

# **An Empirical Analysis of Environmental Consequences of Economic Growth in Asia**

Bandana Khataniar  
Roll No.: 11614108

*A thesis submitted to Indian Institute of Technology Guwahati  
in partial fulfilment of the requirements for the degree of  
Doctor of Philosophy*



Department of Humanities and Social Sciences  
Indian Institute of Technology Guwahati  
Guwahati 781039  
India

June 2016

## **DECLARATION**

I, Ms. Bandana Khataniar, hereby declare that the matter embodied in this thesis is the result of investigations carried out by me in the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, under the supervision and guidance of Dr. Anamika Barua.

In keeping with the general practice of reporting observations, due acknowledgements have been made wherever the work described is based on the findings of other investigators. The sources of secondary data utilized in this thesis are duly acknowledged.

Bandana Khataniar

IIT Guwahati



**Indian Institute of Technology Guwahati**  
**Department of Humanities & Social Sciences**  
**Guwahati 781039**  
**Assam, India**

---

## **CERTIFICATE**

This is to certify that the thesis entitled “**An Empirical Analysis of Environmental Consequences of Economic Growth in Asia**” submitted by Ms. Bandana Khataniar, Roll No. 11614108, for the degree of Doctor of Philosophy in the Department of Humanities and Social Sciences of Indian Institute of Technology Guwahati, embodies bonafide record of research work carried out under my supervision and guidance. The collection of materials from the secondary sources has also been done by Ms. Bandana Khataniar herself.

The present thesis or any part thereof has not been submitted to any other University for award of any degree or diploma.

All assistance received by the researcher has been duly acknowledged.

Dr. Anamika Barua  
Associate Professor  
Thesis Supervisor

## ACKNOWLEDGEMENTS

I extend my profoundest gratitude to my supervisor, Dr. Anamika Barua, of Indian Institute of Technology Guwahati for her support, sound advice and good teaching throughout my thesis-writing. I would have been lost without her help in pursuing my research at Indian Institute of Technology Guwahati. She has made her precious time generously available to me for questions and discussions. Her valuable inputs and comments have been immensely helpful over the period of this research work.

My sincere acknowledgements are also due to Prof. Krishna Barua, Prof. Mrinal Kanti Dutta, Dr. Rajshree Bedamatta and Dr. Sawmya Ray for their valuable advices which are treasures for this research work. My sincere thank goes to Prof. Arupjyoti Saikia whose timely suggestions have been always helpful to plan various activities of this research work.

I would like to thank Dr. Susan J Burns, CEO and Dr. Jeson Ortego, Global Footprint Network for providing me the National Footprint Accounts data of the selected countries of this study on my academic request.

I am grateful to the management of the libraries of Rajiv Gandhi University, Arunachal Pradesh; Indian Institute of Technology Guwahati; Omeo Kumar Das Institute of Social Change and Development, Guwahati; Indian Institute of Sciences, Bangalore and also to the authors and producers of original or derived works. A separate reference section towards the end of the narrative lists these sources in detail.

I am thankful to teachers and scholars from other institutions as well as from IIT Guwahati for extending their hands of support. These include Prof. Bandi Kamaiah, University of Hyderabad; Prof. Nityananda Sarkar, Indian Statistical Institute, Kolkata; Prof. M.P. Bezbaruah, Gauhati University; Monjit Borthakur, Omeo Kumar Das Institute of Social Change and Development; Dr. Debalina

Chakravarty, NIT, Jamshedpur; Debasree Purkayastha, Phastar, United Kingdom; Prof. S. Borbora, IIT Guwahati; Dr. Debarshi Das, IIT Guwahati; Dr. Bodhisattva Sengupta, IIT Guwahati; Dr. Parag Dutta, Guwahati College; Dr. Daisy Das, Cotton Collegiate State University; Dr. Mridusmita Duara, K.K. Handiqui State Open University; and Dr. Lepakshi Borbora, IIT Guwahati for their encouragement and support in pursuing my research work.

I am indebted to my many friends, student colleagues, staff and research scholars of IIT Guwahati for providing a stimulating environment to learn and grow. I am thankful to Rachna Yadav, Kaveri Deb, Madhuri Saikia, Nabanita Mitra, Suparana Katyaini, Nirmala Devi, Munmi Saikia, Pranti Dutta, Mahsina Rahman, Payel Chakravarty, Manali Karmakar, Bhupen Mili, Baban Bayan, Hemanta Barman, Gunjan Kumar, Pankaj Sing, Amalesh Gope, Miza Zulfiqur Rahman and my colleagues of IIT Guwahati.

I would be ungrateful if I don't acknowledge the cooperation and support provided by Durga Sharma and Parag Jyoti Kalita for each and every crisis of my office times.

This thesis would never be accomplished if I had not receive immense cooperation and mental support from my husband, Amitabh. His words of encouragement worked as catalysts during the entire period of this research work. I am obliged to my son, Joor who ungrudgingly supported me and persistently tolerated my absence from his life. I am also grateful to all my family members and my friends and well-wishers for inspiring and helping me in my work.

I am beholden to, especially my parents and in-laws, who supported me in all my endeavours. Their blessings move the fingers that hold my pen!

Bandana Khataniar

Department of HSS, IIT Guwahati

## ABSTRACT

Sustainable Development is an emerging concept that has been at the center of almost all developmental discussion across the world. Over time, sustainability has become a broad, continuously evolving paradigm (Redclift, 1988; 1992; 2005). One of the fundamental debates regarding sustainable development today is substitutability of capitals - whether or not the capitals (natural and man-made) can be and ought to be substituted. Based on this capital approach, two schools of thoughts have emerged: 'weak sustainability' and 'strong sustainability'. Weak sustainability, which stems from the prevailing environmental-economic theories, assumes that the total capital stock is an aggregate stock of man-made and natural capital and so there are no natural resources that cannot be replaced by other forms of capital (Stern, 1997). Weak sustainability concept is strongly opposed and challenged by the strong sustainability thought. Strong sustainability, which stems from ecological economics, does not support the concept of perfect substitutability among capitals. It believes that substitutability among capitals, especially between natural capital and man-made capital is restricted (Daly, 1990; Gowdy, 2000). So, sustainability can be weak or strong, depending on the nature of capital accumulation.

Economic growth is considered to be a precondition for meeting the basic requirements of humanity (Barua and Khataniar, 2015). Prosperity is often transformed into economic growth, where higher economic growth, means an improved quality of life, as it leads to increase in materialistic well-being. Economic growth improves the quality of life, but only up to a certain point, beyond which further economic growth may be associated with a loss of quality of life (Daly and Farley, 1994; Max-Neef, 1995; Fricker, 1998; Galli et al, 2012; Rees, 2012). Our planet is a life-supporting envelope for all biotic and abiotic resources on Earth. It can regenerate its resources at some pre-decided natural time-interval. This regenerative capacity of the planet is also known as 'ecological limit'. Since the 1970s, humanity has been exceeding the ecological limit every year through the unsustainable use of natural resources which leads to degradation

of the environment, in the form of deforestation, pollution, soil erosion, desertification etc. These environmental consequences are already evident across the world. The transitional and developing countries of the world will face more problems because they are still in the initial phase of development and there is also increasing pressure on them from the global economy to produce goods which are more pollution-intense. Their pursuit of achieving higher economic growth is a big challenge to the environment and towards sustainability.

Asia has been regarded as the fastest growing economic region in the world with more than thirty countries. Many of the emerging Asian economies have developed remarkably over the last four decades. The Asian economy is accelerating rapidly with a high annual growth rate of between 4 and 8%. But at the same time, the region has been characterized by unsustainable growth, population increase, increased consumption and urbanization, which is a challenge to the region's sustainable development (UNEP, 2012).

This thesis aims to understand the development path that the countries in Asia have been following from 1970 to 2010. In doing so, this thesis intends to identify the factors, which drive the demand for the natural capital of the Asian countries, which affect the sustainability of these countries. The study used Adjusted Net Savings as an indicator of weak sustainability and Ecological Footprint as an indicator of strong sustainability. The thesis taking a few selected emerging Asian economies and using time-series data for four decades (1970 – 2010), tried to answer the following research questions:

- (i) Is the present pattern of economic growth in the developing countries can be called a Sustainable Development path?
- (ii) What are the underlying factors determining the path of development in the selected countries?
- (iii) What role mainstreaming of natural capital can play in defining the path of development?

To get an in-depth understanding of the development path followed by Asia, ten countries were chosen for this study to fulfill the research objectives. The selection was based on their per capita income, GDP growth rate, population (more than 1 million), the rate of urbanization and the status of the environment. The selected countries are – Bangladesh, China, India, Indonesia, Malaysia, Pakistan, Philippines, Republic of Korea, Singapore, and Thailand. Again, as the selected Asian countries are in differential stages of their development in terms of per capita income, economic growth, urbanization and environmental degradation, they were further classified into three income groups-high, upper-middle and lower-middle based on the World Bank classification.

The methodology of selection of countries and their grouping are discussed in detail in Chapter 3 of the thesis. The study used two methods; a time series trend analysis to know the status of natural capital and a panel data analysis to examine the driving factors leading to demand nature.

Using the time series trend analysis, the first step of the thesis was to understand if the present pattern of economic growth of the selected countries can be called sustainable. The findings, in Chapter 4, showed that in all the selected Asian countries, since the mid-1970s, the human demand has overshoot the available domestic resources and led to an environmental degradation. This overshoot since then has been growing and the countries continue to follow a weak sustainability path by replacing natural capital by man-made capital. Hence, to see which are the factors that have an impact on the continuously increasing demand for nature, in Chapter 5, a panel data model has been used with additional socio-economic variables to study their influence on the demand for nature for all the 10 countries, based on the income groups, as mentioned above. The panel data results found that there is a significant and positive relationship between economic growth and pressure on natural capital, yet the effect is much stronger in upper middle-income countries than in high and lower middle-income countries. While population growth rate and urbanization have little evidence of having significant pressure on nature in all the income groups, richness in natural capital help the middle income

countries to extract more from nature. The study found that high income urbanized nations have higher levels of consumption based impacts which drive the ecological footprint. The middle and lower-income groups are also following the same pattern of growth but there is huge inequity in the access to and benefits from the economic growth that they have achieved. They are thus confronted with the dual challenge of achieving ecological as well as the socio-economic dimension of sustainable development.

Chapter 6 of the thesis brings forth the need to understand the threats posed by economic activities on natural resources and how it leads to resource limitation. Human wellbeing depends on the wellbeing of the natural capital and if natural capital is not integrated into socio – economic policies they may not be left with enough resources to support their productive activities. Further the study advocated mainstreaming natural capital into decision-making processes in the transitional and developing countries of Asia to achieve sustainable development goals. Since the selected Asian economies are following a path of weak sustainability, there is a poor protection of natural capital in these countries. Integration of natural capital in socio / economic policies is still in isolation from other forms of capital. The thesis emphasizes the need for developing proper valuation techniques to capture the complete value of the ecosystem services provided by nature so that natural capital does not come as an add-on in the development decision.

Thus, the study has empirically established that economic growth is the major contributing factor in increasing human's demand for natural capital. This has led the Asian countries to the path of weak sustainability, which allows them to replace natural capital by man-made capital and is also easy to follow compared to strong sustainability path. The study further finds that impact of population and urbanization is not homogenous in all the countries, but varies across income levels. The nexus between ecological footprint and social sustainability is also discussed by considering various indicators like HDI, multidimensional poverty, Gini index, gender equality and education. The discussion supports the view that

to bring intra and intergenerational equity, some of the selected Asian countries, which are rich in biocapacity, like India, Indonesia, Bangladesh, have to increase their per capita ecological footprint so that social sustainability can be achieved. But since some of the services of nature are non-substitutable, mainstreaming natural capital into the decision-making process can help countries to achieve sustainable development goal in all the three dimensions - economy, ecology, and society. So the growth strategies are to be revised in such a manner that natural capital can be integrated into development and financial planning.



## PUBLICATIONS & CONFERENCE PAPERS

### I. Peer-Reviewed Journal Papers

- i) Barua, A., **Khataniar, B.** (2015) “Strong or weak sustainability: a case study of emerging ASIA”, *Asia-Pacific Development Journal*, Vol. 22, No. 1, pp. 1-32.
- ii) **Khataniar, B.** (2015) “Globalization-Economy-Environment in India: An Econometric Analysis”, (In) *South Asia: Past Present and Beyond*, Saikia, B. (Ed), Global Publishing House India, ISBN: 978-93-81563-64-9, pp. 67-73.
- iii) **Khataniar, B.**, Barua, A. (2014) “Climate change and gender vulnerability in Sikkim”, (In) *Eco-Restoration for Development in India's North East*, Sharma, P. et al. (Eds), Global Publishing House India, ISBN: 978-93-81563-40-3, pp. 163-177.
- iv) **Khataniar, B.**, Barua, A., Talukdar, R. (2012) “Dwindling forests in Assam, India: causes and remedies”, *The Clarion*, Vol.1(2), pp.154-167.

### II. Book review

- i) **An Introduction to Ecological Economics** (By *Daly and Farley*, 2007) in the *Amity Journal of Economics*, Vol. 1, Issue 1, 2016.

### III. Papers Presented at various Conferences

- i) Barua, A. & **Khatanar, B.** (2016) “Asia’s demand on nature: approaching critical limits”, *Mainstreaming Natural Capita In Macroeconomic Decision Making*, Geneva, UNEP, 23-24 Feb.
- ii) **Khataniar, B.** and Barua, A. (2016) “Impact of urbanization on energy use and CO<sub>2</sub> emissions: A cross-country analysis of emerging Asian countries”, *8<sup>th</sup> Biennial Conference, Indian Society for Ecological Economics*, IISc Bangalore, 3-6 Jan.

- iii) **Khataniar, B.** (2015) “Globalization-Economy-Environment in India: An Econometric Analysis”, ICSSR sponsored *International Seminar on Socio-Economic Development of South Asian Countries-Past, Present and Beyond*, Rangia College, 18-19 Dec.
- iv) **Khataniar, B.** (2015) “Strong or Weak Sustainability: A time-series analysis of India”, *Graduate Research Meet*, Indian Institute of Technology Guwahati, 28-30 Oct.
- v) **Khataniar, B., Barua, A.** (2013) “Economic growth and environment in the Asia-Pacific region: a time series analysis from Ecological Footprint (EF) perspective”, *7<sup>th</sup> Biennial Indian Society for Ecological Economics (INSEE) Conference on Global Change, Ecosystems, Sustainability*, Tezpur University, 5-8 Dec.
- vi) **Khataniar, B.,** (2013) “Evolution of environmental economics: A time series analysis of India’s footprint for 1970s–2008”, *Northeast Social Scientists’ Meet at OKD Institute of Social Change and Development*, Guwahati, 22-23 Jan.
- vii) **Khataniar, B., Barua, A.** (2012) “Climate change and water: Assessing gender vulnerability – A case study in Sikkim, India”, *14<sup>th</sup> Annual Conference of North Eastern Economic Association*, Sibsagar College, 13-15 Dec.
- viii) **Khataniar, B., Barua, A.** (2013) “Climate change and gender vulnerability in Sikkim”, *Regional Seminar on Eco-Restoration for Development in NORTH EAST INDIA*, Cotton College, Guwahati, 22-23 April.
- ix) **Khataniar, B., Barua, A.** (2012) “Use of logistic regression in deforestation studies”, *Recent Trends in Statistics and its Applications* Arya Vidyapeeth College, Guwahati, 3-4 Feb.

## **ABBREVIATION**

ADB	Asian Development Bank
ANS	Adjusted Net Savings
APFED	Asia Pacific Forum for Environment and Development
BC	Biocapacity
EF	Ecological Footprint
EPI	Environmental Performance Index
ESI	Environmental Sustainability Index
EVI	Environmental Vulnerability Index
FAO	Food and Agricultural Organisation
FDI	Foreign Direct Investment
FE	Fixed Effects
GDP	Gross Domestic Product
GFN	Global Footprint Network
GLS	Generalized Least Square
GNI	Gross National Income
GNNP	Green National Net Product
GPI	Genuine Progress Index
GS	Genuine Savings
HI	High-Income

ISEW	Index of Sustainable Economic Welfare
LMI	Lower Middle-Income
MDG	Millennium Development Goal
MSE	Mean square error
NFA	National Footprint Accounts
OECD	Organization of Economic Cooperation and Development
OLS	Ordinary Least Squares
ROK	Republic of Korea
SD	Sustainable Development
SS	Strong Sustainability
UMI	Upper Middle-Income
UN	United Nations
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WS	Weak Sustainability
WWF	World Wildlife Fund

## Table of contents

Declaration.....	ii
Certificate.....	iii
Acknowledgement .....	iv
Abstract.....	vi
Publications & Conference papers.....	xi
Abbreviations.....	xiii
Table of contents.....	xv
List of figures.....	xix
List of tables.....	xxi
<b>Chapter 1 Introduction.....</b>	<b>1</b>
1.1 Project focus.....	4
1.2 Aim, objectives and research questions of the studied territory .....	5
1.2.1 Aim of the study.....	5
1.2.2 Research questions and objectives .....	5
1.3 Thesis layout .....	7
<b>Chapter 2 Sustainable Development: From Malthus to Ecological Economics</b> .....	<b>11</b>
2.1 Evolution of the concept of Sustainable Development .....	11
2.1.1 Classical Economics and Limit to growth (17 <sup>th</sup> to late 18 <sup>th</sup> century) ....	11
2.1.2 The Industrial Revolution and the era of Neoclassical School (1760- 1900s).....	13
2.1.3 The rise of environmental concerns .....	15
2.1.4 Environment and Resource Economics (1960s- 1990s) .....	17
2.1.5 ‘Limits to Growth’ reinstated .....	18
2.2 Sustainable Development in the Neoclassical Era .....	20
2.3 Growth of Ecological Economics and Strong Sustainability (1987-2010)...22	
2.3.1 Full world economy .....	23
2.3.2 Strong sustainability .....	25
2.4 Mainstreaming natural capital in decision making for Sustainable Development .....	27

2.5 Summing up .....	28
<b>Chapter 3 Research Methodology .....</b>	<b>31</b>
3.1 Introduction .....	31
3.2 Description of the study area .....	31
3.2.1 The study region: Asia .....	31
3.2.2 The environmental concerns in Asia .....	34
3.3 Selection of the countries .....	35
3.3.1 High-income countries .....	37
3.3.2 Upper middle-income countries .....	38
3.3.3 Lower middle-income countries .....	39
3.4 Description of data .....	41
3.4.1 Indicators for weak and strong sustainability .....	41
3.4.2 Ecological Footprint approach .....	42
3.4.3 Adjusted Net Savings .....	45
3.5 Data analysis .....	46
3.5.1 Time series trend analysis .....	47
3.5.2 Panel data analysis .....	47
3.5.2.1 Basic panel data regression model .....	49
3.5.2.2 Error component model .....	49
3.5.2.3 Pooled OLS .....	50
3.5.2.4 Fixed effect approach .....	51
3.5.2.5 Random effect approach .....	53
3.5.2.6 Fixed versus Random Effects .....	55
3.5.2.7 Hausman test: Fixed effects model or Random effects model .....	58
3.5.3 Dependent variables .....	59
3.5.4 Independent variables .....	59
3.5.5 Data transformation .....	62
3.5.6 Test for stationarity .....	62
3.5.7 Test for cross-sectional dependence .....	63
3.6 Source of Data .....	64
3.7 Panel data regression equation .....	64
3.8 Limitation of the data .....	66

<b>Chapter 4 Asia's Growth Pattern: Weak or Strong Sustainability?</b> .....	67
4.1 Introduction .....	67
4.2 Sustainable development path in HI countries .....	68
4.3 Sustainable development path in UMI countries .....	70
4.4 Sustainable development path in LMI countries.....	76
4.5 Summary .....	85
<b>Chapter 5 Underlying Factors Defining the Growth Patterns in Asia: A Panel Data Analysis</b> .....	87
5.1 Introduction .....	87
5.2 Panel data analysis .....	87
5.2.1 Cross-sectional dependency test results .....	88
5.2.2 Unit root test results.....	88
5.3 Panel data estimation results .....	89
5.3.1 Fixed effect and Random effect estimation (overall) .....	90
5.3.2 Estimation results (based on income groups).....	93
5.3.2.1 High-income group .....	93
5.3.2.2 Upper middle-income group .....	96
5.3.2.3 Lower middle-income group.....	100
5.4 Discussion on the findings .....	104
<b>Chapter 6 Mainstreaming Natural Capital into Decision Making for Sustainable Development in Asia</b> .....	105
6.1 Natural vs man-made capital .....	105
6.2 Status of mainstreaming natural capital in Asia .....	108
6.3 Challenges and barriers in the mainstreaming natural capital .....	111
<b>Chapter 7 Environment and Economic Growth: Conclusion and Looking Towards the Future</b> .....	113
7.1 Summary of the findings .....	113
7.2 Limitations and future research possibilities .....	116
<b>References</b> .....	119
<b>Appendices</b> .....	139
Appendix 1 Ranking of Asian countries in various selection criteria of the present study .....	141

Appendix 2 Summary of the existing empirical studies on the relationship between environmental degradation and sustainable development .....	143
Appendix 3 Selection procedure of indicators for Weak and Strong sustainability .....	148
Appendix 4 (a) Input data to the Ecological Footprint and Biocapacity calculation .....	154
Appendix 4 (b) National Footprint Accounts (NFA)'s accounting framework ..	157
Appendix 5 Calculating Adjusted Net Saving .....	158
Appendix 6 Ecological deficit in Indonesia .....	161
Appendix 7 Unit Root Test Results .....	162
Appendix 8(a) Scatter plots of each variable before logarithmic transformation	163
Appendix 8(b) Scatter plots of each variable after logarithmic transformation .	165
Appendix 9 Result for pooled OLS regression 1970–2010 Panel .....	167
Appendix 10 Panel data output tables-Pooled regression .....	171
Appendix 11 Panel data output tables-Fixed Effects and Random Effects .....	173
Appendix 12 Social indicators to measure social sustainability .....	179
Appendix 13 Ecological Footprint of each country at global scale .....	181

## LIST OF FIGURES

Figure no.	Title	Page no.
Figure 2.1	Ecosystem is a subsystem of the economy	15
Figure 2.2	Economy is a part of the ecosphere	16
Figure 2.3	From empty world to full world	24
Figure 3.1	Selected Asian countries according to income group classification	36
Figure 3.2	Distribution of ecological footprint (EF) per capita and biocapacity (BC) per capita across income groups: 1970–2010	37
Figure 4.1a	Trends of ANS, per capita EF, per capita BC in the Republic of Korea	68
Figure 4.1b	Components of ecological footprint per capita in the Republic of Korea	68
Figure 4.2a	Trends of ANS, per capita EF, per capita BC in Singapore	69
Figure 4.2b	Components of ecological footprint per capita in Singapore	69
Figure 4.3a	Trends of ANS, per capita EF, per capita BC in China	71
Figure 4.3b	Components of ecological footprint per capita in China	71
Figure 4.4a	Trends of ANS, per capita EF, per capita BC in Malaysia	73
Figure 4.4b	Components of ecological footprint per capita in Malaysia	73
Figure 4.5a	Trends of per capita EF, per capita BC in Thailand	74
Figure 4.5b	Components of ecological footprint per capita in Thailand	75
Figure 4.6a	Trends of per capita EF, per capita BC in Bangladesh	77
Figure 4.6b	Components ecological footprint per capita in Bangladesh	77

Figure 4.7a	Trends of ANS, per capita EF, per capita BC in India	78
Figure 4.7b	Components ecological footprint per capita in India	79
Figure 4.8a	Trends of ANS, per capita EF, per capita BC in Indonesia	80
Figure 4.8b	Components ecological footprint per capita in Indonesia	80
Figure 4.9a	Trends of ANS, per capita EF, per capita BC in Pakistan	81
Figure 4.9b	Components ecological footprint per capita in Pakistan	82
Figure 4.10a	Trends of ANS, per capita EF, per capita BC in Philippines	83
Figure 4.10b	Components ecological footprint per capita in Philippines	83
Figure A.1	The ratio of Domestic Ecological Footprint (per capita) to Global Bio-capacity (per capita), 1970- 2010	182

---

## LIST OF TABLES

<b>Table no.</b>	<b>Title</b>	<b>Page No.</b>
Table 3.1	Difference between Fixed Effect and Random Effect Models	55
Table 5.1	Fixed and Random effects regression results for all 10 countries	91
Table 5.2	Fixed and Random effects regression results for High-Income countries	94
Table 5.3	Fixed and Random effects regression results for Upper Middle-Income countries	97
Table 5.4	Fixed and Random effects regression results for Lower Middle-Income countries	101
Table 6.1	Status of the indicators of sustainability in the selected Asian countries	106

# Chapter 1

## Introduction<sup>1</sup>

---

Economic growth is regarded as a precondition for acquiring the basic requirements of humanity (Barua and Khataniar, 2015). Nevertheless, economic growth alone is not sufficient to enhance wellbeing, although it plays a pivotal role in increasing the purchasing power of people and thus provides greater opportunity to raise their standard of living. Economic growth does not depend only on human capital, but also on the environment or natural capital<sup>2</sup>. Uninterrupted economic expansion may lead to a damage of the amenities provided by natural capital, which in turn may create a barrier to progress. However, economists, until recently, held the view that the environment is a subgroup of the economy and the economy can grow forever. The only role that nature plays in economic growth processes is as a source of raw materials and as a sink to engross the waste products coming out of economic as well as household activities. This contracted view of the environment has led to the reduction of natural resources at a rate faster than the replenishment rate, generating pollution beyond the assimilative capacity of nature.

