Economic growth and sustainability – an empirical study of the Thai development experience [1]

M. Clarke, S.M.N. Islam and P.J. Sheehan

Centre for Strategic Economic Studies, Victoria University,
PO Box 14428, Melbourne City MC, Victoria 8001, Australia
E-mail: matthew.clarke@research.vu.edu.au

Abstract: Increasing economic growth has long been the dominant position within the public policies of all South East Asian countries. More recently a new issue, sustainability, has emerged within development economic literature, which has significant implications for the continual pursuit of economic growth. Sustainability is concerned with ensuring the current generation meets their present needs without threatening future generations' ability to do likewise. This ability is dependent on a healthy and functioning socio-economic environmental (SEE) system. Economic growth can damage the SEE-system though, through resource degradation, over-harvesting and pollution. Therefore, achieving economic growth and sustainability simultaneously may not be possible. This paper discusses these tensions between economic growth and sustainability by undertaking a number of SEE-based adjustments to GDP in order to measure sustainability. Thailand is used as a case study for a 25 year period, 1975 – 1999. The adjustments include the environmental costs caused by economic growth such as noise pollution, water pollution, the depletion of non-renewable resources, and deforestation. The results show a stark difference in terms of GDP per capita and the SEE-adjusted GDP per capita figure. The paper concludes that with increasing environmental costs of economic growth, pursuing high growth objectives without considerations to the environment threatens sustainability.

Keywords: Thailand; sustainable development; economic growth.

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Biographical notes: Matthew Clarke is a Post-Doctoral Research Fellow in the Centre for Strategic Economic Studies at Victoria University, Australia. He has been working on measures of sustainable welfare based on social choice theory. He has published in various international journals.

Dr Sardar M.N. Islam is Director of the Sustainable Growth Program at the Centre for Strategic Economic Studies at Victoria University, Australia. His principal areas of interest relate to economic modelling, economic growth, resource economics, environmental constraints and sustainable development. He has published six books and 100 technical papers.

Professor Peter Sheehan is Director of the Centre for Strategic Economic Studies at Victoria University, Australia. He has extensive experience in government, academia and on corporate boards, and has published 11 books and over 50 papers.

1 Introduction

Increasing economic growth has long been the dominant position within the public policies of all South East Asian countries [2]. The success of these policies is undeniable as recorded rates of economic growth over the past three decades has been among the world's highest [3]. Economic growth has been necessary to provide the foundations to increase living standards for the growing populations of Thailand. However, this growth has also been accompanied by increased damages to the socio-economic systems.

More recently a new issue, sustainability, has emerged within development economic literature (as well as literature within all social and scientific disciplines), which has serious implications for the continual pursuit of economic growth. Sustainability is concerned with ensuring the current generation meets their present needs without threatening future generations' ability to do likewise [4]. This ability is dependent on a healthy and functioning socio-economic environment (SEE) system. Economic growth can damage the SEE-system though, through resource degradation, loss of social cohesion and pollution. Therefore, achieving economic growth and sustainability simultaneously may not be possible.

A systematic study of sustainability at the aggregate level has not been undertaken for Thailand. The qualitative studies focusing on sustainability that have been undertaken have focused on micro communities or eco-systems or have been policy orientated (see for example the United Nation's Phnom Penh Regional Platform on Sustainable Development). The contribution and objective of this paper is to numerically estimate a reliable and intuitively correct aggregate measure of sustainability for the Thai economy.

This paper will discuss the tensions between economic growth and sustainability by undertaking a number of SEE-based adjustments to GDP in order to measure sustainability. Thailand will be used as a case study for a 25 year period, 1975 – 1999. The adjustments will include the social, economic and environmental costs caused by economic growth such as income inequality, urbanisation, commuting, water, air and noise pollution, deforestation and long-term environmental damage. The results show a stark difference in terms of GDP per capita and the SEE-adjusted GDP per capita figure. The paper concludes that with increasing environmental costs of economic growth, pursuing such growth threatens sustainability.

2 Organisation of paper

This paper is divided into five sections. The first section introduced this paper. The second section reviews the experiences of economic growth within Thailand. The third section reviews sustainability. The concept of a SEE adjusted measure of GDP is introduced and empirically applied to Thailand over a 25 year period in the fourth section. The final section includes the paper's conclusions. The appendices contain the data and the details of the calculations of the different SEE adjustments to GDP.

3 Economic growth in Thailand

This paper focuses on Thailand as a representative South East Asian developing country. Like other South East Asian countries, Thailand has achieved remarkable growth over the last three decades. Its GDP per capita rose nearly twenty times between 1960 to the present. Thailand had experienced some of the highest rates of economic growth for any country between 1991 and 1997 [5].

Thailand is a unique country, with distinct economic characteristics. However, it displays enough common traits for it to be considered a reasonable example of a typical developing country. As Thailand has recently outperformed all other developing (and developed) countries in levels of economic growth, there is little doubt that it is a role model for most of the third world [2,6]. If countries are presently not like Thailand, they aspire to be.

There are three main phases in Thailand's experience of economic growth. The first phase, 1975-1985, is a steady increase in growth. The second phase, 1986-1995, shows accelerated growth, before the final phase, 1996-1999 covers the financial crisis of July 1997 and apparent subsequent rally. The growth rates achieved in Thailand in the second phase were amongst the highest recorded by any country during this time [3].

