Developing Green GDP Accounting for Thai Agricultural Sector Using the Economic Input Output - Life Cycle Assessment to Assess Green Growth

Witsanu Attavanich and Rattanawan Mungkung and Itthipong Mahathanaseth and Santi Sanglestsawai and Athiwatr Jirajari

Department of Economics, Faculty of Economics, Kasetsart University, Department of Environmental Technology and Management, Faculty Environment, Kasetsart University, Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Environment Research Unit, National Metal and Materials Technology Center (MTEC), Thailand

November 2016

Developing Green GDP Accounting for Thai Agricultural Sector Using the Economic Input Output - Life Cycle Assessment to Assess Green Growth

Witsanu Attavanich[1,*], Rattanawan Mungkung[2], Itthipong Mahathanaseth[3], Santi Sanglestsawai[3], and Athiwatr Jirajariyav[4]

[1] Department of Economics, Faculty of Economics, Kasetsart University, Bangkok, Thailand.
[2] Department of Environmental Technology and Management, Faculty of Environment, Kasetsart University, Bangkok, Thailand.
[3] Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Bangkok, Thailand.
[4]Environment Research Unit, National Metal and Materials Technology Center (MTEC), Pathum Thani 12120, Thailand.

Abstract:
There is no indicator measuring Thailand's green growth by valuing the resource degradation and environmental damage costs. This article aims to estimate Thailand's green gross domestic (GDP) that takes into account environmental damage costs with the detailed analysis on the agricultural sector using the Economic Input Output - Life Cycle Assessment (EIO-LCA) approach. The representative product in each sector was selected based on the available life cycle inventory data, economic values and their magnitude of impacts. Here we find that oil palm cultivation (Sector 011 in the economic input-output table), fibre crops (Sector 013), rice cultivation using chemicals (Sector 001), coffee-tea-cocao (Sector 015), and coconut growing (Sector 010), respectively, generated the highest environmental damage value. This study revealed that the total environmental damage costs of agricultural products was $22.05 million per year accounting for only 0.1003 percent of total GDP in agricultural sector while the total environmental damage cost from all sectors is equal to $36,950.79 million accounting for 14.58 of total GDP.

Keywords: *Green GDP, EIO-LCA, Life Cycle Assessment, Economic Input Output, Agricultural Sector, Green Growth*

**Corresponding author. Tel: +66-0-82-4714443*
E-mail address: witsanu.a@ku.ac.th

Introduction

Because the calculation of the conventional Gross Domestic Product (GDP) nowadays does not reflect the externality costs and the damage costs to environment, its improvement may lead to the unsustainable economic growth and economic development. In this connection, there is an urgent need to develop an indicator that will truly reveal the economic growth in relation with environmental damage costs so called "Green GDP", which has been used in several countries to indicate the green growth or sustainable economic development (e.g., Boyd and Banzhaf, 2007). In Thailand, the Office of the National Economics and Social Development Board (NESDB) initiated the development of environmental accounting together with economic accounting, i.e. Integrated Environment and Economics Accounting (SEEA) introduced by the United Nation et al. (2003) since 2009 to measure the green growth. Although the SEEA system covers forest, energy, geothermal and water resource, it does not include the valuation of resource degradation and environmental damage costs in order to calculate the Green GDP.

This study aims to measure the Green GDP that takes into account of environmental damage costs using the Economic Input Output - Life Cycle Assessment approach. The data were collected from several sources. The life cycle inventory data associated with agricultural sector, i.e. inputs (such as seed, land, water, fertilizer, chemical and energy) and outputs (such as main product co-product and emissions to air, water and soil), were gathered from the national life cycle inventory databases. Data from technical reports, peer-reviewed journals of local studies, and reliable sources were supplemented when necessary. The 2005 economic input-output table was obtained from the National Economic and Social Development Board (NESDB, 2007).

Material and methods

There are three steps to assess the green GDP, firstly we collected the life cycle inventory data associated with the economic sectors, i.e. inputs (such as seed, land, water, fertilizer, chemical and energy) and outputs (such as main product co-product and emissions to air, water and soil), from the national life cycle inventory databases. Data from technical reports, peer-reviewed journals of local studies, and reliable sources were supplemented when necessary.

