Modeling environmental impact of service sectors to promote sustainable development of Thailand

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ABSTRACT: The objective of this research is to propose an indicator to assess and rank environmental problems caused by production within the services sector of Thailand. Factors used to calculate real benefit (defined as revenue for a sector, minus the environmental costs) included the costs of (1) *natural resources materials*, (2) *energy and transportation*, (3) *fertilizer and pesticides*, and (4) *sanitary* and *similar service*s. The highest environmental cost in terms of *natural resources materials* and *energy and transportation* was in the service sector — *hotels and places of lodging*, while the highest environmental cost in terms of *fertilizer and pesticides* was in the service sector — *personal services*. The service sector — *movie theaters* had the highest environmental cost for *sanitary and similar services*. Overall, the service sector — *real estate* gained the highest real benefit, while the service sector — *repair not classified elsewhere* had the lowest real benefit. If Thailand were to use an indicator of environmental harm, especially within the services sector, it could help to formulate efficient policies and strategies for the country in 3 areas of development (social, economic, and environmental development).

KEY WORDS: Services sector · Forward linkage · Real benefit · Environment cost · Carrying capacity · Sustainable development

INTRODUCTION

Among the most important factors in the development of a country are environmental and natural resources (TDRI 2007, ADB 2014). However, social and economic changes within Thailand have caused a deterioration in environmental and natural resources, i.e. loss of forests, wild animals, mangrove forests (TDRI 2007), and water resources (Bodini 2012), as well as increased waste. Furthermore, natural resources are limited, whereas consumption of natural resources is unlimited (Chen et al. 2010), and this can cause environmental and natural resources to decrease immediately (NESDB 2015) and continuously. The Thai government has foreseen this, leading ministers to announce a sustainable development policy with the aim to increase economic growth together with social and environmental development (TDRI 2007). Addressing environmental and natural resource degradation should be the first priority for

Thai society in making a development plan (ADB 2014), which must correspond with the economic and social development strategy of the Ministry of Natural Resources and Environment.

Marull et al. (2010) stated that the principal policy of a country must address environmental problems and impacts after the policy has been implemented. Policy prior to this research, however, did not focus sufficiently on environmental issues, leading to ineffective management of environmental problems (Simpson & Bradford 1996). The index of sustainable economic welfare (ISEW) is an indicator used to direct sustainable development of a country and for economic welfare measurement (Bodini 2012). The ISEW not only considers consumption value, but also incorporates unsustainable environmental costs and social costs (Liang & Zhang 2011). Comparing ISEW per capita with gross domestic product (GDP) per capita in Thailand for the period 1977 to 2003 shows that ISEW per capita before 1977 was consistent with

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GDP per capita, during which time the growth rate was positive (ADB 2014). However, after 2003, the 2 indices diverged and economic growth rate decreased (NESDB 2015). ISEW per capita decreased by 6.70%, whereas GDP per capita fell by only 0.89%.

Businesses and consumers are the major players in an economic system (Li et al. 2012). Consumers want to gain high utilization under limited budgets, whereas businesses aim to maximize their profit and reduce expenditures (Hugo & Pistikopoulos 2005). Neither party pays attention to environmental cost, causing over-consumption and over-production (ADB 2014). However, sustainable development for the country should develop in 3 dimensions collectively; namely economic, social, and environmental. Previously, Thailand gave priority to developing only economic growth. Moreover, the National Economic and Social Development Board (NESDB) stated that firms did not consider the cost of (1) *natural resources materials*, (2) *energy and transportation*, (3) *fertilizer and pesticides*, and (4) *sanitary and similar services*, which represent environmental costs (NESDB 2015). As a result, Thailand did not achieve sustainable development because economic growth was accompanied by growth in environmental costs.

The services sector represents the main occupation for many people in Thailand, and it consistently generates high income to the country (TDRI 2007). At the same time, the Asian Development Bank (ADB 2014) found that the services sector has been using environmental and natural resources at an increasingly high rate compared with other sectors of the economy. Thus, the government must give increased attention to managing environmental problems caused by the services sector because this production sector influences the economic growth of the country. Moreover, the government should prioritize its efforts by considering the income and cost of economic sectors in proportion to their scale. Finally, they should prepare solutions to deal with problems and trends that might occur in the future.