Table 1 GDP for Thailand, 1975-1999 (1988 prices, millions of baht)

Year	*GDP per Capita* (1988 baht)	*Annual Growth Rate* In GDP per capita (%)
1975	14662	7.4
1976	15754	7.5
1977	16942	7.6
1978	18237	3.2
1979	18819	3.4
1980	19458	3.8
1981	20206	3.4
1982	20883	4.1
1983	21729	3.6
1984	22504	2.2
1985	22996	3.2
1986	23722	7.8
1987	25561	11
1988	28380	10.3
1989	31316	10.4
1990	34565	7.3
1991	37073	6.6
1992	39506	8.3
1993	42765	5.6
1994	45174	7.4
1995	48511	6.1
1996	51489	-2.5
1997	50184	-9.6
1998	45348	1
1999	45789	

The Thai economy grew on average 7% during the 1970s. Given, the world economy and oil crisis shocks, the withdrawal of the U.S. military, and internal political instability 'the growth of the Thai economy during the period 1971 to 1978 was remarkable' [5, p.108]. It is reasonable to argue that the development of the Thai economy from agricultural to industrialised (at least in terms of composition of GDP) occurred in spite of all government policies and interventions. Tariffs and fuel subsidies protected from domestic industries and violent political upheaval did nothing to increase investors' confidence. The balance of payments was negative, inflation was high, government expenditure was increasingly resulting in higher deficits and overseas debt (whilst low comparatively) also increased through the decade to alarming levels within Thai economic history [7]. Following a slump in primary commodity exports in the early 1980s, the enlarged foreign debt commitment became a serious problem as the economy went into recession [8,9]. In order to limit the impact of the fuel crisis of the mid seventies, the Thai government borrowed heavily to subsidise fuel prices. Increasing interest rates in the early 1980s put great pressure on the Thai government's fiscal position. Whilst the 'debt crisis' of Thailand was not as severe as suffered by other countries [10], it was quite severe from its own conservative standards [8,9].

Ironically, when the Thai government in the-mid 1980s formally dropped the World Bank recommendations, the Thai economy began to show signs of recovery. The economy had been sufficiently realigned from ISI to EOI so that rapid growth was occurring and foreign investment was becoming increasingly attractive [10,11].

The Thai economy entered the 1990s with a growing economy and economic structures in place to increase this economic growth. It was one of the largest markets for Mercedes Benz cars [2]. The 'Golden Age' began in the late 1980s when economic growth in 1988 spurted to 13.2%. Between 1985 and 1992, the total GDP doubled [11]. This made Thailand one of the fastest growing economies in the world during this period [12]. The region and the world economy were moving out of the mid 1980s recessions and growing strongly. Thailand was particularly well positioned to increase its previous role of assuming the industries that the 'newly industrialising countries' were continuing to shed because of high labour costs [5].

Economic growth has been the major priority of the Thai government for some time [13], often to the exclusion of other possible goals [14]. 'In sum, it would seem that the Thai state has accorded the highest priority to economic growth but at the expense of welfare and social justice' [15, p.69]. The Thai government abandoned all policies to plan or control the direction and outcome of economic growth in the early 1990s [11].

In 1996, the Thai economy was characterised by zero growth in export earnings, an increasing balance of payments deficit, increasing private sector debt, increased short-term speculative capital movements and over-heating of property and financial sectors. The crisis wasn't widely predicted though (see [10] as an example as a positive outlook for the future). Again, almost in spite of these concerns, the Thai economy has recovered well from the financial crisis of the late 1990s and is again recording high economic growth rates.

4 Sustainability

If the number of international conferences, books and journal articles are any indication, sustainability and sustainable development (which are considered the same within this discussion) must be the key issue within contemporary economic development at the moment. Sustainability is a wide-ranging concept that has been defined in various ways [16–20]. Recent multilateral recognition has also highlighted the importance of sustainable development as an international issue (see for example the United Nation's *Phnom Penh Regional Platform on Sustainable Development* and recent conference in Johannesburg, the World Bank's *Global Environment Outlook* and at a country level see [21] as a case study of sustainability within Thailand). The Brundtland Commission developed the most widely accepted and least controversial definition. Sustainable development is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' [4, p.1].

Whilst sustainable development is a relatively recent concept [16], its beginnings can be traced back to Fisher [22] and Hicks [23]. More recently, Munasinghe [24] has extended the concept of sustainability away from income flows to incorporate a system analysis of society. This has involved defining sustainability in terms of socio-cultural, environment and economic domains (also see [25] and Holling [26] for similar treatments). Sustainable development must be concerned with all aspects of society [27,28]. Whereas some discussion has taken place on sustainability in terms of environmental and social sub-systems [16, p.29] sustainability must incorporate all sub-systems.

Future economic growth is reliant on a healthy and functioning SEE-system [29]. Recorded rates of economic growth within Thailand over the past three decades have been among the world's highest [30]. Economic growth as been necessary to provide the foundations to increase living standards for the growing population of Thailand. However, this growth has also been accompanied by increased damages to the socio-economic systems [29,31].

Sustainability is concerned with ensuring the current generations meet their present needs without threatening future generations' ability to do likewise [4]. This ability is dependent on a healthy and functioning SEE-system. There is a close relationship between sustainability and social welfare as future social welfare is dependent on sustainability. Within the first social welfare function, the consideration of the damages of economic growth was explicitly to measure social welfare not sustainability. Within the literature, the present debate concerning these costs and benefits can be traced back to the late 1960s when perceived adverse consequences of economic growth on the SEE system through the reduction of environmental quality and resources were first raised. The high levels of economic growth achieved in Thailand and South East Asia more generally, have been accompanied by significant environmental degradation [31,32]. Economic growth can damage the SEE-system though, through loss of social cohesion, resource degradation and pollution.

