Paper presented in

Seventh Biennial Conference

Indian Society for Ecological Economics (INSEE)

Global Change, Ecosystems, Sustainability

December 4-8, 2013

Host:
Tezpur University

Cohost:
OKD Institute of Social Change and Development

Economic growth and the Environment in the Asia-Pacific region: a time series analysis from Ecological Footprint (EF) perspective

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Abstract

Human activities are altering the existing environment of the planet Earth. Green house gas effect, ozone layer depletion, species extinction, breakdown of biogeochemical cycle, deforestation and natural resources depletion and degradation are outcomes, to a great extent, of human induced activities. The economic expansion and population growth in Asia-Pacific over the last 40 years was underpinned by the region's rich natural environment. However, human activities associated with such expansion have placed excessive stress on the environment, resulting in severe environmental degradation. Environmental degradation now poses a serious threat to the region's growth prospects, thus constituting a clear obstacle to attaining sustainable development. This paper is intended to explore the relationship between economic growth and the pressure on nature from the environmental sustainability perspective of all the Asia-Pacific countries having population more than one billion.

In this paper, the pressure on nature is measured mainly by two indicators: Genuine Savings (GS) and Ecological Footprint (EF). The GS is termed as Adjusted Net Savings (ANS) and is calculated as the sum of energy depletion, mineral depletion, net forest depletion and CO_2 damage. On the other hand, EF is defined as the total demand put by a population on a specific environment in terms of land (unit Global Hectares-gha). The land types considered under the measurement of EF are Cropland, Forest land, Grazing land, Fishing land, Carbon land, and Built-up land. Time series analysis of the secondary data reveals that there is a positive relationship between growth and pressure on nature.

We found strong positive correlation between per capita gross domestic product (GDP) and per capita consumption of EF in this region. GS is also correlated with the EF. However the population of this region are not found to be significantly correlated with the EF in this study. It can be inferred from this analysis that the growing economy has intensified human's pressure on the environment of the Asia-Pacific by its enlarged demand.

Key words: *Environmental sustainability, correlation, regression, Adjusted Net Savings, Ecological Footprint*

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1. Introduction

The environment is vital to supporting life, absorbing waste and providing inputs for production (Peirson, 2003). Natural resources, derived from the environment, serve as a *source* of raw materials to economic growth and as *sink* to absorb the waste coming out of economic production. Economic growth is a must for upliftment of the human society. It is a prerequisite for increasing purchasing power of people, to enhance standard of life and to fulfil basic needs of the society. Since economy is a 'part'/subsystem of the 'whole' ecosystem i.e. environment (Figure 1.1) (Getzner, 1999; Daly, 2005), therefore economy cannot grow forever, as the growth is limited by the availability of natural resources or the environment as shown in figure 1.1. This realization has gained popularity among scholars since 1960s (Thirlwall, 2003; Daly, 2005; Asici, 2013). This realisation has also led to the development of the concept of 'Sustainable Development'. The word 'sustainable' was frst used in the famous report of Club of Rome in The Limits to Growth (Meadows, 1972). The Limits to Growth, for the first time expressed the concept of outer limits as "if current trends continued, the global system would overshoot". In 1987, the term 'Sustainable Development' was defined by the Bruntland Report (WCED, 1987) as " the development that meets the need of the present generation without compromising the needs of future generation".

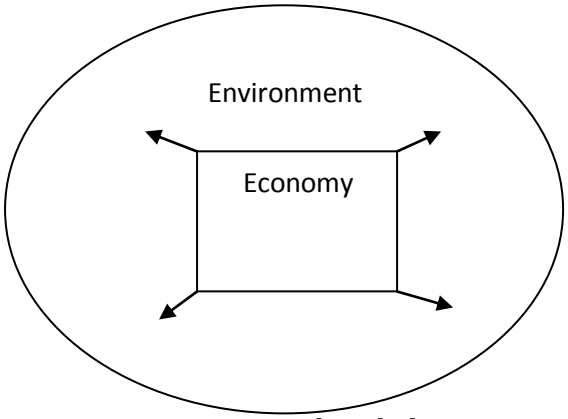


Figure 1.1 Environment is the whole, economy is part

Some notable ecological economists, like Herman E. Daly, Nicholas Georgescu-Roegen, Mathis Wackernagel and William Rees, have claimed that human demand has led to degradation of environment that exceeds the Earth's ecological capacity to regenerate its resources and this 'overshooting' is growing ever since and that the economy is limited by this regenerative capacity of the Earth. So, development should be sustainable. Many attempts have been taken in recent years to operationalize the ecological concept of sustainability (Getzner, 1999). Many mainstream economist and ecologists are in contradictory assumptions about substitutability of natural capital by man-made capita. Based on these views, sustainability may be 'strong' or 'weak'. Both these views emphasise for lasting development, but the requirement for sustainability is different (Nourry, 2008). Weak sustainability (WS) requires a non-declining combined stock of capital and assumes that limited substitution between natural capitals by man-made capital is always possible. Strong sustainability (SS), on the other hand requires non-substitutability of natural capital by any other capital. It deals with specific environmental functions, which pose limits to growth, if disturbed or degraded by man-made activities. An indicator of sustainability must assess non-declining human welfare and sustainability (Nourry, 2008). However, till now no single

indicator has done a perfect job to reflect sustainable development (Pillarisetti and van den Bergh, 2007; Nourry, 2008). Therefore it is essential to study different indicators of development and sustainability to have a better idea of the sustainable development path of a country.

Although WS and SS are based on different assumption, the motto of the two is same: to maintain the capital stocks (Mota et al., 2010). Various studies have shown that WS is a pre-requisite for SS (Atkinson et al., 1997; Neumayer, 2003). When a country is weakly sustainable, it has chance to be strongly sustainable. In other words the study of WS can be regarded to be important to study SS (Mota et al. 2010).

In this paper we concentrate on studying the sustainability of the Asia-Pacific (A-P) countries by considering both WS and SS indicators. We have applied the natural disinvestment components of Adjusted Net Savings (ANS), also known as Genuine Savings (GS) as a WS indicator and the Ecological Footprint (EF) as an SS indicator to see whether the A-P region is on the path of weak or strong sustainability. Using time series data for the period of 1990-2010, this paper makes an attempt to analyse how resource utilization is correlated with growing economy and growing population,

The paper is structured as follows. The next section provides a review of the environmental concerns in the A-P region. Section 3, describes the study region, data and the methodology used to analyse the data. Section 4 presents the results from the statistical analysis. Conclusion and way forward is discussed in section 5.

2. The Economic growth and the environmental concerns in the Asia-Pacific region

2.1 Economic growth and the environment

The interaction between human being and environment has age-old history. Malthus, in 1978, predicted that growth of population would eventually reach the limits of natural resources in absence of technological progress. After that, Boulding (1966), who compared the Earth with a Spaceship, explained that as population and economic activity continue to increase, the scarcity and the waste problems upon the Spaceship (Earth) would worsen. Further, in 1970s, a formula called IPAT was set by Commoner, Ehrlich, and Holden (Commoner et al., 1971). It summarizes the impact of human activities towards growth on the environment. It is stated as

,

where I stands for environmental *impact*; P for *population*; A for *affluence*; and T for *technology*.

