uses a nested CES function to produce three

composite factors consisting of working capital combined with skilled and unskilled labor and physical capital in the urban formal sector. The database for the CGE model is the 1998 social accounting matrix (SAM) of Thailand reported in Jenifer (2002).

In the second step of the recursive model, the linkages between periods are introduced. The static model is solved for a specific year; and then the capital stock, population, domestic labor force, factor productivity, export and import prices, credit supply, and export demand parameters are updated. The updated model is then solved again for the following year, and so on.

The steps for updating factor of production are given by the following steps:

1. Updating the sector shares of investment as follows:

$$INVSHR1^{a}_{f,a,t}=capshr_{f,a,t}*(\beta^{a}*(WF_{f,t}*WFDIST_{f,a,t}/WFKAV^{a}_{ft}-1)+1),$$

where:

Subscript f refers to the capital factor in these equations, a is activity or sector, and t is time. $capsh$ is the sector's capital share.

$INVSHR1$ is the share of sector a in total capital formation.

is the wage distortion factor for the capital factor in sector a.

is the average capital rental rate.

is the capital mobility parameter by activity.

2. The quantity of new real capital formation by sector is updated by calculating the investment share times the total quantity of new capital:

$DKAPS_{f}^{a},a,t=INVSHR1^{a}_{f},\ a,t*(\sum_{c}PQc,t*QINVc,tc/PK_{f},t)$, where:

$\Sigma\ PQ_{c,t}\ QINV_{c,t}$ is the aggregate gross fixed investment expenditure. $DKAPSf$ is the gross fixed real capital formation for sector a in time t. PKf, is the price of capital good.

3. Updating the quantity of aggregate capital:

$QFS_{f},t_{+1}=QFS_{f,t}*(1+DKAPS^{a}_{f,a,}t/QFS_{f,t}-deprate_{f})$.

Total real capital accumulation is equal to total savings which are endogenous. New capital is allocated across sectors by adjusting the proportion of each sector's share in

aggregate investment as a function of the relative profit rate of each sector compared with the average profit rate of the economy as a whole. Sectors with higher (lower) average profit rates will get higher (lower) shares of the available investment. The adjustment process over time leads toward convergence of sector profit rates. Labor supply for all categories except formal-sector unskilled labor is assumed to be exogenously increasing by a certain percent per year. Finally, productivity growth, real government consumption and transfers, world price of exports, and current account balances are set exogenously based on observed trends.

To summarize, the dynamic accumulation process is updated in three ways:

1. By exogenous trends (labor force growth, productivity changes, capital stock growth, and population growth)

2. By economic behavior (distribution of investment by sector and distribution of labor force by sector and category)

3. By implemented policies (trade liberalization, increasing tax on forest production, and imposing environmental tax)

The results under our study show the baseline estimates of changes in exogenous variables. These results explain the changes in the growth rates of wages, prices, sectoral outputs, and GDP that are caused by changes in exogenous variables, holding the growth rates of all other exogenous variables constant.

Model Description

The DCGE model is based on the standard CGE model which explains all of the payments recorded in the SAM using a set of systems of equations so-called models. The model therefore follows the SAM disaggregation, in particular, factors such as land, labour, capital; activities: economic activities by sectors; commodities based on sectors, and institutions: household, enterprises, government and other institutions. The equations define the behavior of the different actors such as: producers and consumers. The production and consumption behaviors are modelled applying nonlinear, first-order optimality conditions. Therefore production and consumption models are estimated using the maximization of profits and utility, respectively.

The households use their income to pay direct taxes, save, consume, and make transfers to other institutions. Exports and domestic sales on the assumption that

suppliers maximize sales revenue for any given aggregate output level, subject to imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET) function.

Transfers from the rest of the world to households are fixed in foreign currency. In fact, all transfers between the rest of the world and domestic institutions and factors are fixed in foreign currency.

The standard CGE model[3] can be summarized comprising four equation blocks as follows:

1. Price Block,
2. Production and Commodity Block,
3. Institutions Block, and
4. System Constraint Block.

The standard CGE model explains all of the payments recorded in the SAM in terms of factors, activities, commodities, and institutions in a form of nonlinear simultaneous equations. Production and consumption decisions are undertaken based on maximization of profits of producers and utility of consumers, respectively. In the following section each equation is described briefly. The notations of variables of these equations are provided in Appendix 1.

Price Block

The price block defines the import price, export price, output (activity) price, consumer price index (CPI) and producer price index.

Import price

The import price in local-currency units is the price paid by importers. The import price shown in Equation (1) states the world price of these imports, reflecting the exchange rate and import tariffs plus transaction costs per unit of the import. The market price paid by domestic commodity demanders is the composite price, PQ that applies only to payments for these imports.

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[3] This section is based on the IFRI's Standard CGE model and DCGE model of Morley, Pirneiro and Robinnsion (2011).

1. $PM_c = (1+t_c).\ pwn_c.EXR + \sum_{c \varepsilon CT} PQ_{c'}.icm_{c'c}$

Export Price

The export price is measured as the free on board (FOB) basis and expressed in foreign currency as shown in Eq (2).

2. $PEc = pwe_c(1+t_c).EXR + \sum_{c \varepsilon CT} PQ_{c'}.ice_{c'c}$

Demand Price of Domestic Nontraded Goods

3. $PDD_c = PDS_c + \sum_{c \varepsilon CT} PQ_{c'}.icd_{c'c}$

Total absorption indicates the total value of domestic final demands, which equals GDP at market prices plus imports minus exports.

4. $PQ_c(1-tq_c).QQ_c = PDD_c\ QD_c + PM_c.QM_c$

Marketed Output

5. $PX_c\,QX_c. = PDS_c\ QD_c + PE_c.QE_c$

Activity Price

6. $PA_a = \sum_{c \varepsilon C} PXAC_{c'}.\theta_{ac}$

Activity price is measured as producer prices times yields.

Absorption is expressed as the sum of spending on domestic output and imports at the demand prices, PDD and PM. The prices PDD and PM include the cost of trade inputs but exclude the commodity sales tax.

Aggregade Intermediate Input Price

7. $PINTA_a = \sum_{c \varepsilon C} PQ_c.i\ ca_{ca}$

Activity Revenue and Costs

8. $PA_{7\alpha}. = (1 - t\alpha_{\alpha})Q\,A_{ac} = PV\,A_{ac}.QV\,A_{ac} + PINT\,A_{ac}.QINT\,A_{ac}$

Consumer Price Index

9. $\overline{CPI} = \sum_{c \varepsilon C} PQ_c.cwts_c$

Consumer price index (CPI) indicates weighted price index of consumers' goods.

Producer Price Index for Nontraded Market Output

10. $DPI = \sum_{c \varepsilon C} PDS_c\,dcwts_c$

II Production and Trade Block

The aggregated domestic output from the output is output of different activities of a given commodity, a CES function is used. The demand for the output of each

activity is derived from cost minimization given quantity of aggregated output subject to this CES function. Activity-specific commodity prices clear the market for each disaggregated commodity.

Demand for value-added is a function of activity level.

CES Technology Activity Production Function

11. $QA_{\alpha} = \alpha_{\varepsilon}^{\alpha}.(\delta_{\varepsilon}^{\alpha}\,QV\,A_{\alpha}^{-\rho} + (1 - \delta_{\varepsilon}^{\alpha}).QINT\,A_{\alpha}^{-\rho})$

CES Technology Value – Added Intermediate Ratio

12. $\frac{QV\,A_{\alpha}}{QVT\,A_{\alpha}} = \left[\frac{PINT\,A_{\alpha}}{PV\,A_{\alpha}} \frac{\delta_{\alpha}^{\alpha}}{I - \delta_{\alpha}^{\alpha}} \right]^{1+\rho}$

Leontief Technology: Demandfor AggregateValue Added

13. $QVA_a = iva_a.QA_a$

Leontief technology : demand for AggregateIntermediate input

14. $QINTA_a = \text{int}\, a_a.QA_a$

Value– Addedand Factor Demand

15. $QVA_a = \alpha_\alpha^{vl}\left(\sum_{j\varepsilon F} \delta_{f\alpha}^{v\alpha} QF\rho_{f\alpha}\right)^{\frac{1}{\rho_a^{va}}}$

Equation (13) illustrates the quantity of value-added is a CES function of disaggregated factor quantities. According to equation (16), factors demand is determined at the point where the marginal cost of each factor is equal to the marginal revenue product of the factor.

The factor demand is determined based on profit maximization subject to a production technology that can be a constant elasticity of substitution (CES) function or, a Leontief function of the quantities of value-added and aggregate intermediate input. The optimal set of factors is determined at the point where the marginal revenue product of each factor is equal to its wage.

In the CGE model, institutions are represented by households, enterprises, the government, and the rest of the world.

Factor Demand

16. $W_f.\overline{WFDIS}_{f\alpha} = PVA_a(1-tv_a).QVA_a\left(\sum_{f\varepsilon F} \delta_{fa}^{va} QF_{f\alpha}^{-\rho}\right)^{-1}$

Disaggregated Intermediate Input Demand

17. $QF_{f2a,a} = \alpha_{f2a,afs}(\sum \partial fsub,\ f2s,(QFSUB_{QFSUB}) - \rho f2sfsub^{\ 1\rho fsafs}$

Market demands represent a composite commodity making up of imports and domestic output. The demands for factor are derived based on the cost minimization subject to imperfect substitutability under a CES aggregation function.

