A Framework of Green Growth Assessment for Thailand's Highway Infrastructure Developments

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ABSTRACT

To promote economic growth, investments in infrastructure projects such as roads, bridges, tunnels, airports, and urban mass transit systems are indeed necessary. However, the growth in infrastructure investment is not without concerns. Transport sector accounts for a large amount of carbon emissions in recent years as the economy continues to expand. This paper presents a new framework of green growth assessment to be used for Thailand's highway infrastructure by combining economic aspects and environmental aspects of the project into a single index. The proposed method is intended to be served as a "green-growth" barometer of major highway projects across Thailand. To demonstrate how the proposed model can be applied in practice, Bangkok's motorway No. 9 is employed as a case study project presented in this paper. The results of this proposed method will be later used to evaluate the green-growth indices of major highways in Thailand. This study may help advance the knowledge and practices of sustainable highway infrastructure developments.

INTRODUCTION

To promote economic growth, investments in infrastructure projects such as roads, bridges, tunnels, airports, and urban mass transit systems are indeed necessary. This is especially true for developing or emerging economies like Thailand. However, the growth in infrastructure investment is not without concerns. For example, several studies confirmed the public's perception about the construction industry as the major contributor of natural resources depletion and high levels of environmental problems. With the huge amount of money expected to be invested in Thailand's infrastructure in the coming years, it can also be expected that the country's natural resources will be extracted at a much faster rate. Materials used in the construction of infrastructure projects may unfortunately cause more environmental damages, and the transportation of materials to the construction sites will bring with it pollution, namely, dust, noise, and material waste. This very complex and complicated environmental problem of stimulating economic growth, either as short-term purposes or long-term ones, through infrastructure investments is faced by many countries around the world.

On a macro-scale, there are a few indicators aiming at comparing economic growth and greenery of countries around the world. Notably among these indicators are the Environmental Performance Index (EPI) by Yale and Columbia University and the Global Competitiveness Index (GCI) by the World Economic Forum.

According to the 2012 EPI report, Thailand ranked 34th; Switzerland 1st; South Korea 43rd; and the United States 49th. This is a huge improvement for Thailand, who in 2010 ranked 67th, compared with South Korea's 94th. However, in terms of the Global Competitiveness Index (GCI) reported by the World Economic Forum, Thailand's infrastructure ranking slightly slipped to 49th in 2012, from 47th in 2009, while South Korea stood at 22th and 20th, respectively. Meanwhile, Thailand's GDP in 2011 grew modestly to $345.65 billion, from $263.51 billion in 2009.

On the other hand, on a micro-scale, several tools and methods of economic evaluation and environmental impact assessment have been developed over the last decade. Examples of economic evaluation methods include the net present value (NPV), the benefit-cost analysis (BCA), and the real options approach (ROA), which is gaining wide acceptance among academics and practitioners (Breadley et al., 2010; de Neufville et al., 2006). As for green assessment, there are Leadership in Energy and Environmental Design (LEED), Building Research Establishment Assessment Method (BREEAM), Comprehensive Assessment System for Building Environment Efficiency (CASBEE), BCA Green Mark, and CEEQUAL.