Secondly, we transformed physical units of all inputs and outputs in the first step into environmental damage costs (US dollar/kilogram) using the Life-cycle Impact assessment Method based on Endpoint modeling (LIME) developed for Thailand by Sampattagul et al. (2013) adapted from Itsubo et al. (2004) and Andeae (2010) covering the classification, characterization and damage assessment based on four safeguard subjects including human health, social assets, primary productivity, and biodiversity. The first two safeguard subjects capture the impact on human life aspect while the last two safeguard subjects capture the impact on ecosystem services. The estimated impacts from all safeguard subjects were then weighted using the willingness to pay obtained from the contingent valuation method to construct the final total environmental damage cost in monetary unit. By using the estimated willingness to pay from Sampattagul et al. (2013), the estimated environmental damage of this study covers only 5 out of 11 environmental impacts according to the LIME framework proposed by Andeae (2010) including the impacts of global warming, human toxicity, ecotoxicity, acidification, and eutrophication.

Thirdly, the estimated total environmental damage costs from the second step in each economic sector together with the price data of the representative product in that sector were combined with the 2005 economic input-output table. By using the economic input-output table, we note that the usual assumption is a fixed proportion of inputs. Due to data limitation and the scope of this study that was eager to explore the details in agricultural sector, the matrix of 180x180 sectors in the economic input-output table was reduced to 56x56 sectors, covering 29 agricultural items and 27 non-agricultural items. The representative product in each sector was selected based on the available life cycle inventory data, economic values and their magnitude of impacts. The study, therefore, assumes that the selected representative products from all economic sectors are well-represent the environmental damage generated from that sector.

Results and Discussion

Using the LIME Thailand method together with the Contingent Valuation Method (CVM) to estimate the environmental damage cost, this study revealed that the first five key sub-sectors causing highest environmental impacts per economic value were oil palm (Sector 011), crops for textile and matting (Sector 013), paddy using chemicals (Sector 001), coffee and tea (Sector 015), and coconut (Sector 010) with the environmental damage cost per USD equal to 0.0513, 0.0422, 0.0353, 0.0232, and 0.0184, respectively as shown in Table 1. It was noticed that the main impacts were associated with crop production, while the livestock sub-sectors caused lower impacts. This finding could be explained by the fact that the data used in the analysis were gate-to-gate, which considered only the impacts associated with production of outputs only excluding the production of inputs (e.g., the feedstock for animal feed production).

This study also revealed that the total environmental damage cost was 19.348 million USD per year accounting for only 0.1003 percent of total GDP in the agricultural sector. Crops for Textile and Matting (Sector 013) had the highest share of environmental damage cost to total value added, which was equal to 1.09 percent of total value added in the sector followed by cassava (Sector 004), agricultural services (Sector 024), sugarcane (Sector 009), and paddy (Sector 001) with 0.5335, 0.4459, 0.3339, and 0.3022 percent of total value added in that sector, respectively (Table 2). This study also investigated that the environmental damage cost generated from rice cultivation using chemicals was 16 times higher than organic rice cultivation. On the other hand, the estimated environmental damage cost generated by the non-agricultural sector was $32,408.97 million per year, which accounted for 15.9597 percent of total value added in the non-agricultural sector. Considering both agricultural and non-agricultural sectors, this article found that the estimated environment damage cost was 32,428 million USD per year accounting for 14.5833 percent of GDP measured by the total value added.

Table 1 Selected Items and Their Corresponding Environmental Damage per USD

Sector Code	Sector	Representative Product	Unit	Product Price per Unit	Environmental Damage Cost per USD
011	Oil Palm	Oil Palm	Kilogram	0.0789	0.0513
013	Crops for Textile and Matting	Cotton	Kilogram	0.4197	0.0422
001	Paddy	Jasmine Paddy	Kilogram	0.3829	0.0353
015	Coffee and Tea	Coffee	Kilogram	0.8923	0.0232
010	Coconut	Coconut	Kilogram	0.3046	0.0184
009	Sugarcane	Sugarcane	Kilogram	0.0166	0.0173
004	Cassava	Cassava	Kilogram	0.0391	0.0163
003	Other Cereals	sorghum	Kilogram	0.1254	0.0149
002	Maize	Maize	Kilogram	0.1371	0.0098
024	Agricultural Services	Plowing Service	Rai	8.5714	0.0085

Note: The exchange rate used to convert baht currency to USD currency is 35 Baht/USD.