18. $WFSUB_{f2a,a}\, Wfdisubf_{sub},\ f2s, a = WF_{f2s^*}\, WFDIST\ f_{a2,a}(1 + tfaf2s, a).QFf2s, a^*.$
$(\sum\ \delta^{1\,\rho fsfs}\, sub,\ f2s, afs^*\, QFSUBfsub,\ f2s, a - \rho f2s, afs).QFSUB -$
$\rho f2s,\ fas^{-1}\ fsub,\ f2s, a$

19. $QFSUB_{fsub} = UNEMPSUBfsub + \sum_{f2sa} QFSUB_{fsub,\, f2s,a}$

20. $WFREAL_f = YFCPI.\sum_{f2sa} QF_{f,aa}\, CPI0$(average real wage per factor unit) =
(average real wage corrected by consumer price index)

21. $$QFS_f = QFS0^* \left[\frac{\dfrac{WF_f * FWFDIST_f * QF_f}{QFS_f}}{\dfrac{CPI\,J}{WF0_f}.CPI0} \right]^{[etalsf]}$$

22. $QINT_{ac} = ica_{c,\alpha}\, QINTA_a$

23. $QXA_{ac} + \sum_{h\varepsilon H} QHA_{ach}\ .\theta_{ac}.QA_a$

Output Aggregation Function

24. $$QX_c = \alpha \left[\sum_{a\varepsilon a} \delta_\alpha^{vac}.QXAC_{ac}^{-\rho c^{ac}} \right]_c^{1/\rho_c^{\alpha c-1}}$$

First – Order Conditionfor Output Aggregation Function

25. $$PXAC_\alpha = PX_c QX_c \left[\sum_{a\varepsilon a} \delta_\alpha^{vac}.QXAC_{ac}^{-\rho c^{ac}} \right]_c^{-1/} \delta_\alpha^{vac}.QXAC_{\alpha C}^{-\rho c^{ac}}$$

Output Transformation (CET) Function

26. $QX_{ac} = \alpha_c^f \left(\delta_\alpha^{vac}.QE_{\alpha C}^{-\rho c^{ac}} + (1 - \delta_c^f) QD_{\alpha C}^{-\rho c^{ac}} \right.$

$$27.\frac{QE_c}{QD_c}=\left[\frac{PE_C}{PDS_C}\cdot\frac{1-\delta_c^t}{\delta_C^t}\right]^{\gamma/\rho_c^T}$$

$$28.QX_c=QD_c+QE_c$$

$$29.QQ_c=\alpha_c^t\left(\delta_c^t QM_C^{-\rho}+QE_C\right)^{-\rho}$$

Investment Demand

$$30.\ QINV_{E_c}=LADJ.qinv_c$$

III. Institution Block

In the CGE model, institutions indicate households, enterprises, and the government, and the rest of the world. The households (receive income from the factors of production (directly or indirectly via the enterprises) and transfers from other institutions. Transfers from the rest of the world to households are fixed in foreign currency. The households use their income to pay direct taxes, save, consume, and make transfers to other institutions.

Government Consumpyion Demand

$$31.QG_c=GADJ.qg_c$$

Government Revenue

$$32.\ YG=.\sum_{i\varepsilon INSDNG}TINS_i.YI_i+\sum_{f\varepsilon F}tf_f.YF_f+\sum_{a\varepsilon A}tva_a.PVA_a.QVA_a$$
$$+\sum_{a\varepsilon A}ta_a.PA_a.QA_a+\sum_{c\varepsilon CM}tm_c.pwm_c.QM_c.EXR+\sum_{c\varepsilon CE}te_c.pwe_c.QE_c.EXR$$
$$+\sum_{c\varepsilon C}tq_c.PQ_c.QQ_c+\sum_{f\varepsilon F}YIF_{govf}+trnsfr_{govrow}.EXR$$

The households and transfers from other institutions. Transfers from the rest of the world to households are fixed in foreign currency. The households use their income to pay direct taxes, save, consume, and make transfers to other institutions.

Government Expenditure

$$33. EG = \sum_{c \varepsilon C} PQ_c . QG_c + \sum_{i \varepsilon INSDNG} trnsfr_{igov} . \overline{CPI}$$

The income that remains after taxes, savings, and transfers to other institutions is spent on consumption.

Institutional Factor Incomes

$$34. YIF_{i_f} = shif_{if} \left[(1 - tf_f) . YF_f - trnsfr_{row\,f} . EXR \right]_i$$

Household Consumption Spending on Marketed Commodities

$$35. YI_{i_f} = \sum_{c \varepsilon C} YIF_{i_f} - \sum_{c \varepsilon C} TRII_{ii} + trnsfr_{igov} . \overline{CPI} + trnsfr_{irow} . EX$$

The final institution is the rest of the world (RoW). Transfer payments between the rest of the world and domestic institutions and factors are all fixed in foreign currency. Household consumption covers marketed commodities, purchased at market prices that include commodity taxes and transaction costs, and home commodities, which are valued at activity-specific producer prices. Household consumption is allocated across different commodities (both market and home commodities) according to linear expenditure system (LES) demand functions, derived from maximization of a Stone.

Investment balances.

The income that remains after taxes, savings, and transfers to other institutions is spent on consumption.

Fixed investment demand

$$40. QINV_c EG = \overline{IADJ} . \overline{qin_{Vc}}$$

$$41. QG_c = \overline{GADJ} . \overline{qj_c}$$

Enterprises may also receive transfers from other institutions. Enterprise incomes are allocated to direct taxes, savings, and transfers to other institutions. Enterprises do not consume. The payments to and from enterprises are modeled in the same way as the payments to and from households.

Factor Income

$$42.\ YG = \sum_{i\varepsilon INSDNG} TINS_{ia}.YI_f + \sum_{a\varepsilon A} tf_{ia} YF_f + \sum_{a\varepsilon A} tva_{ia} PVA_f.QVA_f + \sum_{c\varepsilon C} ta_{ia} PA_a.QA_a + \sum_{a\varepsilon A} tm_c.pwm_c.QM_C.EXR + \sum_{a\varepsilon A} te_c.pwe_c.QE_C.EXi + \sum_{c\varepsilon C} tq_c PQ_c.QQ_c + \sum_{f\varepsilon F} YF_c. + trnsfr_{gov.row}.EXR$$

$$43.\ EG = \sum_{c\varepsilon C} PQ_c.QG_c + \sum_{i\varepsilon INSDNG} YF_c. + trnsfr_{gov.row}\,\overline{CPI}$$

Factor Markets

$$44.\ \sum_{a\varepsilon A} QF_{fa} = QFS_f$$

The equations also include a set of constraints that have to be satisfied by the system. The CGE model includes three macroeconomic balances: the (current) government balance, the external balance (the current account of the balance of payments, which includes the trade balance), and the savings.

Composite Commodity Markets

$$45.\ QQ_c = +\sum_{a\varepsilon A} QINT_{ca}. + \sum_{h\varepsilon H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c$$

Current – Account Balance for the Rest of the World, in Foreign Currency

$$46.\ \sum_{c\varepsilon VCM} pwm_c.QM_c + \sum_{f\varepsilon F} trnsfr_{rowf} = \sum_{c\varepsilon CE} pwe_c.QE_c + \sum_{i\varepsilon INSD} transfr_{irow} + \overline{FSAV}$$

Government Balance

$$47.\ YG = EG + GSAV$$

IV System Constraint Block

In the system control block, the direct tax rate, saving rate, rate of transfer, government investment absorption ratio and government consumption absorption ion ratio.

Direct Tax Rate

48. $TINS_i = \overline{tins_i}(1 + TINSADJ.tins01) + DTINS.tins01_i$

Saving Rate for Institution

49. $MPS_i = \overline{mps_i}(1 + \overline{MPSADJ}.tins01_i) + DTINS.tins01_i$

50. $\sum MPS_i .(1 + TINS_i).YI + GSAV + EXR.FSAV =$

$$\sum_{c \varepsilon C} PQ_C.QINV_i + \sum_{c \varepsilon C} PQ_C.qdst_i$$

Total Absorption

51. $TABS = \sum_{h \varepsilon H}\sum_{c \varepsilon C} PQ_C QH_i + \sum_{a \varepsilon A}\sum_{c \varepsilon C}\sum_{h \varepsilon H} PXAC_{ac}.qdst_c +$

$$\sum_{c \varepsilon C} PQ_C.QG_i + \sum_{c \varepsilon CC} PQ_C.QINV_i + \sum_{c \varepsilon CC} PQ_C.qdst_i$$

52. $INVSHR.TABS = \sum_{c \varepsilon C} PQ_C.QINV_i + \sum_{c \varepsilon CC} PQ_C.qdst_i$

53. $GOVSHR.TABS = \sum_{c \varepsilon C} PQ_C.QG_c$

In updating quantity of capital, investment balance is free to vary to assure that the balance holds. The balancing role is performed by the savings side and this closure represents a case for investment-driven savings.

In this CGE modeling, alternative factor market closures, that is, mechanisms for equilibrating supplies and demands in factor markets can also be used. According to the default closure, the quantity supplied of each factor is fixed at the observed level. An economy-wide wage variable is free to vary to assure that the sum of demands from all activities equals the quantity supplied. Alternatively, it is possible to assume that a factor is unemployed and the real age is fixed. Under a third closure, the factor market is segmented and each activity is forced to hire the observed, base-year quantity. that is, the factor is activity-specific.

5.2 Simulation Design and Results

First, we initialize the model and estimate a base-run forecasts under business as usual (BAU) scenario using sectoral data from the Thailand Social Accounting Matrix (SAM) 1998. The model is based primarily on the standard CGE model of a single period and it is extended by linking variables obtained in each period. Then we ran the model forward for ten years introducing the population growth and updating the capital stock and the labor force in the model. The change between base run of the model or a base-line scenario under BAU and the different policy simulations reflects the impact of those policies or exogenous shocks on the economy. Four sets of policy simulations are conducted. In each simulation, the effect of a policy change on (i) households consumption of agricultural and forestry products, (ii) public consumption, (iii) immediate demand for labour, (iv) investment in agriculture and forestry, (v) exports, (vi) imports, (vii) CPI and (viii) gross domestic product (GDP).

Simulation 1 (SIM1) : Gradual increase in export tax rate

Simulation 2 (SIM2): Gradual reduction of import tariff rate

Simulation 3 (SIM3): Gradual increase in tax rate on agriculture and forestry production

Simulation 4 (SIM4): Gradual increase in commodity tax rate

In SIM1, the effects of gradual increase 10% per annum in export tax on the above mentioned macroeconomic variables, while SIM2 examines the effects of the gradual reduction of import tax. In SIM3, we increased the production tax by 10% annually on agriculture and forestry sector production. Finally, in SIM4 we lowered the tax on agricultural and forestry products by 10% per annum to simulate the effect on environment. The selected simulation results under SIM1 to SIM4 are reported in Table 4.1.

Simulation 1: Gradual increase in export tax rates

First, simulation 1 (SIM1) considers the effects of gradual increase in export tax on macroeconomic performance. In this simulation the export tax is increased by 10% annually for ten consecutive years in the context of preserving environmental

aspects. This SIM1 is performed in order to compare the results of this simulation with those of simulation 2 (which depicts a gradual elimination of tariff on agricultural and forestry imports). The results under SIM1 are presented in Figure 6.1 and Table 6.1 and the findings under each simulation are summarized as follows:

(i) Private consumption of various households under agriculture and forestry sector such as: rural poor (hrp), urban poor (hup) and ruban rich (hrr) declines under SIM1 compared to BAU. In particular, consumption of hrp declines from 70566.1 million Baht under BAU to 70041.5 million Baht (-0.74% or a 0.74% decline) in Year 1 under SIM1. Similarly, private consumption of hup declines from 27651.6 million Baht to 26936.6 million Baht, in comparison, private consumption of hrr declines from 113792.4 million Baht to 111865.1 million Baht (-0.74%) in Year 1. Similarly, consumption of hrr also declines by -0.14% in Year 1.