Dialogues on the environmental consequences of the human-led economic growth started to earn admiration since the 1960s with the work of certain specialists from interdisciplinary arenas. Some noteworthy works amongst them are: “*Silent Spring*”- a book written by Rachel Carson in 1962; “*The Economics of the Coming Spaceship Earth*” - an essay composed by Kenneth Boulding in 1966; “*On Economics as a Life Science*” - an article by Herman Daly in 1968; and “*Production, consumption, and externalities*” - a paper published in 1969 by R.U. Ayres and A.V. Kneese. All these epoch making works were successfully

---

<sup>1</sup>Part of this chapter has been published as a paper titled “**Strong or weak sustainability: a case study of emerging Asia**”, *Asia-Pacific Development Journal Vol. 22, No. 1, pp. 1-32*.

<sup>2</sup>Natural capital is the function that the natural environment offers towards humans and for itself. Traditional definition of capital argues that natural capital is a produced means of production, where “produced” means “produced by humans” (Costanza and Daly, 1992). Ecological economists have included the means of production provided by nature within the extended definition of capital.

followed by an even more intricate effort by Nicholas Georgescu-Roegen's by publishing the book "*The Entropy Law and the Economic Process*" in 1971.

Although varied in subject matters, all these works recommended a communication between the economy and the environment. According to Boulding (1966), unbounded growth is not possible in a finite world. This is because the economy is 'part' or a 'subsystem' of a 'whole ecosystem', namely that of the environment (Daly and Farley, 1994; Getzner, 1999). Therefore, the economy cannot grow forever, as growth is limited by the availability of natural capital or the environment (Daly and Farley, 1994; Lawn and Clarke, 2010; Asici, 2013).

The Brundtland definition of Sustainable development (SD henceforth) which is "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*", emphasizes that for development to be sustainable, countries should safeguard and utilize natural resources in such a way that the present as well as the future generation can fulfill their needs (WCED, 1987). SD is an emerging concept that has been at the centre of almost all developmental discussion across the world. Over time, sustainability has become a broad, continuously evolving paradigm (Redclift, 1992; 2005). There are many differing worldviews of sustainability (Barr, 2008); Dobson (1996) noted that there are over 300 definitions of sustainability. One of the fundamental debates regarding sustainable development today is substitutability of capitals - whether or not the capitals (natural and man-made) can be and ought to be substituted. This capital approach has developed two schools of thoughts: 'weak sustainability' and 'strong sustainability'. 'Weak sustainability', which stems from the fundamental theories related to environment and economy, assumes that the total capital stock is '*an aggregated stock of man-made and natural capital*' and so every natural capital can be replaced by other forms of capital (Stern, 1997). 'Weak sustainability' is influenced by the work of two neoclassical economists: Robert M. Solow (1974; 1986; 1993) and John M. Hartwick (1977; 1978). Since physical growth is more important in this view, more emphasis is given to man-made wealth than the natural capital (Neumayer, 2003).

‘Weak sustainability’ concept is strongly opposed and challenged by the ‘strong sustainability’ thought. ‘Strong sustainability’ which stems from ecological economics does not support the concept of perfect substitutability among capitals. It believes that substitutability among capitals, especially between natural capital and man-made capital, is restricted (Daly, 1990; Gowdy, 2000).

Hence, to achieve strong sustainability, due attention should be given to preserve both natural and man-made capital (Figge, 2005). Earth is a finite system and the supply of natural resources itself is a limit to the economy (Boulding, 1966; Daly and Farley, 1994). So, growth is constrained by the ecological limits. For the strong sustainability school of thought, ecological limit is the main constraint for materialistic growth. The stock of natural resources and assets which provide flows of goods and ecosystem services is called natural capital (WWF et al., 2012). This stock has its own regenerative capacity which needs a specific, naturally fixed time to regenerate. If the stock can provide a sustainable flow of goods and services, then only there will be sustainability in the development. So it is very important to maintain the stock, i.e. natural capital. This is supported by the Brundtland Report also as natural capital is very closely attached to the people, especially to the poor people. Conservation of natural resources, valuation of ecosystem services, accounting or assessment of natural capital, payment for ecosystem services - are some of the already experimented processes (Daily et al., 2011). But what is less experimented is the implementation of these processes, which is possible by the inclusion of natural capital into the decision-making processes, or in other words ‘mainstreaming’ of natural capital. In mainstream economics natural capital serves as a ‘source’ of raw materials and ‘sink’ to absorb waste. Accounting, maintenance, investment and monitoring are some of the primary requirements for environmental mainstreaming. Accounting is required to know how much stock of natural resources is left at present. In 1968, UN released its framework of System of National Accounts (SNA). Since then many developed countries adopted different resource accounting systems. Maintenance of natural capital is important as natural resources provide various ecosystem services including livelihood to poor. At the same time maintenance of natural capital benefits the flow of services for rich countries too (Daily et al.

2011). Conservation of these resources advocates for constant stock of environmental assets for achieving social sustainability (Harte, 1995). Again, any capital for economy needs investment. Investment accumulates the stock of capital. Conservation of forests and wetlands, biodiversity hot spots, are some ways to invest in natural capital. Thus mainstreaming natural capital into decision-making is a challenge to the present generation, especially in the developing countries.

## 1.1 Project focus

Sustainable development encourages economic growth, environmental sustainability and social development in all countries. To achieve social development, SD promotes the countries to achieve more economic growth in an environmentally favorable way. There is a great realization that the earlier economic growth path has tremendous effect on the global environmental consequences. Expectations made by many scholars that in a domain gradually affected by ecological fluctuations, low-income and middle-income countries, particularly those in Asia, will take an ever more dominant part in determining the future health of the biosphere (Lardy, 2002; Panditchpakdi and Clifford 2002; Wang 2003; Galli et al. 2012). But complete analysis or understanding of the environmental consequences of this phenomenon has not been achieved till now. Since 1950s, Asia has been the home of the largest number of population and this trend is projected to continue till 2050 (APFED, 2010). It is also expected that by 2020, half the population of Asia will live in urban areas (UNEP, 2013). More people, especially more urban people, means more consumption and so increased pressure on the natural resources.

Hence, with more than fifty percent of the global population, the decisions made in this region will reverberate around the globe. Especially, policies prepared by countries like China and India might have much more significance in the global sustainability equation as they are enormously growing economies in this region (Galli et al., 2012). Most of the other Asian countries are also experiencing

favorable GDP growth rates. However, it is important to understand that if this growth is sustainable, then what is the status of natural and human capital and the challenges and opportunities available to these countries to mainstream natural capital in their decision-making process.

## **1.2 Aim, objectives and research questions of the studied territory**

### ***1.2.1 Aim of the study***

Using the weak and strong sustainability concept, this thesis aims to examine the path of development followed by a few selected Asian countries<sup>3</sup> in the last forty years (1970 – 2010) and the role that natural capital has played in deciding the development path for the selected countries. To fulfill the aim of this research, the following research questions and objectives have been set up.

### ***1.2.2 Research questions and objectives***

**Question 1.** What is the path of development followed by the selected Asian economies in the last 41 years (1970-2010)?

#### **Objectives:**

1. Using Weak and Strong sustainability indicators, examine the relationship between economic growth and demand for natural capital.
2. Identify the factors which drive the demand for natural capital.

---

<sup>3</sup>In this study the World Bank (2015) definition of the term ‘country’ is considered. According to this definition, country refers to a region which has separate socio-economic statistics reported by authorities.

**Question 2.** *What are the underlying factors determining the path of development in the selected Asian countries?*

**Objectives:**

1. To identify the factors driving the path of development in the selected Asian countries.
2. To analyze the path of development (weak or strong) by examining the status of human and natural capital in the selected countries.

**Question 3.** *What role mainstreaming of natural capital can play in defining the path of development ?*

**Objectives:**

1. To critically examine the challenges and barriers in the mainstreaming natural capital in the selected Asian countries.
2. To identify the enabling factors, which can help the selected countries to follow a strong sustainability path by mainstreaming natural capital?

This study will help to comprehend

- What is the influence of Asia's economic growth on its natural resources?
- Is this growth leading to the replacement of natural capital by the man-made capital i.e. weak sustainability path vs. strong sustainability path?
- Is natural capital taken into account while deciding the development path of the country?

## 1.3 Thesis layout

The present thesis has been organized in the following chapters.

### Chapter 1: Introduction

This chapter provides an introduction to the study by giving the background of environmental degradation, its concerns and its impact on economic growth. It is done in order to introduce a broad understanding of the concept of sustainable development. In this chapter, the statement of the problem, objectives, study area and reference period, the outline of the study have also been introduced.

### Chapter 2: Sustainable Development: from Malthus to Ecological Economics

The chapter provides an examination of the theory of sustainable development by providing an in-depth historical analysis of its origin, objectives and evolution of the concept. The chapter highlights how the proponents of sustainable development deemed it possible to achieve economic growth while ensuring environmental sustainability and how in the era of ecological economics, it is proved wrong. In other words the chapter helps to understand the liaison between human activity and the environment. The chapter further analyses the distinctions between two prime concepts of this study- 'weak sustainability' and 'strong sustainability'. It also brings in the discussion on mainstreaming natural capital in decision-making process.

### Chapter 3: Research Methodology

To provide a greater understanding of the impact of economic growth the developing countries' environment, the region of Asia has been chosen as case study in this chapter. This chapter describes the study area and gives a full description of methods used for selection of variables, study period, and indicators. It describes the nature of information collected and the statistical methods that have been used to analyze the data. It also describes the

methodology of selection of study site (countries) and grouping of these countries based on their income. The selected countries are further categorized into income groups according to recognized norms to have a better idea of the income effects on the environment.

#### **Chapter 4: Asia's growth pattern: weak or strong sustainability?**

The chapter using the time series trend analysis discusses the selected countries' trend of demand for nature since 1970 to 2010 to achieve economic growth. The discussion is done based on the income categories of the countries and findings are then discussed in detail to establish the need to go for further econometric analysis which is presented in Chapter 5. This chapter also explains how economic development has impacted the social indicators in the selected Asian countries.

#### **Chapter 5: Underlying factors defining the growth patterns in Asia: a panel data analysis**

This chapter using panel data econometric method examines the underlying factors behind the growth patterns identified in Chapter 4. The analysis of this chapter unfolds the differences in environmental consequences of economic growth in different countries based on three income groups-high, upper-middle and lower-middle. The selected indicators are then discussed in detail. The future trend that these indicators are likely to follow is also discussed. This chapter also explains how economic development has impacted the social indicators in the selected Asian countries.

#### **Chapter 6: Mainstreaming natural capital into decision making for sustainable development in Asia**

This chapter is to address entirely the 3<sup>rd</sup> research question i.e. to discuss how mainstreaming has been integrated in the decision making in the selected

developing Asian nations. It also discusses the challenges and barriers for mainstreaming.

**Chapter 7: Environment and economic growth: Conclusion and looking towards the future**

This chapter brings together the overall findings of the thesis. This is the concluding chapter of the thesis; hence the scope of future research and the limitations of the study are also discussed in this chapter.





## Chapter 2

# Sustainable Development: From Malthus to Ecological Economics

---

## 2.1 Evolution of the concept of Sustainable Development

Sustainable Development (SD), as a concept, puts responsibility on humanity to think seriously about the consequences of our present activities on the welfare of our future generation. While the term sustainable development is not very old but the fact that environment plays an important role in sustaining life and evolution of human being, is recognized since the time of hunter and gatherer. The hunter – gatherer society (when human hunted animals for food and gathered water and fruits from the forests) depended on natural resources for their lives and livelihood. Gradually the hunter-gatherer society learned the technique to store food which led to the development of a settled human life. However, during the time of hunter and gatherer and also when the settled form of livelihood started, the world was less populated and less polluted too. It could be termed as an ‘empty world’ situation where natural capital was in abundance and it was the man-made capital<sup>4</sup> which was looked as a scarce resource. So, the need was felt to invest in the growth of man-made capital; since the natural capital was in abundance, investment on natural capital was not felt necessary. So gradually economy started to move on to a path of limitless growth.

### *2.1.1 Classical Economics and Limits to Growth (17<sup>th</sup> to late 18<sup>th</sup> century)*

In the 17<sup>th</sup> century, classical economist, Thomas Malthus made the prediction that economic growth will be constrained due to a scarcity of land, as land is a finite

---

<sup>4</sup>**Human-made capital** is divided in two broad types: human capital and manufactured capital. Human capital comprised of the capabilities, intelligence, innovation and education in human beings themselves. The capital which is created by human capital, like factories, buildings, power plants, bridges etc. are called ‘manufactured’ capital (Costanza and Daly, 1992).

natural resource. This was the first time the concerns related to limits to growth was discussed as Malthus predicted that population has a tendency to increase geometrically, whereas the food production increases arithmetically (Malthus, 1798). According to him population always runs faster than the growth in the resources available to feed and shelter people. So inevitably we cannot grow forever if there is a resource scarcity. By resource scarcity, he meant scarcity of land. Probably he was the first economist who raised his voice through writing on the possible impact of population growth on natural resources. This led to the emergence of the first school of thought of economics, known as the Classical Economics. Malthus's argument was supported by David Ricardo, who also realized that population and diminishing marginal return would be a challenge to the future. Ricardo put forward three laws under the tag line of 'stationary state'. These three laws are: *law of capital formation* - capital accumulation by raising the wages strikes at its own roots and no further accumulation is possible and thus growth stops; *law of population growth* - once population grows due to higher wage rate, economy will not grow further; *law of diminishing return* - as more and more labour is applied to land, the additional production of the additional labour will be less and less. Another classical economist John Stuart Mill, in his book "*In Principles of Political Economy*", published in 1848, wrote about 'steady state', which implied a stationary condition of capital, population, and distribution, but not of human improvement. He related wellbeing to the pleasure derived from a healthy natural environment. He also realized that economy cannot grow forever because the scarcity of *non-renewable resources* will act as a constraint to economic growth.

Thus, the classical school believed that due to demographic and ecological constraints the economy cannot grow forever. But they failed to see the technological changes occurring around them at that time. They also failed to see that development may lead to fall in population growth, which we see now in the western world.

However, Malthus and other classical economist like Ricardo and Mill were ignored at that time because the Industrial Revolution was in pace and the world was moving fast with newer technologies, during the 18<sup>th</sup> century. Eventually, Malthus's theory on population growth and natural resource scarcity was termed as 'dismal science' and economy continued to grow. Mill's argument on resource constraint too became invalid when oil came up as a substitute to fossil fuel. So again the economists became confident that growth process can continue forever without any constraint.

### ***2.1.2 The Industrial Revolution and the era of Neoclassical School (1760-1900s)***

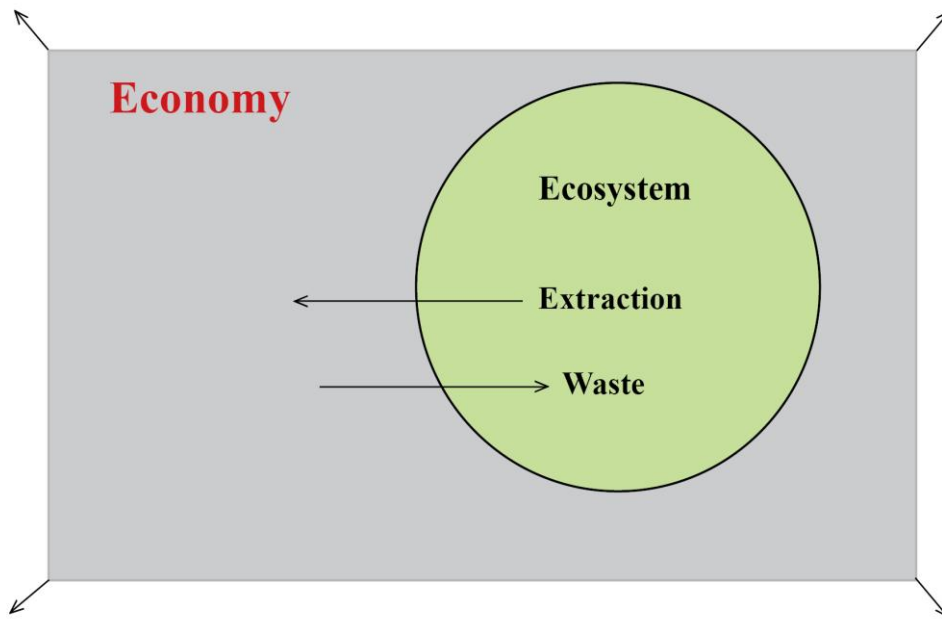
The era of Industrial Revolution was a period in which vital alterations happened in farming, textile and metal manufacturing, transportation, trade and industrial policies and the societal organization (Montagna, 1981). Richness in natural resources of England fuelled the Industrial Revolution to begin in this part of the world in the mid-1700s. Machines and similar products were made by iron and fuelled by coal. At that time, England had abundance in both coal and iron. By the next century, factories and machines changed the nation and this transformed to almost all parts of Europe and North America. There was a revolutionary transition in this era. Machines took the place of most of the tedious, rigorous and time-consuming hand production processes. The improved techniques succeeded in reducing the manufacturing time and could produce large amount of goods at a time. Several important inventions, like the steam engine, flying-shuttle, and roller spinner added to the Industrial Revolution.

It was also the time of expanding trade, global markets, and exchange of ideas and technological advancement, which altogether laid the foundation for Industrial Revolution (Daly and Farley, 1994). This Revolution had tremendous impact on the economy, society and the environment. The man started depending on non-renewable resources, particularly on fossil fuel. Production of various goods

started, market grew, food production was increased, per-capita consumption was increased, income generated and prosperity came to the society in terms of a comfortable life. The Industrial Revolution led to the fall down of classical school and growth of the neoclassical school.

From 1870s, mainstream economists started to evolve towards neoclassical economics (NCE) (Common and Stagl, 2005). The term 'neoclassical economics' was first coined by Veblen in 1900 (Colander et al., 2004). Neoclassical economists had a lot of faith in technology. Technology is a very important dimension of this branch of economists. It is true that technology has been playing a massive role in keeping the earth still livable. Emphasis was given more on the market which was believed to allocate scarce resources efficiently and distribute them in a just manner.

The neoclassical economists considered the constant economic growth as sufficient and measurable representation for the desirable end (Daly and Farley, 1994). Instead of thinking about the 'source', these economists were more attentive towards efficient allocation of the resources. The theory begins with non-physical parameters like - technology, preference, and distribution. This school of thought viewed the economy to be the 'whole' of which society and environment are parts and so any problem regarding later can be solved by growing the economy (Figure 2.1). Since forests, ecotourism spots, fisheries, grasslands, mines, wells, croplands - all contribute to the economy; they are treated as sectors of the macroeconomic system in the neoclassical theories (Daly and Farley, 1994).



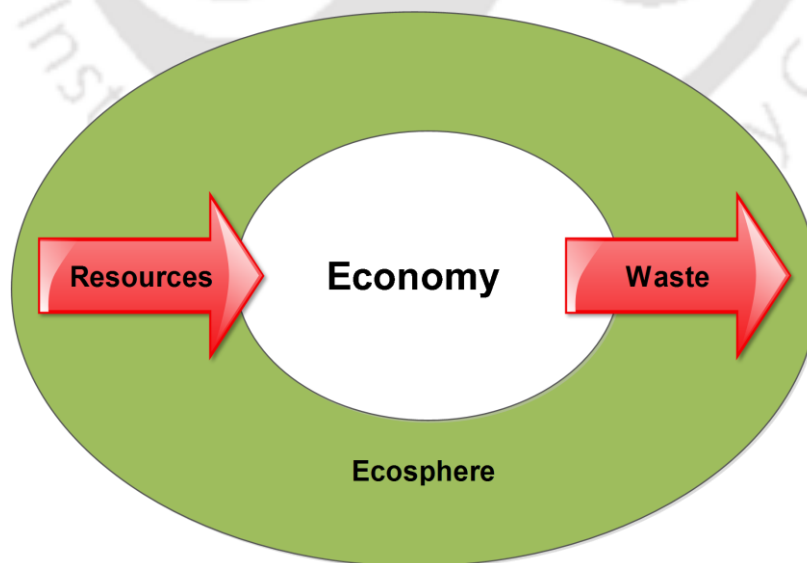
**Figure 2.1 Ecosystem is a subsystem of the economy**

Markets are necessary for NCE which leads to efficient allocation of scarce resources –a situation in which no other allocation of resources would make at least one person wealthier without making someone else poorer. This school of thought emphasizes the exchange of goods and services as the main attention of economic analysis from the microeconomic perspective. Efficiency is so important in neoclassical view that sometimes it is taken as the end in itself to reveal all our desire. The neoclassical economists have formulated a strong belief on the capacity of advanced technology. This view assumes that this efficiency can be achieved through the market mechanism with the help of advance technology. This led to the assumption that there is no limit to growth as technology can overcome any such limits to growth.