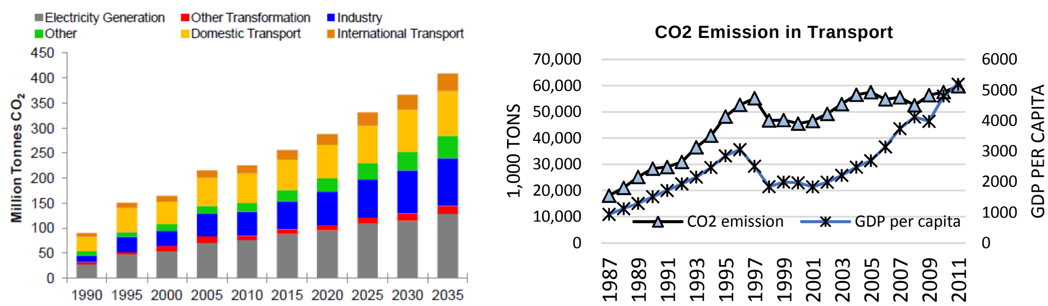
However, as green growth is getting more attention, there is growing criticism of green-growth advocates. Such criticism can be boiled down to two things. One is that the benefits of being "green" may not be worth the added costs. In other words, greenery and growth are in conflict, i.e., green but no growth or growth but not green. The other is that green growth is more like a slogan than a distinctive and doable policy. Despite several tools and methods developed for economic evaluation and green assessment, either on a macro- or micro-scale, there is none that combines economic development objectives (e.g., project economic, regional economic growth) and green goals into a single number or index. Unlike existing environmental impact assessment (EIA), which requires certain types of projects be studied about the impact of a proposed project on the environment, this research is intended to serve as a "green-growth" barometer of major transportation infrastructure in Thailand. Moreover, we hope that this research could extract good practices for infrastructure investment and management with one of the focuses on being green.

LITERATURE REVIEW

Since the Report of the Brundtland Commission was published in 1987, sustainable development has been defined as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (UN, 1987: 54). Can we achieve sustainable development through green growth? And is green growth really a means to achieve sustainable development, or just a different name for an economic growth model?, asked Moon (2010) in an article published in *Korea Observe*. He also questioned about how economic growth can be achieved and what kind of economic growth the country is pursuing?

Transport infrastructure significantly accounts for the total amount of carbon emissions. There is a strong trend that the amount of carbon emissions from transport sector will be increase in the future as global economy expands. In Asia where many countries in the region enjoy a strong economic growth in recent years, the total amount of CO2 emissions from transport sector is keeping on rising. For example, China release the most amount of CO2, and the amount of the CO2 emissions is increasing at the alarming rate. Thailand released about 50 million tons of CO2 over the past few years, and the rate of the emissions is gradually increased.

Most of total CO2 emissions released from Thailand's transport sector are from road mode (account of 97%), whereas the remaining emissions are from air mode (2%), rail mode (0.6%), and water mode (0.4%) (APEC Energy Demand and Supply Outlook, 2013). According to Energy Statistics 2012, an energy report by Thailand's Energy Policy and Planning Office, the amount of CO2 released from Thailand's transport sector is strongly correlated with the economic growth (i.e., GPP per capita), as shown in Figure 1.



(a) (b)

Figure 1. Transport sector CO2 emissions growth and economic growth in Thailand (Source: Thailand Energy Policy and Planning Office)

Economic and environmental (green) assessments. Several methods have been developed to determine and quantify the economic value of a project. Most of these methods are based on the discounted cash flow techniques. Examples of popular method for project economic evaluation include net present value (NPV), payback period, internal rate of return (IRR), profitability index, and benefit cost analysis. Good references to these techniques can be found in Brealey et al. (2010) and Crundwell (2008). To assess how green, or sustainable, the building is, several methods have been developed in recent years. Among these methods are life cycle assessment (LCA), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Building Environment Efficiency (CASBEE), the BCA Green Mark, and CEEQUAL (Wu and Low, 2010). There are several references to these methods. For example, Alyami and Rezgui (2012) provided a good review of green assessment methods.

Limitations of the current green assessment methods. The problem of the existing green assessment methods, as pointed out by, for example, Cole (1998), Cooper (1999), Crawley and Aho (1999), and Kohler (1999), is that these methods were developed for different, local purposes, and are not fully applicable to all regions. Accordingly, categories should be divided in a manner that is in line with the country's goals of economic and social development.

A NEW FRAMEWORK OF HYBRID GREEN GROWTH INDEX

This paper proposes a new method for evaluating the greenness of a highway project and its economic contribution, which is called a hybrid green growth index. The conceptual framework of how this index is to be calculated is presented in Figure 2.