All these predictions and equations which were developed to measure environmental degradation pointed out that with economic growth environmental degradation is going to aggravate. These studies also pointed out that managing natural capital is indispensable for sustainability (Wackernagel et al., 2004).

Recently human led economic activities are leading to environmental degradation altering the global environment on an unprecedented level. The concentration of green house and ozone depleting gases in the atmosphere, the accelerated extinction of species, the breakdown of biogeochemical cycles, deforestation, and natural resource depletion, global warming, water and air pollution-all are undeniably related to human activities, which have become a big challenge everywhere around the world (Spangenberg, 2007; Asici, 2013).

2.2 The Economic Miracle in the Asia-Pacific Region

The Asia-Pacific region is one of the fastest growing regions with some of the largest and most diverse ecosystems on earth (Himalaya, 2012). The combined economy of A-P is the third largest in the world after Europe and North America and is the fastest economically growing region in the world (ESCAP, 2007). Since1970s, the economic growth strategies have been very successful in this region where the GDP growth rate over past two decades have been higher than any other region in the world (WB, 2006). During the period 1990 to 2010, the GDP was over 10 trillion US dollars (ESCAP, 2007). The incomparable economic on-swing of this region has later on been called the "Asian Miracle" (Weber, 2009). Several factors have been responsible for this miracle (Lee and Hong, 2012). A number of empirical studies have been carried out to explain the determinants. They have highlighted the role of exports, investment, human resources, fertility, and institutional and policy variables, such as trade and globalization etc. (Weber, 2009; Lee and Hong, 2012; Asici, 2013). The empirical studies show that the role of economic policies, particularly those relating to openness, played a highly significant role in this region's sustained growth (Lee and Hong, 2012).

However, the report of Asia Pacific Forum for Environment and Development (APFED) of 2005 states that environmental degradation results in serious threat to the region's growth prospects in terms of warming, climate change, devastating flood, drought etc., which are obstacles for sustainable development of the region. So, in this region, the key to sustainability of economy and the environment is to manage natural capital such as forests, biodiversity, freshwater, coastal and marine land, grassland ecosystems etc. so that those can be utilized by the future generation.

The region has an upward trend of overall GDP growth rate (Fig 2.1) starting from 0.98% in 1961 to 6.6% in 2010, defying the ongoing global financial crisis (ESCAP, 2012). Before that this pace was disturbed twice: in the 1997/98's Asian financial crisis and the 2008/09's global financial crisis. Nevertheless, the region managed to rebound quickly from both (Lee and Hong, 2102).

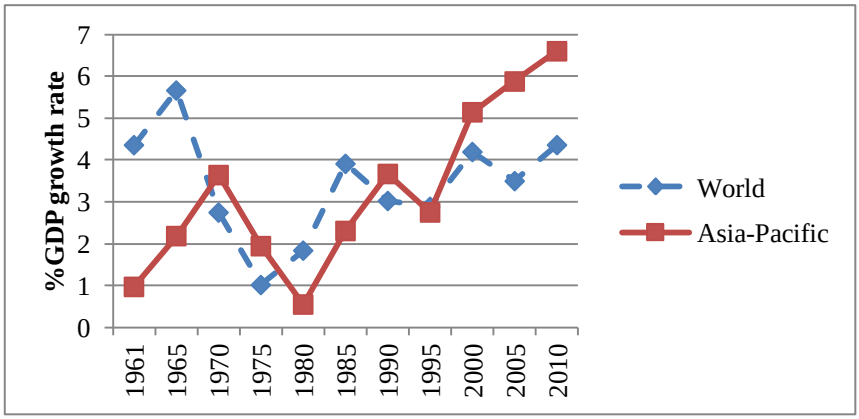


Figure 2.1 Comparison of GDP growth rate in the world and A-P region
Source: World Bank national accounts data, and OECD National Accounts data files

From the figure 2.1, it can be observed that A-P region's GDP growth rate had many ups and downs. But since 1990s, the economy took a turning point. Some surveys show that during that period many donors had concentrated on Asian countries with their aid projects for renewable energy (Yu and Taplin, 1997). Different aid donors have different project interests. For instance, China and the US seem to be interested in the building and upgrading of hydro power plants; France favours installing solar energy systems in the region. Other donors including the United Nations Development Programme, the Pacific Energy Development Program, Japan and the South Pacific Applied Geosciences Commission mainly give their aid for technical assistance for energy projects, technique training courses, and assessments of energy resources (Osborne, 1996). German aid in the region appears to be more directed towards biomass energy projects such as wood stoves and fuel wood projects (Yu and Taplin, 1997). During the period 1987 to 1997, the World Bank invested in Indonesia and Philippines in various projects including geothermal energy development, rural electrification, geothermal power projects etc. (World Bank, 1993). Economic output in Asia and the Pacific quadrupled since that period, largely fuelled by rapid industrialisation and international trade (APFED, 2005).

But this tremendous economic development of the A-P regions was not an isolated phenomenon. It has largely been driven by adopting a labour-intensive export-oriented industry development strategy supported by heavy exploitation of human resources as well as natural resources (*see* APFED, 2005; Jha, 2005). Countries with open market policies or globalization improved significantly in economic performance, particularly since 1970s (Yu, and Taplin, 1997; APFED, 2005; Weber, 2009). These policies supported export-oriented strategy coinciding with an increasing rate of foreign direct investment, mostly by multinational companies; high domestic savings; market liberalization and technological progress (Weber, 2009). A growing share of the world's industrial production now takes place within this region and it is also a target market of essential industrial, mining, manufactured and agricultural goods (APFED, 2005). As a result of economic growth, increased population, rising standards of living in the A-P, demand and consumption of energy have significantly increased. It is projected that the total primary energy supply for the

region will be more than double in 2020 than the level of 1997. All these future energy demand and consumption would have major environmental implications, especially in relation to climate change and global warming (APFED, 2005).

Along with economic growth population growth is also a major concern in A-P region. Overgrazing, shifting cultivation, forest degradation are some worth mentioning effects of population growth. As consequences forest fires, pests, disease and natural disasters have caused greater damage. Approximately 3.5 billion people, 58% of the world's population, live in Asia and the Pacific (UN-ESCAP, Population Data Sheet, 2003), an area accounting for only about 30% of the Earth's land space. Several of the most populous countries in the world are found in the region, including China with 1. 35 billion people and India with 1.26 billion (UN-ESCAP, 2012), together accounting for almost 40% of the world's population (APFED, 2005). Five countries- Bangladesh, China, India, Indonesia, and Pakistan, account for half of the global annual population growth. According to population projections by the United Nations, a constant increase in population is expected in all subregions of the A-P.