(ii) Public consumption declines from 830.5 million Baht under BAU to 824.3 million Baht (-0.74%) in Year 1, while it declines from 1083.6 million Baht in Year 10 under BAU to 922.4 million Baht (-21.6%) under SIM1. Similarly, public consumption in year 10 also lie below the ones under BAU in same period.

(iii) Total intermediate demand for agriculture including forestry product declines from 506316 million Baht under BAU to 502583 million Baht (-0.74%) in Year 1 under SIM1. In comparison, it falls from 660627 million Baht to 39220.6 million Baht (-3.3%) in Year 10.

(iv) The demand for labour for agriculture and forestry sector increases from 190729 million Baht under BAU to 190743 million Baht (0.01%) in Year 1 under SIM1. In comparison, it falls from 248858 million Baht to 284780.5 million Baht (-14.4%).

(v) Agriculture and forestry production declines from 1350300 million Baht under BAU to 1149009 million Baht (-14.9%) in Year 1. In Year 10, the production declines from 1761835 million Baht to 1583704 million Baht (-12.3%).

(vi) Total investment in agriculture and forestry sector increases from 479546 million Baht under BAU to 479610 million Baht (0.01%) in Year 1. In comparison, it increases from 625698 million Baht to 746582 million Baht (19.3%) in Year 10.

(vii) The agriculture and forestry imports increase slightly from 2610 million Baht (0.01%) in Year 1 under BAU to 2613.2 million Baht (0.01%) in same year under SIM1, in comparison, it increases from 3409 million Baht under BAU to 4021.9 million Baht in Year 10.

(viii) The agriculture and forestry exports increase slightly from 201320 million Baht under BAU to 201309.1 million Baht in Year 1 under SIM1, in comparison, it increases from 262676.9 million Baht under BAU to 23878 million Baht(-9.1%) in Year 10 under SIM1.

(ix) The effect on consumer price index (CPI) indicates a tendency to decline slightly under SIM1. In particular, CPI remains unchained. It declines from 1 under BAU to 0.958 (-4.2%) in Year 10.

(x) On the benefit of export tax on GDP, it increases at decreasing rate from 4714647 million Baht under BAU to 4798669 million Baht in Year 1 under SIM1, while it falls from 6151545 million Baht under BAU to 5947191 million Baht in Year 10 under SIM1.

Figure 6.2 shows the impact of export tax on the ten-year growth rate of the economy. The base run BAU has foreign savings equal to 6.8 percent of GDP and a ten-year growth rate of 4.5 percent. If export taxes are reduced to 5.4 percent of GDP, the growth rate decreases to 4.4 percent. The effect of imposing environmental tax on production simulation is different from a reduction in export tax because it directly affects consumption in the first step. Tables 4.3 and 4.4 show the effects on sectoral growth rates of output, exports, and imports under the different policy scenarios. The tables indicate how the economy reacts to the changes in the environmental tax on forestry production, exports respond positively and imports negatively to a reduction in capital inflows, but the changes are relatively small.

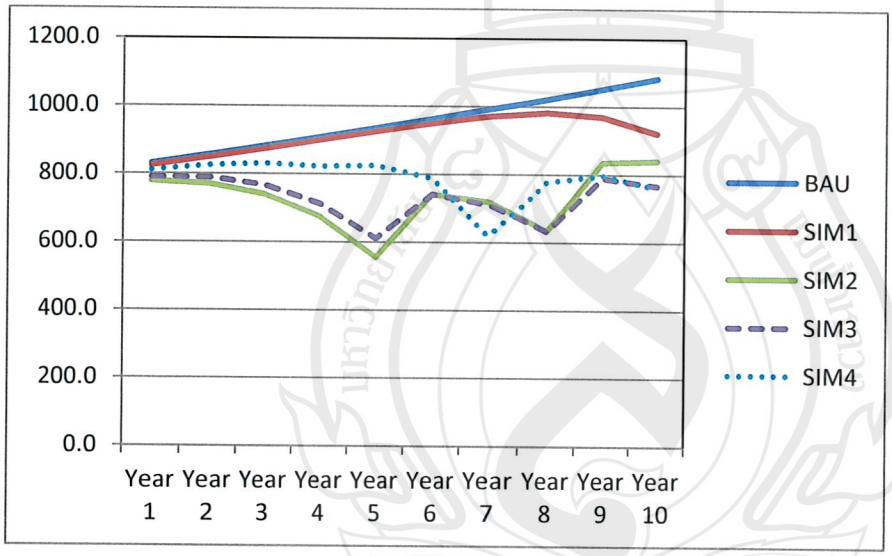
Table 5.1 Consumption of Agricultural and Forestry Products

Year	val C	House-hold type	BAU	SIM1	SIM2	SIM3	SIM4
1	agr	hrp	70566.1	70041.5	66830.7	67637.0	68980.3
2	agr	hrp	72683.1	72136.0	66304.6	67641.3	70123.1
3	agr	hrp	74863.6	74283.6	63957.2	66024.9	70531.2
4	agr	hrp	77109.5	76471.7	58738.0	61712.8	69667.0
5	agr	hrp	79422.8	78667.2	48933.7	53376.1	69123.7
6	agr	hrp	81805.4	80786.7	56808.8	58182.5	65390.8
7	agr	hrp	84259.6	82627.8	53105.5	53874.0	51171.3
8	agr	hrp	86787.4	83714.0	43866.2	44887.1	58167.7
9	agr	hrp	89391.0	83006.4	55364.4	53294.5	56522.7
10	agr	hrp	92072.7	79391.7	54202.7	49497.1	47317.7
1	agr	hup	27651.6	27445.8	25984.7	26359.4	26936.6
2	agr	hup	28481.1	28266.2	25610.3	26244.6	27305.1
3	agr	hup	29335.6	29106.9	24407.0	25406.7	27322.4
4	agr	hup	30215.6	29962.3	21899.3	23368.3	26735.5
5	agr	hup	31122.1	30817.6	17312.3	19540.3	26321.5
6	agr	hup	32055.8	31636.2	20849.0	21761.0	24395.4
7	agr	hup	33017.4	32328.6	19179.6	19872.1	17465.8
8	agr	hup	34008.0	32684.6	15152.9	15980.7	20889.0
9	agr	hup	35028.2	32246.0	20699.6	20250.5	20243.3
10	agr	hup	36079.0	30524.8	20450.6	18904.0	16164.5
1	agr	hrr	113792.4	112949.4	109727.8	110531.9	111865.1
2	agr	hrr	117206.2	116331.2	110515.7	111841.1	114288.0
3	agr	hrr	120722.4	119804.8	109541.2	111581.9	116008.6
4	agr	hrr	124344.0	123358.8	105781.2	108700.4	116491.4
5	agr	hrr	128074.4	126961.5	97554.5	101917.9	117501.1
6	agr	hrr	131916.6	130531.4	108466.5	109589.3	115243.5
7	agr	hrr	135874.1	133868.7	106648.3	107209.2	102176.8
8	agr	hrr	139950.3	136502.1	99663.6	100447.5	112207.4
9	agr	hrr	144148.8	137404.9	113158.4	110989.7	112648.8
10	agr	hrr	148473.3	135521.7	113758.6	109091.7	105712.6

Table 5.2 Public Consumption of Agricultural and Forestry Products

Year	Sector	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	Agri	830.5	824.3	778.22	790.1	810.6
Year 2	Agri	855.4	849.0	770.11	788.6	824.5
Year 3	Agri	881.1	874.2	739.54	766.7	830.0
Year 4	Agri	907.5	899.9	674.39	712.0	821.5
Year 5	Agri	934.7	925.6	554.43	609.9	824.7
Year 6	Agri	962.8	950.3	740.68	741.0	788.1
Year 7	Agri	991.7	971.2	718.61	711.6	619.0
Year 8	Agri	1021.4	982.1	633.18	631.9	777.5
Year 9	Agri	1052.1	969.9	836.30	789.7	797.0
Year 10	Agri	1083.6	922.4	840.61	767.1	760.4

Figure 5.1 Public Consumption of Agricultural and Forestry Products



Simulation 2: Gradual reduction of import tariff rate

The results under SIM2 are presented in Figure 6.2 and Table 6.2 and the findings under each simulation are summarized as follows:

(i) Private consumption of various households: rural poor (hrp), urban poor (hup) and ruran rich (hrr) under agriculture and forestry sector declines under SIM2, compared to BAU. In particular, consumption of hrp declines from 70566.1 million Baht under BAU to 66830.7 million Baht (-5.2%) in

Year 1 under SIM2. Similarly, private consumption of hup declines from 27651.6 million Baht to 25984.7 million Baht (-6%), in comparison, private consumption of hrr increases from 113792.4 million Baht to 109727.8 million Baht (0.65%) in Year 1. The private consumption of hrp declines from 92072 million Baht to 79391 million Baht (-41.1%), in comparison, that of hup falls from 36079 million Baht to 30524 million Baht (-43.3%) in Year 1. The consumption of hrr declines from 148473 million Baht to 135521 million Baht (-23.3%).

(ii) Public consumption falls from 830.5 million Baht under BAU to 778.2 million Baht (-0.74%) in Year 1, while it declines from 1083.6 million Baht under BAU to 840.6 million Baht (6%) in Year 10 under SIM2.

(iii) Total intermediate demand for agriculture and forestry products declines from 506316 million Baht under BAU to 502583 million Baht (-1.28%) in Year 1 under SIM2, while it declines from 660627 million Baht under BAU to 446700.6 million Baht (-32.3%) in Year 10 under SIM2.

(iv) The demand for labour for agriculture and forestry sector increases from 190729 million Baht under BAU to 200185 million Baht (4.96%) in Year 1 under SIM1. In comparison, it falls from 248858 million Baht to 351572 million Baht (41.2%) in Year 10.

(v) Agriculture and forestry sector production declines from 1350300 million Baht under BAU to 1161753 million Baht (0.94%) in Year 1 under SIM1, in contrast, it declines from 1761835 million Baht in Year 10 under BAU to 1505967 million Baht (-104%) in year 10 under SIM2.

(vi) Total investments in agriculture and forestry sector increase from 479546 million Baht under BAU to 527496 million Baht(10%) in Year 1 under SIM2. In comparison, it falls from 625698 million Baht to -154132 million Baht (-124.6%).