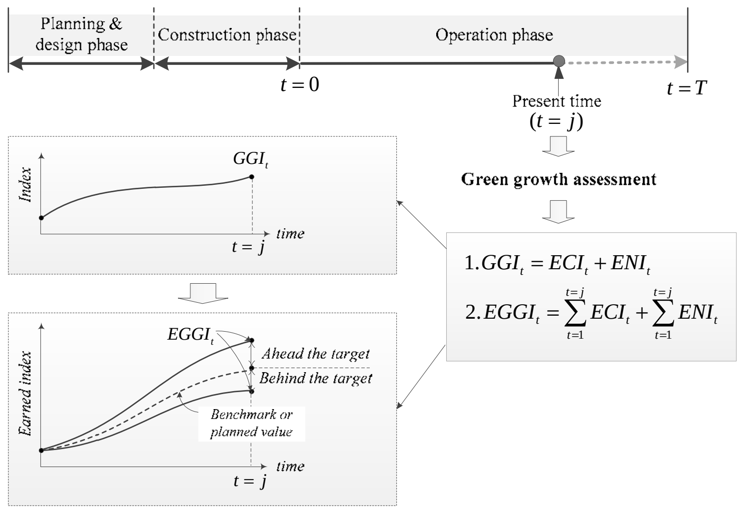


Figure 2. A conceptual framework of green growth assessment.

As shown in Figure 2, at any particular time during the operation phase, a project can be assessed to determine its green growth index. For example, we can use project's information of the present time period ($t = j$) to determine the green growth index (i.e., $GGI_{t=j}$). The green growth index is a time dependent variable, which means that its value will change over time depending on how it is operated and managed by the project owner. Green-growth index (GGI) is computed by

$$GGI_t = ECI_t + ENI_t \quad (1)$$

where ECI_t is project's economic index at time t and ENI_t is project's environmental index at time t. The ECI_t can be calculated by the following equation

$$ECI_t = \frac{[B_t - C_t]}{A_t\left[\sum I\right]} \ , \quad (2)$$

where B_t and C_t is total benefits (revenues) and total cost in year t, respectively; and, $A_t\left[\sum I\right]$ is the amortization of total investments. As for the ENI_t, it can be estimated as

$$ENI_t = \frac{BM_t}{X_t} \ , \quad (3)$$

Where BM_t is the benchmark of environmental damages/costs at time t, and X_t is the total amount of environmental damages/costs released by the project in year t. Earned green-growth index (EGGI) is the cumulative index of the project, which can be computed as

$$EGGI_t = \sum_{i=1}^{i=t} ECI_i + \sum_{j=1}^{j=t} ENI_j \tag{4}$$

Major components of the proposed green growth assessment are presented in Figure 3. In planning and design phase, categories are adopted from Soderlund (2007).

Economic Aspect

1) Project-level economic
- Investment costs
- Operation and maintenance costs
- User benefits (e.g., time, cost, safety)

2) Regional-level economic
- Regional growth of economic activity (e.g., sales, jobs, wages, value added)
- Overall growth of economic activity
- Land development (e.g., property values)
- Fiscal impacts (e.g., government revenues and costs)

Environmental Aspects

1) Planning & design phase
- Sustainable alignment
- Materials and resources
- Stromwater management
- Energy and environmental control
- Innovation and design

2) Construction phase
- Construction activities (e.g., site disturbance, waste material generation, noise pollution, emission and energy use)

3) Operation phase
- CO2 emission

Figure 3. Main components of green growth assessment for highway projects.

A CASE STUDY PROJECT

Motorway No. 9 (al so known as Kanchanaphisek Road) is an 8-lane outer ring road located in the outer fringes of Greater Bangkok. Its total length is about 64 km (approximately 40 miles), and the initial construction cost is about 12,000 million Thai baht (THB). According to a recent study by the Office of Transport and Traffic Policy and Planning, the average CO2 emissions of vehicle use in Thailand is presented in Table 1. Information related to construction and operation of the project is shown in Table 2.