Table 2 Environmental Costs and Its Share to Total Value Added in 2005

Sector Code	Sector	Environmental Damage Cost (1,000 USD)	Total Value Added (1,000 USD)	Share of Environmental Damage Cost to Total Value Added (%)
013	Crops for Textile and Matting	102	9,329	1.0915
004	Cassava	1,986	372,282	0.5335
024	Agricultural Services	1,585	355,375	0.4459
009	Sugarcane	1,254	375,678	0.3339
001	Paddy	10,753	3,557,843	0.3022
002	Maize	698	331,078	0.2108
003	Other Cereals	26	12,426	0.2086
006	Beans and Nuts	158	104,308	0.1512
019	Swine	459	334,704	0.1372
022	Poultry Products	239	245,321	0.0973
	Other Agricultural Sector	2,089	13,600,390	0.0154
	Agricultural Sector	**19,348**	**19,298,733**	**0.1003**
	Non-Agricultural Sector	**32,408,973**	**203,066,958**	**15.9597**
	All Sectors	**32,428,321**	**222,365,690**	**14.5833**

Note: The exchange rate used to convert baht currency to USD currency is 35 Baht/USD.

As a result, it was recommended that the government should promote more organic rice cultivation. The organic system should also be applied to other sub-sectors, such as vegetables and pork, to reduce the environmental damage costs. Agricultural zoning should take into account of potential environmental damage costs of crop and livestock, to mitigate the environmental impacts. Farms should be promoted to apply the Good Agriculture Practices (GAP), including the wider implementation of eco-farms to move forwards the green agricultural cities. There is a need for research and development to increase values of agricultural products to enhance the ration of economic value per environmental impact value to increase the Green GDP from agricultural industry for sustainable development.

Conclusion

This study measured the Green Gross Domestic Product (Green GDP) taking into account the environmental damage cost using the Economic Input Output - Life Cycle Assessment approach together with the Life-cycle Impact assessment Method based on Endpoint modeling (LIME) developed for Thailand. We found that the environmental cost generated from agricultural sector (19.348 million USD per year) was very small as compared to non-agricultural sector ($32,408.97 million per year). Overall, the estimated environment damage cost accounted for 14.5833 percent of GDP.

Acknowledgement

This research were supported by a grant from the Cluster and Program Management Office at the National Science and Technology Development Agency (NSTDA).

References

Andrae, A.S.G. 2010. Chapter3: Environmental Life Cycle Assessment from a LIME Perspective. In: Global Life Cycle Impact Assessments of Material Shifts Global Life Cycle Impact Assessments of Material Shifts. (p.23 – 58). London: Springer.

Boyd, J. and Banzhaf, S., 2007. What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units. *Ecological Economics 63*(2): 616–626.

Itsubo, N., Sakagami, M., Washida, T., Kokubu, K. and Inaba, A. 2004. Weighting across Safeguard Subjects for LCIA through the Application of Conjoint Analysis. *The International Journal of Life Cycle Assessment 9*(3): 196–205.

National Economics and Social Development Board. 2007. I/O 2005 [Online]. Available at: http://www.nesdb.go.th/ewt_news.php?nid=5671&filename=io_page [Accessed on 26 April 2016].

United Nations, European Commission, International Monetary Fund, Organization for Economic Co-operation and Development, World Bank. 2003. Integrated Environmental and Economic Accounting [Online]. Available at: http://unstats.un.org/unsd/envAccounting/seea2003.pdf [Accessed on 26 March 2016].

Sampattagul, S., P. Malakul Na Ayudhaya, P. Piumsomboon, and C. Rewlay-ngoen. 2013. Developing of Life Cycle Environmental Impacts Assessment Model of Thailand Based on Concept of LIME Method. Research Project#P-11-00477. National Science and Technology Development Agency