(vii) The agriculture and forestry imports increase slightly from 2613 million Baht under BAU to 2943.4 million Baht (12.6%) in Year 1, in comparison, it rises from 3409 in Year 10 under BAU to 4991.9 million Baht (46.4%) in same year.

(viii) The agriculture and forestry export increases slightly from 201320 million Baht under BAU to 200863.8 million Baht (-0.23%) in Year 1 under SIM2,

in comparison, it decreases from 267626.9 million Baht in Year 10 under BAU to 262119.8 million Baht (-0.21%) in same year under SIM2.

(ix) The effect on CPI indicates a tendency to decline during 10 years under SIM2. In particular CPI falls slightly from 1 unit under BAU to 0.99 unit (-1.3%) under SIM2, in comparison, it declines from 1 in Year 10 under BAU to 0.741 (-25.4%) in Year 10.

(x) On the benefit of gradual reduction of import tax on GDP, it has led an increase from 4714647 mil Baht under BAU to 4798669 million Baht (-1.3%) in Year 1, while it declines from 6151545 million Baht (-31.5%) in Year 10 under BAU to 3863989 million Baht in same year under SIM2.

Table 5.3 Total Intermediate Demand for Commodity

ivalDIT	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	506316.3	502583.0	499814.68	500493.7	501681.1
Year 2	521505.8	517652.7	510856.89	512399.5	515369.2
Year 3	537150.9	533163.1	518795.61	521758.9	528163.8
Year 4	553265.5	549110.9	520740.55	525957.9	538879.1
Year 5	569863.4	565468.6	510829.23	520054.8	547701.9
Year 6	586959.3	582149.5	506618.25	515567.7	550923.1
Year 7	604568.1	598920.2	490293.72	499337.3	533927.1
Year 8	622705.2	615185.4	448531.81	458953.9	529644.6
Year 9	641386.3	629461.7	461312.67	463699.1	519123.8
Year 10	660627.9	639220.6	446700.68	438976.4	479322.9

Figure 5.2 Total Intermediate Demand for Commodity

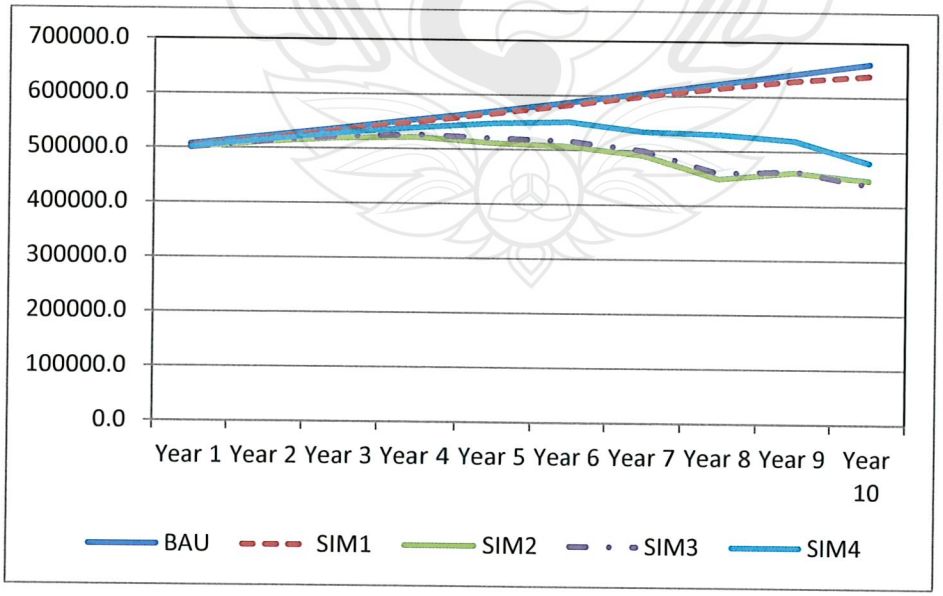
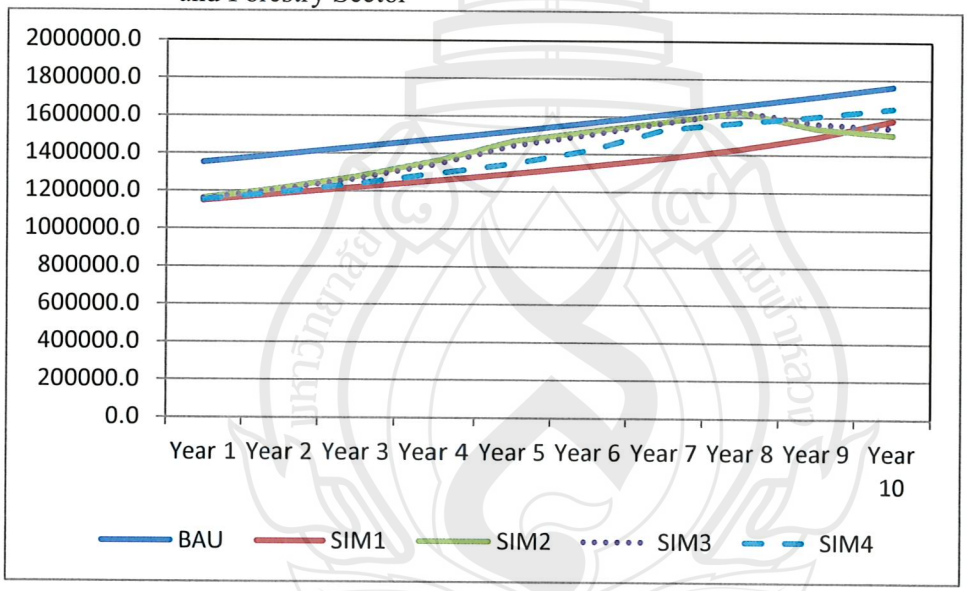


Table 5.4 Supply of Agricultural and Forestry Products to the Agriculture and Forestry Sector

	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	1350300.0	1149009.0	1161753	1159116.0	1153149.2
Year 2	1390809.0	1183527.4	1212992	1206908.7	1193146.1
Year 3	1432533.3	1219148.5	1275972	1265293.2	1238290.0
Year 4	1475509.3	1256002.2	1357149	1340832.6	1291531.8
Year 5	1519774.5	1294362.1	1466513	1442267.6	1348152.1
Year 6	1565367.8	1334847.7	1518761	1501741.6	1417980.6
Year 7	1612328.8	1378905.5	1572109	1566118.2	1531927.4
Year 8	1660698.7	1429891.8	1625420	1629945.4	1571080.2
Year 9	1710519.6	1495185.3	1539479	1564697.0	1604125.8
Year 10	1761835.2	1583704.0	1505967	1543411.2	1647523.2

Figure 5.3 Supply of Agricultural and Forestry Products to the Agriculture and Forestry Sector



Simulation 3: Gradual increase in agriculture and forestry sector production

The results under SIM3 are presented in Figure 6.3 and Table 6.3 and the findings under each simulation are summarized as follows:

(i) Private consumption of various households: rural poor (hrp), urban poor (hup) and ruran rich (hrr) under agriculture and forestry sector falls under SIM3 compared to BAU. In particular, consumption of hrp declines from 70566.1 million Baht in BAU to 67637 million Baht (-4.1%) in Year 1

under SIM3. Similarly, private consumption of hup falls from 27651.6 million Baht to 26359 million Baht (-6.3%), in comparison, private consumption of hrr declines from 113792.4 million Baht to 110531.9 million Baht. The same consumption patterns exist in Year 10.

(ii) Public consumption declines from 830.5 million Baht under BAU to 790.1 million Baht (a 5% decline) in Year 1, while it declines from 1083.6 million Baht under BAU to 767.1 million Baht (-27.7%) under in Year 10 under SIM3.

(iii) Total intermediate demand for agriculture (forestry) products decline from 500493.7 million Baht under BAU to 502583 million Baht (3.91%) in Year 1, while it declines from 660627 million Baht 1 under BAU to 438976.4 million Baht (50.7%) in Year 10.

(iv) The demand for labour for agriculture and forestry sector increases from 190729 million Baht under BAU to 198217 million Baht (3.93%) in Year 1 under SIM3. In comparison, it increases from 248858 million Baht to 375126 million Baht (50.7%).

(v) Agriculture and forestry productions decline from 1350300 million Baht under BAU to 1159116 million Baht (-0.2%) in Year 1, in contrast, it declines from 1761835 million Baht in Year 10 under BAU to 1543411.2 million Baht in same year.

(vi) Total investments in agriculture and forestry sector increase from 479546 million Baht under BAU to 514141 million Baht (7.2%) in Year 1 under SIM3. In comparison, they fall from 625698 million Baht to -250259 million Baht (-140%) in Year 10.

(vii) The Agriculture and forestry imports increase slightly from 2613 million Baht 3 under BAU to 2858.2 million Baht in Year 1 under SIM3, in comparison, it increases from 3409 million Baht in Year 10 under BAU to 5827.1 million Baht (-10.5%) in same year.

(viii) The Agriculture and forestry exports decline slightly from 201320 million under BAU to 200952.2 million Baht (-0.18) Baht in Year 1 under SIM3, in comparison, it decreases slightly from 267626.9 million Baht in Year 10 under BAU to 262252.4 million Baht (-0.16%) in same year under SIM3.

(ix) The effects on CPI indicate a tendency to decline during 10 years under SIM3. In particular, CPI falls from 1 unit under BAU to 0.9925 unit (-0.75%) under SIM3, in comparison, it declines from 1 unit under BAU to 0.7047 (-29.5%) in year 10.

(x) On the benefit of gradual reduction of import tax on GDP, it has led an increase from 4714647 million Baht under BAU to 4747421 million Baht (-0.39%) in Year 1 under SIM3, while it falls from 6151545 million Baht under BAU to 3727155 million Baht (-31.2%) in Year 10 under SIM3.