RESULTS AND DISCUSSIONS

From information presented in Tables 1 and 2, green growth assessment of the case study project is presented as shown in Table 3. Also, the green growth index or GGI of the case study project is graphically presented in Figure 4. It can be seen that the economic index of this project has increased in recent year, while its environmental index tends to decrease. The overall green growth index of this project is gradually increased. Accordingly, based on the results of this study, the project’s contribution is moving more towards economic growth than to greenness. On a macro-scale analysis, we found that the project-level economic growth of this case study project is not correlated with the regional-level economic growth, as shown in Figure 5. The explanation for this may be because this project is a tolled highway with an enclosed boundary.

Table 1. Average CO2 emission of vehicle use in Thailand.

Types of vehicle	Average CO2 emission (g/km)	
	30 kph	60 kph
Motorcycle	33	29
Petrol Engine	178	129
Light Diesel	203	154
Heavy Diesel	821	577

Source: *The Study to Develop Master Plan for Sustainable Transport System and Mitigation of Climate Change Impacts* by Office of Transport and Traffic Policy and Planning, Thailand's Ministry of Transport

Table 2. Construction and operation phase.

Year	Traffic volume	Construction (million THB) [I]	OandM costs (million THB) [C]	Revenue (million THB) [B]	Net income (million THB) [B]-[C]	Project's cash flow [B]-[C]-[I]
1996	-	4,000	-	-	**(4,000)**	**(4,000)**
1997	-	4,000	-	-	**(4,000)**	**(4,000)**
1998	-	4,000	-	-	**(4,000)**	**(4,000)**
1999	14,924,557		144	512	369	656
2000	22,950,525		299	788	489	1,087
2001	24,398,272		238	837	600	1,075
2002	28,934,657		53	993	941	1,046
2003	34,179,372		59	1,173	1,114	1,232
2004	40,439,965		90	1,388	1,298	1,478
2005	44,412,187		120	1,524	1,404	1,644
2006	43,891,384		157	1,507	1,350	1,663
2007	49,253,584		147	1,691	1,543	1,838
2008	50,191,094		119	1,723	1,604	1,842
2009*	53,926,203	4,833	135	1,851	1,716	-2,847
2010*	61,263,227	1,250	136	2,103	1,967	989
2011	69,644,788		150	2,391	2,240	2,541
2012	70,449,196		159	2,418	2,259	2,577
2013E	116,843,441		136	4,011	3,875	4,147
Total	**725,702,452**			-		

**Expansion from 4 lanes to 8 lanes*

Table 2. (*Continued*) Construction and operation phase.

Year	Project CO2 (tons)	Traffic induced CO2 (tons)	Total CO2 emissions (tons)	Cumulative CO2 emission (tons)	Regional GPP growth (%)	Regional transport GPP growth
1996	74,667		74,667	74,667	8%	10%
1997	74,667		74,667	149,333	-4%	5%
1998	74,667		74,667	224,000	-4%	5%
1999	9,920	96,160	106,080	330,080	4%	11%
2000	9,920	147,872	157,792	487,873	8%	6%
2001	9,920	157,200	167,120	654,993	8%	11%
2002	9,920	186,429	196,349	851,342	4%	7%
2003	9,920	220,221	230,141	1,081,483	7%	2%
2004	9,920	260,559	270,479	1,351,962	9%	6%
2005	9,920	286,152	296,072	1,648,034	9%	9%
2006	9,920	282,796	292,716	1,940,750	6%	-1%
2007	9,920	317,346	327,266	2,268,016	4%	-13%
2008	9,920	323,386	333,306	2,601,322	4%	3%
2009*	84,587	347,452	432,038	3,033,361	0%	-2%
2010*	28,598	394,725	423,323	3,456,684	6%	4%
2011	19,840	448,728	468,568	3,925,252	7%	2%
2012	19,840	453,911	473,751	4,399,003	-	-
2013E	19,840	752,834	772,674	5,171,677	-	-
Total	**495,905**	**4,675,772**	**5,171,677**	**-**		

Table 3. Green growth assessment of Bangkok's highway No. 9.