5 Socio-Economic Environmental (SEE) system sustainability

Economic sustainability is dependent on the following conditions:

- the rate of decline of non-renewable resources
- the excess rate of harvest of renewable resources
- the assimilative capacity of nature to absorb waste
- pollution reducing technology and capital [16].

Economic sustainability occurs if the economic system can remain stable and support the economic activities and needs of current and future generations in addition to withstanding the pressures and shocks emanating from other sub-systems.

Environmental sustainability is concerned with maintaining an ecological system that can support viable communities. Bound by the two thermodynamic laws, our environment cannot grow and so it must be able to have waste emptied into it. Presently, great (economic) pressures are reducing the capability of the ecological system to resist the constant stress our existence is placing on it. Whilst the growing economy is using natural resources, the ability of the environment to resist this stress is constantly reduced. Therefore the need for natural resources, for example, is clearly identified as a competing priority for both economic and environmental sustainability. One requires their use and the other requires their maintenance.

Environmental sustainability in terms of being able to increase social welfare requires an understanding of and operation within the carrying capacity of the ecological sub-system [30]. Operating within this threshold level however, does not mean maintaining an ecological status quo. The environment is dynamic and fluid and the ecological sub-system is constantly adapting and evolving. What it does require though is that the boundaries in which the ecological sub-system does move and evolve are not corrupted or removed through excess harvesting, pollution or other pressures.

Social sustainability is less tangible than economic or environmental sustainability. Society appears to have in-built adaptive systems well suited to sustaining itself. Social sustainability is concerned with maintaining social and human relationship in the face of external pressures. As with the environment, a sense of *bio-diversity* within society is an important concept. Reducing the vulnerability and maintaining the health (i.e., resilience, vigour and organisation) of social and cultural systems and their ability to withstand shocks, is also important [33,34].

Therefore, sustainability requires successful management of simultaneous, and often competing, priorities across a number of sub-systems. It may have been that previously each sub-system had greater strength and flexibility as their threshold points were not under pressure from large populations, pollution or over resource use and therefore easily able to absorb external stresses. However, such a golden age (if it ever did exist) has passed and as sustainability becomes more urgent, reorganisation and expectations of these sub-systems may be required to ensure sustainability can continue.

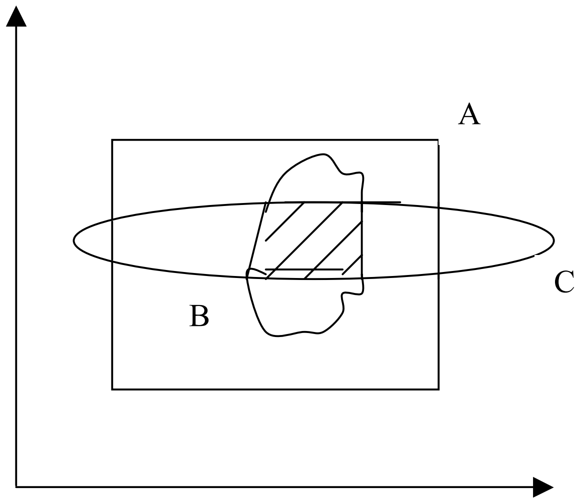
Economic growth is dependent upon a healthy and functioning SEE system. This adjusted GDP measure provides data on the health and robustness of this system [35].

As sustainability is dependent upon a healthy and robust SEE system, it is possible to illustrate this within a simplified two dimensional graph in which the axes are the control variable and whose coordinates are their current values [27].

As the SEE system approaches the boundaries of this region, sustainability becomes threatened, more dangerous and less comfortable.

> "Human survival depends on the system remaining within the small subset of all possible outcomes in which it is positioned and within the tolerable limits on all the critical control axes." [27, p.43]

Figure 1 Sustainability space [14]



Note: A grossly simplified two-dimensional section through phase space for the earth. The regions shown on it suggest possible survival regions for three systems, *A*, *B*, *C*. System A can itself tolerate a wide range of conditions, but it depends upon systems *A* and *C* which cannot. Thus the effective survival region for system *A* is the intersection of those for *A*, *B*, and *C*, the shaded are shown.

5.1 SEE adjustments

Within this paper, the desirability of economic growth is largely dependent on the costs and benefits it produces in terms of its effects on the SEE system [16]. Within the literature, the present debate concerning these costs and benefits can be traced back to the late 1960s when perceived adverse consequences of economic growth on the SEE system through the reduction of environmental quality and resources were first raised.

The high levels of economic growth achieved in Thailand and South East Asia more generally, have been accompanied by significant environmental degradation [29,31,32].

One important method to measure the impact of these negative environmental impacts on future well-being is to adjust GDP accordingly. *The resultant measure is a direct measure of sustainability since it does indicate the extent of increase of environmental damage as the economy grows which threatens sustainability and growth become unsustainable progressively.* Economic growth is dependent upon a healthy and functioning SEE system. This adjusted GDP measure provides data on the health and robustness of this system.

$$\text{SEE AGDP} = f(\text{GDP} - \text{ED}) \quad (1)$$

where SEE AGDP = socio-economic environment adjusted GDP
GDP = gross domestic product
ED = environmental damage

Within this paper, eight SEE adjustments will be made to Thailand's GDP over a period of 25 years, 1975 – 1999 (t). These SEE adjustments are income inequality (I), commuting (C), urbanisation (U), water pollution (W), air pollution (A), noise pollution (N), deforestation (D) and long-term environmental damage (L). The full calculation of these adjustments can be found in Clarke [36].