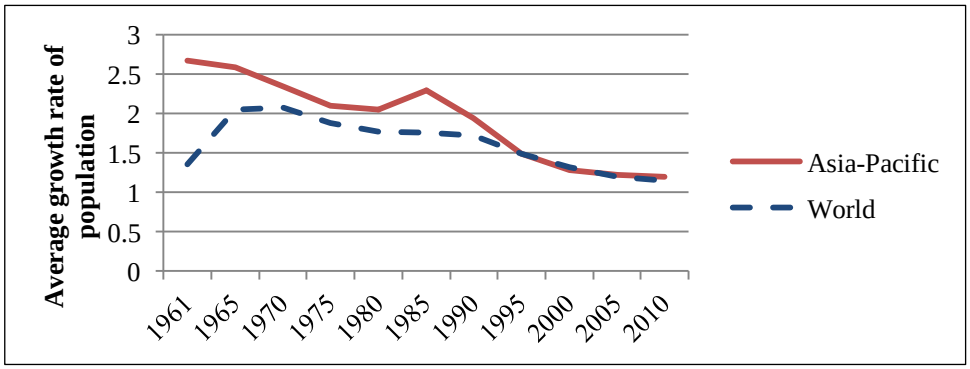


Figure 2.2 Population growth trend in the Asia-Pacific and World
Source: World Bank

Although the population growth rate has slowed down in A-P region during the past decades (as shown in figure 2.2), still, the huge population of this region is a matter of concern to its economy, society and to the environment. According to UNESCAP and ADB (2000) report, population growth is a key environmental issue in most of the countries of South Asia and South Pacific (Jha, 2005).

2.3 The Environmental Concern in the Asia Pacific Region

While environmental concerns in the West were heard almost uniquely from towards the end of 1960s, in the A-P region, such concerns started growing after 1970s only. The environmental concerns in the A-P are evident from the series of events that are listed in Table 2.1. Such growing environmental concerns demanded integration of development and environment in the region, because natural resources are considered to be necessary production inputs and the environmental quality determines welfare (Costantini and Monni, 2008)

Table 2.1 Important events of environmental concerns in the A-P region

1971	The Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat, Iran	It is an international treaty for the conservation and sustainable utilization of wetlands, and loss of wetlands now and in the future, It helped to create awareness about the importance and threats to wetlands in A-P as well as in the world.
1973	CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, held at Washington	Is a multilateral treaty includes provisions and rules for trade of specimens of wild animals and plants with 16 non-Parties of which maximum are from the A-P region such as, Democratic People's Republic of Korea, Federated States of Micronesia, Iraq, Kiribati, Marshall Islands, Nauru, Tajikistan, Timor-Leste, Tonga, Turkmenistan and Tuvalu.
1997	The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC)	Is an international treaty that sets binding obligations on industrialized countries to reduce emissions of greenhouse gases. Most of the countries of the A-P are its signatories.
1965-1990	Pollution in the Han and Nakdong river of Korea and Taiwan respectively	Industrial wastes polluted these rivers and 20% of the farmland. Both countries had spontaneous Environmental movements. Finally the polluting parties were either forced to make immediate improvements of the conditions or to pay compensation to victims. Some were even forced to shut down or move locations. The people were able to force the government to come out with new restrictions on toxics, industrial waste, and air pollution (Bello, 2003).
1970s to 1980s	Environmental movements in Thailand, Indonesia, Philippines, Malaysia	People of South East Asia protested against nuclear power and hydroelectric dams, deforestation and marine pollution. Mass campaigning was organized to save Himalayas. Chico River Dam in the northern Philippines was most discussed and opposed (Bello, 2003). In 1980, Malaysia passed a National Forest Act to classify forests and to set limits on harvesting and deforestation
1980s	Environmental concerns in India, China, Bangladesh	The biggest event that developed the movement was the Bhopal gas leakage in 1984. After that voices raised against Coca Cola plants, big dams, coal or oil-powered plants, nuclear plants, polythene carry bags (Jhola Andolan) etc. to protect environment and nature. Activists in the Indian environmental movement consider global warming, sea levels rising, and glaciers retreating decreasing the amount of water flowing into streams to be the biggest challenges for them to face in the early twenty first century (Bello, 2003). China has more relaxed environmental laws than other countries in Asia; so many polluting factories have relocated to China causing pollution in China. Water pollution, water scarcity, soil pollution, soil degradation, and desertification are issues currently in discussion in China (Bello, 2003). In Bangladesh environmental activists have started to raise their concerns against big dams like Tipaimukh. They are also concerned about desertification caused by such dams.

As stated above, not only the economic growth, but population growth and urbanisation, social transformation, and technological advancement are some other important characteristics in several countries in this region (APFED, 2005). These changes are fuelled by the region's rich natural resources and services. For example, Thailand is earning good revenue from rubber plantation, shrimp farming and cash-crops (APFED, 2005). All these economic goods are acquired at the cost of natural resources like forests and coastal ecosystems. In Philippines, mining activities and forest conversion for agricultural expansion are two major economic activities based on its natural resources. Water is a resource which is extensively utilized in all economic purposes. In A-P region, China, India, Pakistan, Indonesia, the Russian Federation and Iran are the six largest consumers of this natural asset; Bangladesh, Thailand and Vietnam are also such Asian countries where water withdrawal is very high, above 70 billion cubic meters per year (ESCAP, 2007). According to Statistical Year Book for the Asia and Pacific (2012), the region produced more energy than any other region in the world in 2009, accounting for 46% of total global production. At the same time the region accounted for 50% (up from 38% in 1990) of the world's total CO_2 emissions in the same year. China has been the single largest emitter of greenhouse gases worldwide (ESCAP, 2011; ESCAP, 2012).

3. Methodology

Many of the developing Asian economies have grown impressively over a period of nearly 20 years. Developing Asian economies here includes the People's Republic of China; India; Indonesia; the Republic of Korea; Malaysia; Pakistan; the Philippines; Singapore; Thailand; and Viet Nam (Lee and Hong, 2012). In this study the main aim was to conduct a time series analysis of the growth pattern with regards to high, middle and low income countries in the A-P to analyse how this growth pattern is putting pressure on natural resources of the Asia-Pacific countries and to see how resource utilization is correlated with growing economy and growing population. This is mainly done to see whether these countries are following a strong sustainability path or a weak sustainability path as discussed in Section 1. Our time series consists of the period from 1990 to 2010. As it is beyond the scope of this study to do this analysis for all the fifty eight (58) Asia Pacific countries, so we selected the ten countries, as mentioned above, based on the following criteria:

Asia-Pacific countries having -

- high economic growth rate and accounts for about 95% of emerging Asia's GDP.
- high rate of environmental degradation and CO_2 emission
- high population growth rate, which is higher than the world population growth rate of 1.2% in 2010 (ASPEC, 2011).

3.1 The study region

The selected countries are further classified as High Income (HI), Middle Income (MI) and Low Income (LI) as per The World Bank classification (UNDP, 2006) as given below:

- High Income- countries with a per capita gross national income US$ 10,066 or more
- Middle Income- countries with a per capita gross national income from US$ 826 to US$ 10,065
- Low Income-countries with a per capita gross national income US$ 825 or less

A brief description of the selected countries in terms of their location, per capita income as an indicator of economic prosperity and key environmental issues are discussed in Table 3.1 below. This also provides a brief summary of the environmental scenario in these countries.