### ***2.1.3 The rise of environmental concerns***

General public awareness concerning environmental degradation, such as pollution from nuclear activities, pesticides, chemical fertilizers, detergents etc., rose in the 1960's. This agenda was first raised significantly, scientifically and

publicly by Rachel Carson in 1962 as a modern issue in her epoch-making book “Silent Spring” (Guha, 1999). Being a biologist working for many years in the fields of fish and wildlife, Carson was worried about accelerating utilization of chemicals and pesticides to get more yields from crops. She worked for awakening people about the harmful effects of pesticides in agricultural fields, water and on forests. Another important and paradigm breaking article in this phase was Kenneth Boulding’s “*The Economics of the Coming Spaceship Earth*”. Boulding termed an ‘empty world’ a ‘cowboy’ economy and the future’s ‘full world’ a ‘spacemen’ economy where the earth has become a single spaceship, without having source of raw materials to extract or sink to pollute and so in such a situation, man must find his place in a cyclical environmental structure (Boulding, 1966). However proponents of this agenda although did not talk anything directly about the concept of SD but they tried to answer the question regarding the interaction between economic activities and natural resources. These works had brought in awareness about economy-environment interaction and its outcome and that limitless growth is not possible in a resource-limited sphere (Boulding, 1966). The reason, as stated by Daly and Farley (1994), Getzner (1999), is that the economy is existed as a ‘part’ or ‘subsystem’ of the ‘whole ecosystem’ i.e. of the environment (Figure 2.2).



**Figure 2.2 Economy is a part of the ecosphere**

Economy, therefore, cannot be expanded infinitely, because of the constrained put by accessibility of environmental resources (Daly and Farley, 1994; Lawn and Clarke, 2010; Asici, 2013). The rise of environmentalism of this era was worried about the *future* of mankind and about the requirement of putting restrictions on economic events generated from interaction between man, economy and nature (Stern, 1997).

#### **2.1.4 Environment and Resource Economics (1960s- 1990s)**

These environmental concerns led to the growth of two overlapping fields within neoclassical economics - environmental economics and natural resource economics. Environmental economics is concerned about 'sink', i.e. economy's insertion into the environment and the pollution problems; while natural resource economics is concerned about 'source', i.e. what economy extracts from the environment and the problems of allocation of resources. During this phase, the natural resources included air, water, agricultural resources (land, soil), renewable resources (forests, fisheries, and wildlife) and non-renewable resources (oil, metals and minerals).

Environmental economics is based on the ecology of the ecosystem. The prime focus of this branch of economics is to study the 'flow' of biotic and abiotic processes like rate of energy flows, the distribution and flows of biochemical substances in land and water ecosystems, and of gasses and particulates present in the atmosphere. Environmental economists study global warming, climate change, pollution, purification of water in watersheds etc. (Dasgupta, 2000). Such studies have provided valuable understandings of the effects of human-led activities on the sink services of the environment. In environmental economics, natural resources are valued in "quality" indices, e.g. soil quality, the freshness of the air, the salinity of water such as those for air, soil, or water (Dasgupta, 2000).

Resource economics, on the contrary, is a study of the natural environment, which deals with the relations and interdependence between human economies and

ecological systems. Issues associated with supply of natural resources into human sphere are prime concerns of this discipline. It wants to study the 'stock' of natural resources with the objective to develop methods of environmental management to ensure economic sustainability. In resource economics, stocks of natural resources are 'quantities' such as biomass units for forests, animal herd size (in numbers), acre-feet for aquifers, etc.

Though there are fundamental distinctions between these two paradigms, both study renewable resources, and insights from one field of study have helped to understand the other (Dasgupta, 2000). So after some time of their emergence, resource and environmental economics were merged. These discussions now form a part of the sustainable development discourse.

### ***2.1.5 'Limits to Growth' reinstated***

Although the thoughts of the classical economists did not receive much attention then, but they could foresee the potential threat from scarcity of resources even at the time when resources were available in abundance and there was no sign of scarcity. The environmental concerns of the 1960s led to almost a revolutionary movement. Environmental economists were mostly involved into it and tried to link the theory of external effects of human-led activities from an economic point of view. This movement started to give more emphasis on the seemingly inefficient activities of the contemporary economies. It also focused on changing lifestyle of people which started to consume more beyond basic requirements. Gradually, the unjustifiable style of life became identical with the hunt of economic progress, and many people started to think about adverse effects of such growth. But this movement was not new. The notion of absolute limits advocated by the classical economists was brought back and people started to reinstate that due to demographic and ecological constraints the economy cannot grow forever and there is a limit to growth.

This 'limit to growth' concept has become the title of a famous report called "*The Limits to Growth*" which was published by the "Club of Rome" in 1972. The report considered non-renewable resources. This report too accepted the contribution of technology by the following words:

*"Over the past three hundred years, mankind has compiled an impressive record of pushing back the apparent limits to population and economic growth by a series of spectacular technological advances"* (Meadows et al., 1972, pp. 129).

Nonetheless "*The Limits to Growth*" publicized for the first time the impression that growth could be restricted by the limited regenerative capacity of the natural capitals (Meadows et al., 1972). Using sophisticated computer simulation model, the authors focused attention on depletion of non-renewable resources and resulting increase in commodity prices. The report was about to search for a model to represent a sustainable global structure without unexpected strong breakdown; and is skilled to fulfill basic needs of people. So "*The Limits to Growth*" mainly talked about ecological limits assuming that population and industrial capital would grow exponentially, and consequently, there would be a similar growth in demand for food and non-renewables resources which apparently lead to growth in pollution (Ekins, 1993).

So the concept of outer limit, that if resources get depleted economy cannot grow, has thus emerged in this way among the mainstream economists. Till then there was no proper definition of SD. However, "*The Limits to Growth*" report used the word sustainability very meaningfully. In the *Introduction* of the report, the authors explained their concerns on sustainability. The continued growth patterns of global population, industrialization, environmental pollution, food production and resource degradation would limit growth by 2072 which might result in an unexpected and irrepressible fall in both population and industrial capability. However, it is not impossible to reach a stable and sustainable ecological and economic condition where each person would be able to meet his basic needs with equal opportunity. People should start working to achieve such a condition at the

earliest (Meadows et al., 1972). Though the term SD was not defined, ‘the limits to growth’ agenda very rightly could understand the relation between the environment and economy.

Environmental discussions became more important and essential because of the apprehension that economic growth might jeopardize the existence of the humankind and the earth. This anxiety gathered momentum during the 1960s with the publications of paradigm-breaking books and articles like Rachel Carson’s “Silent Spring” (Carson, 1962), Garrett Hardin’s “The Tragedy of the Commons” (Hardin, 1968), etc. Towards the last part of the 1960s, the environmental anxieties touched almost all parts of the Western world, where people usually thought about two factors responsible for environmental degradation- economic growth and growth of population (UNEP, 2003). These views were reflected in the Club of Rome’s global growth model for the future of the world which was constructed precisely to explore five key drifts-accelerating industrializations, speedily growing population, extensive malnourishment, degradation of non-renewable resources, and a worsening environment (Meadows et al., 1972, pp. 21).

## **2.2 Sustainable Development in the Neoclassical Era**

The environmental movement of the 1960s and the publication of “*The Limits to Growth*” had brought massive changes in people’s prevailing view on the economy-environment-development nexus and the debate shifted terrain. At around the same time in 1972, the “United Nations Conference on Human Development” (UNCHE) was held in Stockholm, which gave official importance to environmental management. Following this effort, the International Union for the Conservation of Nature (IUCN) in association with the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF) launched the World Conservation Strategy in 1980. It was actually the first attempt where the theme of Sustainable Development was coined (Moldan et al., 2012; Holden et al., 2014). After five years, this theme of sustainability was picked up by the

“World Commission on Environment and Development” (WCED) and reflected in its report *Our Common Future* as the most recognized definition of SD as “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, point no. 1, pp.41). This document is also known to be “Brundtland Report” as the commission was chaired by Gro Harlem Brundtland, the then Prime Minister of Norway.

The Brundtland Commission has come up with this definition of SD in an official manner in the neoclassical era (1980s) when technological optimism had been influencing the macroeconomic theories about economic growth and environment nexus (England, 2000). This was also reflected in the Brundtland Commission’s definition of SD. The report showed its strong faith on technology by these words, “*The accumulation of knowledge and the development of technology can enhance the carrying capacity of the resource base*” (WCED, 1987, point no. 10, pp. 42). The *Our Common Future* had denied accepting that growth is restricted by population and accessibility of resources crossing of which may cause an ecological disaster.

The Brundtland Report did recognize the ecological systems - water, species of plants and animals, forests, deserts, materials etc. But it ignored many goods and services of such ecosystems which are important for lives on earth; especially the life-supporting services, like carbon sequestration and recreational services, like-landscapes, waste absorption etc., of the environment.

Thus in the neoclassical era, the models related to SD look the environment as a source of capital that is available for creating wealth, and that the generations of the future time should be endowed with the capacity to wealth creation similar to the generation of the present time. Alternatively, the upcoming generation may be satisfactorily recompensed for any environmental damage by managing other sources of bringing affluence (Beder, 2000). Therefore there will not be any discontinuity in growth. This view of looking at the economy-environment

interaction is stated as 'weak sustainability' (WS). WS is the extended version of the neoclassical economic theory growth which accounts for non-renewable or exhaustible natural resources. The underlying postulate is that substitution is possible between natural capital and man-made capital (Getzner, 1999). According to WS view, the total capital stock must not decline and should remain at least constant for a development to be sustainable. The proponents of this view are concerned about satisfying growing population's needs and aspirations. Hence, the theories of growth are more focused towards means and measures to achieve materialistic growth of people. One renowned proponent of this view is Solow, whose growth model expected that technological advancements can improve the standard of living (England, 2000). Again while working with the investments of the resource rents, another proponent Hartwick wrote: "*no generation short-changes a future generation by depleting the stock of exhaustible resources without providing the future generation with, in some sense, the depleted stock equivalent in the form of reproducible capital*" (Hartwick, 1978, pp. 350). This talks about sustainability; but at the same time, it assumes that capitals can be substituted. Till 90s, policy discussions and environmental debates focused only on this simplified way of looking at developmental interactions with the environment. So, based on the neoclassical definition of capital stock and assumptions of sustainability, it can be said that an economy may be weakly sustainable, even if its environment is degraded, provided its total stock of capital is enough to compensate the monetary portion of the environmental loss.

### **2.3 Growth of Ecological Economics and Strong Sustainability (1987-2010)**

In 1968, Herman E. Daly wrote an essay to bring together some of the more salient similarities between biology and economics and to argue that, far from being superficial, these analogies are profoundly rooted in the fact that the ultimate subject matter of biology and economics is one, viz., the life process (Daly, 1968). This essay established, with the help of cost-benefit analysis, that economics is the part of ecology which is dominated by commodities and their

interrelations. These discussions laid the foundation of a trans-disciplinary field - *Ecological Economics*. The field *Ecological Economics* acquired momentum with the establishment of the journal “Ecological Economics” and raised several issues regarding the vagueness of the Brundtland definition of SD. In this context, Daly (1996) has given a more comprehensive definition of SD as “*a progressive social betterment without growing beyond ecological carrying capacity*”. If the rate of pollution and environmental degradation were at the same rate as an economic activity or population growth the damage to ecological and human health would be appalling. However, according to Goodland and Daly (1996), “a transition to sustainability is possible, although it will require changes in policies and the way humans value things”. Things, in this view, are natural resources (Daly, 2005). The proponents of Ecological Economics, like Daly, Nicholas Georgescu-Roegen, Ekins, Pearce and Atkinson etc., emphasized that environment performs four categories of functions<sup>5</sup> for which the total economic value is difficult to calculate. For them, the economy is only a ‘part’ of the ‘whole’ ecosystem which is finite and has now reached a stage where its regenerative and assimilative capacities have become very strained (Goodland and Daly, 1996; Wackernagel and Rees, 1997). So there is a complete change in the picture of the SD concept.

### **2.3.1 Full world economy**

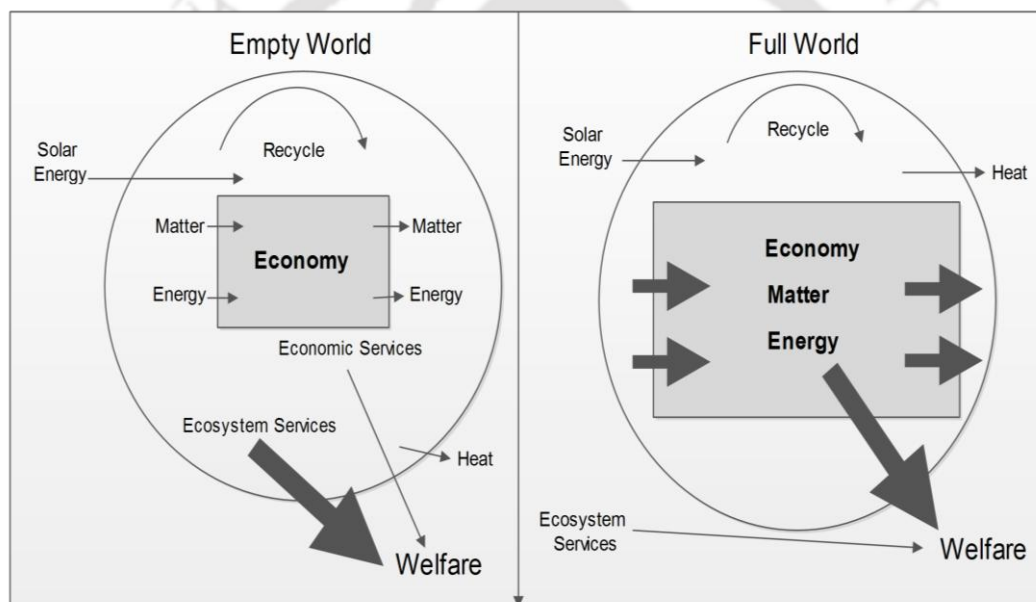
Before Industrial Revolution, as a subsystem, the economy was very small relative to the larger ecosystem. Resources were abundant and so the opportunity cost to the expansion of the economy was insignificant. This ‘empty world’ view has become inappropriate when human development approaches the carrying capacity of an existing ecosystem (Farina et al., 2003). Continuously growing material economy within the finite, limited ecosphere eventually has led to a ‘full world’ situation in which the ‘opportunity cost’ of growth is significant. One example of this full world situation is the shooting prices of oil. According to ecological

---

<sup>5</sup>Functions of natural capital are usually categorized as: (1) source of raw materials for production and consumption processes; (2) sink to dispose of the wastes coming out in both production as well as consumption processes; (3) amenities such as landscapes, tourist spots, ecotourism sites etc.; and (4) functions to support human life, as well as to support the previous three services (Pearce and Turner, 1990; Ekins et al., 2003).

economists, humanity has already arrived at this economy (*see* Daly and Farley, 1994).

Welfare to the society has two broad sources: services from the man-made capital (i.e. from the economy) and services from the natural capital (ecosystem services). In an ‘empty world’, welfare from the ecosystem services is more (thick arrow), whereas in a ‘full world’ economy it is less (thin arrow). These two situations are depicted in Figure 2.3, which is basic to ecological economics (Daly and Farley, 1994).



**Figure 2.3 From empty world to full world**

(Adapted from Daly and Farley, 1994)

In a full world, it is difficult to grow limitlessly. Because all economic production require a flow of natural resources generated by some stock of natural resources. This flow comes from ecosystem structure. The stocks are also funds that provide ecosystem services. Obviously an excess rate of flow affects both stocks and their services (Daly and Farley, 1994). Hence, the ‘full world’ situation hampers the ability of the natural resources to serve in the future.

### **2.3.2 Strong sustainability**

The proponents of WS looked at the environment as a source of natural capital, which has economic value in terms of money, and which can be extracted for the profit of humankind. Economists began looking at SD mostly from the perspective of WS after the works of some renowned scholars, like Dasgupta and Heal, Hartwick and Solow mostly (*see* Dietz and Neumayer, 2007). In their works, the proponents of WS have successfully applied the substitutability assumption of WS. Till the 90s, policy discussions and environmental debates focused only on this simplified way of looking at developmental interactions with the environment.

But this view was highly challenged in 1990s by the Ecological Economists who regarded the environment to be contributing more than just economic services which is non-substitutable by man-made wealth. They argue that forthcoming generations should not receive a ruined environment, no matter how many additional sources of wealth are accessible to them. This view is referred to as 'strong sustainability' (SS).

In this view, the economy is an open subsystem and the ecosphere is finite, non-growing and materially closed, where only solar energy can enter. The physical growth of the economy encroaches on the other parts of the finite ecosphere. So, if the economy is to be expanded, some important ecosystem function would have to be sacrificed (Daly and Farley, 1994). For example, the opportunity cost of getting highly priced timber is the carbon regulatory services of the trees. That means growth has cost and hence there is every possibility that at some point further growth may become uneconomic.

In 1999, Gowdy and McDaniel (1999) established, by taking the case study of Nauru, a small Pacific Island nation, that WS is a short-run concept. Nauru has acquired a good economic growth at the cost of its natural resource: phosphate. But as a result of its mining activities, 80 per cent of the island is totally

devastated, lands became unusable for habitat, many species have been extinct, much more became endangered and the nation has become dependent only on the Global economy (Gowdy and McDaniel, 1999).

So the proponents of SS consider that natural capital and manufactured capital are complimentary and only marginal substitution is possible between the two (Costanza and Daly, 1992; Daly, 1996; Stern, 1997; Gowdy and McDaniel, 1999) and have put emphasis on maintaining each capital separately, rather than just to maintain the total stock of capital (Figge, 2005). In defining SS, economists go deeper into the divisions of natural resources as renewable and non-renewable (Gowdy, 2000). To this view, technology is important, but as a means to develop, not the end. Technology cannot substitute the ozone layer. Instead proponents of SS blamed technology for all the losses to biodiversity (Costanza et al., 1997). To defend this view, they gave examples of new agricultural techniques such as use of pesticides, DDT etc. which solve the immediate threat to crops but their by-products accumulate in soil and water and adversely affect production and human health in return. These technologies are only short term measures to solve some problems, as Rachel Carson could see long before in 60s.

The SS concept is dominant in the ecological economics. Further to interpret and assess sustainability, ecological economics has presented a sequence of pioneering procedures, such as calculations of intergenerational fairness, distinctions between WS and SS, the assessment of ecosystem services, broadening our interpretation of ecological values along with mushrooming effort on measurements of SD (*see* Sneddon et al., 2006). In a nutshell, ecological economics may be treated as an effort to nourish and polish the noble idea of the broad vision of SD advanced by the Brundtland Commission. This branch of study has been trying to do this largely by bridging the gap between economics and natural science (*see* Norton and Toman, 1997; Sneddon et al., 2006).

## 2.4 Mainstreaming natural capital in decision making for Sustainable Development

Until 1970s, economy was considered as a ‘whole’ and the environment hardly played any role except as a ‘source’ and a ‘sink’. As already discussed in previous sections, after the publication of the *Limits to Growth* report, the prospects for sustainability shifted terrain. Mainstream economists showed their faith on technological optimism to increase economic inventories of natural resources (England, 2000). However in 1968 UN released the framework for SNA in the context of treatment of income from unsustainable use of natural resources (Dasgupta, 1990; Dasgupta and Maler, 1991). After this effort, many attempts were made to estimate natural resource accounts (Murty, M.N., Panda, M., 2016). Emphasis of environmental concerns in late 19<sup>th</sup> century was primarily given to air and water pollution with an immediate impact on the local surroundings (Daily et al., 2011). Pollution reduction is a costly business and so actions to reduce pollution occurred primarily in relatively wealthy countries (Daily et al., 2011). Since 1990s, the focus of the environmental issues has broadened by emphasizing the role of natural capital in the economic process. There was a growing realization that the economy is a part of the environment (Daly and Farley, 1994; Getzner, 1999). So, the economy is unable to expand limitlessly as growth is restricted by the accessibility of ecological goods and services (Daly and Farley, 1994; Lawn and Clarke, 2010; Asici, 2013), which is an important capital for economic prosperity. This focus on natural capital brings out the various dimensions of human well-being that hinge on living natural capital (Daily, 1997). Although Brundtland Report has not used the term ‘natural capital’ but it does recognize that there is an inequality in using planet’s ecological capital which is the planet’s core ‘environmental’ as well as ‘development’ problem and that the future generation has to bear the losses of such inequality.

United Nations have defined natural capital as natural assets which provide natural resource inputs and environmental services for economic production, comprised of natural resource stocks, land and ecosystems (UN, 1997). This

definition also has its limitation as it looks at natural resources as service provider for economic production and thus come from a 'weak sustainability' viewpoint. However, there has been a growing recognition in the recent decade, that the functions of the natural capital as 'ecosystem services' is not only to provide raw materials to and absorb waste of the economy but also to serve humanity with beautiful landscapes and life supporting services which are non-substitutable by man-made capital. As defined by Costanza and Daly (1992), natural capital is the stock of natural resources that provides a flow of treasured goods and services for the forthcoming generation. Hence natural capital is crucial for sustainable development as stock of natural resource is able to yield sustainable flow of goods and services when it is allowed to be regenerated. Therefore like other forms of capital, there is a need to maintain natural capital for the benefit that flows from ecosystem services by investing in natural capital. The central focus of the concept of sustainable development is the development of human kind of both present and future. For development and survival of human, resources are essential. Till now the SD agenda worries about natural resources as only source of materials to enhance development and as sink to absorb wastes. But hardly natural resources are looked from the capital approach. Capital means capable of more production. More production gives prosperity and welfare (Hinterberger et al., 1997). So, if natural resource serves as the capital for development, then the stock of capital should also be sustainable to enable the future generation to use them for their welfare. Therefore mainstreaming natural capital into the environmental and development policies is now a new paradigm in the whole agenda of sustainable development. This is supported by the ecological economics where biophysical limits to economic growth has taken root and which advocates for conserving natural resources for socio-economic sustainability. Mainstreaming of natural capital is a 'strong sustainability' concept as it advocates for maintaining natural resources separately.