Accordingly, the formulation of policy and strategies to develop the country must address the real benefit and environmental costs in the 3 dimensions mentioned above (ADB 2014). In addition, the prioritizing of environmental problems should be clearly defined. All of these factors could be included in an index to indicate environmental problems and lead to sustainable solutions in the future, which is the main emphasis of this research.

The objective of this study is to propose an indicator to evaluate environmental impacts of the services sector in Thailand, leading to more sustainable consumption and production in this sector of the economy.

MATERIALS AND METHODS

Scope of study

The environmental and natural resource costs are calculated for each service sector using data from Thailand's input-output table. This table expresses the country's total output as a production lineage in which the goods and services produced by one industry are used as input into the production of the goods and services of another industry. The value of the output of each industry can be expressed as the sum of the values of all the inputs to that industry down through the lineage. The calculation uses input data categorized as *natural resources materials, energy and transportation, fertilizer and pesticides,* and *sanitary and similar services*. The effects from consumption of the services are not included in environmental cost.

The main calculations in this study use data from the input-output table of Thailand for 2015, which are the most current data. The precision of the calculations is limited by the economic and social descriptions used to create the input-output table.

Conceptual framework

The conceptual framework (Fig. 1) for evaluating service sectors in terms of their environmental costs is based on the aims and concepts of sustainable development. Three supporting concepts are welfare economics of A. C. Pigou, natural resource economics, and ecology economics (ADB 2014).

Modeling

The model used in this study is related to the input-output table, in which the relationships of the data are categorized by rows and columns as in Table 1 (Leontief 1986).

Rows present the output distribution of product sector i for n product sectors and the gross product of product sector i can be defined, for $1 \le i \le n$, by
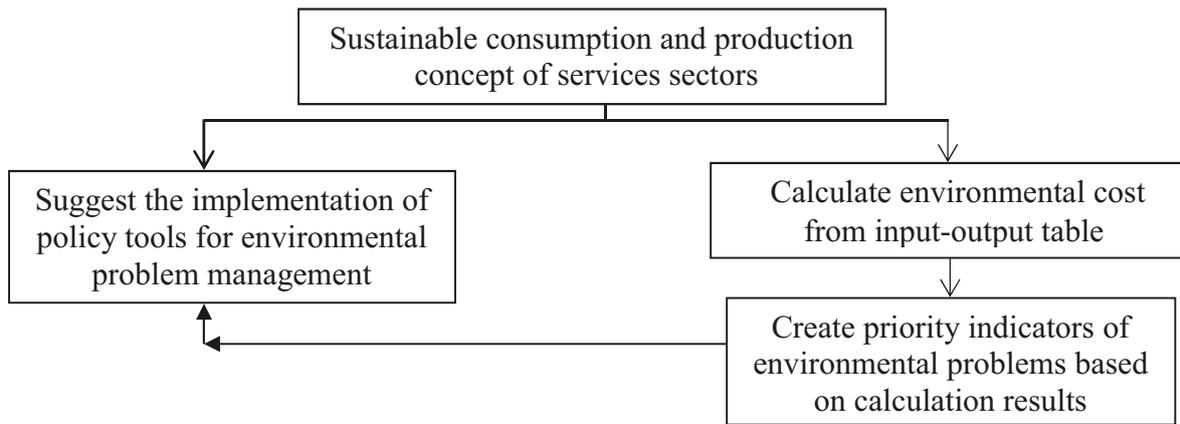
$$X_i = \sum_{i=1}^{n} X_{ij} + F_i \qquad (1)$$

Fig. 1. Conceptual framework

where X_i refers to gross product of product sector i, X_{ij} refers to the product distribution of product sector i of goods and services production for product sector j, and F_i refers to the final demand of product sector i.