Table 3.1 Asia-Pacific countries under consideration

Income-group	*Country*	*Sub-region*	*Real GDP per capita of 2010 (2005 US $)*	*Key Environmental Issues*
High Income	Republic of Korea	Northeast Asia	20540.18	Limited access to potable water; urban air pollution; environmental contamination; acidification of inland waterways; Industrialization; trans-boundary air pollution
	Singapore	Southeast Asia	41986.83	Industrial pollution; limited natural fresh water resources; waste disposal problems; heavy Industrialization
Middle income	China	Northeast Asia	4432.96	Acidification of inland waterways and acid deposition; degradation of water; loss of agricultural land; loss of biodiversity; natural disaster, inadequate infrastructure for municipal effluent; deforestation and soil erosion; poverty.
	India	South Asia	1375.39	Deforestation; soil erosion; overgrazing; desertification; loss of biodiversity; pollution; high rate of population growth; natural disasters; urbanization; vehicular emissions; tourism; green revolution/ agrochemicals and run-off; reliance on bio-fuels.
	Indonesia	Southeast Asia	2951.70	Deforestation; loss of biodiversity; pollution in urban areas; national and trans-boundary seasonal smoke and haze; land degradation; urbanization; unmanaged industrial and municipal wastes; vehicular congestion and emissions; extensive land clearance and forest fires; mining activities; national and trans-boundary industrial pollution (from Singapore and Malaysia), tourist developments in coastal regions beyond exerting carrying capacity.

	Malaysia	Southeast Asia	8372.83	Urban air pollution; water pollution; deforestation; loss of biodiversity; loss of mangrove habitats; national and trans-boundary smoke/haze due to vehicular congestion and emission; deficiencies in urban infrastructure - industrial and municipal effluents; extensive land clearance and forest fires; unmanaged coastal developments; tourist developments beyond existing carrying capacity
	Philippines	Southeast Asia	2140.12	Deforestation; loss of biodiversity; pollution; pollution of coastal mangrove habitats; natural disasters; illegal forest cutting; land clearance; rapid urbanization and deficiencies in urban infrastructure; unmanaged industrial and municipal effluents, tourist developments beyond existing carrying capacity
	Thailand	Southeast Asia	4613.68	Deforestation; loss of biodiversity; land degradation and soil erosion; shortage of water resources; flood; coastal degradation and loss of mangrove habitat; urban air pollution; non-strategic and sporadic development and destruction of critical watersheds; unmanaged aquaculture developments; exceeding growth in tourism, deficiencies in urban and rural infrastructure, pollution of freshwater resources
Low income group	Pakistan	South Asia	1018.87	Water pollution; shortage of natural freshwater resources; deforestation; soil erosion; coastal habitat loss and degradation of marine environment; desertification; loss of biodiversity; natural disasters, urbanization and deficits in urban infrastructure; industrial wastes; population increases in coastal areas; rise in tourism; depletion of mangroves; over fishing; increased demands for natural resources; hunting/poaching; green revolution/ agrochemicals and runoff.
	Vietnam	Southeast Asia	1224.31	Deforestation and soil degradation; loss of biodiversity; loss of mangrove habitat; water pollution; threats to marine life; groundwater contamination; limited potable water supply; natural disasters; industrialization; extensive aquaculture and overfishing; growing urbanization and infrastructure deficiencies

Source: (UNESCAP and ADB, 2000)

The table briefly describes the geographical distribution of some major environmental issues along with their proximate causes for South Asia, Southeast Asia and Northeast Asia. It is seen that industrialization and urbanization are major underlying factors of most of these environmental problems. Deforestation, pollution and degradation of various ecosystem are the key environmental issues in these parts of the A-P.

3.2 Methodology

Time series method is adopted to analyse various trends in this study. Time series show trends that allow researchers to test the noise in the data (Wackernagel et al., 2004). It also provides a comparative base for different methodological alternatives. Many researcher and scholars have been using time series analysis in their study. Some worth mentioning are Lammers et al. (2008) for studying footprint of Ireland; Sovacool (2013) for exploring the dimensions to energy security in the A-P; Galli et al. (2012) for analysing footprint and bio-capacity of China and India; Mota et al. (2010) for measuring welfare and weak sustainability in Portugal etc.

Wellbeing of people depends on multi-dimensional factors: natural resources, human capital, environmental quality and accumulation of physical capital. Traditional measure of well-being, like GDP, only indicates economic sustainability i.e. rising GDP per capita may not necessarily reflect the increasing welfare of people. So the indicators of development are essential to meet the principles of both economic and environmental sustainable development (Asici, 2013). Relevant indicators on the income-environment interaction can be listed as follows: Adjusted Net Savings (ANS) or Genuine Savings (GS), Ecological Footprint (EF), Environmental Sustainability Index (ESI), Genuine Progress Indicator (GPI), Index of Sustainable and Economic Welfare (ISEW), Environmental Performance Index (EPI), Environmental Vulnerability Index (EVI) and Green Net National Product (GNNP) (Pillarisetti and van den Bergh, 2007; Asici, 2013) . The discussion is still going on regarding the best aggregate indicator of sustainability. On the income-environmental sustainability nexus, appropriate indicators are EF and ANS/GS, because other indicators mentioned above are either more appropriate to measure quality of life (for example ISEW) or to assess the likelihood of potential damages caused by environmental problems (i.e. EVI), or are based on undertaken policies (such as EPI) (Singh et al., 2012). GS is based on 'weak sustainability' concept which assumes perfect substitutability between physical, natural and human capital (Pillarisetti and van den Bergh, 2007).

Many researchers and scholars have been working with these indicators to keep an eye-watch on nations' sustainability path. Ahmet A. Asici, in 2013, conducted a very comprehensive panel data analysis to explore the relationship between the economic growth and the pressure on nature with the help of natural disinvestment component of the GS/ANS data for 213 countries, between 1970 and 2008. Before that a research was carried out for Portugal for the years 1990 to 2005 (Mota et al., 2010).The researchers estimated green net national income and GS to include them in a green accounting model for Portugal.

The environmental sustainability indicator EF has also been extensively applied by scholars in various studies. Some of them are cited here.

Zhang (2008) used EF and BC data of the year 2003 for some Asia-Pacific countries to examine a variety of policy responses, at national, regional and international levels, to deal with growing concerns about the environmental challenges in Asia. Galli et. al. (2012) have

utilised GDP and EF time series data from 1960 to 2005 for China and India to discuss how their economic growth have contributed to global environmental problems. A similar study has been conducted for Taiwan (Wang et al., 2012). In this study, Taiwan's EF, BC and Ecological deficit are analysed from 1961 to 2005. In this line, works that can be mentioned further are: Footprint calculation of Ireland and for Footprint analysis for Malaysia (*see* Lammers et al., 2008; Begum et al., 2009).