## **2.5 Summing up**

The objective of this chapter was to give an overview of the evolution of the concept of sustainable development since 17<sup>th</sup> to the 21<sup>st</sup> century. A review of

literature shows that the concept of SD has been evolving with the changing global situation and there is a need for further research to understand this concept completely. This conceptual definition has opened up many new definitions, discussions and controversies among scholars. But it is also accepted that the Brundtland definition has turned the need for integration of environment and development for ensuring the welfare of the future generation, into a global agenda and has shifted the concept of SD from the conventional development paradigm (Munasinghe, 1993) to an ecological-based development by “leading beyond concepts of physical sustainability to the socio-economic context of development” (Adams, 2001). All the interactions, discussions, criticisms and experiments have contributed lot to create a global awareness on the fact that we are living within the limits put by the environment and we have to preserve the natural resources, not only for the future generation, but for the present generation too. Though SD is said to have three pillars - economy, society and environment, sustainable economic development is regarded as the main concern to achieve social welfare and to produce resources (Azam et al., 2015) from the perspective of utility. Economic growth is still being taken as the main instrument to eradicate the most fundamental challenge to human civilization - *poverty*. But growth, in terms of gross domestic product (GDP) can not be a complete measure of SD. Because GDP never takes into account the cost of environmental degradation. Declining natural capital poses a direct threat to the lives of that section of the rural poor in developing nations which still earns their livelihood from the nature (Dasgupta, 2010). Although the importance of natural capital is recognized by both poor and rich countries alike, but the poor and developing economies, faced with multidimensional realities, often degrade their natural capital while working for achieving economic development. They tend to follow a growth path of developed countries as economic growth can help them to eliminate multi-dimensional poverty. Most of the developing countries, particularly in Asia, have to feed majority of the world population. Further, societies of these countries are vulnerable to many social evils like illiteracy, lack of medical facilities, unemployment, disparities, inequalities among rich and poor as well as to natural calamities like flood, climate change, drought, desertification etc. Hence to meet these multiple challenges, natural capital is under threat, due to growing demand

for food, water, energy and materials, as well as the to fulfill the need for land for towns, cities and infrastructure (APFED, 2010; Dahiya, 2012; WWF and ADB, 2012). With the growing population and changing lifestyle, the pressure on the environment in the evolving Asian economies is likely to increase in the future. Strategies will be needed that will ensure sustainable use of resources as well as effective way to maintain the natural capital.



## Chapter 3

# Research Methodology

---

### 3.1 Introduction

This chapter offers a description of the study area, the data used for the study and the sources from where the data was obtained. The chapter also discusses the methods applied to achieve the objectives of this thesis along with the limitations of the methods and the data used.

### 3.2 Description of the study area

#### 3.2.1 *The study region: Asia*

Growing economically has become the most influential tool for dropping scarceness and enlightening the standard of living in emerging nations. Rapid and sustained growth is crucial for developing countries to achieve MDGs. Although significance of natural capital is documented by both poor and rich countries alike, but for poor and developing economy, faced with multidimensional realities, preserving the environment is still seen as a constraint and not as an opportunity for sustained economic growth. These countries seem to treat economic growth as a solution to various socio-economic problems and to eliminate multi-dimensional poverty.

Many of the developing Asian economies have developed remarkably over the last four decades. As Lee and Hong (2012) have suggested, developing Asia comprises of twelve emerging economies- “the People’s Republic of China; Hong Kong, China; India; Indonesia; the Republic of Korea; Malaysia; Pakistan; the Philippines; Singapore; Taipei, China; Thailand; and Viet Nam”, as these countries altogether contribute about 95% of developing Asia’s GDP. Industrialization and international trade were very rapid in the sub-regions of Northeast Asia, South Asia, and Central Asia since 1998. 4 to 8% growth rate has

been recorded annually in these regions which is quite high. In Southeast Asia, though the annual GDP growth rate fell significantly in 1998 due to the Asian monetary catastrophe, it exceeded 4% in 2002 and recovered fruitfully from the economic downturn. Pacific nations' GDP growth rates are comparatively lower than the rest of the Asian region. According to Lee and Hong (2012), Asia's real GDP in purchasing power parity (PPP) terms increased from about \$3.3 trillion in 1980 to a projected \$24.5 trillion in 2009- almost 7.5 times increase, compared to only 3 times increase in the global economy. Such magnificent economic growth has helped many Asian countries to reduce poverty and to increase their influence in the global economic platform.

According to many projections (*see* APFED, 2005; Galli et al., 2012), current economic Asian trends are likely to last, or enhance even more swiftly in the next 10-12 years compared to other regions of the world. It could become the most dynamic region and a growth centre for the world by 2025. Asia's economic expansion, over the last 40 years, is being supported by the region's richness in natural resources (APFED, 2005). Human actions related with such extension have already placed too much pressure on the environment, resulting in serious environmental degradation, which now poses a grave risk to the region's growth projections, thus establishing a clear hindrance to achieving sustainable development. Therefore, it is critical to achieve sustainable development in this region so that sustainable development can be achieved globally.

The Global Environment Outlook 5, i.e. GEO-5 describes Asia, along with the Pacific countries, as the most expanding economic region in the world, with "*unsustainable growth, population increase, increased consumption and urbanization*" which are the challenges of the region's sustainability (UNEP, 2012). This report has brought very alarming results that if the present trend continues at least till 2030, this region will have 45% share to the global energy-driven carbon dioxide (CO<sub>2</sub>) releases and by 2100 this figure will reach up to 60 per cent. In another study conducted by Lee and Hong (2012), it is found that developing Asia has achieved its tremendous growth over the last 30 years (the

80s onwards) mainly by accumulation of resources. Another important work on the growth-environment linkage in Asia is that of Ian Coxhead (2003). Taking 13 developing Asian countries<sup>6</sup>, Coxhead found that rapid economic growth is a threat to sustainable development to these countries and the cost of increasing environmental and natural resource problems, in these countries, will ultimately reduce the capacity of the region for future growth (Coxhead, 2003). The study also highlighted the lack of integration of environmental policies with mainstream economic policies such as trade, investment etc. and since natural resources are unprotected by effective property right institutions, it gives a larger scope to the trade policies to distort the natural resources leading to its depletion.

Thus, Asia is represented as a region with high economic growth rate, large population and accelerating population growth rate which is greater than the global population growth rate of 1.15% in 2014 (Bank, Population growth (annual %), 2016b) and high rate of urbanization. However, this is accomplished at the cost of high rate of environmental degradation including carbon dioxide emissions. For example China's GDP growth rate in 2010 was 10.4% (average growth rate from 1961 to 2010 is 10.3%), but it was the single largest emitter of greenhouse gases worldwide in 2009, emitting 6.8 billion tons of CO<sub>2</sub> (ESCAP, 2012). Similarly, water scarcity and degradation of forest have also become serious threats in the Asian countries. Countries like Singapore, Maldives, India, Afghanistan, Papua New Guinea, the Republic of Korea and Pakistan (APFED, 2010) are facing severe water crises and the land area covered by forests also decreased manifold in many Asian countries like 16% points in Indonesia, 14% points in Cambodia, 11% points in Philippines, and 10% points in Myanmar. Natural resources are required for production and to maintain a given population. But when there is an increase in the population it may affect those resources. The 'overpopulation' school favors growing population as the core issue behind unsustainable use of natural resources which in turn results in depletion of the environment (Brander, 2007).

---

<sup>6</sup>These countries are "Bangladesh, Cambodia, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam".

### ***3.2.2 The environmental concerns in Asia***

Many researchers like Callicot and Ames, Guha, Paul Pedersen etc. have proven that Asian people are very close to the environment (*see* Yencken, 2000). Many Asian cultures restrict unsustainable usage of environmental resources (Kalland and Persoon, 1998). In spite of such a pleasant association with environment, as the ADB Report (1997) stated that *“Asian region has lost almost 50 per cent of its forest cover and countless unique animal and plant species during 1960-90s and that no other region has as many heavily polluted cities and rivers and lakes as this region has. This is because the economic growth in the region is fuelled by the region’s rich natural resources and services”*. For example in Thailand, economic events like rubber estates, shrimp farming and cash-crops are contributing to GDP at the disposal of natural resources like woodlands, jungles and coastal area ecosystems. In the Philippines, two natural resource-based economic activities are prominent - mining and change in forest land cover into croplands (Coxhead, 2003). Water consumption is another human activity which is alarmingly increasing. As per the ESCAP (2007) report *“China, India, Pakistan, Indonesia, the Russian Federation, Bangladesh, Thailand, Viet Nam and Iran are the largest consumers of water resources with water withdrawal as high as 70 billion cubic meters per year”*. On the other hand, the Statistical Year Book for the Asia and Pacific 2012 writes that, Asia produced more energy than any other region in the world in 2009, accounting for 46 per cent of total global production. At the same time, the region accounted for 50 per cent (up from 38 per cent in 1990) of the world’s total CO<sub>2</sub> emissions in the same year. China has been the single largest emitter of greenhouse gases worldwide (UN-ESCAP, 2011; UN-ESCAP, 2012). Asia is vulnerable to natural calamities. Around 75% of the world’s most destructive natural catastrophes during the period 1970-1997 have been recorded to be occurred in Asia, *“mostly in poverty-ridden developing countries”* (UN-ESCAP and ADB, 2000). The intensities and effects of all these calamities have increased due to some reasons like high rate of population growth and its high concentration, urbanisation, environmental degradation and climate change (APFED, 2005).

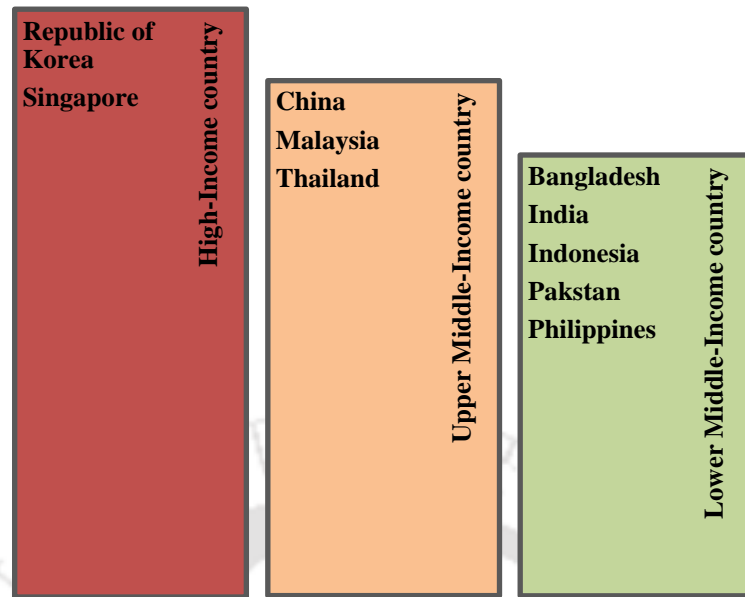
Hence, Asia has become the fastest growing economy with severe environmental damages, high population growth rate and urban growth rate, which are challenges to sustainable development (UNEP, 2012). In this context, the primary motive of this study is to examine using empirical analysis Asia's demand for nature in the last 4 decades, the status of the natural capital along with human capital and to analyze the path of sustainability – weak or strong - followed by Asian economies. The study also examines the underlying factors behind the growth pattern and tries to understand what the future holds for these emerging economies.

### 3.3 Selection of the countries

The Asian region comprises of more than thirty (30) countries. It is beyond the scope of this thesis to study all. Hence, for this study, ten Asian countries were selected based on their per capita income, GDP growth rate, population (more than 1 million), the rate of urbanization and the status of environment. The selection of the countries based on the above mentioned selection criteria are given in Appendix 1. The ten countries chosen for this study are – “*Bangladesh, China, India, Indonesia, Malaysia, Pakistan, the Philippines, Republic of Korea, Singapore and Thailand*”. The selected countries were then grouped into three income groups based on the World Bank classification<sup>7</sup> (Bank, New Country Classifications, 2015) and are shown in the flow chart below (Figure 3.1).

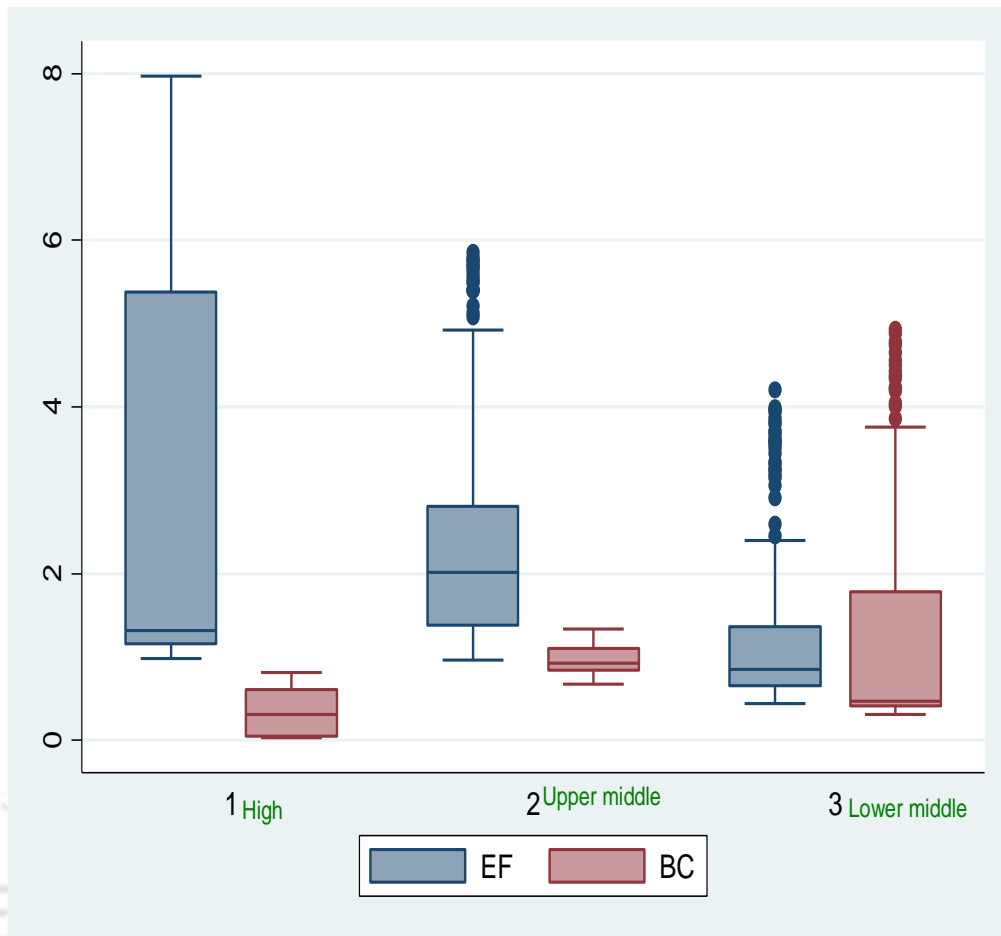
---

<sup>7</sup>The World Bank has applied this classification to 188 World Bank member countries and all other countries having more than 30,000 people. The classification was done according to 2014 gross national income (GNI) per capita, and calculated using the *World Bank Atlas* method. According to this classification low-income (LI) economies are ones in which GNI per capita is \$1,045 or less; lower middle-income (LMI) economies are those in which GNI per capita is between \$1,046–4,125; upper middle-income (UMI) economies are those where GNI per capita is between \$4,126–12,735; and high-income (HI) economies are ones in which GNI per capita is \$12,736 or more.



**Figure 3.1 Selected Asian countries according to income group classification**

The classification of the selected countries into income groups was done because the selected Asian countries are in differential stages of development in terms of per capita income, economic growth, urbanization and environmental degradation. As shown in Figure 3.2, the demand for nature (ecological footprint) and its supply (biocapacity) also takes different forms in different income groups within Asia. Therefore it may be too ambitious to assume that economic growth of all countries irrespective of their income has the homogenous impact on the natural resources and on environmental degradation (Asici, 2013). Moreover there is also a possibility that a high-income country would not have similar environmental consequences as that would be felt in middle and low-income countries (Muradian and Martinez-Alier, 2001).



**Figure 3.2 Distribution of ecological footprint (EF) per capita and biocapacity (BC) per capita across income groups: 1970–2010**

### 3.3.1 High-income countries

The two countries under this income group are Republic of Korea and Singapore. These two countries are East Asian countries. Like other East Asian countries, Republic of Korea and Singapore had witnessed a strong economic transformation in the 2<sup>nd</sup> half of the 20<sup>th</sup> century resulting increase in per capita income (Shrestha, 2013). However, these countries have faced a severe economic crisis in 1997-98 due to East Asian crises, since then there has been a slowdown in their economic growth.

Republic of Korea's GDP is the 11<sup>th</sup> in the world and that of Singapore's is 36<sup>th</sup>. Singapore and Republic of Korea are trade partners (Yue, 2005). As per the World

Bank development indicators (2014) database, Republic of Korea earns almost 38.2% share of GDP from heavy industries like electronics, telecommunications, automobile production, chemicals, shipbuilding, steel and exports to the United States, China, Japan, Hong Kong and Singapore. The country imports goods like machinery, electronics, electronic equipments, oil, steel, transport equipment, organic chemicals, plastics etc. from the countries like China, Japan, United States, Saudi Arabia, Qatar, Germany.

For Singapore, electronics, chemicals, oil drilling equipments, petroleum refinery, rubber processing and products, processed food and beverages, ship repair, construction, life sciences, trade, tourism are the major industries. Malaysia, China, Hong Kong, Indonesia, United States, Japan, South Korea are its export partners as well as import partners except Hong Kong and Indonesia.

### ***3.3.2 Upper middle-income countries***

The countries chosen in this group are China, Malaysia, and Thailand. All are East Asian countries. All of them are characterized by high growth transitional economy moving from agriculture towards industrialization. Within a short period of time, they have reached upper middle-income status (Shrestha, 2013). All these three countries export and import goods among themselves as well as with other Asian countries. In 2014, all the three countries under this group have more export than their imports.

At present, China is the largest (in PPP) and the most advanced economy in the world (Bank, 2016a; Knoema, 2016). As per the World Bank development indicator (2016), industry's share of China to its GDP is almost 42.7% in 2014 and its main industries are mining and ore processing, iron, steel, aluminium, coal, machine building, textile, petroleum, automobiles, rail, cars, consumer products and much more. Most of these industries are extractive in nature from the environment. United States, Japan, South Korea are some of its trading partners. China is mainly an export-oriented country which exports almost every single category of industrial products.

Malaysia's growth model is ideal among ASEAN nations. Malaysia produces electronics, pharmaceuticals and petroleum. It also processes logging, timber, rubber and palm oil resulting in massive deforestation in the country. Along with these Malaysia exports wood and wood products.

Thailand achieved the UMI status within a very short period of time. During the initial stage of economic development, the country protected the domestic firms from foreign competition through import substitution (Shrestha, 2013). But soon, especially after the stable political reforms of 1997, Thailand's economic growth accelerated and now in 2015, it is the 20<sup>th</sup> in terms of PPP (Bank, 2015). Thailand is earning good revenue from rubber plantation, shrimp farming and cash-crops (APFED, 2005). Fishery products are its important export goods. All these economic goods are acquired at the cost of natural resources like forests and coastal ecosystems. The fuels Thailand uses are imported, mostly from the United Arab Emirates. One-third of its total GDP comes from manufacturing sector which is highly polluting and CO<sub>2</sub> emitting sector.

### ***3.3.3 Lower middle-income countries***

The countries under this group are Bangladesh, India, Indonesia, Pakistan and the Philippines. Bangladesh, India and Pakistan are South Asian countries whereas Indonesia and Philippines are East Asian countries. These countries are less-developed yet resource-rich. Population is very dense in this region: average density of these five countries is 474 per km<sup>2</sup> in 2014 as per World Bank database calculation. Unlike the other two income groups, imports are more than exports in the lower middle-income group.

Poverty in Bangladesh is profound and extensive (Aminuzzaman, 2010). But presently, Bangladesh's economy is flourishing. From 2011 onwards, its GDP growth rate has been showing above 6%. Following the similar trend of other industrializing Asian countries, 30% of its GDP share is occupied by industries like textiles, jute, steel, pulp and paper, leather, natural gas etc. (Hossain and Tamim, 2006). It is noticed that Bangladesh exports goods to mostly European

countries and the United States; but imports from Asian countries-China, India, Singapore, and Malaysia.

India is the 2<sup>nd</sup> most populous country and the 3<sup>rd</sup> greatest economy (in PPP) in the world (World Bank, 2016b; Knoema, 2016). The estimated growth rate for 2016 is above 7. Some other important industries are: petroleum products, chemicals, textiles, steel, machinery, cement, mining, etc. Trade partners of India are China, UAE, European Union, Saudi Arabia, Hong Kong and Switzerland.

Indonesia is also a big economy of East Asia and 8<sup>th</sup> largest economy (nominal) in the world (Bank, Gross domestic product 2014, PPP, 2015). Almost all of its main industries are heavily dependent on natural resources, like petroleum and natural gas, textiles, mining, cement, plywood, rubber, food and tourism. Indonesia trades with Asian countries and with the United States. The Indonesian economy is export oriented.

Pakistan is also a densely populated country and its economy is not very rich (GDP growth rate 4.4% in 2014). Pakistan's economy is dependent mainly on agriculture. 25.1% share of GDP comes from agriculture whereas industry's share is less: 21.3%. Pakistan's export is the lowest among all the selected 10 Asian countries. The country has trade relation with China, UAE, Saudi Arabia, Malaysia, Kuwait, United States, Afghanistan, and Germany.

The Philippines is a poor but flourishing and rapidly industrializing country. The country is rich in natural resources and so many industries depend directly on these resources, like wood products, food, petroleum refining, fishing etc. In the Philippines, mining activities and forest conversion for agricultural expansion are two major economic activities based on its natural resources. The country maintains export - as well as import relations with many Asian countries and with US and Germany.

## 3.4 Description of data

### 3.4.1 Indicators for weak and strong sustainability

In 1992, the “*United Nations Conference on Environment and Development*” held in Rio de Janeiro, recommended that sustainable development indicators should be developed which can be utilized in decision-making process (Nourry, 2008). Since then, scholars from divergent fields have described the requirement and methods of assessing sustainable development with the help of various indicators. Many composite indicators have been created to quantify the sustainability of the on-going development. Though, the debate about constructing the best comprehensive indicator of sustainability is still going on. Till now, no single indicator could perform a perfect job to represent sustainable development (Pillarisetti and van den Bergh, 2007; Nourry, 2008).