Year	Amortization of investment [A] (million baht)	Net economic benefit [B-C] (million baht)	ECI = [B-C]/[A]	Benchmark CO2 [BM] (Mt)	CO2 emissions [X] (Mt)	ENI = [BM]/[X]	GGI
1996	290	-	-	-	-	-	-
1997	580	-	-	-	-	-	-
1998	872	-	-	-	-	-	-
1999	872	369	0.42	0.3728	0.3301	1.13	1.55
2000	872	489	0.56	0.3728	0.1578	2.36	2.92
2001	872	600	0.69	0.3728	0.1671	2.23	2.92
2002	872	941	1.08	0.3728	0.1963	1.90	2.98
2003	872	1,114	1.28	0.3728	0.2301	1.62	2.90
2004	872	1,298	1.49	0.3728	0.2705	1.38	2.87
2005	872	1,404	1.61	0.3728	0.2961	1.26	2.87
2006	872	1,350	1.55	0.3728	0.2927	1.27	2.82
2007	872	1,543	1.77	0.3728	0.3273	1.14	2.91
2008	872	1,604	1.84	0.3728	0.3333	1.12	2.96
2009*	1,236	1,716	1.39	0.7456	0.4320	1.73	3.11
2010*	1,331	1,967	1.48	0.7456	0.4233	1.76	3.24
2011	1,331	2,240	1.68	0.7456	0.4686	1.59	3.27
2012	1,331	2,259	1.70	0.7456	0.4738	1.57	3.27
2013E	1,331	3,875	2.91	0.7456	0.7727	0.96	3.88

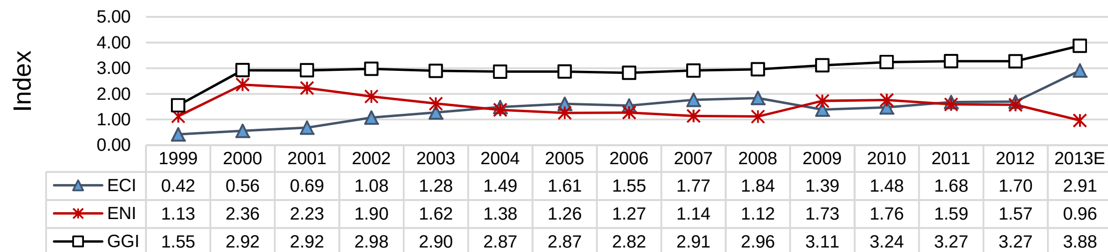


Figure 4. Green growth index of Bangkok's motorway No.9.

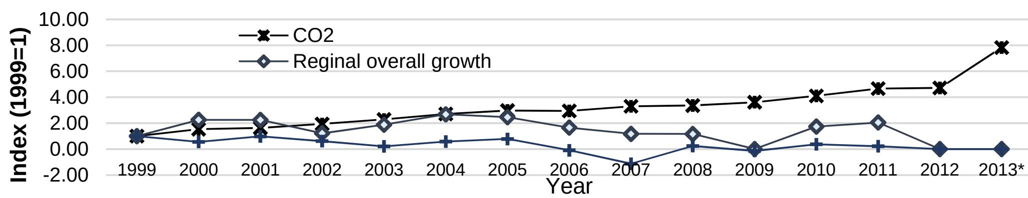


Figure 5. Relationships between carbon emission and regional economic growth of Bangkok's motorway No.9.

CONCLUSIONS

This paper has presented a new framework of green growth assessment for highway projects. The goal of the proposed framework is to integrate project environmental index with economic one so that to determine which directions the project is moving towards. To illustrate how the model can be used in real practice, Bangkok's motorway No.9 is employed as a case study. The results show that the green growth index of the case project gradually increase, with economic index being a main driver of such growth. Based on the application of the proposed framework, the case project obtain both economic and green indices greater than 1, which implies that the project not only has positive economic impact but it is also considered being green. However, the project's green or environmental index of late is deteriorating. The project managers and operator of this project may, therefore, use this information in order to manage the project in the future, that is, whether to manage it so as to increase its economic aspect or so as to improve its environmental one, or both.

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