Out of all the indicators of WS, GS received considerable recognition as it was developed and published by the World Bank and comprehensive data are available for almost all countries from 1960. Again GS is superior to other environmental quality indicators in its capacity to represent more broadly the changes in environmental sustainability (Asici, 2013). Moreover the natural disinvestment component of the GS is measured within the country where extraction/production takes place. So, considering GS it is possible to observe the impact of growth on domestic environment (Asici, 2013). So far, GS presents the best attempt at measuring WS with considerable scope for future developments (Mota et al., 2010). On the other hand EF has been marketed by the World Wide Fund (WWF) and its data is also available in its reports (Pillarisetti and van den Bergh, 2007). EF has the same assumptions as the 'strong sustainability' view. EF presents a picture of a population's demand for resources against nature's available supply and can be used at global, regional, national and local levels (Begum et al., 2009). By applying the footprint over time the progress towards sustainability, or its opposite, can be measured (Lammers et al., 2008). However, to the best of our knowledge, these two indicators have not been studied together before in any other study using time series data, specifically for the Asia-Pacific region, regarding the interaction between economic growth and environment.

The section below provides a brief discussion on these indicators:

(i) Genuine Savings or Adjusted National Savings

The World Bank (Bank, 1997) proposed the original GS rate, which is modified and renamed as Adjusted National Savings (ANS). It combines the investments on three forms of capital, physical, human and natural, all measured in current $US. Mathematically,

$$ANS = NNS + E - R - P \quad (1)$$

where NNS stands for net national saving, E for current education expenditures, R for resource rents (depletion of energy, minerals and forests), and P for carbon dioxide (CO_2) damage (Asici, 2013). NNS is computed as gross national saving net of depreciation of fixed capital. The negative results of GS are interpreted to mean that a country is pursuing an unsustainability path that will have negative effects on welfare and development in the long run (Everett and Wilks, 1999), i.e. future welfare may be reduced.

(ii) The Ecological Footprint

The proponents of 'strong sustainability' strongly believe that natural capital can not be and should not be substituted by man-made economic assets (Pillarisetti and van den Bergh, 2007). EF is such an indicator which analyses whether a nation is growing within or beyond its environmental carrying capacity. The EF is proposed and developed by Mathis Wackernagel and William Rees in 1996 (Wackernagel and Rees, 1996). It is a resource and emissions accounting tool measuring direct and indirect human demand in *global hectares* for the planet's regenerative capacity (bio-capacity) and comparing it with the bio-capacity available on the planet. The measure considers the demand for six main types of bio-productive areas, each providing different resources and ecosystem services. These are: (1) *cropland*-consists of the area required to grow all crop products, including livestock feeds, fish meals, oil crops and rubber; (2) *grazing land* measures the area of grassland used in addition to crop feeds to support livestock; (3) *fishing grounds* (both marine and inland) for the provision of fish-based food products; (4) *forest land* for the provision of fuel wood, timber and other forest products; (5) *carbon uptake land* for the absorption of anthropogenic carbon dioxide emissions; and (6) *built-up area* representing productivity lost due to the occupation of physical space for shelter and other infrastructure: transportation, housing, industrial structures and reservoir of hydroelectric power generators etc (*see* Wackernagel and Rees, 1996; Galli et al., 2012).

By adding up the Ecological Footprint of all products consumed and the CO_2 emissions released by the residents of a nation, the final consumption Ecological Footprint of that nation is obtained. Consumption Ecological Footprint (EF_C) is calculated by adding to the final Footprint value the Footprint embedded in locally produced products (EF_P) and in the imported products (EF_I) and subtracting the Footprint of exported products (EF_E), as in Eq. (2):

$$EF_C = EF_P + EF_I - EF_E \quad (2)$$

Total availability of bio-capacity in each Nation is calculated as the sum of the bio-capacity supplied by each land type. For any land use type, bio-capacity (BC) is calculated as in Eq. (3):

$$BC = A \times YF \times EQF \quad (3)$$

where A is the area available for a given land use type and YF and EQF are the yield and equivalence factors, respectively. In our study, to get an idea about whether a nation is developing within or beyond its ecological limits, a measure called Ecological Balance (EB) is calculated as Eq. (4):

$$EB = BC\text{-}FP \quad (4)$$

A negative EB value indicates that the nation is running ecological deficit, otherwise it has an ecological reserve. According to the National Footprint Accounts 2011 edition (GFN, 2012),

1.8 global hectares (gha) BC is available per person in the world, but human are presently consuming 2.7 gha of BC.

3.3 Data and data sources

Time series data is considered for the period 1990-2010 for each of the countries under study. Secondary data are collected from trustworthy sources like World Bank, United Nations Development Programmes (UNDP) reports, Global Footprint Network (GFN) database and Asian Development Bank (ADB) reports. The variables considered in this study are: Per capita GDP growth rate at 2005 constant US$, population growth rate, log real value of per capita GS, per capita EF in global hectares and per capita BC in global hectares. EB in global hectares has been estimated for each nation over the period 1990-2010.

4. Results and Discussion

Analyses of population, per capita Ecological balance and per capita GDP in constant US$ trends, in the three income-groups classified, provided some interesting information. HI countries are characterized by high per capita consumption footprint, high per capita genuine savings, comparatively low population growth rate and high deficit of ecological balance. MI and LI countries are characterized by lower genuine savings rate and lower ecological footprint. Though these countries represent a larger population, it is seen from the time series analysis of population trend that growth rate of population is gradually diminishing.

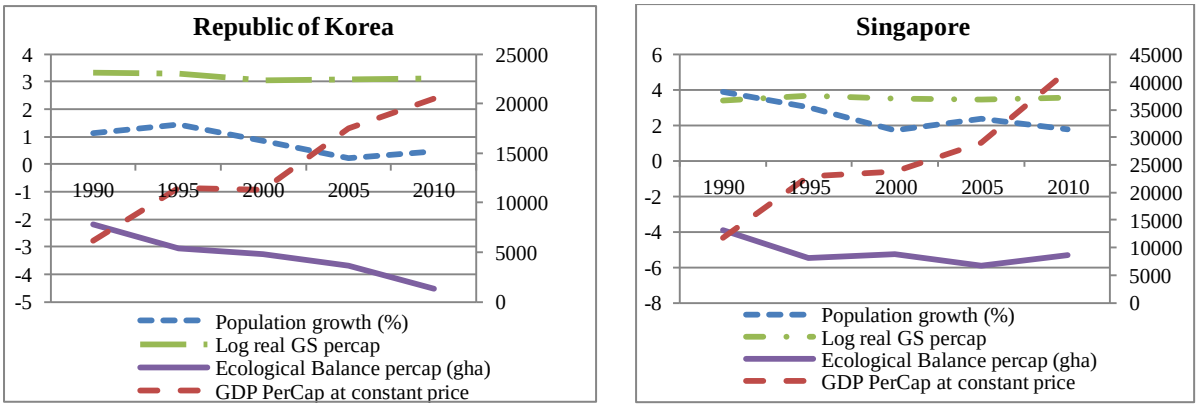
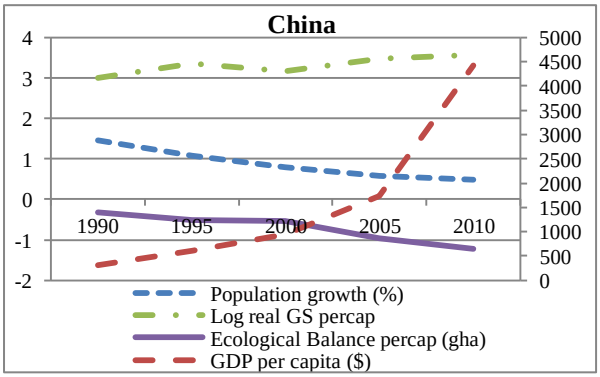
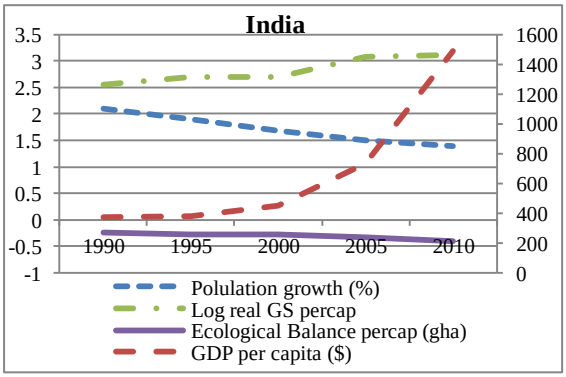