$$\text{SEE AGDP}_t = f(\text{GDP}_t - [I_t, C_t, U_t, W_t, A_t, N_t, D_t, L_t]) \quad (2)$$

6 Income distribution

It is often argued that the mechanisms that promote economic growth also promote economic concentration, and a worsening of the relative and perhaps absolute position of the lower income groups [37]. Chotikapanich argues that whilst average income levels have increased in Thailand, as they have has been unequally distributed, 'the benefits of economic progress are not equally enjoyed by the whole population' [38, p.237]. Income distribution inequality has been on the increase in Thailand since the 1960s [39–42]. Between 1981 and 1997, inequality between the richest 10% and the poorest 10% of the Thai population, increased from a multiple of 17 to a multiple of 38 [2]. Therefore an equally distributed equivalent income [28] which calculates the equivalent welfare level based on an equally distributed income is a sensible start.

The formula for this equally distributed equivalent income is:

$$I = 1 - \sum_{i=1}^{n} (y^I / \mu)^{1/1-\in} \qquad \in \neq 1 \quad (3)$$

where I = level of inequality
y^i = income of individuals in the i^{th} income range
$f(y^i)$ = proportion of the population with incomes in the i^{th} range
μ = mean income
$\in$ = society's perspective on equality

If *I* falls, then the distribution has become more equal. If *I* equals 0 there is complete equality. If *I* equals 1 there is completely inequality. Society's perspective on the importance of equality ranges from zero to infinity. If $\in = 0$ then society is indifferent to inequality. If $\in = \infty$ then society is concerned with the position of the lowest individual or income group.

Table 2 Income distribution and Atkinson's measure of inequality for Thailand

	1975	*1981*	*1986*	*1990*	*1992*	*1994*	*1996*	*1998*	*1999*
Quintile 1	6	5.4	4.6	4.2	3.9	4.0	4.2	4.2	3.8
Quintile 2	9.3	9.1	739	7.4	7.0	7.3	7.5	7.6	7.1
Quintile 3	13.3	13.4	12.1	11.5	11.1	11.6	11.8	11.9	11.3
Quintile 4	21.4	20.6	19.9	19.2	19.0	19.6	19.9	19.8	19.3
Quintile 5	50.1	51.5	55.6	57.7	59.0	57.5	56.7	56.5	58.5
μ (bath)	12143	16184	18417	26481	29943	34470	38227	31952	32828
I	**.3319**	**.3574**	**.4198**	**.4521**	**.4757**	**.4600**	**.4453**	**.4428**	**.4757**

Source: Clarke [42]

7 Urbanisation

There is a strong case in linking rising urbanisation with national income in developing countries where the rise of the city has been swift, spectacular and in tandem with economic growth. The process of industrialisation relies on a centralised workforce and thus the migration from the rural and agricultural sector to the concentrated urban centres [43, p.521]. The majority of the new mega-cities in the world are located in the developing world. Thailand is in a unique position in that whilst there is 'a remarkably low level of urbanisation for the Kingdom's level of economic growth' [5, p.20] the concentration of urbanisation is high in Bangkok [44]. A major reason for the increase in Bangkok's population is rural-urban migration. Whilst the Thai government has been trying to reduce the flows of migrants to Bangkok for the past two decades, it has not proved successful [45]. Rural-urban migration is not particular to Thailand. It is a phenomenon of the developing world more generally [46,47]. The cost of urbanisation is of major concern for residents of Bangkok.

The paper will calculate the cost of urbanisation based on a World Bank [21] study which estimated that due to pollution levels associated with urbanisation, the average Bangkok citizen will spend 8% of their income on overcoming air pollution and 10% of their income on accessing drinkable and safe water.

$$CU = BY(0.08) + BY(0.1) \quad (4)$$

where CU = cost of urbanisation
BY = average income for Bangkok residents

8 Commuting

The individual decision to commute to work in a private vehicle, rather than use public transport, is taken on grounds of convenience, comfort and access. The decision to drive can be understood within a *prisoner's dilemma* framework. Individual preferences do not consider the impact of all other individuals making similar decisions. A social choice perspective allows the negative impact on social welfare of these aggregated individual choices to be included in the calculations. If everyone cooperates and chooses public transport over private transport, everyone benefits. However, within this scenario, the individual is assured of receiving greater benefits if they choose to defect rather than cooperate and drive their own vehicle (even if everyone else also defects) [27]. Under these conditions the welfare implications of social choice theory versus market preferences are obvious. 'Despite their expense, cars are no longer perceived as a luxury' [48, p.42].

An additional car on the road will not make much difference to the experience of other drivers. However, each day eight hundred additional cars are registered in Bangkok [49]. This equates to over an extra two kilometres of bumper to bumper traffic being added to the crowded streets of Bangkok every day. As a result, it is always peak time on Bangkok roads and the average speed is between 5 to 8 kilometres per hour [5]. The major casualty of this is time. If the road system had capacity to carry this extra load, then the problem may not be as serious. However, it appears that the current road system is unable to cope with any increases [5] and current roadworks and additional roads being built are also inadequate in keeping up with the increase in cars [50]. Whilst the opening of many toll roads and the Skytrain have undoubtedly improved the situation, the OECD [51] have predicted an increase of over 300% over the next three decades.

The cost of commuting is only calculated for municipal populations in Bangkok as Thailand's urbanisation problems are concentrated primarily in Bangkok [5]. Other 'cities' in Thailand have relatively low levels of urbanisation and thus are excluded from these calculations as it is expected that such costs would be quite minor.