Columns show the structure expenses or cost of goods production for product sector j (X_j) that can be defined, for $1 \leq j \leq n$, by

$$X_i = \sum_{j=1}^{n} X_{ij} + V_j \qquad (2)$$

where V_j refers to the value added of product sector j, only if input value is directly proportional to the output value. Then X_{ij} can be defined by the relationship of output (X), input coefficient (A), and final demand (F) of the production structure for the economic system that can be defined by

$$X = AX + F \qquad (3)$$

$$X = [I-A]^{-1} F \qquad (4)$$

$[I-A]^{-1}$ is the Leontief inverse matrix, which is important for economic system analysis using an input-output table. The inverse matrix acts as a direct and indirect input coefficient of the production supply chain that can be used for supply chain length and intensity calculation. The environmental cost when studying each product or service's production can use the multiplication of the environmental cost coefficient and the inverse matrix. Finally, the result represents the total effect of the supply chain that accumulated the environmental cost of each product or service's production. The result also shows the intensity of backward environmental effects of direct and indirect input and output. Furthermore, the result presents names, sectors, and intensity of environmental cost, which are useful for formulating an efficient policy and environmental problem-solving.

Relationships in the input-output table bring about a small change in the final demand of each product sector (ΔF), which is called a multiplier for final goods and services. Eq. (5) presents the multiplier for the final goods and services calculation.

$$\Delta X = [I-A]^{-1} \Delta F \qquad (5)$$

Table 1. Matrix used to create the input-output table of economic sectors X_i = value of the output of sector i (i = 1...n); X_{ij} = sales by sector i to sector j, or the value of inputs from sector i used to produce the output of sector j (i = 1...n; j = 1...n). It represents the amount of the ith sector output used by the jth sector to produce its output; L_j = wages in sector j (j = 1...n). It represents the use of labor in the production of the ith product; N_j = interest and profits in sector j; M_j = imports of sector j; C_j = personal consumption expenditures for the output of sector i; I_j = investment expenditures for the output of sector i; G_j = government purchases of the output of sector i; E_j = exports of the output of sector i

Producing sector	Using sector	Processing sectors 1	2	Final demand				Total outputs (X)
Processing sectors	1	x_{11}	x_{12}	c_1	i_1	g_1	e_1	x_1
	2	x_{21}	x_{22}	c_2	i_2	g_2	e_2	x_2
Payments sectors	Value added	l_1	l_2	l_c	l_1	l_g	l_e	L
		n_1	n_2	n_c	n_1	n_g	n_e	N
	Imports	m_1	m_2	m_c	m_1	m_g	m_e	M
Total outlays (X')		x_1	x_2	C	I	G	E	X

If final demand (ΔF) changes, environmental cost will increase (ΔE). Eq. (6) represents the increasing of environmental cost:

$$\Delta E = R[I-A]^{-1} \Delta F \qquad (6)$$

where R is the coefficient of inverse matrix.

RESULTS AND DISCUSSION

Table 2 lists the top 10 service sectors in terms of forward linkage (distribution chain connecting a producer or supplier with customers), real benefit, and each category of environmental cost. Real benefit is the revenue for a sector, minus the environmental costs. The average real benefit was 0.709. If the real benefit for a given industry is lower than the average, it can be considered to represent a loss, while values higher than the average represent profit. The average value for environmental cost in terms of *natural resources materials* was 0.0276; for *energy and transportation*, 0.119; for *fertilizer and pesticides*, 0.006; and for *sanitary and similar services*, 0.001. If the cost for a particular industry is lower than the average, there is further capacity for production. Environmental cost values that are higher than the average signify that there is no further capacity for production.

Highlights from the findings include the following:

(1) The service sector with the highest environmental cost in terms of *natural resources materials* was *hotels and places of lodging*. The cost index was above average, signifying that this sector does not have capacity for further production. In contrast, the lowest *natural resources materials* environmental cost was for *life insurance services*.

(2) *Hotels and places of lodging* also had the highest environmental cost in terms of *energy and transportation*. The lowest *energy and transportation* environmental cost was for *other insurance services*.

(3) The highest environmental cost in terms of *fertilizer and pesticides* was found in *personal services*, while the lowest was in *real estate*.