Table 5.5 Quantity of Agricultural and Forestry Product Exports

ValEX	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	201320.0	201309.1	200863.8	200952.2	201170.2
Year 2	207359.6	207334.9	206895.7	206985.6	207207.3
Year 3	213580.4	213521.6	213112.8	213203.9	213427.2
Year 4	219987.8	219845.4	219522.8	219614.9	219836.5
Year 5	226587.4	226240.4	226134.8	226226.5	226435.1
Year 6	233385.1	232539.4	232880.6	232987.0	233240.0
Year 7	240386.6	238332.2	239877.2	239987.4	240275.2
Year 8	247598.2	242652.9	247097.1	247208.7	247452.7
Year 9	255026.2	243398.6	254476.3	254600.1	254878.4
Year 10	262676.9	238782.4	262119.8	262252.4	262539.6

Figure 5.4 Quantity of Agricultural and Forestry Product Exports

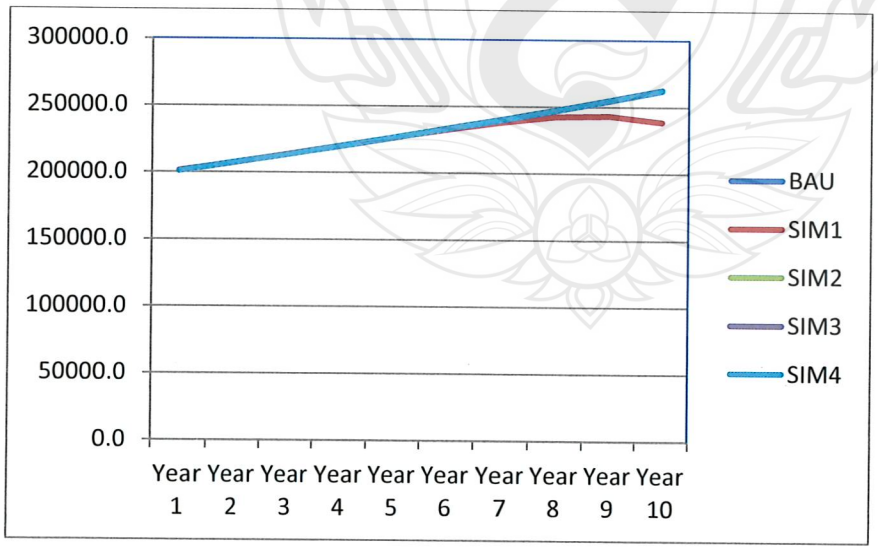


Table 5.6 Quantity of Agricultural and Forestry Product Imports

ValIM	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	2613.0	2613.2	2943.4	2858.2	2711.4
Year 2	2691.4	2692.0	3284.8	3144.1	2875.4
Year 3	2772.1	2773.5	3832.2	3609.8	3116.7
Year 4	2855.3	2858.7	4737.7	4399.2	3496.6
Year 5	2941.0	2949.3	6329.0	5762.3	3807.7
Year 6	3029.2	3049.6	5266.1	5209.6	4503.4
Year 7	3120.1	3169.8	5904.1	6021.4	6576.4
Year 8	3213.7	3334.3	7138.9	7341.8	5678.1
Year 9	3310.1	3598.8	5149.6	5700.8	5739.6
Year 10	3409.4	4021.9	4991.8	5827.1	6070.0

Figure 5.5 Quantity of Agricultural and Forestry Product Imports

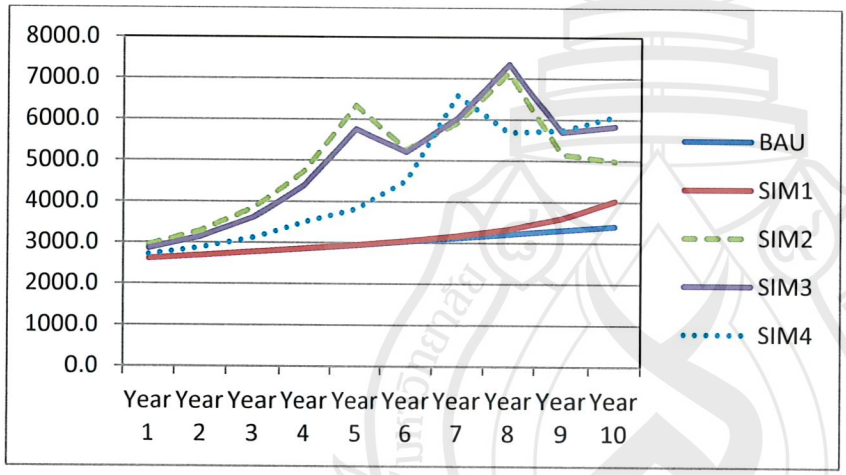


Table 5.7 Employment Effects

	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	190729	190742.9	200185.9	198217.0	245207.3
Year 2	196450.9	196484.9	213741.6	210511.5	260539.6
Year 3	202344.4	202427.4	233153.0	228257.2	294425.6
Year 4	208414.7	208617.6	262022.4	255126.4	349243.9
Year 5	214667.2	215162.6	306909.5	296279.8	326543.0
Year 6	221107.2	222316.1	298847.7	297400.9	375322.7
Year 7	227740.4	230682.9	324967.5	326652.1	357705.9
Year 8	234572.6	241686.8	370916.6	372739.8	355593.9
Year 9	241609.8	258512.8	338271.6	351680.2	410081.4
Year 10	248858.1	284780.5	351572.1	375126.7	470147.8

Figure 5.6 Employment Effects

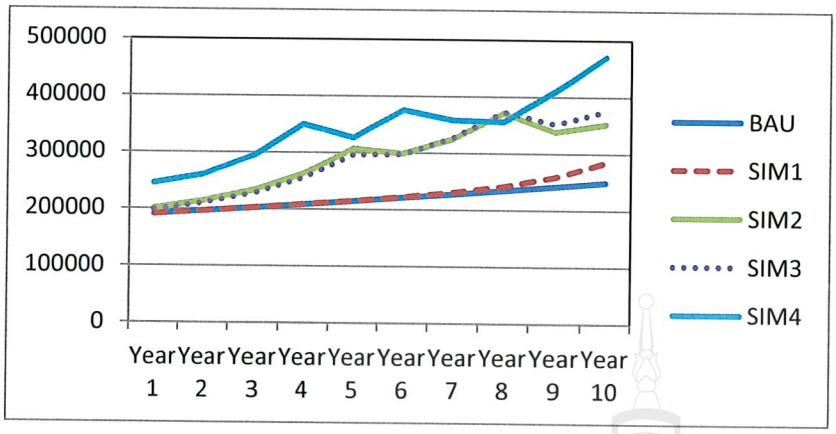
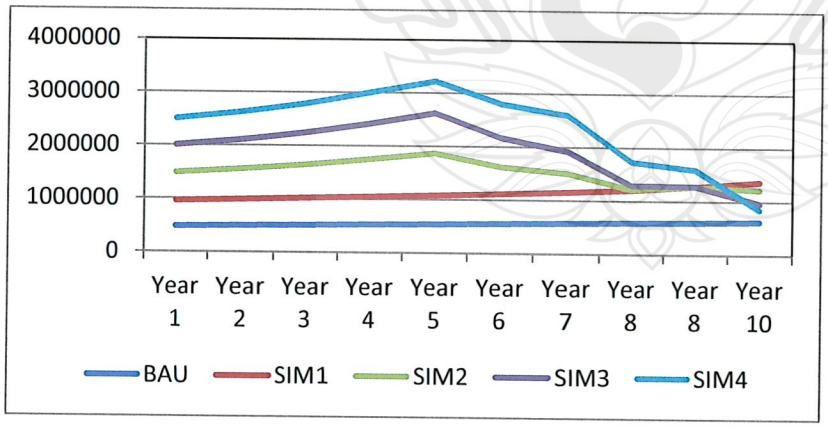


Table 5.8 Investment Effects

	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	479546	479610	527496	514141	493219
Year 2	493932	494074	568399	549582	516071
Year 3	508750	509081	625365	600199	545448
Year 4	524012	524805	700730	670794	583359
Year 5	539733	541653	787091	753311	599393
Year 6	555925	560586	505503	549526	631187
Year 7	572602	583881	352503	412951	677782
Year 8	589780	616720	14457	70643	438147
Year 9	607474	669490	5079	547	311422
Year 10	625698	746582	154132	-250259	-123629

Figure 5.7 Investment Effects



Simulation 4: Gradual increase in commodity tax rates

The results under SIM4 are presented in Figure 6.4 and Table 6.4 and the findings under each simulation are summarized as follows:

(i) Private consumption of rural poor (hrp), urban poor (hup) and ruran rich (hrr) under agriculture and forestry sector falls under SIM4 compared to BAU. In particular, consumption of hrp declines from 70566.1 million Baht under BAU to 68980.3 million Baht (-2.2%) in Year 1 under SIM3. Similarly, private consumption of hup declines from 27651.6 million Baht to 26936.6 million Baht (-2.51%), while private consumption of hrr declines from 113792.4 million Baht to 111865.1 million Baht (0.12%) in Year 10.

(ii) Public consumption declines from 830.5 million Baht under BAU to 810.6 million Baht (-2.3%) in Year 1, while it falls from 1083.6 million Baht under BAU to 760.4 million Baht (-23.9%) under in Year 10 under SIM4.

(iii) Total intermediate demand for agriculture and forestry products declines from 501681.1 million Baht under BAU to 502583 million Baht (-9%) in Year 1 under SIM4, while it falls from 660627 million Baht 1 unit under BAU to 479322.9 million Baht (-27.4%) in Year 10 under SIM4.

(iv) The demand for labour in agriculture and forestry sector increases from 190729 million Baht under BAU to 245207 million Baht (28.5%) in Year 1 under SIM4. In comparison, it falls from 248858 million Baht to 470147 million Baht (88.9%).

(v) Agriculture and forestry productions decline from 1350300 million Baht under BAU to 1153149.2 million Baht (-0.2%) in Year 1 under SIM4, in contrast, it declines from 1761835 million Baht under BAU to 1647523.2 million Baht (-10.5%) in Year 10 under SIM4.

(vi) Total investments in agriculture and forestry sector increases from 479546 million Baht in Year 1 under BAU to 493219 million Baht (2.8%) in same year under SIM1. In comparison, it falls from 625698 million Baht to -123629 million Baht (-119%) in Year 10.

(vii) The agriculture and forestry imports increase slightly from 2613 million Baht under BAU to 2711.4 million Baht (3.7%) in Year 1 while, it

increases from 3409 million Baht under BAU to 6070 million Baht (7%) in Year 10.

(viii) The agriculture and forestry exports decrease slightly from 201320 million Baht under BAU to 201170.2 (-0.07%) in Year 1, in contrast, it decreases from 267626.9 million Baht under BAU to 262539.6 million Baht (-.05%) in Year 10 under SIM4.

(ix) The effect on CPI reflects a tendency to decline during 10 years under SIM4. In particular CPI falls from 1 unit under BAU to 0.996 unit (-0.4%) under SIM4. It declines from 1 unit under BAU to 0.718 (-28.2%) in Year 10 under SIM4.