The cost of commuting per registered car in 1990 in Bangkok was US $219 based on Tanaboorboon's [52] calculation. This figure can then be multiplied by the number of registered cars each year to calculate the cost of commuting. For example it was US $400 million in 1990, US $613 million in 1994 and US $79.5 million in 1975. As a percentage of adjusted national income (which is the basis of the ANI) this figure intuitively appears correct. It increased from 2.4% of national income in 1980 to 5.8% in 1994. This is the range of other estimates [33,53–56]. It also appears to correlate with an increasing number of cars each year in Bangkok having an increasingly larger negative impact on people's welfare.

$$CC = NRC(219.EX) \tag{5}$$

where CC = cost of commuting
NRC = number of registered cars in Bangkok
EX = exchange rate

9 Air pollution

Air pollution occurs due to emission of pollutants into the atmosphere. Prior to industrialisation, the major pollutant was suspended particulate matters caused by fire (i.e. smoke). However, the atmosphere quickly absorbed this pollution with little cost to humans. However, since industrialisation and urbanisation, the level, mix and concentration of pollutants has substantially risen and changed and is no longer quickly and completely absorbed by the atmosphere. The result is poor air quality and the subsequent health and loss of amenity consequences of this.

There are five major air pollutants within Bangkok (and most industrialised cities throughout the world): carbon dioxide (CO_2), carbon monoxide (CO), nitrogen monoxide

(NOX), sulphur monoxide (SOX) and suspended particulate matters (SPM). These pollutants are by-products of production processes, human activities and increased consumption levels. Previous work has estimated the costs of pollution abatement for each of these pollutants. Converted to Thai currency (1988 prices) these abatement costs are .03335 baht per kilogram of carbon dioxide and carbon monoxide, 2.84 baht per kilogram of nitrogen monoxide, 7.4 baht per kilogram of sulphur monoxide and 4.15 baht per kilogram of suspended particulate matters.

The amount of emission for each of these pollutants in each sector can calculated and the cost of each pollutant subsequently calculated by analysing the data of the five main polluting sectors: transportation; electricity; industry; household; and commercial sectors and others. The data for the various pollution emissions is found in the Department of Energy Development and Promotion (various issues).

$$AP = (cCO_2+cCO+cNOX+cSOX+cSPM) \quad (6)$$

where
AP = air pollution
cCO_2 = cost of carbon dioxide (.03335 baht per kilogram)
cCO = cost of carbon monoxide (.03335 baht per kilogram)
cNOX = cost of nitrogen monoxide (2.84 baht per kilogram)
cSOX = cost of sulphur monoxide (7.4 baht per kilogram)
cSPM = cost of suspended particulate matters (4.15 baht per kilogram)

10 Water pollution

Economic growth places pressure on water resources through the dumping of wastes in rivers, decreasing water levels through inappropriate development (such as golf courses in developing countries) or the increase in salinity through overuse of land. Water is necessary for the survival of all, therefore water pollution of whatever kind reduces well-being. According to surveys undertaken, the perception of people in Bangkok is that their water quality is decreasing with the growth of urbanisation [44,50]. It is possible to measure the cost of water pollution within urban areas by estimating the cost of restoring the quality of water. This method calculates the expenses to clean up or restore previous water quality caused by water pollution.

It is possible to measure the cost of water pollution within urban areas by estimating the cost of restoring the quality of water. This method calculates the expenses to clean up or restore previous water quality caused by water pollution. Using previous estimates, each person approximately adds 12.6 grams of biochemical oxygen demand (BOD) per day to canals and river systems, or 4.6 kgs of BOD per person per day [57].

Water pollution is also caused by industry, a study in 1986 found that 5 industries caused 99.6% of water pollution. These were the food , drink, paper, chemical and textile industries. By calculating the growth of each industry in terms of GDP, it is possible to extrapolate the 1986 figure of 514,381 tonnes of BOD both forward and backward to estimate the amount of water pollution caused by each industry each year).

The final calculation of the cost of water pollution is made by estimating the cost of cleaning this pollution to be 7.5 baht (in 1988 prices) per kilogram of BOD. This is then doubled to account for non-point of survey sources of pollution:

$$WP = [(7.5 \times IP) + (7.5 \times 4.6 \times MP)] \times 2 \quad (7)$$

where WP = cost of water pollution
IP = industrial pollution
= FI + DI + PI + CI + TI
FI = food industry BOD
DI = drink industry BOD
PI = paper industry BOD
CI = chemical industry BOD
TI = textile industry BOD
MP = municipal population BOD
= municipal population x 4.6 kgs per years

11 Noise pollution

It is difficult to estimate the cost of noise pollution, but it is equally difficult to dismiss the loss of amenity that noise causes. Unlike air pollution, noise pollution is not suitably measured by associated health costs. Certainly exposure to noise can lead to hearing loss and jangled noise, but generally the diseconomy of noise is immediate and not long lasting. Therefore, estimates of noise pollution must focus on loss of amenity rather than loss of health.

The estimate in this study is that the cost of noise pollution is equal to one percent of GDP each year. This estimate is based on a report of the World Health Organisation for the USA three decades ago (cited in [58]). Whilst this study is dated, it is assumed that it remains a relevant estimate of noise pollution for Bangkok today. Certainly the increased traffic and industrial activities that have accompanied this growth in GDP would suggest that it is reasonable to assume that noise pollution has also increased proportionately [44,59]:

$$NP = GDP(0.01) \quad (8)$$

where NP = cost of noise pollution
GDP = gross domestic product

12 Deforestation

When natural resources are not owned, they are considered free. As a result, over-harvesting, destruction, or lack of maintenance causes a ‘tragedy of the commons’. The individual preference costs for cutting down a hectare of forest to increase land available for farming are close to zero as there are many millions more hectares of forest remaining. But when this preference is aggregated, deforestation has a social cost not reflected by these individual choices. Social choice perspective captures these costs to social welfare.