(4) *Movie theaters* were found to have the highest environmental cost for *sanitary and similar service*s. In contrast, *other community services* had the lowest environmental cost for this category.

(5) The highest real benefit in the services sector was for *real estate*, while the lowest real benefit was for *repair not classified elsewhere*. The lowest level of real benefit could signify loss in profit.

(6) The highest forward linkage in the services sector was for *movie theaters*, while the lowest forward linkage was for *real estate*.

This research is a pilot study of environmental costs of production of services in the economic system of Thailand, using the input-output database to account for differences among sectors. Environmental cost contributes damage to the environment and is affected by the behavior and decisions of producers, consumers, and the government (ADB 2014). The environmental cost cannot be estimated from activities occurring in the market alone. Instead, the estimation of the environmental cost of each production sector in Thailand needs to incorporate environmental cost, which reflects environmental cost. The information can be used to compare the environmental cost of production sectors, and could help to create an environmental problem management indicator (TDRI 2007). The environmental cost modeled in this study relies on 4 groups of economic data, including costs of (1) *natural resources materials*, (2) *energy and transportation*, (3) *fertilizer and pesticides*, and (4) *sanitary and similar services*.

This research calculates the forward linkage of goods and services production by the addition of 1 unit of GDP. The result from this calculation portrays the economic connectivity of each product sector resulting from economic growth and economic net income (ADB 2014). The purpose of environmental problem management is to reduce negative impacts from the environmental costs to the economic system. Production sectors have been systematically studied and significant environmental costs of production have been identified already.

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Thailand and other Association of Southeast Asian Nations (ASEAN) countries have not created an environmental problem indicator using real benefit, environmental cost, and environmental problems, and this has led them to formulate ineffective policies and plans for their countries (ADB 2014). More developed countries, like Japan and European countries, give importance to environmental stewardship, and their efforts can be reflected in higher green GDP. This methodology would help Thailand formulate efficient policy and forecast future conditions more accurately, allowing the nation to deal with crises arising from environmental problems (NESDB 2015).

Table 2. Top 10 service sectors ranked by forward linkage, real benefit (revenue minus environmental costs), and environmental costs. Value data are ratios

Forward linkage		Real benefit		Natural resources materials cost		Energy and transportation cost		Fertilizer and pesticides cost		Sanitary and similar services cost	
Value	Sector	Value	Sector	Value	Sector	Value	Sector	Value	Sector	Value	Sector
0.692	Movie theaters	0.903	Real estate	0.033	Hotels and places of lodging	0.326	Hotels and places of lodging	0.013	Personal services	0.012	Movie theaters
0.649	Business services	0.89	Other insurance services	0.015	Restaurants and drinking places	0.139	Business and labor associations	0.004	Restaurants and drinking places	0.009	Hotels and places of lodging
0.599	Radio, television, and related services	0.88	Life insurance services	0.015	Movie theaters	0.137	Personal services	0.002	Libraries and museums	0.008	Amusement and recreation
0.588	Restaurants and drinking places	0.868	Banking services	0.012	Motion picture production	0.133	Movie theaters	0.001	Amusement and recreation	0.007	Real estate
0.579	Hotels and places of lodging	0.833	Libraries and museums	0.011	Personal services	0.128	Restaurants and drinking places	0.001	Other community services	0.006	Life insurance services
0.569	Motion picture production	0.832	Education	0.01	Radio, television, and related services	0.124	Sanitary and similar services	0.001	Hospitals	0.006	Motion picture production
0.512	Repair not classified elsewhere	0.81	Amusement and recreation	0.01	Hospitals	0.12	Other community services	0.001	Hotels and places of lodging	0.005	Business services
0.459	Hospitals	0.789	Other community services	0.009	Business services	0.115	Radio, television, and related services	0.001	Motion picture production	0.005	Other insurance services
0.452	Banking services	0.774	Research	0.008	Sanitary and similar services	0.113	Hospitals	0	Movie theaters	0.005	Hospitals
0.45	Personal services	0.741	Business and labor associations	0.008	Amusement and recreation	0.11	Business services	0	Education	0.004	Education

The results of this examination of environmental costs by each sector is consistent with the research of Bodini (2012), and Bailey et al. (2004). The results of the real benefit analysis is also consistent with the research of Simpson & Bradford (1996), who used the average value of total sectors to create the environmental costs index.