Studies have been applying various indicators for the purpose of assessing sustainability (Singh et al., 2009; Lawn and Clarke, 2010). Some of the most widely used indicators on the income-environment nexus are - Genuine Savings (GS), renamed as Adjusted Net Savings (ANS) (Hamilton and Clemens, 1999; Nourry, 2008; Mota et al., 2010; Asici, 2013; Kubiszewski et al., 2013; Greasley et al., 2014); Green National Net Product (GNNP) (Nourry, 2008; Mota et al., 2010); System of Environment-Economic Accounting (SEEA) (Dietz and Neumayer, 2007); Index of sustainable and economic welfare (ISEW) (Nourry, 2008); Ecological Footprint (EF) (Parker, 1998; Wackernagel et al., 2004a; Lammers et al., 2008; Nourry, 2008; Hubacek et al., 2009; Begum et al., 2009; Galli et al., 2012; Wang et al., 2012); The Environmental Sustainability Index (ESI) (Pillarisetti and van den Bergh, 2008; Hara et al., 2009); Environmental Performance Index (EPI) (Yale Centre for Environment Law & Policy, 2010); Environmental Vulnerability Index (EVI) (Kaly et al., 2004; Barnett et al., 2008) etc.<sup>8</sup> Many of these indicators have been used to measure weak and strong sustainability. For example Mota et al. (2010) have used GS (or ANS) and GNNP

---

<sup>8</sup>A detailed review of the literature where the above mentioned indicators are used is presented in Appendix 2.

for assessing weak sustainability in Portugal during 1990-2005; GNNP, GS, ISEW and GPI are used as weak sustainability indicators and the EF as a strong sustainability indicator by Nourry (2008) to assess sustainability of France; EF is used as strong sustainability indicators by many researchers like Wackernagel et al. (2004a), Lammers et al. (2008), Begum et al. (2009), Galli et al. (2012) etc.

However to examine the weak and strong sustainability studies have mostly used Ecological Footprint as an indicator for SS and Adjusted Net Savings as an indicator variable for WS<sup>9</sup>. This is because all the 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 policy performance to reduce environmental stress on human health and to promote natural resource management (such as EPI) (Singh et al., 2009).

Hence, in this study, trend of ANS in the selected countries will tell the status of the total stock of capital and EF will provide the status of natural capital for the selected countries. This will also depict Asia's demand for nature in the study period to achieve the high economic growth.

### ***3.4.2 Ecological Footprint approach***

The approach of ecological footprint offers an accounting system tool to measure one vital characteristic defining the resource dimension of sustainable development. This system tracks how much natural capital is demanded for man-made products against available natural resources. The tracking is done in terms of regenerative capacity of the existing natural resources (Galli et al., 2014). In this ecological accounting system, two important ecological indicators are used:

---

<sup>9</sup>Appendix 3 depicts selection of EF and ANS as indicator for Weak and Strong sustainability.

*Ecological footprint (EF)*: It is the demand of a population for natural capital. EF quantifies the biologically productive land and sea - that a population needs to fulfill its materialistic as well as life-supporting needs.

*Biocapacity (BC)*: Biocapacity is regarded as the supply which tracks the ecological resources and their regenerative capability to yield renewable natural capital and ecosystem services.

In this methodology, surface area of the earth is used as a measure of life-supporting natural capital. The reason behind doing so, as Monfreda et al. (2004) argues, is that many primary ecosystem services are determined by the surface areas, land or sea, of the earth where photosynthesis takes place. Six types of land or sea areas are considered as providers of different natural resources and ecosystem services:

*(1) cropland which provides plant-based food and fibre products; (2) grazing land for provisioning animal-based food and other products from animals; (3) fishing grounds (marine and inland) to provide fish and other fish-based commodities; (4) forest land for the provision of timber and other forest products; (5) carbon uptake land to assimilate anthropogenic CO<sub>2</sub> emissions; and (6) built-up land, which is the land lost for shelter, development and other infrastructure* (Galli et al., 2012; Borucke et al., 2013).

All these land types have different productivity and features. But EF methodology expresses these variations of land productivities in one single unit called global hectare (gha henceforth) which is defined as a hectare of naturally productive land or sea area with average global productivity in a certain year (Monfreda et al., 2004; Borucke et al., 2013). The advantage of using this unit is twofold. First, it permits the addition of ecological footprint or biocapacity of different land types; second and the most importance is that due to this standard unit, global sustainability studies can compare EFs and BCs across countries (Wackernagel et al., 2004b; Borucke, et al., 2013).

Thus, EF quantifies human demand and BC acts as an ecological yardstick and quantifies nature's ability to meet this demand of humanity (Galli et al., 2014). By comparing EF and BC, one can study to what extent earth's regenerative capacity, which is a consistent representation of the life-supporting service of natural capital (Monfreda et al., 2004), has been used up to fulfill humanity's consumption demand. If such comparison finds biocapacity to be larger than ecological footprint, the situation is called reserve; conversely a deficit occurs when EF is higher than BC (Galli et al., 2012).

Hence, EF is perhaps the most comprehensive indicator for measuring the fundamental conditions for sustainability (Galli et al., 2012) and EF has the same assumptions as the SS view. The World Wildlife Fund (WWF) has marketed EF and its data is also available in its reports (Pillarsetti and Van den Bergh, 2007). For this study the data on EF and BC was obtained directly from the Global Footprint Network (GFN henceforth)'s National Footprint Accounts (GFN, 2014).

The equation for calculating EF and BC are respectively

$$EF = \frac{P}{Y_N} \cdot YF \cdot EQF \dots\dots\dots(i)$$

$$BC = A \cdot YF \cdot EQF \dots\dots\dots(ii)$$

where P is the weight of product harvested,  $Y_N$  is the annual average yield for production P, and YF and EQF are the country-specific yield factor and equivalence factor respectively. Since productivity of each land type is different locally and globally, a yield factor is used for each land type to handle this difference. The different land use types are then converted into global hectares using equivalence factors (EQFs)<sup>10</sup> for each land use type (Borucke et al, 2013).

---

<sup>10</sup> *Equivalence factor (EQF)*:- Units of different land use types are different. So to facilitate a common unit, equivalence factor is used which allows land of different types to be converted into the common unit of global hectares. The EQF itself is a productivity-based scaling factor. These equivalence factors are based on assessments of the relative productivity of land under different land types in any given year. EQFs vary each year according to different land use types.

For biocapacity, the calculation utilizes the area 'A' of land in that land-use type (cropland, forest land, grazing land, etc.), multiplied again by the yield factor and equivalence factor as shown in the above equation for BC.

The input data and the accounting framework for calculating EF and BC for average residents of any country are given in Appendix 4 (a) and 4 (b).

### **3.4.3 Adjusted Net Savings**

Adjusted Net Savings (ANS) was developed by D.W. Pearce and G. Atkinson in 1993. ANS relies on the 'weak sustainability' theory, which assumes that physical capital, natural capital and human capital are substitutable (Pillarisetti and van den Bergh, 2007). Adjusted net savings are equal to net national savings plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, and carbon dioxide. So ANS gives the status of total stock of capital at a particular year in a particular country. The WB calculates ANS for each country every year because investment in education and depreciation of natural resources vary in each year. This series of ANS considered in this study excludes particulate emissions damage (Bank, 2014).

Amongst all the WS indicators, ANS has been considerably recognized as the best indicator due to the following causes: (i) ANS was proposed and circulated by the World Bank; (ii) wide-ranging statistics are accessible for nearly all nations from 1960; (iii) it is capable of elaborating variations in ecological sustainability in a more efficient and reliable manner than the other similar indicators (Asici, 2013); (iv) the 'natural disinvestment component' of ANS is estimated within the country wherever withdrawal/production is originated; (v) it is flexible towards any further improvements (Mota et al., 2010). The main components of ANS are produced or manufactured capital, human capital such as knowledge, skills, etc. and natural capital. In this methodology all values are monetized and expressed in a common monetary unit of percentage of gross national income (GNI) and summed up as (Pillarisetti, 2005; Thiry and Cassiers, 2010)

$$ANS = \frac{GNS - D_p + EDU - \sum R_{n,i} - CO_2 \text{ Damage} - PM10 \text{ Damage}}{GNI}$$

Where,

$GNS$  = Gross National Savings,

$D_p$  = Depreciation of physical capital,

$EDU$  = current expenditure on education,

$R_n$  = Rent from depletion of  $i^{\text{th}}$  natural capital (energy, mineral and forest depletion are included). An economic rent represents the excess return to a given factor of production

$CO_2$  damage = Damage from carbon dioxide emissions (currently estimated at US\$20 per ton of carbon times the number of tons of carbon emitted),

$PM_{10}$  damage = Damage from particulate matters;

$GNI$  = Gross National Income at market prices

The method that the World Bank follows to calculate ANS is described in Appendix 5.

### 3.5 Data analysis

The time chosen for the study is 1970-2010. This study looks into 10 countries (cross-sectional units) for 41 years (time-series).

The study used two methods to analyze the data: a time series trend analysis, and a panel data analysis. Method and the justification behind each of these analyses are discussed below.

### ***3.5.1 Time series trend analysis***

The time series trend analysis allows one to know what happened in the past and also provides an idea of what will happen in the future. This method is used in several studies for a particular country, countries, or region for the purpose of sustainability assessment. Some worth mentioning studies are Haberl et al. (2001), Erb (2004), Wackernagel et al. (2004), Lammers et al. (2008), Nourry (2008), Begum et al. (2009), Galli et al. (2012), Pereira and Ortega (2012), Geng et al. (2014) etc. All these studies mainly demonstrate that the concerned country's expanding economy has increased the pressure on the environment by its enlarged demand for natural capital. Gao and Tian (2016) used this method to assess the influence of resource exploitation on natural capital.

A trend analysis was conducted in this study first to examine the path of sustainability and the status of the natural capital based on its demand and supply, using time series data of 41 years (1970-2010). The trend analysis for adjusted net savings (ANS), ecological footprint (EF) and Biocapacity (BC) allowed examining the path of growth the chosen countries have been following and its impact on total stock of capital, natural capital and biocapacity. Further the trends of the components of EF, i.e. crop land, grazing land, forest land, fishing ground, carbon uptake land and built-up land were also plotted to see which component makes a significant contribution to the countries' per capita EF.

### ***3.5.2 Panel data analysis***

Panel data refers to the pooling of observations on cross-sectional observations over several time periods (Baltagi, 2005). Panel data analysis is considered more sophisticated compared to simple regression time series analysis (Barua, 2009) as it includes both the cross-sectional and time series data and can measure effects from unobserved variables better than time series or cross section. In addition, panel data set also follows the same cross-section units over time.

A panel data have observations on the same units (or entities) over several different time periods (Park, 2011) i.e. in panel data the same cross-sectional units are surveyed over time. Since this type of arrangement pools data for both space (entities) and time, it is also called pooled data (Gujarathi and Sangeetha, 2007). The regression models used for panel data are generally known as “panel data regression models”. A cross-sectional regression analysis would be able to provide information on how the individual countries have performed in one particular period of time (say for the year 1970) in terms of the demand on natural capital-EF. Therefore, the information through cross-section analysis will be useful to just understand how in that particular year one country has performed in comparison to another country. However, it fails to provide any information as to how one country itself has performed over the years. On the contrary, information for one country over the 41 years, say, can be obtained by time series analysis; but not how it has performed over the years in comparison to the other country. Heterogeneity is always there in the time series or cross-section data. Panel data estimation techniques can take care of such heterogeneity problem by allowing for individual (country here) specific variables and can examine fixed effects and/or random effects in the longitudinal, i.e. panel data (Park, 2011).

Panel data includes both the cross-sectional as well as time series data. In other words, it considers variation from one country to another (inter-country) as well as variation within each country over time (intra-country) (Barua, 2009). In this way, panel data can be able to give more information on the variables, less collinearity among the variables, more degrees of freedom and more efficiency (Baltagi, 2005).

This study looks into 10 countries (cross-sectional units) for 41 years (time series). The data has two dimensions - space and time and hence constitutes a panel data. So panel data estimation techniques are used to fulfill the research

objective. This study has a balanced<sup>11</sup> panel data having 410 (10 x 41) data points in total.

### 3.5.2.1 Basic panel data regression model

Based on the above discussion, the basic panel data regression model can be given as

$$y_{it} = \alpha + X'_{it}\beta + u_{it} \quad (1)$$

It is different from cross-section or time series as it has double subscripts,  $i$  and  $t$ , denoting individuals (cross-section) and time respectively. There are  $k$  regressors or explanatory variables in the model,  $\alpha$  is a scalar,  $\beta$  is a  $k \times 1$  vector of coefficients of  $X$ s.  $X_{it}$  is the  $it^{\text{th}}$  observation on  $k$  explanatory variables. Panel data models examine ‘group effects’ (i.e. effects due to individuals), ‘time effects’, or both (Greene, 2012).

### 3.5.2.2 Error component model

Most of the panel data applications utilize a one-way error component model for the disturbances where the error is decomposed in two components, like the following

$$u_{it} = u_i + \varepsilon_{it} \quad (1.1)$$

where  $u_i$  denotes the unobserved time-invariant individual-specific effect that is not included in the regression model and  $\varepsilon_{it}$  denotes the remainder disturbance which varies with individuals and time and can be thought of as the usual disturbance in the regression.

Replacing (1.1) in (1) we get

---

<sup>11</sup>*Balanced and unbalanced panel*: If each cross sectional unit has the same number of time series observations, then the panel is called a *balanced panel* (Gujarathi and Sangeetha, 2007). Again if the number of observations differs among panel units, it is termed to be unbalanced.

$$y_{it} = \alpha + X'_{it}\beta + u_i + \varepsilon_{it} \text{ --- (1.2)}$$

The key objective of the panel data analysis is to estimate consistent and efficient estimators of the partial effects, i.e. regression coefficients:

$$\beta = \frac{\partial E[y_{it}/x_{it}]}{\partial x_{it}}$$

This is done depending of the assumptions about the unobserved effects- $u_i$ s. Different panel data estimation methods thus can be used. The most popular are below.

### 3.5.2.3 Pooled OLS

If individual effect  $u_i$  does not exist ( $u_i=0$ ), the equation (1.2) becomes

$$y_{it} = \alpha + X'_{it}\beta + \varepsilon_{it} \text{ --- (1.3)}$$

In this case, the ordinary least square estimates provide consistent and efficient parameters for the common  $\alpha$  and the slope vector  $\beta$  (Gujarathi and Sangeetha, 2007; Park, 2011). This is called ‘pooled’ OLS panel data regression estimation. OLS assumes the following (Greene, 2012, pp. 16):

- i. The dependent variable  $y_{it}$  is a linear function of a set of independent variable and the error (disturbance) term.
- ii. There is no exact linear relationship among independent variables, i.e. there is no multicollinearity).

- iii. The independent variables are exogenous, i.e. the expected value of disturbances is zero or disturbances are not correlated with any regressors.
- iv. Disturbances have the same variance (i.e. homoscedasticity) and are not autocorrelated.
- v. The observations on the independent variable are not stochastic but fixed in repeated samples without measurement errors.
- vi. The disturbances are normally distributed

But if there is an individual-specific effect, i.e.  $u_i$  is not zero, then there is unobserved heterogeneity, i.e.  $u_i$  and  $x_{it}$  are correlated, then the least square estimator of  $\beta$  is no longer unbiased and consistent as a consequence of omitted variables without additional information about the unobserved factors. There are other panel data models, described below, to deal with such problems.

In this study, a pooled regression equation was fitted by pooling all the 410 observations together to run the OLS regression model and neglecting the cross-section and time series nature of the data. In other words, it was denied that heterogeneity or individuality might arise among the countries/income groups. Although this model has this disadvantage, but it is used to get an overall idea of the average impact of economic growth, available BC, population growth, and urbanization on the EF of the selected countries as a whole.

#### ***3.5.2.4 Fixed effect approach***

Pooled regression fails to distinguish among the countries, which is a matter of concern of this study indeed. In the fixed effects model, the individual-specific effects  $u_i$  is a random variable that is allowed to be correlated with the explanatory variables. In this way, the individuality of the cross-sectional units is taken into account (Gujarathi and Sangeetha, 2007). In this model, the intercept is allowed to

vary over the countries keeping the slope coefficients as constant across individuals. Then the model (1.2) becomes

$$y_{it} = (\alpha + u_i) + X'_{it}\beta + \varepsilon_{it}$$

$$y_{it} = \alpha_i + X'_{it}\beta + \varepsilon_{it} \text{ --- (1.4)}$$

The model (1.4) is known as the fixed effects (FE) regression model. It is called ‘fixed effects’ because although the intercept may vary across individuals (countries), each individual’s intercept is fixed over time, i.e. time invariant, no subscript for time  $t$ . Equation (1.4) can be solved by two methods-least square dummy variable (LSDV) or ‘within’ estimation technique. By including differential intercept dummies, the fixed effect intercepts can be allowed to vary between individuals in the LSDV model. When there are a large number of individuals, variation within each individual can be used, instead of a large number of dummies (Park, 2011). This model is also a fixed effects model, but does not require dummy variables for estimation. It uses deviations from cross-sectional (or time periods) means and known as ‘within’ estimation.

Averaging the error component model of (1.2) over time for each  $i$  (between transformation), we get

$$\bar{y}_i = \alpha + \bar{X}_i\beta + u_i + \bar{\varepsilon}_i \text{ --- (1.5)}$$

Subtracting (1.5) from (1.2) for each  $t$  (within transformation), we get

$$y_{it} - \bar{y}_i = (X_{it} - \bar{X}_i)\beta + (\varepsilon_{it} - \bar{\varepsilon}_i) \text{ --- (1.6)}$$

Here  $u_i$ s have disappeared. So, no need to assume that  $u_i$  is uncorrelated with  $X_{it}$ . That is, time-invariant unobserved heterogeneity is not existed any more. In

addition, the problem of incidental parameters, i.e. loss of degrees of freedom due to large  $N$ , is solved. The within estimates are identical to those of LSDV and report correct sum of squared errors (Park, 2011).

The fixed effect 'within' estimation model is suffered from three disadvantages. First, the data transformation wipes out all time-invariant variables<sup>12</sup>. So, in that case, an LSDV will be preferable if the model has time-invariant independent variables. Second, 'within' estimation model produces biased statistics. Third, since the intercept term is not there, the  $R$  of the model is misleading.

### **3.5.2.5 Random effect approach**

When there are too many parameters associated with a large number of cross-sectional units or time periods in the fixed effect models, there are lesser degrees of freedom. In other words, FE model fails to give full knowledge on the unobserved effects. This ignorance of FE model can be rectified, however, by expressing through the error term or disturbance term  $\varepsilon_{it}$  (Gujarathi and Sangeetha, 2007). Instead of fixing the specific unobserved effects  $u_i$ s can be assumed random (Baltagi, 2005; Gujarathi and Sangeetha, 2007). This method of estimation is known as error component model or random effects (RE) model. The random effects model is an appropriate specification if we are drawing  $N$  individuals randomly from a large population.

So, by treating the unobserved effects as random variable, (1.2) becomes

$$y_{it} = \alpha + X'_{it}\beta + (u_i + \varepsilon_{it})$$

---

<sup>12</sup> For example, gender, citizenship, ethnic group, ability, attitude etc.

Thus by putting  $u_i + \varepsilon_{it} = \gamma_{it}$ , the model becomes

$$y_{it} = \alpha + X_{it}'\beta + \gamma_{it} \text{ --- (1.7)}$$

The composite error term  $\gamma_{it}$ , thus consists of two components,  $u_i$  or the cross-sectional error term and  $\varepsilon_{it}$ , which is the combined time series and cross-section error components. In this case the usual assumptions are  $u_i \sim \text{IID}(0, \sigma_\mu^2)$ ,  $\varepsilon_{it} \sim \text{IID}(0, \sigma_\varepsilon^2)$  and the  $u_i$  are independent of  $\varepsilon_{it}$ , i.e. the individual error term is not correlated among themselves. In addition, the  $X_{it}$  are independent of the  $\mu_i$  and  $\varepsilon_{it}$ , for all  $i$  and  $t$  (Baltagi, 2005), i.e. errors are not correlated across cross-sections or time series units (Gujarathi and Sangeetha, 2007).

So, in this case, the composite error  $\gamma_{it}$  has homoscedastic variance,  $\text{var}(\gamma_{it}) = \sigma_\mu^2 + \sigma_\varepsilon^2$  for all  $i$  and  $t$ . However, the error terms of a given cross-sectional unit at two different time points are correlated and the correlation coefficient is

$$= \sigma_\mu^2 / (\sigma_\mu^2 + \sigma_\varepsilon^2)$$

This correlation coefficient remains the same for any given cross-sectional unit for any two time periods. This is in contrast to the AR (1) scheme. Also, the structure of the correlation remains identical for all cross-sectional units.

Because of this structure, OLS is inefficient in RE model as the equation (1.7) violates the assumption that errors are uncorrelated to other errors in the cross-sectional units (Barua, 2009) and so the method of generalized least squares (GLS) is used (Gujarathi and Sangeetha, 2007). The GLS based on the true variance components is BLUE<sup>13</sup> for the RE model (Baltagi, 2005).

However, an RE model is estimated by GLS if the covariance structure of a cross-sectional unit is known (Wooldridge 2005; Park, 2011). If it is not known, which is obvious, a feasible GLS (FGLS) or estimated GLS (EGLS) method is used to

---

<sup>13</sup> BLUE - Best linear unbiased estimate.

estimate the entire variance-covariance matrix. All the feasible GLS estimators are asymptotically efficient as either  $N$  or  $T \rightarrow \infty$  (Baltagi, 2005).

In this study, there might be some omitted variables that may be constant over time but vary between the countries (time-invariant), and others may be fixed between the countries but vary over time (time-variant). This is where a random effect model can be used, as random effect estimator mixes both ‘within’ and ‘between’ estimators.

### 3.5.2.6 Fixed versus Random Effects

Panel data models test ‘fixed effects’ or ‘random effects’ present in the models due to individuals or time points. The basic dissimilarity between the two models-FE and RF lies in the role played by the dummy variables. The two models can be compared as follows.

**Table 3.1**

**Difference between Fixed Effect and Random Effect Models**

<b>Characteristics</b>	<b>Fixed Effect Model</b>	<b>Random Effect Model</b>
Functional form	$y_{it} = (\alpha + u_i) + X'_{it}\beta + \varepsilon_{it}$	$y_{it} = \alpha + X'_{it}\beta + (u_i + \varepsilon_{it})$
Assumption	Slope/coefficient of the regressors do not vary across cross-sectional units or over time	Individual effects are not correlated with independent variables/regressors
Intercepts	Vary between groups and/or across time	Constant
Variance due to error	Constant	Distribution is random

		through groups and/or time
Slopes	Constant	Constant
Estimation technique	LSDV, within effect estimation	GLS, FGLS (EGLS)
Hypothesis test	F test	Breusch-Pagan LM test

*Adapted from* (Gujarathi and Sangeetha, 2007; Park, 2011)

In the context of this study with 10 cross-sectional units and 41 time periods, the individual specific unobserved effects may be correlated with the observed explanatory variables. These country-specific effects may be geographical location, policy, custom, culture, Government's willingness or ability etc. If this is the case then the RE model will be biased and FE model should be used to get unbiased estimates (Barua, 2009). But then time-invariant effects will not be accounted for. FE models are inappropriate for time-invariant variables, including ecological elements of interest in the context of this study.

On the other hand, the RE model can provide separate estimates of the parameters on the time-constant covariates (Greene, 2005, pp. 377). Estimating time-constant covariates is relevant in this study as it can provide information on the various determinants of the dependent variable EF per capita. Although, in most applications, the assumption that the unobserved effects are uncorrelated to regressors  $X_s$  could be wrong (which could be the case in this study too), but the magnitude of the bias could be low.