As economic growth increases, so to does pressure on land use. Land is required for factories and housing and farming is pushed to more and more unproductive land. All these activities reduce well-being as people lose their traditional land tenure and are forced to farm unproductive land, which results in harder work for fewer results. The majority of developing countries are reliant on agriculture for subsistence farming for the majority of the population. Due to the increasing demand for land through the forces of economic growth, wetlands and forests are facing increasing pressure and more is disappearing each year. To achieve the record levels of economic growth in Thailand, the environment, and particularly the forests, have been exploited [5,8,10]. This exploitation has included the denuding of large forest tracts to allow extra cultivation, the over-harvesting of forest and timber products and the destruction of forests for mining purposes [5]. As a result of this type of forest use, only 17% of Thailand remains forested [49].

The major problems of deforestation include the loss of wildlife soil, watersheds, bio-diversity and access to livelihoods by traditional farmers [9,60]. Forests have provided a livelihood for rural Thai people for centuries. As this food source decreases so to does the ability to live independently or to remain outside of the money economy. At a national policy level, the recognition that forests add both to economic growth and quality of life, at the village and national levels, is now explicitly recognised [61,62]. The policy aim is to maintain a balance in the use of natural resources, such as forests, between the economic benefit and the continuing functioning of a healthy eco-system.

Based on a study undertaken by Panayotou and Parasuk [63], the cost of deforestation is 886 baht per hectare of forest lost. Deforestation causes local soil erosion, regional flooding and continental and global unseasonable climates. Soil erosion is very serious for farmers. A loss of 5 centimetres of topsoil results in a twenty-two percent reduction in maize yields and an 15 centimetre reduction in topsoil reduces maize yields by half. The calculation of the cost of deforestation 'is specified in double-log linear function form, and is estimated with data from 1961 – 1987' [63,56]. This estimate is probably conservative as it only considers the cost of soil erosion. The real cost of deforestation would be higher if other factors, such as loss of wildlife, wildlife sanctuaries, flooding and global climate change were incorporated:

$$D = DF(886) \tag{9}$$

where D = cost of deforestation
DF = hectares of deforestation

13 Long-term environmental damage

There are three factors within Thailand that cause increases in the greenhouse effect [64]. The first is deforestation, the second is wet rice farming and the third is the through fuel consumption. The damage caused each year to the environment is cumulative. The cost of long-term environmental damage is therefore also cumulative and so each year's damage is added to the previous running total.

Each tonne of carbon emission has a cost of 21.59 baht. This figure is estimated based on Nordhaus [65] which values the damages from temperature increase or greenhouse effect in the USA in 1981. This value is transferred to Thailand by adjusting for GDP, shadow exchange rate in 1981 and inflation. Deforestation causes the loss of 246 tonnes of carbon dioxide absorption per hectare of forest destroyed each year. Wet rice farming releases 9.216 kilograms of methane per year for each 400 square metres of paddy, which can be converted to a carbon equivalent by multiplying it by 68.6 and dividing the total by 3.664. (This second figure is the ratio weight of a molecule of carbon dioxide and an atom of carbon). Likewise, this figure of 3.664 is used to convert carbon dioxide emissions to carbon equivalents. The data on forest areas comes from the Royal Forestry Department (various issues), the Ministry of Agriculture (1992) and the Department of Energy Development and Promotion (various issues).

$$ED_t = cCD + cCWR + cCF \qquad (10)$$

where ED = long-term environmental damage
cCD = cost of carbon emissions of deforestation
= 21.59 x tonne of carbon emission
cCWR = cost of carbon emissions of wet rice farming
= 21.59 x tonne of carbon emission
cCF = cost of carbon emissions of fuel consumption
= 21.59 x tonne of carbon emission

13.1 Damage in other South East Asian countries

Thailand is not unique with respect to these various SEE system costs of economic growth. Deteriorating water and air quality, deforestation, income inequality urbanisation, and long-term environmental damage are being experienced throughout South East Asia [31,66].

14 Data sources

A survey of relevant economic and scientific data is gathered, collated and utilised to allow for a quantification of the costs and benefits of economic growth and sustainability issues in Thailand.

Techniques developed by others [16,28,42,57,58] are used and refined to more closely fit the Thai experience. Whilst economic data is collected by the Thai government to assist in the calculations of the national accounts, many of the calculations required are not included in these accounts. Data gathered by tertiary institutions and local and international non-government organisations are therefore used (also see [67]).