Decisions on the management of environmental problems under a limitation of resources in administration under the sustainable production concept need to use the correct natural resources and environment capital databases. These decisions can be implemented with appropriate planning for environmental management for the pretext of society to lead to sustainable development.

The sector groups with the highest natural resources materials costs according to this study are *hotels and places of lodging*, *restaurants and drinking places*, and *movie theaters*. In these sector groups, the state should promote economic and effective consumption, so that use is reduced, and recycling and reuse is promoted, by utilizing new economic tools such as specifying the right to use resources (property rights), financial instruments, and fiscal instruments (Xu 2010, NESDB 2015).

The sector groups which showed the highest costs of *fertilizer and pesticides* were *personal services*, *restaurants and drinking places*, and *libraries and museums*. Tools and controls to check that the use of *fertilizers and pesticides* does not exceed levels that are dangerous for humans and ecology, as well as economic incentive instruments, such as fiscal instruments of differing taxes for dangerous and non-dangerous products, could be introduced (Ness et al. 2007).

Sector groups with the highest *sanitary and similar services* costs are *movie theaters*, *hotels and places of lodging*, *amusement and recreation*, *real estate*, *life insurance services*, *motion picture production*, *business services*, *other insurance services*, *hospitals*, and *education*. Fiscal instruments such as pollution tax should be considered here. In addition, local administrations could improve regulation by using differing charges and fines for different activities to reflect the costs of waste disposal (ADB 2014).

The indicator showed that the top 10 production sectors with the highest environmental issues were (1) *movie theaters*, (2) *business services*, (3) *radio, television, and related services*, (4) *restaurants and drinking places*, (5) *hotels and places of lodging*, (6) *motion picture production*, (7) *repair not classified elsewhere*, (8) *hospitals*, (9) *banking services*, and (10) *personal services*. Fiscal incentive instruments should be considered here, such as the reduction of corporate income tax for energy conservation based on actual savings, which has been shown to give more benefit than reduction of tax from money invested for conservation of energy, although both methods are tools that have been used for conservation of energy (TDRI 2007, NESDB 2015).

CONCLUSIONS

Thailand has adopted policies predominantly focused on economic growth and prosperity from very early in its history. Former governments emphasized improving GDP without taking into consideration the consequences of such policies on Thailand's environment (TDRI 2007). This mismanagement has led to subsequent instability and crises in the country. The rapid economic development of Thailand has come at the cost of environmental degradation and the depletion of its natural resources. This calls for proactive measures that address the complex nature of the issues and the creation of environmental indicators that can be effectively used to set state policies and strategies in the future.

Indicators of environmental issues are essential tools to help direct policies and strategies of Thailand's government. The real benefit from each production sector can not only be judged by the size of the output, but must also reflect the level of environmental cost created by the production. Consequently, it is necessary to calculate an environmental indicator in order to prioritize the most urgent environmental issues in order to achieve more sustainable development. This study aimed to develop indicators to help guide decisions to achieve more sustainable development. The indicators were divided into 5 categories; namely *natural resources materials* costs, *energy and transportation* costs, *fertilizer and pesticides* costs, *sanitary and similar services* costs, and forward linkages (NESDB 2015). To calculate the indicators, average cost values for each production sector were used. If a sector had environmental costs that were higher or equal to the sector average, the sector was considered inefficient in its production of services, and should take measures to lower environmental costs. Researchers also developed forward linkage values in order to identify sectors causing environmental harm that needs to be addressed immediately. The sectors with highest forward linkage should have priority, followed by others, according to their forward linkage value (ADB 2014). Thailand's economic development plan must integrate

environmental indicators such as those from this research to create efficient strategies and policies for sustainable development. In the past, Thailand did not incorporate environmental indicators in policy planning, and as a result, the environment and natural resources have been mismanaged to beyond a sustainable capacity. The indicators in this research will greatly improve state policies addressing environmental sustainability.

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