The within estimator, or fixed-effects estimator, only uses the within variation and ignores the other two. Much of the variation in this study could be a result of between variation, that is, information contained in the means (across states or time). So if an FE estimator is used it might ignore a great deal of important

information in the data and this could lead to a misleading interpretation of the data.

The assumption behind the EF model is that something within the individual may influence the results which need to be controlled. This rationale works behind the assumption of the correlation between error of the entity and the predictor variables. FE removes the effect of those time-invariant individualities so that one can measure the net effect of the predictors on the result.

Fixed effect model might be particularly applied only to the cross-sectional units of individuals, firms, or countries in this study, not to any additional ones outside the sample units (Greene, 2005, pp. 370). Random effect instead is an appropriate specification, if certain number of individuals, firms or countries is randomly drawn from a large population of reference. Thus, fixed effect is a good method of estimation if the inference is restricted to the number of cross-sectional units that are studied and general conclusions cannot be drawn. In contrast, the random effect approach is not only conditional upon the sample, which is under study, but the interpretation affects the population from which this sample was randomly drawn. The use of random effect model would allow extending the inference to be drawn from the outcome to the other countries, which are following similar economic transition like the states under study.

Further, the type of relations used in the subsequent analyses to evaluate the possible impacts of ecologically unequal distribution of natural capital for lower middle-income countries relative to high-income countries involves an essential time-invariant control (Jorgenson and Clark, 2011). Thus, RE model estimation technique was used for the analyses that include such interactions as well as time-invariant measures for ecological factors. All FE and RE models include unreported period-specific intercepts (i.e., period effects), which controls for the potential unobserved heterogeneity that is cross-sectionally invariant within years and lessens the likelihood of spurious regression (Wooldridge, 2005, pp. 366).

### ***3.5.2.7 Hausman test: Fixed effects model or Random effects model***

As this study has a balanced panel, both fixed and random effect models could be estimated, both of which deal with heterogeneity bias. However, while selecting FE model or RE model the attention should be more on the relationship between the individual-specific unobserved effects and the independent variables, rather than on a theoretical discussion of whether there is a random population or a specific set of population from which the sample is drawn (Barua, 2009). Even if one is interested in drawing an inference for a larger number of individuals a random effects framework seems appropriate, the fixed effects estimator may be still appropriate if  $u_i$  and  $x_i$  are correlated as it eliminates the effect of  $u_i$  from the model (1.2).

Hence, it was important to check statistically the data before running an analysis as to which model would fit best the data in hand. Statistically, fixed effects models always give consistent results, but they may not be the most efficient model to estimate. Random effects can give more accurate  $p$ -values as they are a more efficient estimator, so one should run random effects if it is statistically justifiable to do so. The choice of an appropriate estimation technique is made on the basis of the Hausman test. Hausman (1978) suggested a test for the null hypothesis that  $u_i$  and  $x_i$  are uncorrelated. The general idea of a Hausman test is that two estimators are compared: one which is consistent under both the null and alternative hypothesis and one which is consistent under the null hypothesis only. The intuition is simple:

If  $x_i$  and  $u_i$  are uncorrelated, both estimators are consistent and it would be expected that the difference would be relatively small (insignificant  $p$ -value,  $\text{Prob}>0.05$ ). If  $x_i$  and  $u_i$  are correlated, random effect is biased, and one would expect the difference to be large (significant  $p$ -value).

In the case of the data used for this study, the Hausman test showed that the coefficients under the random effects model do not differ statistically from the

fixed effects model. So the null hypothesis could not be rejected and it implies that RE model would provide an efficient estimate, although here is little difference among the standard errors of the FE and RE models.

### **3.5.3 Dependent variables**

**Ecological Footprint (EF):** Per capita EF has been employed as the dependent variable to evaluate the relationship between demand for nature and other explanatory variables. EF is expressed in global hectares (gha) and is composed of six land types-*carbon, forest, crop, grazing, fishing ground and built-up land* as discussed in section 3.4.2.

### **3.5.4 Independent variables**

On the Eve of Rio+20, The United Nations Environment Programme published the 5<sup>th</sup> Global Environment Outlook which shows its concern for four forces which challenge the sustainability of Asia. These are unsustainable growth, population increase, increased consumption and urbanization (UNEP, 2012). The summary highlights these drives to be the acting agents behind the environmental change in the Asia as well.

So, these drivers are considered in this study to examine what role they play in the sustainability path followed by each of the selected Asian countries. These socio-economic variables along with the environmental variable biocapacity are described below along with their units of measurement and their expected relationship with environmental degradation. These variables have been chosen for the analysis because they represent important concepts discussed in the literature in relation to demand on natural capital.

(a) **Biocapacity (BC):** This is a ‘measure of the ecologically productive land available to provide the ecosystem services’ consumed by the people (Ferguson, 2002; Borucke et al., 2013). An ecosystem is capable of producing various

biological materials useful to humans and absorbing wastes materials generated by humans. This ability of that ecosystem is called its Biocapacity. So, BC is our ecological budget or nature's regenerative capacity (Borucke et al., 2013). Like EF, BC is also expressed in global hectares (gha). This environmental indicator is considered to examine how the natural richness of the selected Asian countries has helped to choose their sustainability paths. Biocapacity in this study deals with the degree to which accessibility and supply of natural resources affect the demand for natural capital and consumption patterns of the selected Asian countries. The expected sign of the relationship between BC and demand for natural capital can either be positive or negative or may not have any impact. Irrespective of the amount of BC available, the country may still demand higher natural capital if they follow a path of weak sustainability, substituting natural capital by man-made capital.

(b) *Gross Domestic Product (GDP)*: GDP is an 'indicator of aggregate output produced in an economy'. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes, minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources (World Bank, 2014). Economic growth of the selected Asian countries is represented by per capita GDP for each country. GDP per capita is gross domestic product divided by midyear population. Data are in constant 2005 U.S. dollars to ensure that there are no inflation effects. This economic indicator is considered for this study to examine the relation between environmental impacts and economic growth. Many studies have claimed that natural resources are extracted to increase economic growth which adversely affects the environment (UNEP-GEO-3, 2002; Coxhead, 2003; Dinda and Condo, 2006; Galli et al., 2012). The expected sign of relationship of GDP per capita with demand on natural capital is positive.

(c) *Population (POP)*: Population has always been a matter of concern for sustainable development since the era of Malthus. On his book Population Bomb

Boulding (1966) wrote about the relationship between growing population and its impact on the earth's environment. Till today many researchers include a population measure in their models to check the influence of population on the environment (Barua 2009). The total human population is continuously growing. The WWF reports (2006, 2008, 2014) have shown that amount of biological capacity available per person has fallen, as total population increases and have implications in every environmental issue (WWF, 2006, 2008, 2014). Consequently, the gap between the supply of and demand for natural resources has widened (Galli et al., 2012). Studies like Galli et al. (2012), have found that population growth is a dominant factor, especially in middle income countries. Following these studies, it was decided to opt for including population growth rate as an explanatory variable for econometric models. It is hypothesized that when population increases consumption also increases and as a result more pressure falls not only on the natural resources but also on the human capital. This may hamper the capacity of the environment in the future. The expected sign of the relationship between environment and population is positive; meaning the more the population growth rate higher is the demand on the environment.

(d) *Urbanization (URBP)*: Urbanization is represented by urban population. It is a phenomenon of land use changes, economic transformation as well as of social changes. In this process, people from rural areas migrate to urban areas due to several reasons. Through the process of urbanization, the world has undergone rapid changes in recent decades. Agricultural land, forest land, and grazing lands are mostly cleared for urban development which is a major threat to the environment. The global population scenario has transformed in the past decades. Rapidly growing urban populations put pressure on the natural services of the cities too. The Living Planet Report (WWF, 2014) says that urbanization is growing fastest in the developing world and it is estimated that by 2050, Asia will have the largest urbanization (UNDESA, 2012) in the world. So in this study urbanization is considered as an additional explanatory variable to examine its relationship with the environment in the selected Asian countries. The unit is taken as a percentage of total population. The expected sign of the relationship

between environment and urbanization is positive; meaning the higher the urbanization pressure higher is the demand on the environment.

### ***3.5.5 Data transformation***

Since the values of the selected variables are fluctuating between the countries, values of these variables are transformed to natural logarithmic scale. Logarithmic transformation of data also helps to avoid violent fluctuations in the data and to eliminate the problems of possible heteroscedasticity. The underlying assumption is that the time series data becomes easily stationary after logarithmic processing and the characteristics of time series data don't change (Yang et al., 2012). So the new sequence of logarithmic series is respectively named *lnef*, *lnbc*, *lngdpp*, *lnpop* and *lnpercenturbp*, and all the data analysis is completed by using software STATA version 11.

### ***3.5.6 Test for stationarity***

One important issue needs to be addressed in panel data is the stationarity of dependent and independent variables. This is generally done by testing the unit roots in a given series. In panel data, this practice is not very old, although testing the existence of unit roots in time series data has become an integral part of the econometric research for long (Baltagi, 2005).

One of the assumptions of the ordinary regression equation is the stationarity of the dependent and independent variables (Asici, 2013). Time series data are generally has a trend and when inferences are drawn from such data, the results may become spurious. For a short time dimension, there is not much to bother about stationarity of the variables (Asici, 2013). But since in this study, the time dimension is 41 years, so unit root tests were performed to verify if the variables under study are stationary i.e. free of unit roots before conducting the panel data analysis on all the transformed variables mentioned above.

In this study three different, but frequently cited panel unit root tests are performed. The first test, Levin-Lin-Chu (LLC henceforth) was proposed by Levin et al. (2002). LLC gives a more powerful panel unit root test for fixed effects than performing unit root test for each cross-section (Baltagi, 2005). This test assumes that each time series possesses a common unit root and the autoregressive coefficient is equal through cross-sections (Poumanyong and Kaneko, 2010). LLC suggests using this panel unit root test for panels of size with a number of cross-sections between 10 and 250 and time points between 25 and 250 (Baltagi, 2005, pp. 241). It requires a strongly balanced data. This is, however, not a problem in this study as the study has a strongly balanced data. The limitation of LLC test is also overcome by the second panel unit root test- Im-Pesaran-Shin (IPS henceforth), which is proposed and modified by Im, Pesaran and Shin (Im et al., 2003; Baltagi, 2005). IPS unit root test has one significant advantage over other panel unit root tests. It does not impose a common autoregressive parametric restriction on the panels and is based on a set of Augmented Dicky-Fuller regressions to estimate the t-statistic. IPS also allows variability of the autoregressive coefficient across cross-section (Poumanyong and Kaneko, 2010). The third test is the most commonly suggested test for large N by Maddala and Wu (1999), known as Augmented Dicky-Fuller (ADF henceforth) test. The null hypothesis in all these tests is that all panels contain unit roots and the alternative hypothesis is some panels are stationary.

### ***3.5.7 Test for cross-sectional dependence***

Panel unit root tests assume that there is no cross-sectional dependence (Baltagi, 2005). So to check if there is cross-sectional dependence in the panel data in this study, the error cross-section dependence (CD) test is applied before conducting the panel unit root tests. This test has been suggested by Pesaran (2004) that is applicable to a various panel data models including stationary and unit root dynamic heterogeneous panels. The Stata command 'xtcsd' is used for testing the presence of cross-sectional dependence in both fixed and random effect models in this study. Although the command is suitable for short T and large N (De Hoyos

and Sarafidis, 2006), the same is tested in this study because if there are cross-sectional dependence, unit root tests, especially LLC cannot be applied if a cross-sectional correlation is present.

### **3.6 Source of Data**

This study is an empirical study based on secondary data. Annual time series data from 1970 to 2010 for ten Asian countries namely Bangladesh, China, India, Indonesia, Malaysia, Pakistan, Philippines, Republic of Korea, Singapore and Thailand have been collected from trustworthy sources for the following variables - GDP per capita, annual population growth rate, urbanisation (% of total population) and ANS (per cent of GNI) were obtained from the World Bank's World Development Indicator (Bank, 2015) website. Per capita GDP of each country are in constant 2005 US\$ prices. The data was available for all the 10 countries, which have a full set of environmental data as well as information on social and economic variables at country level for the period of 1970-2010.

To collect per capita EF data and per capita BC data, the Global Footprint Network has been consulted. The GFN releases National Footprint Accounts (NFA) annually. The NFA 2011 Edition has calculated EF and BC for more than 200 countries and territories, as well as global totals (GFN, 2014). The data has been collected through an academic request to the GFN.

### **3.7 Panel data regression equation**

Based on the above discussion, in this study, a logarithmic form of the above panel data models by including additional variable for each state has been used.

The regression equation for static panel data become

$$ef_{it} = \beta_0 + \beta_1(\ln bc)_{it} + \beta_2(\ln gdpp)_{it} + \beta_3(\ln pop)_{it} + \beta_4(\ln percenturbp)_{it} + \alpha_i + \varepsilon_{it}, \text{--- -- (A)}$$

where,

$ef_{it}$  is the level of environmental degradation in terms of ecological footprint per capita consumption in SS perspective of the  $i^{\text{th}}$  country on year  $t$ ;  $i=1,2,\dots,N$ ,  $t=1,2,\dots,T$  years.  $\beta_0$  is the intercept.  $\alpha_i$  is a country specific effect allowing an idiosyncratic yearly ecological footprint for each country. It accounts for factors such as country-specific policies, government's ability and willingness, geographical location, resource endowments, technology, efficiency and climate.  $\beta_1, \beta_2, \beta_3$  and  $\beta_4$  are the coefficients (slopes) to be estimated. The term  $\alpha_i$  (intercept) sweeps out the variation between countries with estimates based on only variation within each country.  $bc$  indicates biocapacity available per capita in global hectares;  $gdpp$  indicates per capita GDP at 2005 constant price (US\$);  $pop$  is the population growth rate per year; and  $percenturbp$  indicates urban population as a percentage of total population.

The 10 countries are divided into three income groups-High (HI), upper middle (UMI) and lower middle (LMI), so there are actually three panels each for one income group. HI is a panel of two East Asian countries-Republic of Korea and Singapore; UMI is a panel of three South Asian countries-China, Malaysia and Thailand and the 3<sup>rd</sup> panel LMI consists of 5 Asian countries-Bangladesh, India, Indonesia, Pakistan and the Philippines

The panel regression is estimated by using the econometric software STATA 11.

### 3.8 Limitation of the data

Statistical data has always uncertainty. Here in this research, the data are collected only from two trustworthy sources, ANS, GDP, urban population and population from the World Bank and EF and BC from the GFN. ANS is calculated by the WB, like wise EF and BC are computed by the GFN. While WB is the only source for ANS; GFN is the only source for EF and BC which is collected through an academic license. The license only disclosed data for the period 1970-2010 along with the data for the components of EF. Due to this limitation, this study had to restrict the analyses till 2010 although a complete data set was available for all the explanatory variables from 1970 till 2014. So results may be biased as latest data could not be considered.

Institutional factors like international agreements, environmental policies etc. could not be included in the econometric analysis. However, the role of these factors influencing the environmental pressure and in the mainstreaming natural capital has been discussed in the **concluding chapter** of the thesis.

## Chapter 4

# Asia's Growth Pattern: Weak or Strong Sustainability?<sup>14</sup>

---

### 4.1 Introduction

This chapter discusses the outcomes of the time series trend analysis using data for adjusted net savings (ANS), per capita ecological footprint (EF), and per capita biocapacity (BC) for the ten emerging Asian economies under this study for a period of 41 years (1970-2010). Further, the trends of the six components of EF, i.e. cropland, grazing land, forest land, fishing ground, carbon uptake land and built-up land were also plotted to see which component made a significant contribution to the countries' per capita EF. The analysis wants to know if the accelerating economic growth has been putting pressure on the natural resources of the selected Asian emerging countries and if the present pattern of economic growth in the developing countries can be called a Sustainable Development path.

The analysis also tries to examine the path of sustainability followed by the selected countries - weak or strong. An increasing trend of ANS will imply that the total capital stock is growing and an increasing trend of EF will imply that this stock is increasing at the cost of deteriorating natural capital. Hence, this is a case of weak sustainability. If the increasing ANS is not accompanied by increasing EF, then it will imply that the total capital stock is growing without replacing natural capital. Instead, both natural and the man-made capital are increasing. This is the case of strong sustainability.

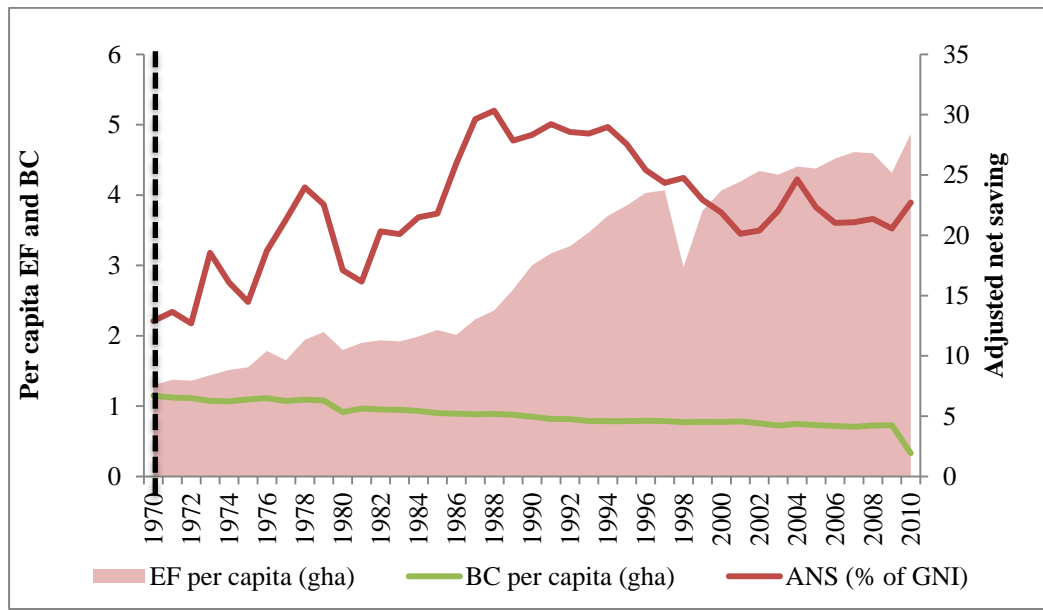
Results are enumerated below according to the three different income groups under this study— high-income, upper middle-income and lower middle-income.

---

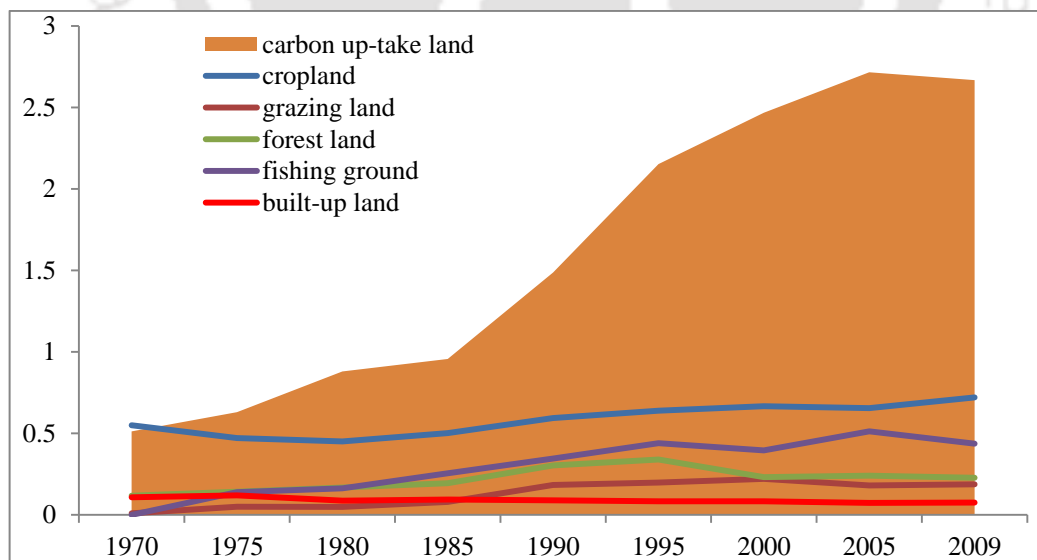
<sup>14</sup>Part of this chapter has been published as a paper titled “**Strong or weak sustainability: a case study of emerging Asia**”, *Asia-Pacific Development Journal* Vol. 22, No. 1, pp. 1-32.

## 4.2 Sustainable development path in HI countries

Beginning with the results for HI countries - Singapore and Republic of Korea - Figures 4.1a and 4.2a track the per person EF and BC, and ANS and Figures 4.1b and 4.2b show the components of EF since 1970.

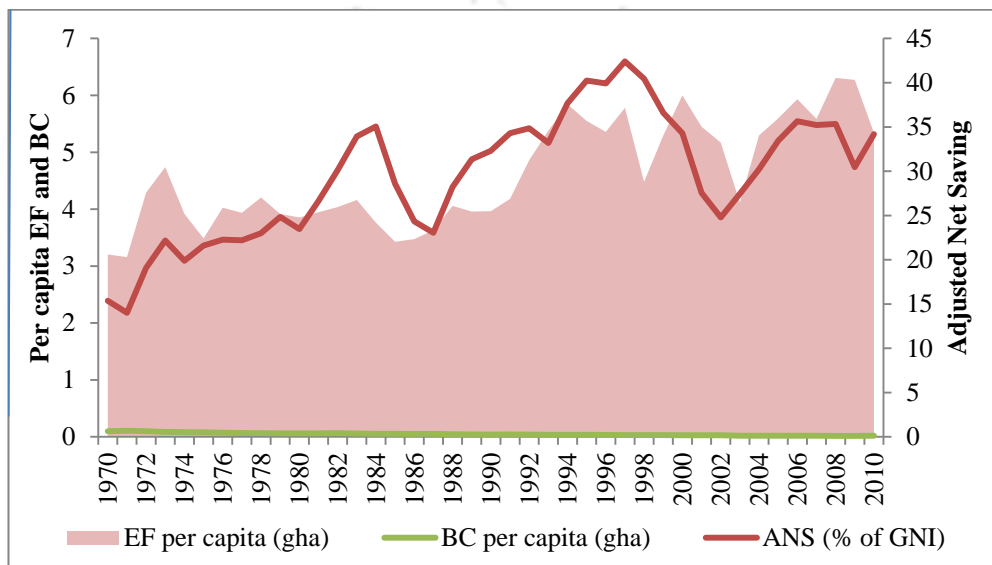


**Figure 4.1a Trends of ANS, per capita EF, per capita BC in the Republic of Korea**

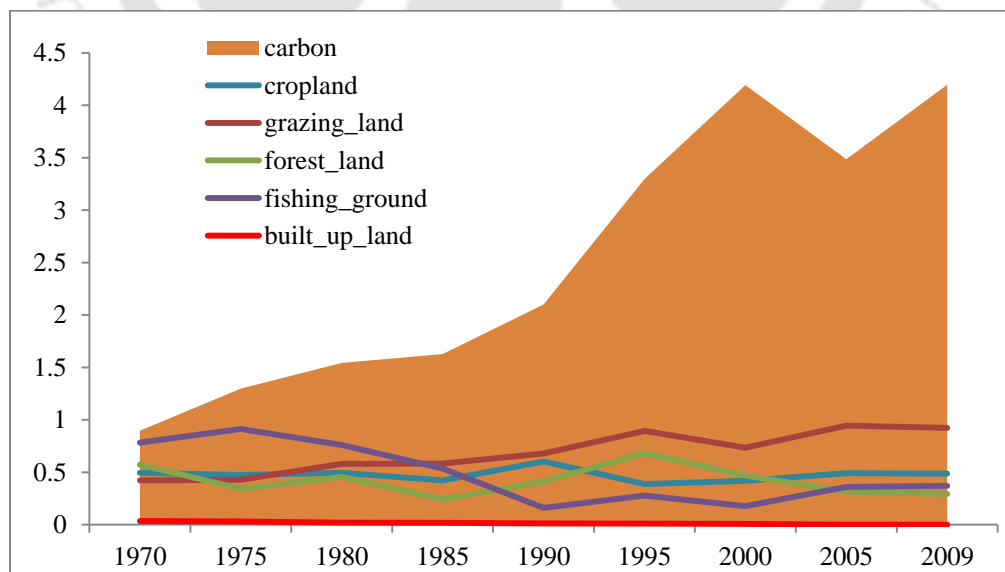


**Figure 4.1b Components of per capita ecological footprint in the Republic of Korea**

The increasing trend line of per capita EF of the Republic of Korea (Figure 4.1a) indicates that in HI countries, the increasing share of per capita average ecological footprint is remarkably high. Between 1970 and 2010, the trend moved from 1.3 gha to 4.87 gha per capita. It is interesting to see that ANS in this country showed a 9.8% increase in 2010 from 1970 and total income (GDP) increased approximately eleven times throughout this period.