(x) On the benefit of gradual reduction of import tax on GDP, it has led an increase from 4714647 million Baht under BAU to 4776914 million Baht in Year 1 under SIM4, while it declines from 6151545 million Baht in Year 10 under BAU to 3887642 million Baht (-31.2%) in Year 10 under SIM4.

Table 5.9 Price Effects (CPI)

PIXCON	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	1	1.000	0.990	0.9925	0.996
Year 2	1	1.000	0.980	0.9853	0.993
Year 3	1	1.000	0.964	0.9723	0.987
Year 4	1	1.000	0.935	0.9485	0.977
Year 5	1	0.999	0.881	0.9038	0.961
Year 6	1	0.999	0.832	0.8501	0.937
Year 7	1	0.997	0.785	0.7985	0.880
Year 8	1	0.992	0.690	0.7041	0.838
Year 8	1	0.980	0.753	0.7401	0.804
Year 10	1	0.958	0.741	0.7047	0.718

Figure 5.8 Price Effects (CPI)

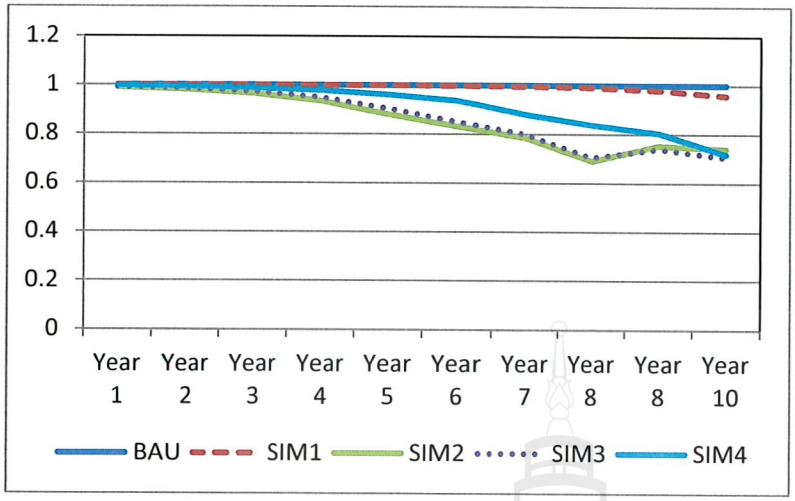
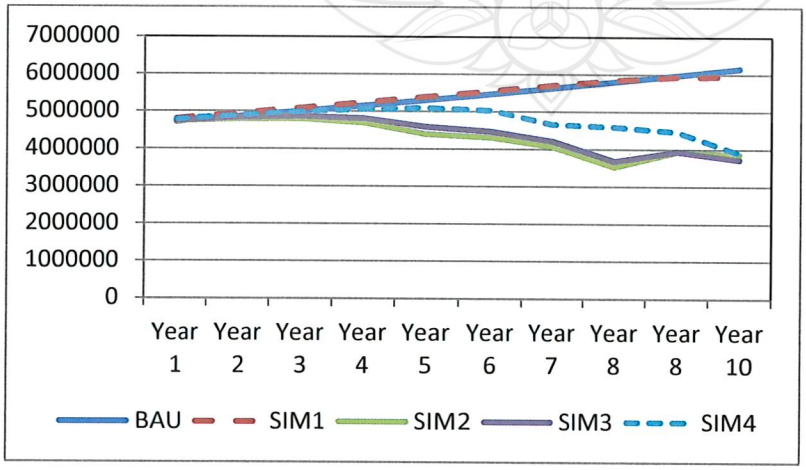


Table 5.10 GDP at Basic Prices

GDP-BP	BAU	SIM1	SIM2	SIM3	SIM4
Year 1	4714647	4798669	4726958	4747421	4776914
Year 2	4856086	4942471	4790169	4830561	4894510
Year 3	5001769	5090362	4794323	4865997	4993173
Year 4	5151822	5242136	4691856	4811162	5053538
Year 5	5306377	5397111	4391635	4591607	5087060
Year 6	5465568	5553430	4307604	4470041	5032443
Year 7	5629535	5706369	4067814	4214334	4658648
Year 8	5798421	5844260	3525291	3684260	4588377
Year 8	5972374	5939085	3930895	3941868	4460118
Year 10	6151545	5947191	3863989	3727155	3887642

Figure 5.9 GDP at Basic Prices



It is interesting to note that the comparison of the results under base-run and SIM 1 to SIM4 shows the effects of these policy alternatives. SIM1 has a big impact on GDP. It is clearly evident that gradual reduction of import tariff has led a decline in GDP that remains well below the base line scenario. Overall welfare in terms of GDP decreases under all simulations. On the other hand, investment in agriculture and forestry sector decreases under SIM1 and SIM2 in the long run compared to the base-line scenario. These simulation results suggest that import liberalization is also not helpful for long-run increases in export, import and domestic production. On the other hand, domestic production remains below the base-line scenario throughout the whole part.

The supply of agriculture and forestry commodity influences the growth rate of GDP over the ten years of the simulation. Changes in production are potentially a bigger source of instability than other sources because of the absolute size and because they directly affect consumption. The results indicate that raising the environmental tax by this amount has a significant negative impact on GDP but a positive effect on exports. This means that during the ten years of our simulation, there is a steadily widening gap between the base run and the alternative with the higher export tax under SIM3.

In simulation 4, if tariff on forest production is introduced, macro variables perform well under this simulation. Consumption, investment and capital stock increase by 9, 13 and 5 per cent respectively in the long run compared to the BAU. On the other hand, export, import and domestic goods increase by 17, 7 and 3 per cent respectively in the long-run. Overall welfare decreases by 4%. Under gradual increases in environment tax on forest product and import tariff have negative impacts on exports over the next 10 years.

The summary of findings under four policy shocks can be summarized as follows:

(i) The private consumption of households falls largely under 4 policy alternatives. Secondly, the size of policy effects on consumption differ and the second policy measure: import tariff under SIM2 imposes a larger effect in terms of size effect. The use of tax on environment has led a decline of consumption of hup and hrr.

(ii) The public consumption declines under four policy shocks, compared to a base line scenario. In which a large decline was found under SIM2 use of a gradual reduction of import tariff.

(iii) On the effect of each policy shocks on intermediate demand, the import tariff policy has imposed a larger impact under SIM1 compared to SIM3 and SIM4. However, these results lie below the ones under BAU to for the period under study. The environmental tax has a negative effect on consumption compared to one under BAU. This constitutes a largest effect under four policy shocks.

(iv) The effect of policy change on demand for labour indicates a positive effect. SIM1 results in a largest impact on intermediate demand for labour. It lies above the ones under BAU to Year 1 to in Year 10.

(v) On supply effect of these four types policy alternatives, the findings suggest that use of one of four alternatives would result in decline of production under economic sectors under study. It reports effect on production of agriculture sector from Year 1 to Year 10. The export tax policy shock has larger effect (a relatively large drop of production) under SIM1.

(vi) With respect to impact on export, the findings suggest that use of one of four alternatives results in decline of production in under economic sectors under study. It reveals the effect on production of agriculture sector from Year 1 to Year 10. The export tax policy shock has a larger effect (a relatively large drop of production) under SIM1.

(vii) On import effects, SIM2 shows a decline of production under economic sectors under study. The export tax policy shock has a large negative effect on GDP.

(viii)The effects of these policies on economic instability in terms of CPI are reported in Table 6.6. The gradual reduction of environment tax has relatively less pressure on CPI. The 10 % increases CPI under BAU. The effect on CPI under 10% export tax cut leads a decline of CPI to 0.992 compared to 1 under BAU in Year 1.

In brief, tariff liberalization was not beneficial to investment in the long-run. Although consumption, export and import increase in the first few years, they tend to decline and remain well below the baseline scenario in the long-run. It seems to generate lower consumption, investment, export and import in the long-run compared to the baseline scenario. Overall welfare in the context of GDP also decreases. The tariff liberalization of forestry import generates better scenario compared to export tax.

Demand for labour increases in all scenarios; production, exports, public consumption fall in all simulations.

5.3 Policy Implications of the Results

The section provides set of economic policy instruments to coordinate micro and macro-economic policies in particular, trade policy in the presence of environmental policy. The result suggests the trade liberalization in the presence of environmental policy has a positive effect the welfare of the country. The choice of policy alternatives depends on the expected or desired outcomes.

From the welfare aspect, use of policy alternative 1 (i.e. SIM1) could provide a more decline in supply of agriculture and forestry products with minimal effects on GDP as shown in Figures 6.3 and 6.7. In contrast, use of policy alternatives 2 and 3 have more negative effects on GDP. Thus use of policy alternative 4 (SIM4) provides relative higher GDP compared to policy alternatives 2 and 3.

From the perspective of reducing public consumption of forest products, policy alternatives 3 and 4 enable to provide effective policy measures on the control of consumption of forest products in view of sustainable environment, while other things remain constant. Similarly, policy alternative 1 (SIM1) enables to provide gradual increase in investment, in contrast, alternative 4 (SIM4) provides a relatively large employment effect.

In addition, in selecting policy alternative to meet simultaneously couples of objectives such as welfare and price stability objectives, suitable policy alternatives can be monitored under this framework. Finally, similar reasoning can be applied in selecting policy alternatives to meet couples of objectives such as export objective and environment objectives at the same time.

CHAPTER 6

CONCLUSION

This study provides important insights on the current state of forest and forest cover change; the determinants of forest degradation applying a logit model at household level; and the impact of macroeconomic policy change on forestry sector and macroeconomic variables.

Thailand is situated in the tropical zone, covering two main types of tropical forest—deciduous and evergreen. The total forest areas comprise 18972 sq.km. in 2010 and thus 37.1 percent of the country area is covered by the forests. The total forest areas declined from 19549 sq.km. in 1990 to 18972 sq.km. in 2010 indicating the forest area depletion rate of 2.9 percent. Since 1985, the National Forest Policy attempted to set a more realistic target of 40 % total land areas as forest reserve area, while about 15% was targeted for conservation forest and the remaining 25% was for commercial forest.

On the forest cover trends in GMS, the forest cover area of Thailand (37%) was less than that of Myanmar (48.3%) in 2010 , while the forest cover s of Cambodia and Lao PDR show 57.2% and 68.2% respectively. The forest area in Northern Thailand constituted 73057.3 sq.km which is about 56.3% of total forest area in Thailand. Land area of Northern Thailand covered 33% of total land area.

The research examines the impacts of socio-economic variables, biophysical and spatial variables and resource use situation on deforestation in Northern Thailand. It is based on households survey comprising 719 households living near forests or within forest areas in 28 villages under five Provinces: Chiang Rai, Chiang Mai, Mae Hong Son, Nan and Phayao. The households are clustered on the basis of levels of income, age, education, changes in use of natural resources, land and forestry regulations, and examines the impacts on the forestry sector.