Table 3 Summary of SEE adjustments

Income Distribution	I	=	$1 - \sum_{i=1}^{n} (y^I / \mu)^{1/1-\epsilon}$	$\epsilon \neq 1$
Urbanisation	CU	=	BY(0.08) + BY(0.1)	
Commuting	CU	=	NRC(219.XR)	
Air Pollution	AP	=	(cCO_2+cCO+cNOX+cSOX+cSPM)	
Water Pollution	WP	=	[(7.5 x IP) + (7.5 x 4.6 x MP)] x 2	
Noise Pollution	NP	=	GDP(0.01)	
Deforestation	D	=	DF(886)	
Long-term Environmental Damage	ED	=	cCD + cCWR + cCF	

Table 4 Data for SEE adjustments

Year	*GDP (1988 baht)*	*BY (1988 baht)*	*RC (vehicles)*	*CO_2 and CO (kilotons)*	*NOX (kilotons)*	*SOX (kilotons)*	*SPM (kilotons)*
1975	621555	16289	334804	52588	220	267	138
1976	680778	17502	394804	57596	241	248	152
1977	750054	18608	461205	62740	263	270	159
1978	824706	20042	522316	67288	282	321	206
1979	867797	20368	545249	70795	289	336	203
1980	913768	21047	571267	70687	290	371	257
1981	967374	21710	733920	72879	300	362	235
1982	1020084	22591	891241	75901	311	376	238
1983	1075922	23368	1048562	80062	336	409	272
1984	1138329	23831	1205883	85705	370	451	300
1985	1191089	23982	1363204	90031	389	497	343
1986	125638	24333	1520526	92631	401	494	332
1987	1377026	25435	1677847	103813	449	591	423
1988	1559804	27012	1835169	115374	502	678	496
1989	1750228	30941	1721586	133749	586	781	552
1990	1946119	34834	2045814	151441	664	946	703
1991	2111740	39878	2112518	165832	717	1109	863
1992	2282995	45397	2373288	180329	771	1205	939
1993	2494748	44934	2656107	201600	851	1337	1035
1994	2669573	44288	2963043	225034	952	1510	1157
1995	2884495	50898	3241681	249357	1060	1680	1275
1996	3095336	55846	3549082	274150	1162	1897	1464
1997	3502012	56806	3849082	373717	1565	1613	987
1998	2787395	52742	4149082	404374	1694	1745	1068
1999	2823416	58624	4449082	435018	1822	1852	1149

Table 4 Data for SEE adjustments (continued)

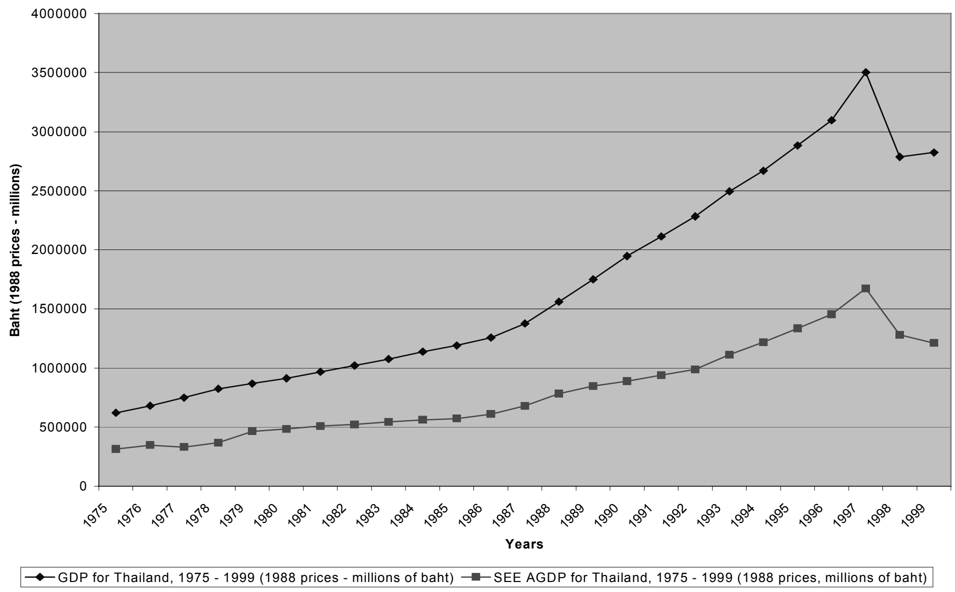
Year	*IP (in tons)*	*MP (in tons)*	*DF (hectares)*	*CD (in tons)*	*CWR (in tons)*	*CF (in tons)*
1975	233800	37333	69991930	209059750	9189440	42087630
1976	261266	35667	66415700	42359888	1861973	8527835
1977	295534	34897	127722500	292704576	12336750	58678206
1978	321427	36019	127722500	277843224	12642708	63170668
1979	329832	37012	38316750	122882628	12571370	66678868
1980	371445	38088	38316750	117066362	12693181	66589310
1981	399356	39593	38316750	111637162	12686335	68622964
1982	435343	41390	38316750	106564248	12634379	71551834
1983	465633	39919	34229630	63276474	12705554	75452850
1984	514795	40918	34229630	61870102	12752952	81013157
1985	493076	42462	33718740	60503759	12751752	85245021
1986	514263	43390	12772250	59175359	12808867	87586900
1987	544566	44316	12772250	14196483	12452680	98295429
1988	634920	45966	12772250	55653859	12221205	109356238
1989	721909	46933	12772250	9625764	1211156	127103326
1990	763923	45740	28609840	84509423	11981094	144239628
1991	855655	46204	28609840	80776639	11949520	158280507
1992	915806	47057	28098950	72985646	11877480	172069327
1993	956685	47325	28609840	35169971	11791370	192372921
1994	1066215	49317	28098950	25549316	11788624	215246696
1995	1178198	49947	28609840	24536788	11783810	238875088
1996	1248663	50858	28098950	43364211	11783810	262871574
1997	1285450	50083	28609840	31720553	8619758	19228833
1998	1173973	45740	28098950	35756851	9716583	216756158
1999	1189951	45582	5108900	35741023	9712281	216660206

15 Results

There are three distinct periods of economic growth within Thailand over the last 25 years. The first period, 1975 to 1987 is a period of reasonable and steady growth. The second period, 1988 to 1997 is a period of accelerated growth, which finishes dramatically in 1997 due to the financial crisis of this time. The final period is the fallout of this crisis and shows GDP falling before showing signs of recovery in 1999.