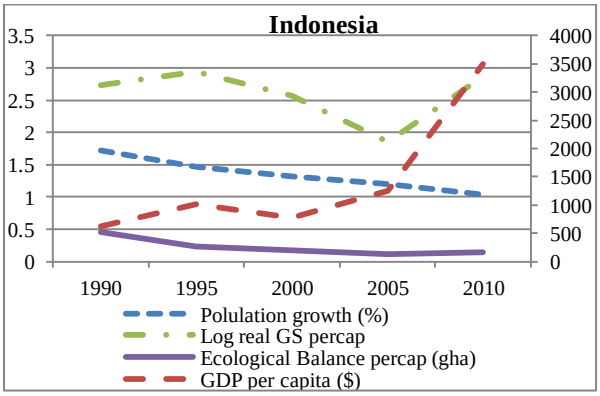
Figure 4.1 (a) & (b) High Income countries



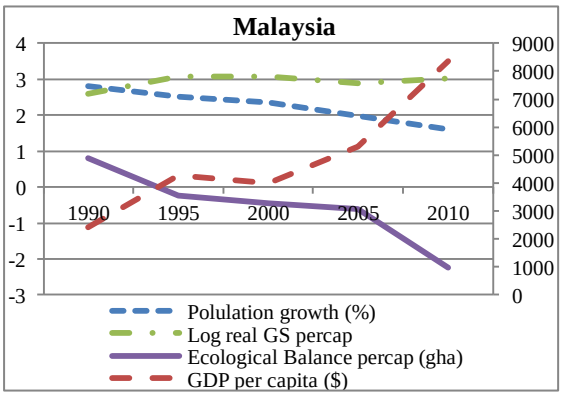
(a)



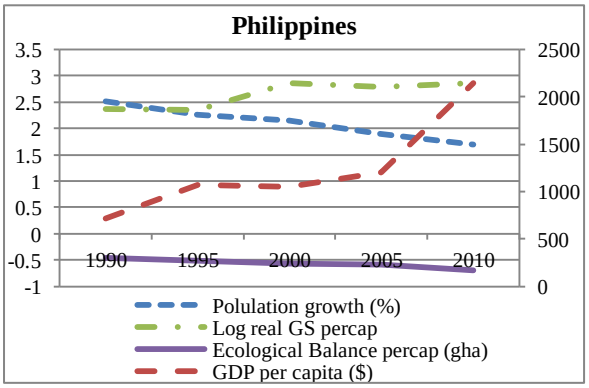
(b)



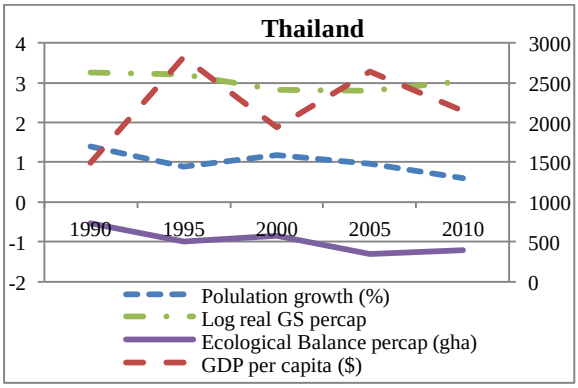
(c)



(d)

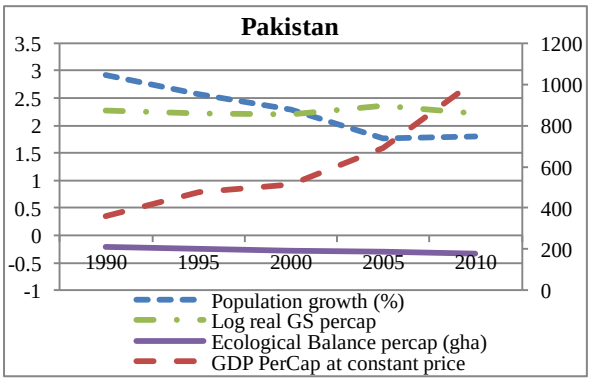


(e)

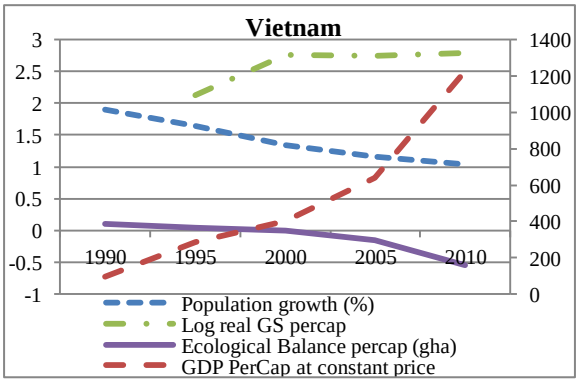


(f)

Figure 4.2 (a), (b), (c), (d), (e), (f) Middle Income countries



(a)



(b)

Figure 4.3 (a), (b) Low Income countries

For High income countries, Figure 4.1 (a) shows that Republic of Korea has a sharply declining per capita ecological balance in response to its high rate of GDP per capita; Figure 4.1 (b) shows similar trend for Singapore with a slightly improving situation for its per capita ecological balance. Out of the six MI countries, the best performer is seemed to be Indonesia in terms of sustainability [Figure 4.2 (a), (b), (c), (d), (e), (f)]. The GS trend line of Indonesia shows no such rise [Figure 4.2 (c)]. However GDP of this nation is raising sharply, population is growing at a slower pace; bio-capacity is showing a slight improvement than 2005 level, which is rare in other MI countries under study. In all other MI countries ecological balance has become deficit against a high rate of economic growth. Thailand is seemed to be the worst performer in all the three parameters: GDP, GS and EF [Figure 4.2 (f)]. In all other five countries the trends of GDP and GS are found to be more or less same - *upward rising*. In contrast, Thailand has a completely different trend: when GDP goes up, GS declines; when GDP starts falling, GS increases [Figure 4.2 (f)]. Ecological Balance per capita of Thailand is decreasing along with the increasing trend of per capita GDP. However from the above statistical representation, it is clear that after 2005, Ecological Balance of this country has started to increase. The figure represents a non-acting behaviour of the population on the environment of Thailand. This indicates that population of Thailand is not the soul factor for pressure on environment. However Malaysia has the maximum ecological deficit among these countries [Figure 4.2 (d)] and has been continuously declining. Here population growth rate is also the highest.