**Figure 4.2a Trends of ANS, per capita EF, per capita BC in Singapore**



**Figure 4.2b Components of per capita ecological footprint in Singapore**

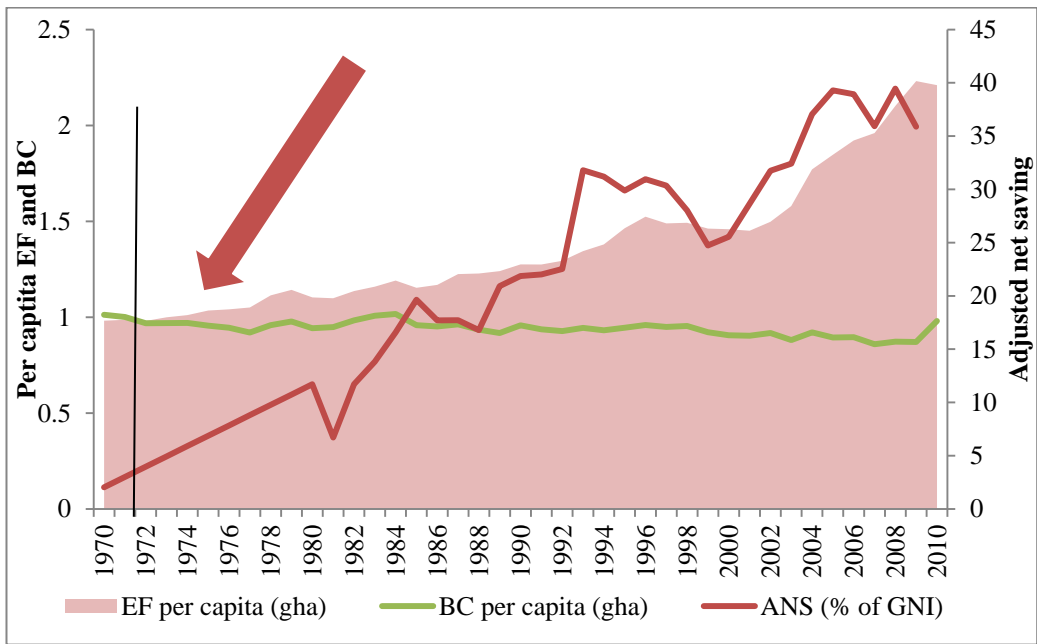
The ecological footprint of Singapore has increased from 3.20 gha (1970) to 5.34 gha (2010) per capita (Figure 4.2a). Each individual of this country demands 4.5 gha ecologically productive land on average during the study period, which is higher than average high-income countries' ecologically productive land which is 3.38 gha per capita (WWF, 2012). ANS has become almost double in Singapore during the study period.

An increase in per capita consumption and energy intensive lifestyle is the driving force of natural capital extraction and utilization by HI countries (*see* Galli et al., 2012). The graph showed that both the HI countries have an average per capita EF of almost 5 gha, which is higher than many developed countries. The overshoot ( $EF > BC$ ) happened much before the study period and this overshoot continued to grow, which has widened the gap between EF and BC, indicating increasing human demand on nature. On the other hand, during this period, ANS has increased by 1.8%, while GDP rose almost four times. These HI countries are not very rich in natural resources. With limited natural resources, about 70 per cent of Singapore and Republic of Korea's footprint comes from carbon emissions (*see* Figure 4.1b and 4.2b), produced within the country as well as indirectly through activities driven by Singapore and Republic of Korea's economy in other countries (WWF, 2010). This also indicates that economic growth of Singapore and Republic of Korea is largely driven by increased consumption of fossil fuels.

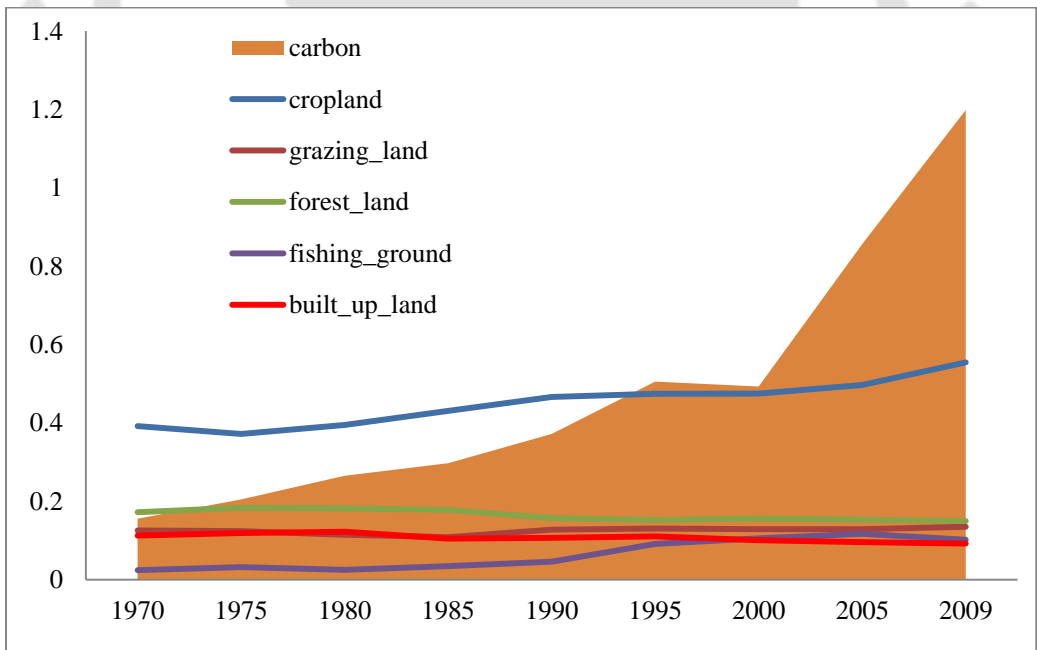
So the increasing gap between EF per capita and BC per capita shows that this group is following a weak sustainability path. But now these countries are trying to invest in natural capital by following green growth strategy, e.g. green technology which is evident from stable ANS from 2000 onwards.

### **4.3 Sustainable development path in UMI countries**

All the UMI countries selected for this study are enriched with supply of natural resources. However, the increasing trend of the per capita ecological footprint is an issue of real concern in all the UMI countries.



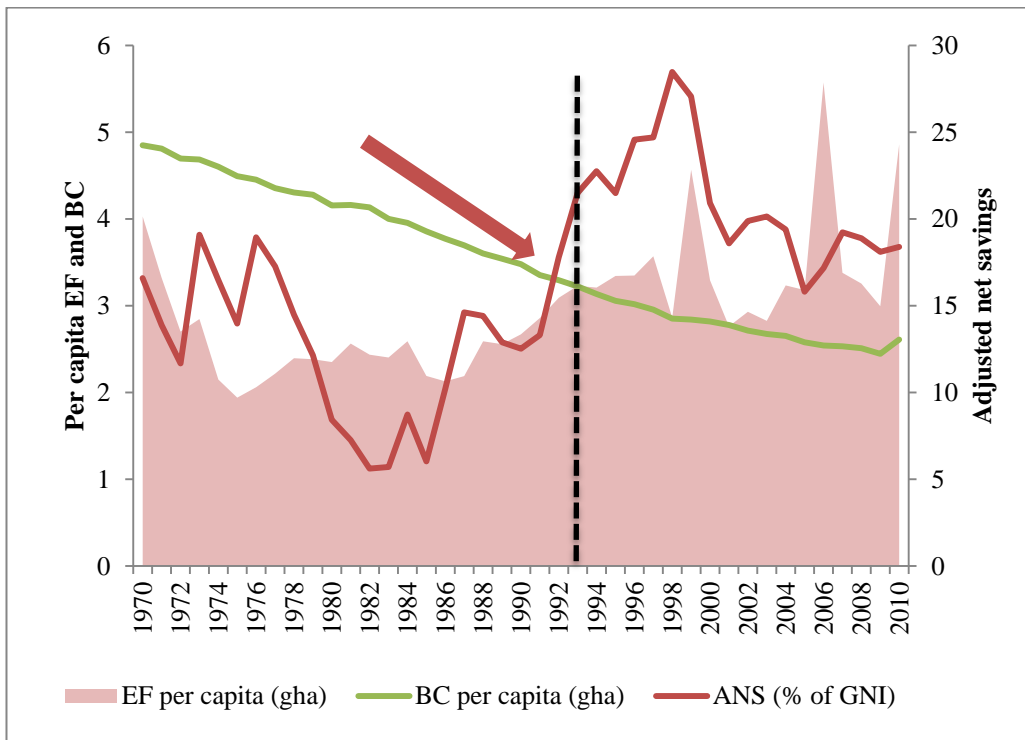
**Figure 4.3a Trends of ANS, per capita EF, per capita BC in China**



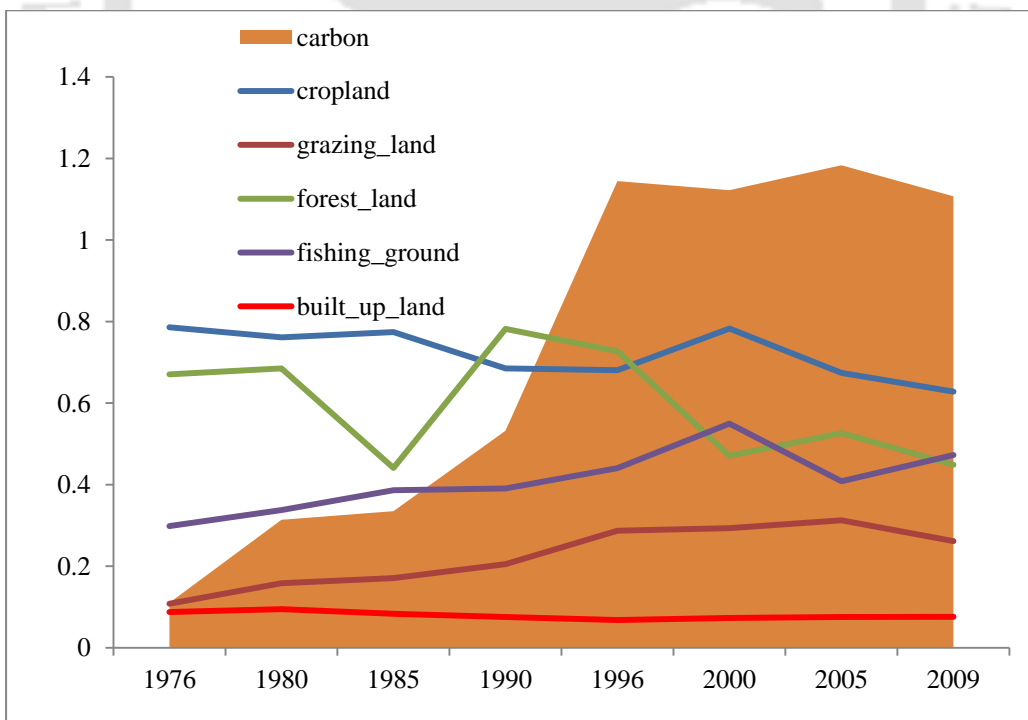
**Figure 4.3b Components of per capita ecological footprint in China**

China is rich in biocapacity. It was the 2<sup>nd</sup> environmentally rich country with 9.9% of the total global biocapacity in 2008 (WWF, 2012). In 1970, each Chinese had almost 1 gha of supply of nature; in 2010 also, a Chinese could enjoy 0.98 gha of biocapacity. So, biocapacity per capita in China is not declining much. But the main concern in this country is its continuously increasing EF per capita trend. In 1970, China had an ecological reserve (supply>demand). But in 1972, per capita EF crossed the per capita BC and China met overshoot. Since then per capita EF of China has increased almost 125% (1972-2010), even more than many industrialized countries. Analysing the fluctuations in the consumption footprints of various land-use data from 1970 to 2010 (Figure 4.3b), it is seen that the cropland had the largest share to the total footprint till 1992, as consumption has been more for agriculture-based production than for others. China has been known as an agricultural economy having a huge population to feed (Gao and Tian, 2016). But from 1993 onwards, carbon uptake land has increased and become the largest share of the total per capita ecological footprint suppressing the cropland footprint. There is almost a 7.7 times increase in carbon footprint from 1970 to 2010. This was caused mainly by an increase in energy-intensive consumption due to socio-economic changes (Gao and Tian, 2016).

During the same period, there is a tremendous increase in the ANS of this country. In 1970, ANS was 1.06 (% of GNI); in 2010 it has become almost 36% despite a decline during 1995-2000 due to the Asian crisis. This means that China's growing environmental impact has been driven by the depletion of natural capital and accumulation of per capita ecological footprint.

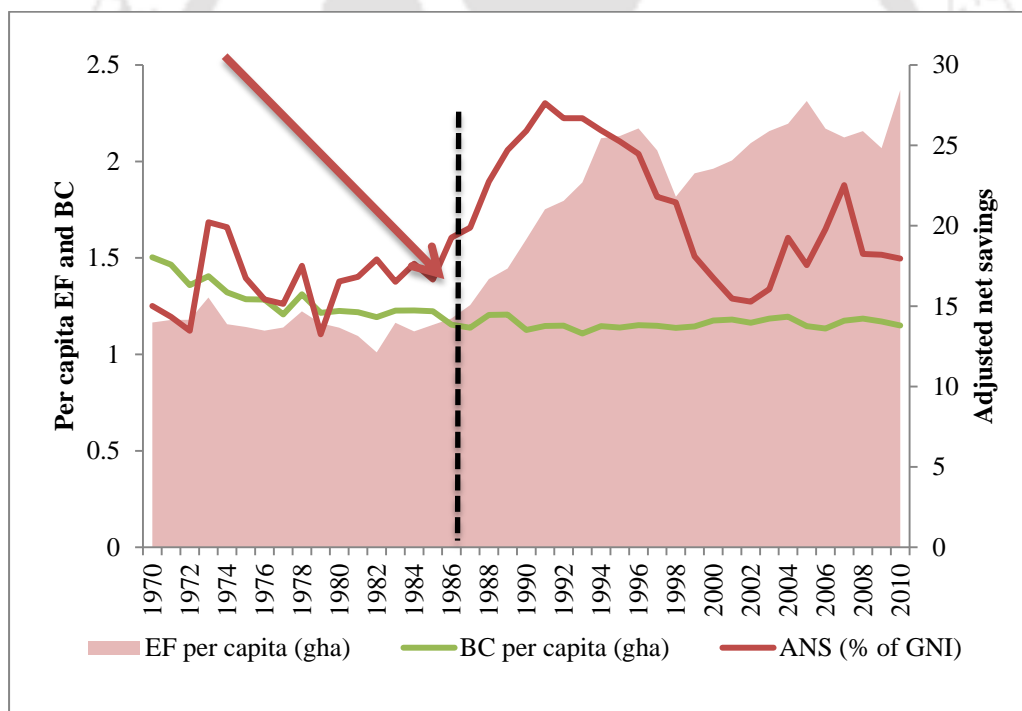


**Figure 4.4a Trends of ANS, per capita EF, per capita BC in Malaysia**

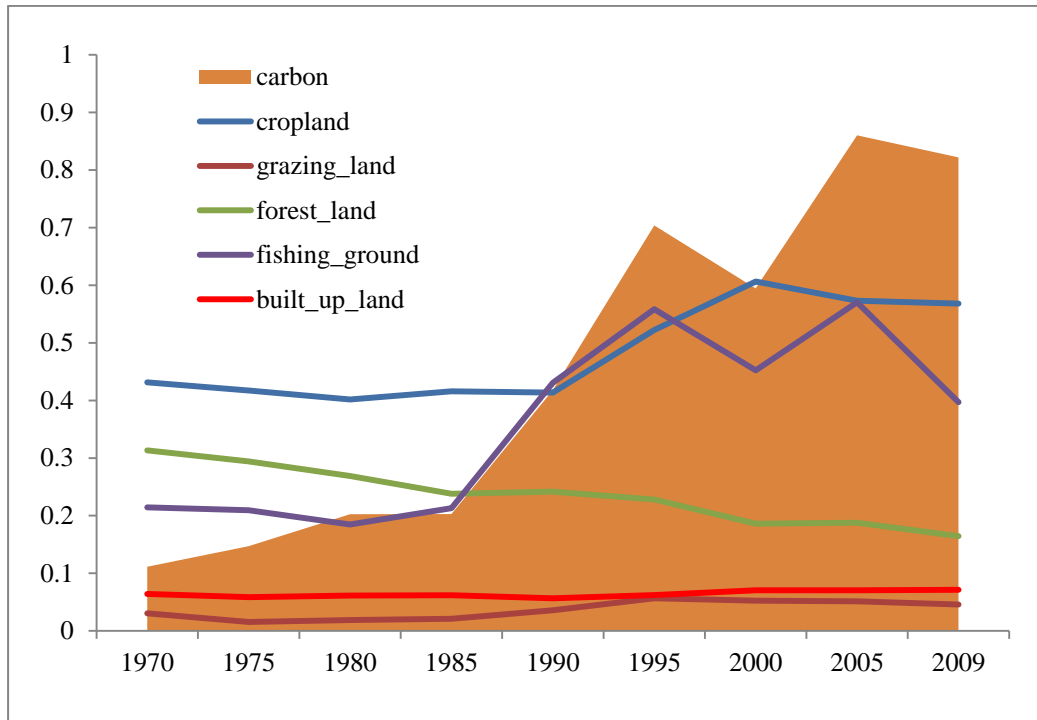


**Figure 4.4b Components of per capita ecological footprint in Malaysia**

Till 1990 Malaysia was a lower middle-income country. After that, it has become an UMI country. Average Malaysian EF was 4.03 gha in 1970, lower than its per capita BC of 4.85 gha. But in 2010 Malaysia's per capita EF has stretched to 4.86 gha. There is almost a 20.7% increase in per capita EF against a 46% decrease in its per capita BC during this period. Overshoot happened in Malaysia in 1992. This was mainly because of an upswing in the carbon footprint (Figure 4.4b) fuelled by energy consumption from 1993. Trade openness leads to material comfort and hence increased the consumption of energy (Shahbaz et al., 2013; Shahbaz et al., 2015). This has been resulted in a deficit in BC of 2.25 gha. ANS has increased by 1.8% between 1970 and 2010, and GDP increased by four times (Figure 4.4a). Between 2000 and 2005, Malaysia's ANS declined, as the country was hit hard by the East Asian crises, it recovered soon after that.



**Figure 4.5a Trends of ANS, per capita EF, per capita BC in Thailand**



**Figure 4.5b Components of per capita ecological footprint in Thailand**

Thailand (Figure 4.5a) had very high savings per capita, resulted in increasing ANS, during the period from 1970 to 1995. However, this variable started to decline after 1995 and continued on a downward trend until 2000. As mentioned earlier this was the time of the East Asian crisis and most of the East Asian countries suffered from that crisis. Thailand recovered soon from this crisis (Pansuwan, 2009-2010). Since 2005, both adjusted net savings and the ecological footprint per capita have shown increasing trends. Per capita biocapacity is decreasing in Thailand and the country met overshoot in the year 1986 (i.e. demand has crossed supply). Since then there is a 0.3% reduction in its per capita supply of natural capital. But per capita EF has risen by 99% during this period (1986-2010). These trends imply that per capita consumption of natural capital is the main driver to the environmental impact of Thailand. Major increase has been in the carbon footprint component (Figure 4.5b). This was mainly because of the country's growing importance in the manufacturing sector, especially between 1986 and 1996 when the sector attained an annual average growth rate of around 13% (Pansuwan, 2009-2010). During the same period, its share to total export also

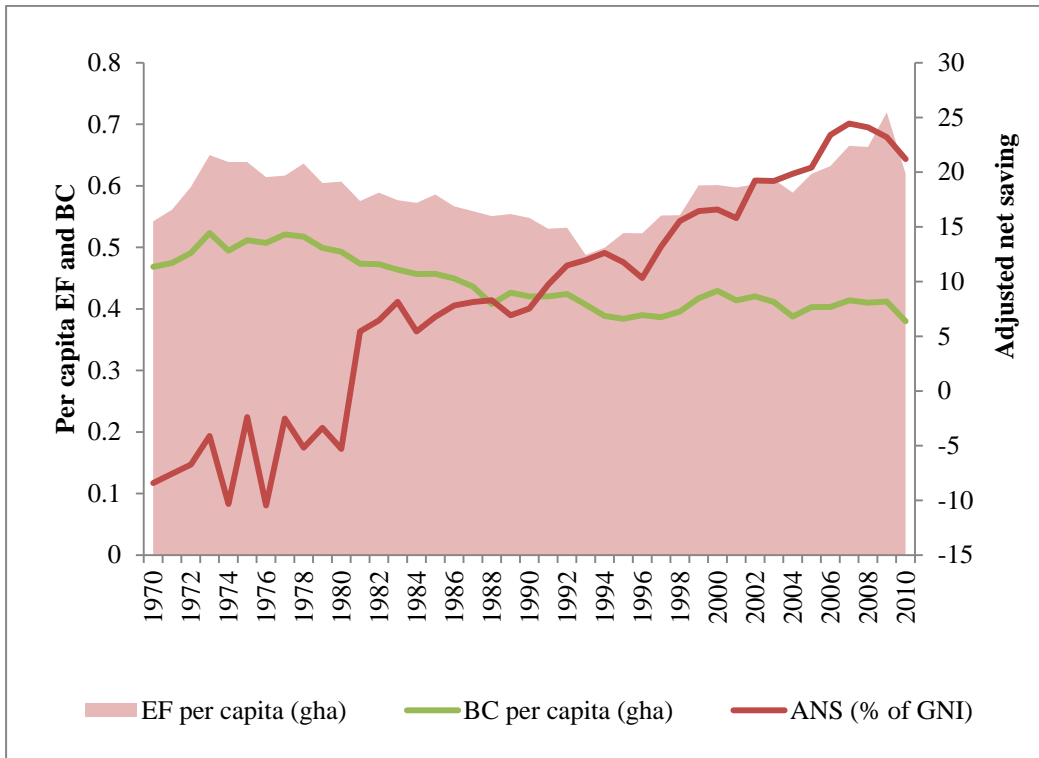
increased. More emphasis was given in manufacturing of clothing, footwear, leather products, furniture, toys, jewels and gems, and electronics which are heavy emitters of carbon-di-oxide and other particulates.