This is quite different to the path of the SEE AGDP index. The overall trend is much flatter resulting in a divergence between the two indices. The SEE AGDP measure is becoming more distant from the unadjusted measure indicating that the associated SEE system costs of economic growth are increasing throughout the period. This divergence therefore indicates that sustainability is becoming less likely as the costs of economic growth begin to impact on the health and functioning ability of the SEE system. This is more evident in the final year in which positive economic growth is recorded in 1999, but the SEE AGDP continues to fall.

Figure 2 Comparison of GDP and SEE AGDP for Thailand, 1975–1999 (1988 prices – millions of baht)



Such a fall indicates impoverishing growth or unsustainable growth. Impoverishing growth or unsustainable growth is a type of economic growth when the economy has grown in quantitative terms but the economy's reproductive capacity has declined because of social, economic and environmental degradation and damage [30]. Future work will need to continue this time series to see if this movement is simply a fluctuation or the beginning of a new trend. If it is the beginning of a new trend, future sustainability is under threat from the present damages being caused to the SEE system by economic growth.

When these SEE adjustments are made to GDP, the social, economic and environmental costs of economic growth are evident. As mentioned previously, this new SEE AGDP measure is a measure of sustainability since it does indicate that the SEE may not be as robust and healthy as expected when simply considering unadjusted GDP as an indicator.

Various tentative policy recommendations can be drawn from the results of this paper. Based on the approach developed, it is possible to improve the social welfare of all Thais through various public policy actions. The obvious starting point is to place greater emphasis on social outcomes over simply trying to achieve higher economic growth as a remedy for all other non-economic goals as appears to be the current case [13]. Along the lines of this study, greater public policy emphasis could be given to:

- decreasing income inequality levels
- reducing the infrastructure pressure (such as water supply and sanitation) caused by overcrowding and urbanisation
- improving air and water quality and reducing noise pollution through more stringent regulations or the enforcement of existing legislation
- protection of forests and forest resources
- reduction of greenhouse gas emissions across all sectors of society [31] for further discussion of these policy initiatives)

Whilst achieving economic growth will allow some of these policies to be enacted, achieving economic growth on its own is not sufficient to ensure such outcomes. To increase social welfare, specific public policies (such as these tentative recommendations) must be undertaken. The current emphasis on achieving economic growth is not adequate on its own to ensure improvements in social welfare.

16 Conclusions

Whilst the precise interaction between economic growth and social, economic and environmental damage is subject to controversy, this paper supports the position that economic growth as presently experienced in Thailand does threaten sustainability as it is damaging the SEE system upon which future economic growth is reliant. Achieving future economic growth and maintaining a healthy and robust SEE system will not occur unless there are specific and deliberate policy interventions in all areas of economic development policies, macroeconomic policies, sectoral policies, environmental policies, legislative policies, financing policing and international policies.

References and Notes

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Appendix A

See Adjustments for Costs caused by Economic Growth in Thailand, 1975 – 1999 (1988 prices – millions of baht)

Year	*GDP*	*GDP adjusted for inequality*	*Commuting*	*Urbanisation*	*Air*	*Water*	*Noise*	*Deforestation*	*Long-terms environmental damage*	*SEE AGDP*
1975	621555	415261	3066	18084	4117	4067	6216	62013	4960	312738
1976	680778	451935	3466	20164	4509	4454	6808	58844	5965	347724
1977	750054	494736	3829	22255	4913	4956	7501	113162	6932	331187
1978	824706	540471	3939	24634	5516	5362	8247	113162	13575	366036
1979	867797	565022	3787	25712	5759	5503	8678	33949	16893	464742
1980	913768	591071	3560	27382	6046	6143	9138	33949	20087	484766
1981	967374	621635	4704	29172	6069	6854	9674	33949	23175	508037
1982	1020084	642775	5441	31258	6302	7151	10201	33949	26170	522304
1983	1075922	664532	6171	30869	6774	7583	10759	30327	28255	543795
1984	1138329	688872	7192	32420	7382	8336	11383	30327	30344	561487
1985	1191089	705935	9141	33843	7930	8033	11911	29875	32428	572773
1986	1256538	729043	9710	35177	8030	8364	12565	11316	34498	609383
1987	1377026	805423	10012	37963	9299	8833	13770	11316	35653	678576
1988	1559804	919660	10164	41374	10508	10213	15598	11316	37762	782725
1989	1750228	995442	9133	48611	12146	11533	17502	11316	38981	846220
1990	1946119	1066278	10218	53538	14244	12145	19461	25348	41914	889411
1991	2111740	1132104	9947	62459	16144	13528	21117	25348	44848	938713
1992	2282995	1196974	10647	70775	17521	14443	22830	24896	47047	988815
1993	2494748	1327580	11497	70927	19479	15060	24947	25348	49194	1111128
1994	2669573	1441569	12107	70560	21880	16733	26696	24896	51269	1217428
1995	2884495	1578828	12406	81507	24307	18422	28845	25348	53460	1334533
1996	3095336	1716983	13289	90561	27105	19493	30953	24896	56206	1454480
1997	3502012	1946944	17099	93200	29257	20033	30520	25348	58210	1673277
1998	2787395	1553137	22264	87740	31657	18296	27874	24896	60469	1279941
1999	2823416	1480317	22495	98231	34056	18533	28234	4526	62727	1211515

Source: See Clarke [36] for full calculations