Two Low income (LI) countries were considered: Pakistan and Vietnam. Both the countries are well maintaining their GDP and GS. Population is increasing; but at declining rate in both the countries. When we observe the figures 4.3 (a) and (b), Ecological Balance is decreasing, i.e. Bio-capacity is decreasing, EF is increasing; which is an indication that demand of environmental resources are increasing in both countries. The only difference between these two countries is that Vietnam has started its journey towards growth from negative figures. In 2010, finally both its GDP and GS have increased and reached a comparatively stable situation. Population has also a decreasing trend in both countries. So it can be inferred that population is not fully responsible for negative results of the Ecological Balances.

Throughout the period from 1990 to 2010 the EF of Republic of Korea, Singapore, China, India, Philippines, Thailand and Pakistan is over-passing its BC. And the resulting consequence i.e. the Ecological Balance is always being a negative factor coming downwards in these countries. This is a clear condition of "overshoot".

We examined how many countries of the A-P region in different income groups are considered unsustainable by each indicator independently and by combination of all three. The table 4.1 suggests that nine out of the ten developing countries of the A-P region are in unsustainable development path when EF is considered only. But all these countries are showing economic sustainability in terms of GDP. Also positive GS of each of these countries indicates weak sustainability exists in all countries.

Table 4.1 Number of countries on Unsustainable Trajectories, Nations classified by income

Indicator/Parameter	Low income countries	Middle income countries	High income countries	Total
GDP only	0	0	0	0
GS/ANS only	0	0	0	0
EF only	2	5	2	9
GDP, EF & GS	0	0	0	0

Table 4.2 provides the rank of performance for each of the indicators along with bio-capacity (BC) and population and Table 4.3 ranks the countries according to their Ecological Balance. As an HI country, Singapore is the top performer in all except BC. Table 4.3 shows that it is the poorest performer in Ecological Balance. It is interesting to note that this is a fully urbanized country with 100% urban population (ESCAP, 2007). Among MI countries, Malaysia performed top in all indicators except GS, while it is not well performing in Ecological Balance.

Table 4.2 State of sustainability in Countries: rank of performer

Income group	*Name of the country*	*GDP only*	*GS only*	*EF only*	*BC only*	*Population growth rate*
HI	Republic of Korea	2	3	2	6	10
	Singapore	1	1	1	10	1
MI	China	6	2	6	5	9
	India	8	6	9	8	5
	Indonesia	7	8	5	2	7
	Malaysia	3	5	3	1	3
	Philippines	5	7	7	7	4
	Thailand	4	4	4	3	8
LI	Pakistan	9	9	8	9	2
	Vietnam	10	10	10	4	6

The results emphasize the lack of agreement among the indexes for all countries under consideration. While GDP and GS view all HI, MI & LI countries on a sustainable path, EF suggests the opposite. For example the Singapore and Republic of Korea are strange and disturbing as GDP and GS rank them at the top 1st and top 2nd of the list. But EF considers these two nations as the poorest performers. Similarly Vietnam which is ranked as the top performer (lowest EF) is registered as a bottom performer by GDP and GS (10th from the bottom).

Table 4.3 Rank of countries in average Ecological Balance: environmental sustainability

Name of the country	*Ecological Balance=BC-EF*	*Rank*
Republic of Korea	-3.34	9
Singapore	**-5.18**	10
China	-0.71	7
India	-0.30	4
Indonesia	**+0.21**	1
Malaysia	-0.55	5
Philippines	-0.56	6
Thailand	-0.98	8
Pakistan	-0.27	3
Vietnam	-0.11	2

So, in case of Ecological Balance, all the countries other than Indonesia have deficit. Among those, Singapore has the highest bio-deficit followed by Republic of Korea. Among MI countries, Thailand has ranked top in bio-deficit. As LI country Vietnam has less deficit of Ecological Balance than Pakistan.

From these tables 4.1, 4.2 and 4.3, implications can be drawn that while positive Ecological Balance and increasing real GDP per capita project Indonesia as "strongly" sustainable and negative Ecological Balances projects all other countries as 'unsustainable nation's, GDP and GS, by and large, rank the advanced countries (HIs and some MIs) favourably and view LI countries with lowest ranks of sustainability. These nations can thus be considered to be on a "weak" sustainable path.

Taking a brief critical look at the sustainability indicators methodology, serious limitations of these are revealed. GS is based on perfect substitution of all forms of capital which can be yield seriously misleading implications and policies (Pillarisetti and van den Bergh, 2007). For example, GS has ranked Indonesia 8th, while it is only the environmentally sustainable nation. Now, if Indonesia destroys all its forests and invests that income in infrastructure development, then its GS might increase. Thus relying on GS for policy can result in an "irreversible loss of '*critical natural capital*'" (Everett and Wilks, 1999; Muradian and Martinez-Alier, 2001). Thus assumption of perfect substitution between different forms of resources can give trivial and intuitive results (Pillarisetti and van den Bergh, 2007). On the other hand EF considers positive reserves of ecological resources as central to sustainability. In this view our results support those studies indicating that human consumption has exceeded the Earth's carrying capacity by 30% (Pillarisetti and van den Bergh, 2007).

However it may lead to an impractical suggestion that every country should stay within its ecological capacity defined by its political boundaries. This is difficult because of growing pace of international trade and other social international interchanges. Given the increasing importance of these countries as recipients of foreign direct investment and as significant producers of the global economy, achieving environmental sustainability without jeopardizing the other determinants of human welfare continues to be a big challenge that has to be confronted.

5. Way forward

Using all the indicators for this study, it is seen that Indonesia is now in a strong sustainability path among the ten developing countries of the Asia-Pacific region, considered in this study. All others have serious ecological deficit though are economically sustainable. But environmental sustainability should be there if humankind has to survive in this world. Some former studies too have got similar results by applying WS and SS indicators that growing economic patters have influenced human pressure on bio-capacity indicating resource overshoot in the nation as well as rising pressure on the earth (*see* Wang et al., 2012; Galli et al., 2012; Asici, 2013). However methodological and measurement shortfalls of these indicators and using them to rank the sustainable nations of the A-P region or commenting on human consumption may have some contradictory results. GS itself has GDP biases. Again methodological problems attached to EF calculation can make the estimate unreliable. Thus a comprehensive approach taking more realistic account of human consumption and its impact on environment of the Asia-Pacific region is needed to track progress towards sustainable development. Also the root factors of these trends are also to be found out and analysed in an elaborated manner. This work is in progress.