The survey instruments under village questionnaires are classified into 14 categories such as: basic demographic profile, human development profile, property assets, land tenure and use systems, food security, accessibility rights, open asses, livelihood patterns, poverty mapping, environment, migration, management practices, risk and vulnerability profile, and land use situation. The survey instruments used in the household survey contain eight categories: basis demographic profile; human

development profile; property type; land tenure and use system; food security, accessibility rights and open access; livelihood patterns; poverty mapping; use of natural resources; and forest management practices.

The model is used in the context of a variant of Vance and Geoghegan (2002), Barbier and Bergeron (2001) and Barbier, (1998) focusing on temporal and spatial aspects of possible determinants of deforestation given economic condition. The prediction on the effects of degradation is made in this study applying the survival analysis to identify the effect of household level explanatory variables including bioeconomic variables on the probability of deforestation. Thus the model captures property the inter-temporal behavior of both ecology and economics.

The second part of the research includes the study on effects of sectoral and macroeconomic policies on deforestation and forest management using intertemporal dynamic computable general equilibrium (DCGE) model. The model is designed to be useful as a development tool for the policymakers in performing trade and environmental issues, in particular, trade impact of forestry sector. A modified version of intertemporal CGE employed by Morley, Pirneiro and Robinnsion (2011) in the context of a recursive dynamic model that enables short term adjustment in factors employed in the short run as the economy responds to shocks. The model is recursive dynamic and is solved in two stages. First, the model determines a within-period equilibrium, given parameters and exogenous variables. Second, some parameters and exogenous variables change over time. The variables and parameters used as linkages between periods are aggregate capital stock, population, domestic labor force, working capital supply, factor productivity, export and import prices, export demand, tariff rates, and transfers to and from the rest of the world.

Four policy simulations are performed. In SIM1, the effects of gradual Increase 10% per annum in export tax on the above mentioned macroeconomic variables, while SIM2 examines the effects of the gradual reduction of import tax. In SIM3, we increased the production tax by 10% annually on agriculture and forestry sector production. Finally, in SIM4 we lowered the tax on agricultural and forestry products by 10% per annum to simulate the effect on environment.

6.1 Findings of the Study

The first set of policy instruments in this study reflects factor affecting forest degradation and their impact on household income distribution. The second set of economic policy instruments includes coordination of micro and macro-economic policies in particular, trade policy in the presence of environmental policy. The result suggests the trade liberalization in the presence of environment has a positive effect on welfare of the country.

The findings under Chiang Rai suggest that households' biological factors do not seem to be important factors of degradation, in contrast, household income, forest ownership, land ownership and commercial production show the significant effects on forest degradation. If forest area increases by 10%, forest degradation will increase by about 0.1%. In contrast, if forest area increases by 10% degradation will increase by 0.4%. The effect of commercial production has larger effect. A 10% increase in forest production will lead to 5% increase in degradation. The results also are significant at 1% level.

The findings under Phayao show that households' biological factors do not seem to influence degradation. However, the coefficients of AGE, FAMILY, EDU, INCOME, FORO, LNDO, FORP, LNDFO show the significant effects on forest degradation. If forest land increases by 10%, forest degradation will increase by about 0.3%. In contrast if forest ownership increases by 10% degradation will increase by 0.4%. The effect of commercial production has relatively larger effect. A 10% increase in forest production will lead to 3% increase in degradation.

In the case of Chiang Mai shows, the evidence shows that the coefficients of EDU, INCOME, FORP show the significant effects on forest degradation. If forest land increases by 10%, forest degradation will increase by about 0.6%. However, the effect of EDU has a minimal effects. Moreover, if forest and land ownership increases by 10% degradation will increase by 23%. The effect of commercial production has relatively larger effect. A 10% increase in forest production will lead to 3% increase in degradation. The results also show significance at 1% level. Similar conclusion can be drawn from model 2 of this table.

The findings under Nan Province indicate that households' biological factors and income indicate the important determinants of degradation. The coefficients of AGE, EDU and INCOME show the significant effects on forest degradation. The

effects of age and education are larger than income effect. If AGE factor increases by 10%, forest degradation will increase by about 6%. In contrast, if education factor (schooling) increases by 10% degradation will increase by 19%. The effect of households' income has relatively smaller effect. A 10% increase in forest production will lead to 0.5% increase in degradation. The results also denote significant at 1% level for AGE and EDU. The finding can be summarized as follows:

(i) Villages surrounding forest areas in Thailand experienced forest degradation in varying degree depending on age structure, education, foreign ownership, land ownership, and commercial production of forest:

(ii) Forest ownership, land ownership, and commercial production have had a larger effects on households' income as well as forest degradation ; and

(iii) Income inequality exists among households living near forest and within forest areas under study depending on the existing opportunities given in the community.

It is apparent that such linkages are relatively complex and policy options and instruments for policy makers. The study highlighted the relationship between, spatial, biological and economic effects of trade policies.

At macro level, this research addresses an issue of great significance to trade and environment policy and practice. The conclusions from this analysis show that the most effective evaluative perspective is gained by focusing on macro level impacts.

The summary of findings under four policy shocks can be summarized as follows:

(i) The private consumption of households falls largely under 4 policy alternatives. Secondly, the size of policy effects on consumption differ and the second policy measure: import tariff under SIM2 imposes a larger effect in terms of size effect. The use of tax on environment has led a decline of consumption of hup and hrr.

(ii) The public consumption declines under four policy shocks, compared to a base line scenario. In which a large decline was found under SIM2 use of a gradual reduction of import tariff.

(iii) On the effect of each policy shocks on intermediate demand, the import tariff policy has imposed a larger impact under SIM1 compared to SIM3 and SIM4. However, these results lie below the ones under BAU to for the period under study. The environmental tax has a negative effect on consumption compared to one under BAU. This constitutes a largest effect under four policy shocks.

(iv) The effect of policy change on demand for labour indicates a positive effect. SIM1 results in a largest impact on intermediate demand for labour. It lies above the ones under BAU to Year 1 to in Year 10.

(v) On supply effect of these four types policy alternatives, the findings suggest that use of one of four alternatives would result in decline of production under economic sectors under study. It reports effect on production of agriculture sector from Year 1 to Year 10. The export tax policy shock has larger effect, i.e., a relatively large drop of production under SIM1.

(vi) With respect to impact on export, the findings suggest that use of one of four alternatives results in decline of production in under economic sectors under study. It reveals the effect on production of agriculture sector from Year 1 to Year 10. The export tax policy shock has a larger effect (a relatively large drop of production) under SIM1.

(vii) On import effects, SIM2 shows a decline of production under economic sectors under study. The export tax policy shock has a large negative effect on GDP.

(viii)The effects of these policies on economic instability in terms of CPI are reported in the report. The gradual reduction of environment tax has relatively less pressure on CPI. The 10 % increases CPI under BAU. The effect on CPI under 10% export tax cut leads a decline of CPI to 0.992 compared to 1 under BAU in Year 1.

6.2 Recommendations

1. The findings highlight regional consequences of trade liberalization on households' consumption of resources, income, and the forestry sector. Since these effects vary across provinces, it suggests that the effective policy alternatives should be developed for the need of each province.

2. Since major factors of degradation indicated education, employment and households' income, the forestry management policy should be designed to eradicate rural poverty as suggested by the present study.

3. The forest and land ownership regulations have had a positive effect on degradation and thus in addition to these regulations, the establishment of effective

forest management practices are recommended in minimizing risks and the measures for sustainable environment given situations.

4. The commercial production of forestry products influences a relatively large impact on degradation, the introduction of production tax or export tax on forestry products should be exercised to ensure for strategic trade instruments to protect forest and sustainable forest growth by looking at the expected outcomes provided under various policy scenarios as found in the findings of the study.

5. The environmental regulations should be encouraged to enhance regional competitiveness, specialization, industrial redeployment, and trade in forest products through policy coordination among the related ministries.

6. In addition, this method of forest management could productively be used an technical transfer to evaluate protected areas in other GMS countries to evaluate impacts of other large-scale environmental projects.

7. From the welfare aspect, use of policy alternative 1: gradual increase in export tax could provide a more decline in supply of agriculture and forestry products with minimal effects on GDP. In contrast, use of policy alternative 2: gradual reduction of import tariff and alternative 3: a gradual increase in commodity tax have more negative effects on GDP. Thus use of policy alternative 4: gradual increase in agricultural and forest production tax provides a relatively higher GDP compared to policy alternatives 2 and 3.

8. From the perspective of reducing public consumption of forest products, policy alternatives 3 and 4 enable to provide effective policy measures on the control of consumption of forest products in view of sustainable environment, while other things remain constant. Similarly, policy alternative 1 (SIM1) enables to provide gradual increase in investment, in contrast, alternative 4 (SIM4) provides a relatively large employment effect.

9. In addition, in selecting policy alternative to meet simultaneously couples of objectives such as welfare and price stability objectives, suitable policy alternatives can be monitored under this framework. Finally, similar reasoning can be applied in selecting policy alternatives to meet couples of objectives such as export objective and environment objectives at the same time.

6.3 Policy Implications of Study

The significant and positive estimates for the stringency of environmental regulations variable are found indicating a more stringent forestry policy measures are needed to give rise to less degradation. The results reveal the strong view on the link between forest degradation and its determinants: socioeconomic, resource use and trade policies.

The implications of the study can be drawn from this results. First, the restrictive forestry regulation has contributed to lower impact on degradation. Second, other non- socio-economic factors and resource-use condition in the community have positive associations with forest degradation. Finally, the commercial production of forest are associated with substantial degradation. The estimations for the non-environmental policy variables are in line with those expected under logit model.

This approach presented in this chapter analyzes a forest area system in Northern Thailand with respect to socioeconomic and environmental impacts at the community level. To measure socioeconomic outcomes, data are used from our surveys conducted in 28 villages in five provinces in Northern Thailand.

In addition, this method of forest management could productively be used to evaluate protected areas in other GMS countries to evaluate impacts of other large-scale environmental projects. It would complement existing studies, including case comparisons or household survey work, by providing a broader overview of impacts across a larger number of sites.

In addition, it is crucial to identify the determinants of forest degradation in the wake of trade liberalization and their impact on the income distribution of people in such region, which would contribute to effective public policy in environmental management as well as eradication of rural poverty. Thus impacts of changes in land use restrictions and sustainable forest degradation may help corporate managers and policy makers in making land use and forest management decisions. Implications on management of forest as a means for enhancing household income with minimal impact on of forest degradation.