References

APFED. (2005). *Part I: Overview of the Asia-Pacifc Region.* Asia-Pacific Forum of Environment and Development.

Asici, A. (2013). Economic growth and its impact on environment: A panel data analysis. *Ecological Indicator , 24*, 324-333.

Atkinson, G., Dubourg, R., Hamlton, K., Munasinghe, M., Pearce, D., Young, C. (1997). *Measuring Sustainable Development: Macroeconomica and the environment.* U.K.: Edward Elgar.

Bank, W. (1997). *Expanding the Measure of Wealth.* Wshington DC: World Bank.

Begum, R.A., Pereria, J.J., Jaafar, A.H., Al-Amin, A.Q. (2009). An empirical assessment of ecological footprint calculations for Malaysia. *Resources, Conservation and Recycling , 53*, 582-587.

Bello, W. (2003, February 15). The environmental movement in the Global South. *Environmental Justice* .

Bennett, M. (1995). *The Gulf War.* Retrieved from Database for Use in Schools: http://www.soton.ac.uk/~engenvir//environment/waler/oil.gulf.war.html [Geo-1-002]

Boulding, K. (1966). The economicsof the coming Spaceship Earth. In H. (. Jarrett, *Environmental Quality in a Growing Economy.* Baltimore: Hohn Hopkins University Press.

Commoner, B., Corr, M., Stamler, P.J. (1971). The causes of pollution. *Environment , 13* (3), 2-19.

Costantini, V., Monni, S. (2008). Environment, human development and economic growth. *Ecological Economics , 64*, 867-880.

Daly, H. (2005). *Economics in a Full World.* Scientfic American.

ESCAP. (2007). *Statistcal Yearbook for Asia and the Pacific.* Thailand: United Nations Publication.

Everett, G., Wilks, A. (1999). *The World Bank's Genuine Savings Indicator: a Useful Measure of Sustainability.* London: Hamlyn House.

Galli, A., Kitzes, J., Niccolucci, V., Wackernagel, M., Wada, Y., Marchettini. (2012). Assessing the global environmental consequences of economic growth through the Ecological Footprint: A focus on China and India. *Ecological Indicators , 17*, 99-107.

GEO-3. (2003). *Integrating Environment and Development: 1972-2002.* UNEP.

Getzner, M. (1999). Weak and strong sustainability indcators and regional envronmental resources. *Environmental Management and Health , 10* (3), 170-176.

GFN. (2012, May 7). *National Footprint Accounts.* Retrieved Nov 20, 2012, from Global Footprint Network: http://www.footprintnetwork.org

Himalaya, C. (2012, 06 20). *Ecological footprint and nvestment In Natural Capital in Asa and the Pacific.* Retrieved 09 19, 2012, from Clmate Himalaya: http://chimalaya.org

Jha, R. (?). Alleviating Environmental Degradation in the Asia-Pacific Region: International cooperation and the role of issue-linkage. 1-45.

Jha, R. (2005). Alleviating Environmental Degradation in the Asia-Pacific Region: International cooperation and the role of issue-linkage. In T. B. Centre, *Regional Integration in the Asia-Pacific: Issues and Prospects* (pp. 191-234). University of South Australia: OECD.

Kula, E. (1998). *Histor of Environmental Economic Thought.* London: Routledge.

Lammers, A., Moles, M., Walsh, C., Huijbregts, M.A.J. (2008). Ireland's footprint: A time series for 1983-2001. *Land Use Policy , 25*, 53-58.

Lee, J-W, Hong, K. (2012). Economic growth in Asia: Determinants and prospects. *Japan and the World Economy , 24*, 101-113.

Meadows, D. R. (1972). *The Limits to Growth.* London: Pan Books.

Mota, R.P., Domingos, T., Martins, V. (2010). Analysis of genuine saving and potential green net national income: Portugal, 1990-2005. *Ecological Economics , 69*, 1934-1942.

Muradian, R., Martinez-Alier, J. (2001). Trade and environment: from a 'Southern' perspective. *Ecological Economics , 36*, 281-297.

Neumayer, E. (2003). *Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms.* Massachusetts: Edward Elgar Publishing.

Nourry, M. (2008). Measuring sustainable development: Some empirical evidence for France from eight alternative indicators. *Ecological Economics , 67*, 441-456.

Osborne. (1996, March 8). Delegation of the European Commission to Australia and New Zealand. (X. Y. Taplin, Interviewer)

Peirson, J. (2003). Development and the Environment. In A. Thirlwall, *Growth and development, with special reference to developing economies-7th edition*. New York: Palgrave Macmillon.

Pillarisetti, J.R., van den Bergh, J.C.J.M. (2007). *Sustainable Nations: What do Aggregate Indicators Tell Us?* Amsterdam: Tinbergen Institute.

Press, I. (1999). *The Environmental Impacts of War.* Retrieved from http://www.islandpress.org/ecocompass/war/war.html

Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K. (2012). An overview of sustainability assessment methodologies. *Ecological Indicator , 15*, 281-299.

Spangenberg, J. (2007). Biodiversity pressure and the driving forces behind. *Ecological Economics , 61*, 146-158.

UNDP. (2006). *Human Development Report 2006.* Unted Nations Development Programme. New York: Palgrave Macmillan.

UNESCAP and ADB. (2000). *State of the Environment in Asia and Pacific 2000.* New York: Economic and Social Commission for Asia and the Pacific and Asian Development Bank.

UN-ESCAP. (2012). *Populataion Data Sheet.* Retrieved February 13, 2013, from Economic and Social Commission for Asia and the Pacific: http://www.unescap.org/pop/data_sheet/2012

UN-ESCAP. (2003). *Population Data Sheet.* Retrieved December 12, 2012, from UNESCAP: http://www.unescap.org/pop/data_sheet/2003/index.asp

Wackernagel, M., Monfreda, C., Schulz, N.B., Erb, K-H., Haberl, H., Krausman, F. (2004). Calculating natonal and global ecological footprint time series: resolving conceptual challanges. *Land Use Policy , 21*, 271-278.

Wackernagel, M., Rees, W. (1996). *Our Ecological Footprint: Reducing Human Impact on Earth*. Gabriola Island, B.C.: New Society Publishers.

Wang, Ben-C., Chou, F-Yi, Lee Y-Jaan. (2012). Ecological footprint of Taiwan: A discussion of its implications for urban and rural sustainable development. *Computers, Environment and Urban Systems , 36*, 342-349.

WB. (2006). *World Development Indicators.* Washington: World Bank.

WCED. (1987). *Our Common Future.* World Commission on Envronment and Development. Oxford: Oxford University Press.

Weber, E. (2009). Common and uncommon sources of growth in Asia Pacific. *Journal of the Japanese and International Economics , 23*, 20-36.

Yu, X., Taplin, R. (1997). A survey: international aid for renewable energy in the Pacific Islands since the 1970s. *Energy Policy , 25* (5), 501-516.

Zhang, Z. (2008). Asian energy and environmental policy: Promoting growth while preserving the environment. *Energy Policy , 36*, 3905-3924.