It would enable to contribute the economic and environmental perspective of management practice in Thailand and suggests effective environmental management model to Thailand and other GMS countries.

This research provides insightful information on trade and investment with environmental focus to the following organizations: (a) Office of the National Resources and Environment Policy and Planning, Thailand, (b) Department of Industry and Mineral Resources, (c) Department of Trade Promotion, (d) Environmental Impact Evaluation Bureau and (e) Natural Resources Management Program at Mae Fah Luang University and (f) Others such as NGO (Non-government Organizations) in Thailand.

The section provides set of economic policy instruments to coordinate micro and macro-economic policies in particular, trade policy in the presence of environmental policy. The result suggests the trade liberalization in the presence of environmental policy has a positive effect the welfare of the country. The choice of policy alternatives depends on the expected or desired outcomes.

In conclusion, this study identifies the linkages between trade, environment and income distribution of Northern Thailand by highlighting policy instruments for intervention policies for sustainable economic development.

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APPENDIX TABLES

Appendix 1: A Formal Statement Of The Dynamic CGE Model

NOTATIONS

Symbol	Explanation	Symbol	Explanation
$a \in A$	activities	$c \in CMN(\subset C)$	commodities not in *CM*
$a \in ACES(\subset A)$	activities with a constant elasticity of substitution (CES) function at the top of the technology nest	$c \in CT(\subset C)$	transaction service commodities
$a \in ALEO(\subset A)$	activities with a Leontief function at the top of the technology nest	$f \in F$	factors
$c \in CX(\subset C)$	commodities with domestic production	$fsub \in F$	factors used in composite factors
$c \in C$	commodities	$f2s \in F$	composite factors
$c \in CD(\subset C)$	commodities with domestic sales of domestic output	$i \in INS$	institutions (domestic and rest of world)
$c \in CDN(\subset C)$	commodities not in *CD*	$i \in INSD(\subset INS)$	domestic institutions
$c \in CE(\subset C)$	exported commodities	$i \in INSDNG(\subset INSD)$	domestic nongovernment institutions
$c \in CEN(\subset C)$	commodities not in *CE*	$h \in H(\subset INSDNG)$	households
$c \in CM(\subset C)$	imported commodities	$fls \in F$	factors with supply curve

PARAMETERS

Symbol	Explanation	Symbol	Explanation
$cwts_c$	weight of commodity c in the consumer price index (CPI)	$\overline{qg_c}$	base-year quantity of government demand
$dwts_c$	weight of commodity c in the producer price index	$\overline{qinv_c}$	base-year quantity of private investment demand
ica_{ca}	quantity of c as intermediate input per unit of activity a	$shif_{if}$	share for domestic institution I in income of factor f
$icd_{cc'}$	quantity of commodity c as trade input per unit of c' produced and sold domestically	$shii_{ii'}$	share of net income of i' to I (i' ∈ INSDNG'; I ∈ INSDNG)

$ice_{cc'}$	quantity of commodity c as trade input per exported unit of c'	ta_a	tax rate for activity a
$icm_{cc'}$	quantity of commodity c as trade input per imported unit of c'	te_c	export tax rate
$inta_a$	quantity of aggregate intermediate input per activity unit	tf_f	direct tax rate for factor f
iva_a	quantity of aggregate intermediate input per activity unit	$\overline{tins_i}$	exogenous direct tax rate for domestic institution i
$\overline{mps_i}$	base savings rate for domestic institution i	$tins01_i$	0–1 parameter with 1 for institutions with potentially flexed direct tax rates
$mps01_i$	0–1 parameter with 1 for institutions with potentially flexed direct tax rates	tm_c	import tariff rate
pwe_c	export price (foreign currency)	tq_c	rate of sales tax

PARAMETERS

Symbol	Explanation	Symbol	Explanation
pwm_c	import price (foreign currency)	$trnsfr_{if}$	transfer from factor f to institution i
$qdst_c$	quantity of stock change	tva_a	rate of value-added tax for activity *a*
$etals_j$	parameter in labor supply equation		
$INVSHR1_a$	capital shares	PK_r	price of capital
$DKAPS_{fa}$	gross fixed capital formation	QF_{fa}	next period sectoral capital stock
$WFXAV$	average capital rental rate	$deprate^k$	capital stock depreciation rate

GREEK LETTERS

Symbol	Explanation	Symbol	Explanation
α_a^a	efficiency parameter in the CES activity function	δ_c^t	constant elasticity of transformation (CET) function share parameter
α_a^{va}	efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
		$\rho f2s,afs$	CES exponent for factor (that goes into composite factor) for f2s aggregate

$af2s,afs$	shift parameter for factor (that goes into composite factor) for f2s CES aggregates	$\delta fsub,f2s,afs$	share parameter for factor (that goes into composite factor) for f2s CES aggregates
α_c^{ac}	shift parameter for domestic commodity aggregation function	γ_{ch}^{m}	subsistence consumption of marketed commodity c for household h
α_c^{q}	Armington function shift parameter	γ_{ach}^{h}	subsistence consumption of home commodity c from activity a for household h
α_c^{t}	CET function shift parameter	θ_{ac}	yield of output c per unit of activity a
β_{ach}^{h}	marginal share of consumption spending on home commodity c from activity a for household h	ρ_a^{a}	CES production function exponent
β_{ch}^{m}	marginal share of consumption spending on marketed commodity c for household h	ρ_a^{va}	CES value-added function exponent
δ_a^{a}	CES activity function share parameter	ρ_c^{ac}	domestic commodity aggregation function exponent
δ_{ac}^{ac}	share parameter for domestic commodity aggregation function	ρ_c^{q}	Armington function exponent
δ_c^{q}	Armington function share parameter	ρ_c^{t}	CET function exponent

VARIABLES

Symbol	Explanation	Symbol	Explanation
$\overline{CPI}$	consumer price index	$\overline{MPSADJ}$	savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	quantity supplied of factor
$\overline{FSAV}$	foreign savings (FCU)	$\overline{TINSADJ}$	direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	government consumption adjustment factor	$\overline{WFDIST}_{fa}$	wage distortion factor for factor f in activity a
$\overline{IADJ}$	investment adjustment factor	$QFSUBfsub,f2s,a$	quantity demanded of factor fsub from activity and factor f2s
$WFSUBfsub$	average wage of factor fsub (used in composite factor)	$QFSUB_{fsub}$	Supply of fsub (used in composite factor)
$DMPS$	change in domestic institution savings rates (= 0 for base; exogenous variable)	QF_{fa}	quantity demanded of factor f from activity a
DPI	producer price index for domestically marketed output	QG_c	government consumption demand for commodity
EG	government expenditures	QH_{ch}	quantity consumed of commodity c by household h
EH_h	consumption spending for household	QHA_{ach}	quantity of household home consumption of commodity c from activity a for household h
EXR	exchange rate (LCU per unit of FCU)	$QINTA_a$	quantity of aggregate intermediate input

$GOVSHR$	government consumption share in nominal absorption
$GSAV$	government savings
$INVSHR$	investment share in nominal absorption
MPS_i	marginal propensity to save for domestic nongovernment institution (exogenous variable)
PA_a	activity price (unit gross revenue)
PDD_c	demand price for commodity produced and sold domestically
PDS_c	supply price for commodity produced and sold domestically
PE_c	export price (domestic currency)
$PINTA_a$	aggregate intermediate input price for activity a
PM_c	import price (domestic currency)
PQ_c	composite commodity price
PVA_a	value-added price (factor income per unit of activity)
PX_c	aggregate producer price for commodity
$QINT_{ca}$	quantity of commodity c as intermediate input to activity a
$QINV_c$	quantity of investment demand for commodity
QM_c	quantity of imports of commodity
QQ_c	quantity of goods supplied to domestic market (composite supply)
QT_c	quantity of commodity demanded as trade input
QVA_a	quantity of (aggregate) value-added
QX_c	aggregated quantity of domestic output of commodity
$QXAC_{ac}$	quantity of output of commodity c from activity a
$TABS$	total nominal absorption
$TINS_i$	direct tax rate for institution i (i ∈ INSDNG)
$TRII_{ii'}$	transfers from institution i' to i (both in the set INSDNG)
$WFREAL_f$	average real price of factor f
WF_f	average price of factor f

VARIABLES

Symbol	Explanation
$PXAC_{ac}$	producer price of commodity c for activity a
QA_a	quantity (level) of activity
QD_c	quantity sold domestically of domestic output
QE_c	quantity of exports
YF_f	income of factor f
YG	government revenue
YI_i	income of domestic nongovernment institution
YIF_{if}	income to domestic institution i from factor f

APPENDIX 2: SUPPLEMENTARY TABLES

Appendix Table 2.1—Micro SAM accounts

Category	Account		Description
Activities/commodities (continued)	aagric	cagric	Agricultural products
	aagex	cagex	Agricultural products exports
	acoff	ccoff	Coffee
	alvstk	clvstk	Livestock
	apfood	cpfood	Agro industry
	ahila	chila	Weave
		chilam	Weave imports
	atxtl	ctxtl	Textiles
	almfg	clmfg	Light manufacturing
	achem	cchem	Chemicals
	ahmfg	chmfg	Heavy manufacturing
	autility	cutility	Utility (water, energy)
	aconst	cconst	Construction
	ascom	cscom	Commerce
	astrncom	cstrncom	Transportation
	asexp	csexp	Hotels and restaurants
	asothr	csothr	Others
	asgov	csgov	Government
Transportation costs	trt		Transportation costs
Trade costs	trc		Trade costs
Factors	flabf-rusk		rural formal labor skilled
	flabf-runs		rural formal labor unskilled
	flabc-ursk		Urban informal labor skilled
	flabc-urns		urban informal labor unskilled
	flabc-rusk		rural informal labor skilled
	flabc-runs		rural informal labor unskilled
	Phycap		Physical capital
	Fincap		Financial capital / working capital
	Flbr-ursk		Urban skilled labor
	Flbr-urns		Urban unskilled labor
Enterprises	ent		Enterprises
Households	hur-sk		urban household skilled
	hur-ns		urban household unskilled
	hru-sk		rural household skilled
	hru-ns		rural household unskilled
Government	gov		Government
Taxes	dtax		Direct taxes
	atax		Activity tax
	mtax		Import tariffs
	itax		Production tax
	iva		Value-added tax
	subs		Subsidies
Change in stocks	dstk		Change in stocks
Savings and investment	s-i		Savings and investment
Rest of world	row		Rest of world

Bibliography

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