GDP per capita in all these three upper middle-income countries-China, Thailand, and Malaysia -is very high. An extremely skewed consumption per capita, in most of these UMI countries, with a handful of people having access to most of the resources, has played a significant role in increasing the ecological footprint of these nations (Marcotullio, 2001; Galli et al., 2012). As ANS is positive ( $>0$ ) and is in increasing trend in all these three UMI countries and since all the three countries have already met overshoot, these countries are following weak sustainability path.

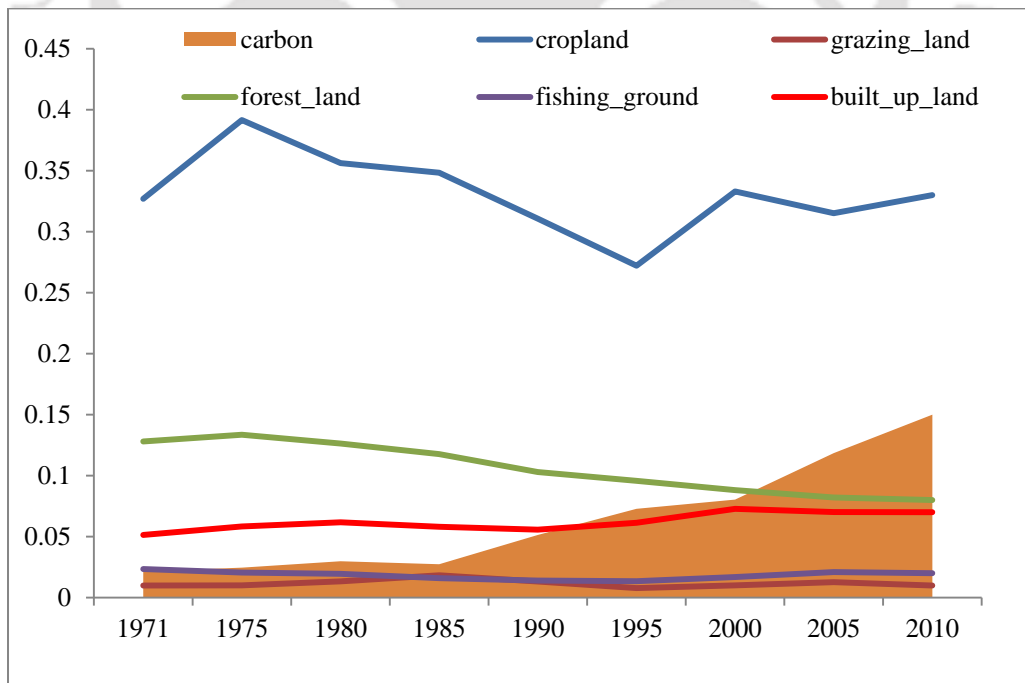
All these three countries are rich in natural resources/biopotential (supply). In spite being rich in biopotential, these countries have overshoot their demand for nature (China - 1971, Thailand -1988, Malaysia - 1992) and the gap between BC and EF since the overshoot is widening, making them resource deficit countries. The main concern in these countries is its continuously increasing trend of EF per capita (*see* Figure 4.3a, 4.4a, 4.5a) and an increasing share of carbon footprint (*see* Figure 4.3b, 4.4b, 4.5b). The share of other components of EF – cropland, grazing land, forestland fishery ground – is gradually declining which also indicates that these economies are moving away from agriculture to industry and service sector. For example, in 2008, nearly 40% of China's total Ecological Footprint was accounted for by long-term investments in infrastructure (WWF, 2012).

#### **4.4 Sustainable development path in LMI countries**

The last group is the lower middle-income group – Bangladesh, India, Indonesia, Pakistan and Philippines.



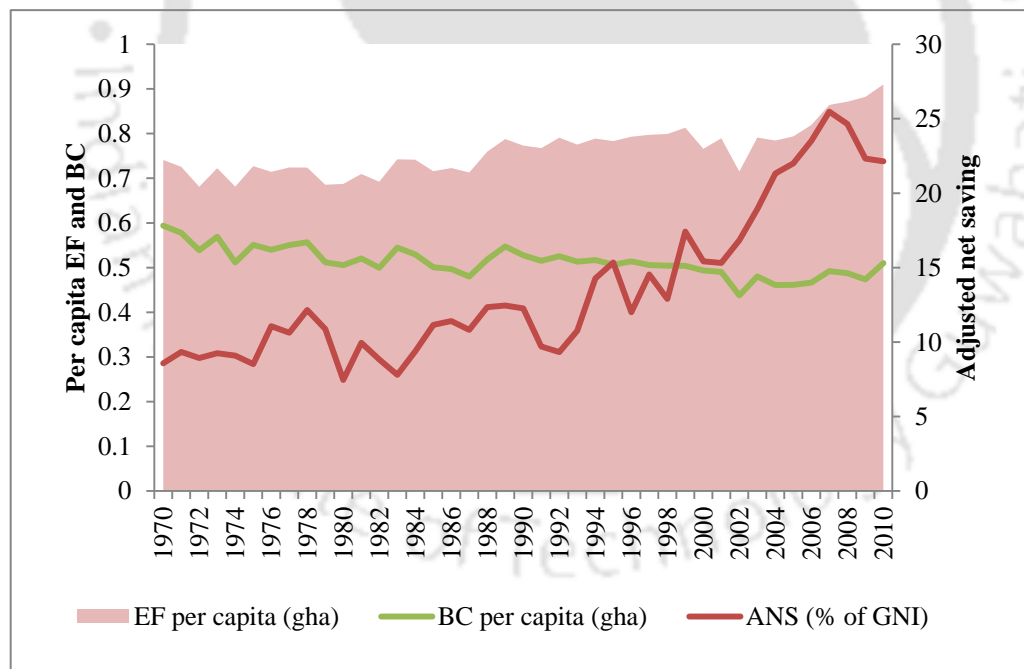
**Figure 4.6a Trends of ANS, per capita EF, per capita BC in Bangladesh**



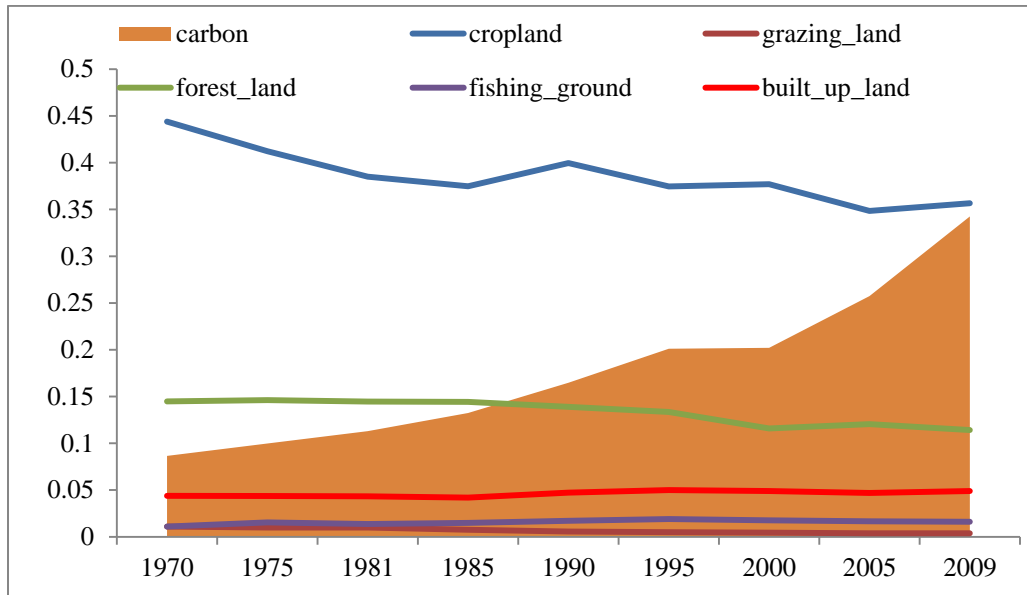
**Figure 4.6b Components of per capita ecological footprint in Bangladesh**

Till 1980, Bangladesh had experienced negative rates of ANS. Up until this year; complicated political state of affairs hindered Bangladesh to move economically forward. In spite of this, Bangladesh has witnessed 2.5 times increase in its adjusted net savings rates (Figure 4.6a) while GDP increased by 1.9 times during the study period. Per capita EF of this LMI country is not very high, only 0.62 gha in 2010, but is still higher than the available per capita BC resulting in ecological deficit.

While coming to the time series trends of the components of EF per capita (Figure 4.6b), it is seen that in Bangladesh, cropland footprint has the largest share. It explains two things—first, Bangladesh is still adopting conventional livelihood processes and second, population has a very high pressure on its natural resources. But carbon footprint is gradually increasing since 1985 which indicates a slow transition of the Bangladesh economy.



**Figure 4.7a Trends of ANS, per capita EF, per capita BC in India**



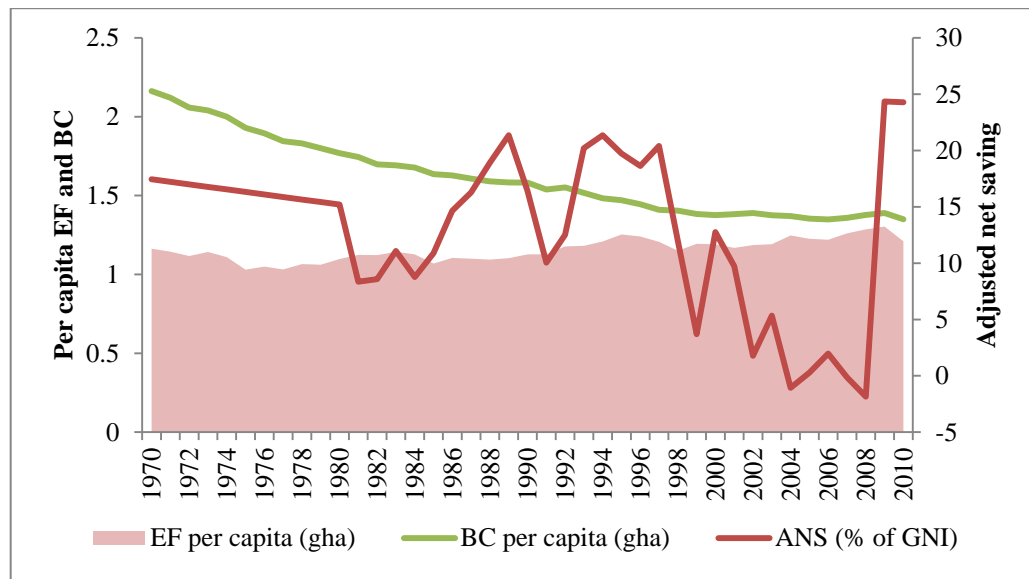
**Figure 4.7b Components of per capita ecological footprint in India**

In India (Figure 4.7a) both ANS per capita and EF per capita have shown increasing trends. India has a huge population. So, per capita footprint is not as high as the UMI countries. It shows a disparity in consumption patterns in India between rich and poor. During the study period, per capita BC reduced by 14%, per capita EF increased by 23%. So the gap between EF and BC is widening. ANS rates are continuously increasing in India. The Asian crisis could not affect India much; only ANS was almost constant during 1995-2000.

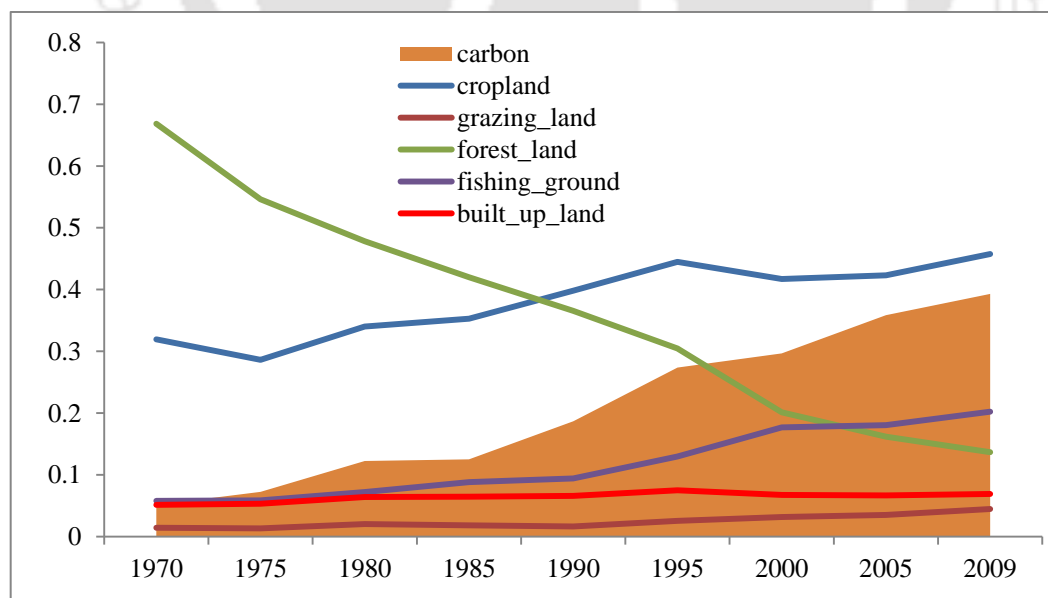
There is a declining cropland and forest land per capita footprint in India (Figure 4.7b); but carbon footprint is gradually increasing. This trend indicates that India is also transforming from an agricultural economy to manufacturing economy. With economic growth, India is slowly advancing towards development, urbanization and industrialization, which have resulted in significant changes in land use - converting agricultural land to non-agricultural purposes. This is also the reason for a sharp decline in cropland footprint and a sharp intensification in the carbon up-take land footprint in this country.

Indonesia, Pakistan and the Philippines had very high ANS rates between 1970 and 1995. However, this variable started to decline after 1995 and the downward

trend continued till end of 2000s. This was also the time of the East Asian crisis and most of the East Asian countries suffered economic crises. However, the situation has changed after 2000, as these countries have succeeded in gaining good per capita ANS since 2005. The increase in per capita ANS in these countries was accompanied by a significant increase in their per capita ecological footprint.



**Figure 4.8a Trends of ANS, per capita EF, per capita BC in Indonesia**



**Figure 4.8b Components of per capita ecological footprint in Indonesia**

Indonesia (Figure 4.8a) is environmentally a rich country. It had 2.6% of the total available global biocapacity in 2008 (WWF, 2012). In 2010, average Indonesian enjoys 1.35 gha BC, but average EF per capita is 1.21. This indicates that Indonesia has an ecological reserve. But its biocapacity is declining at a very fast rate. Already there is a 37.6% decrease in its per capita BC from 1970 to 2010 which is reflected in sharp decline of the forest land footprint (Figure 4.8b). In addition per capita EF is increasing (4%) during the same period along with an increasing trend of carbon footprint. However cropland footprint is not decreasing rather increasing and have the largest share to the per capita EF of Indonesia. This clearly indicates the increasing pressure of population on natural capital.

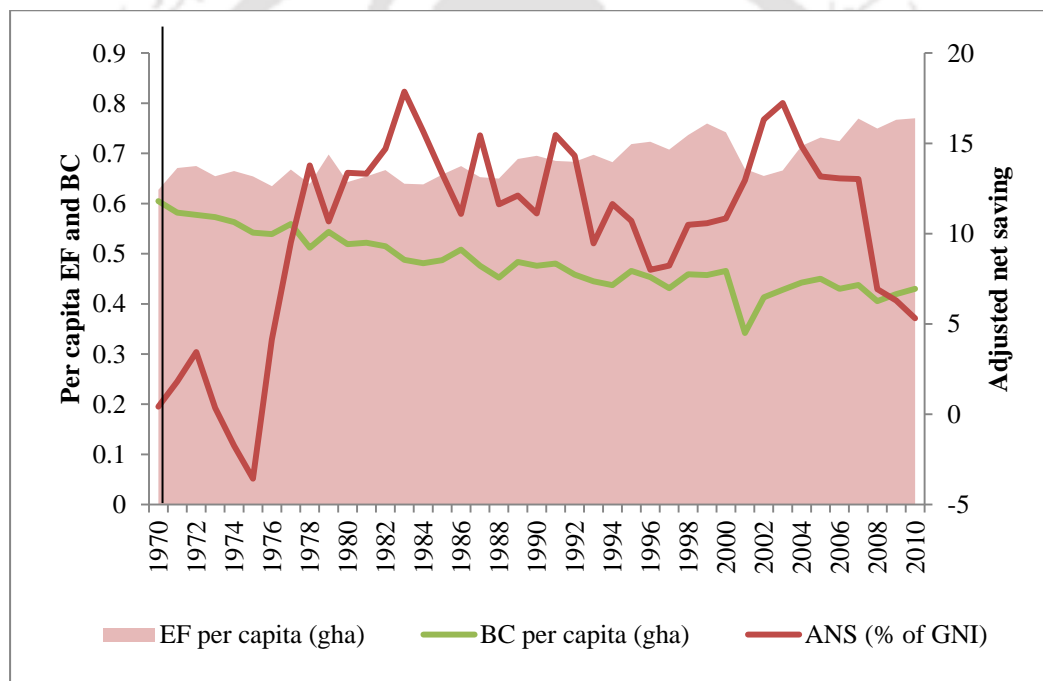
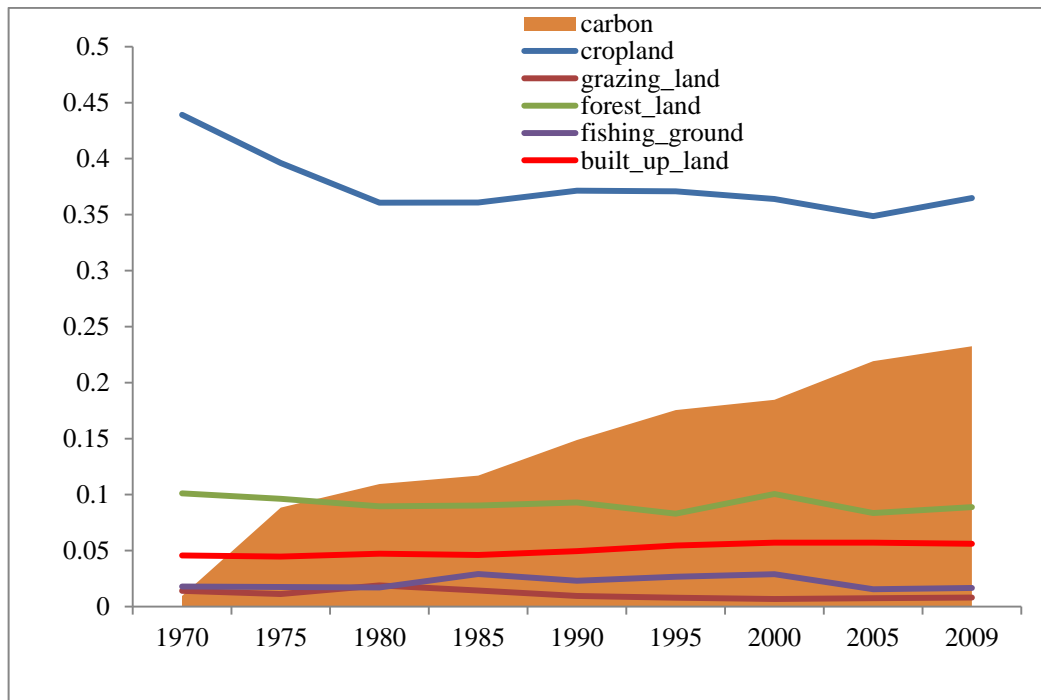


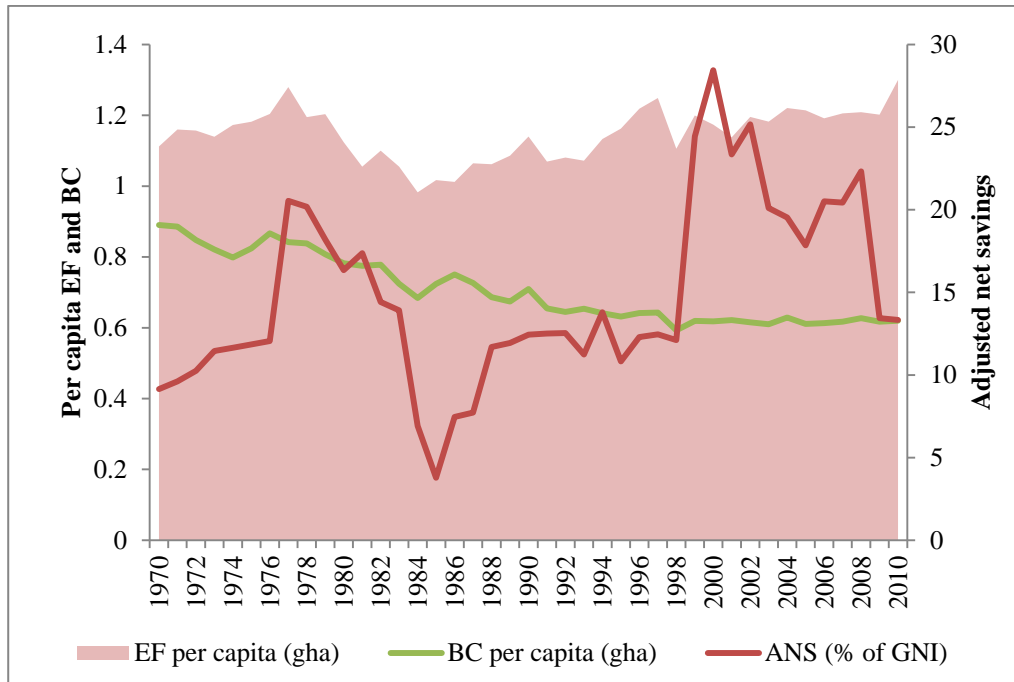
Figure 4.9a Trends of ANS, per capita EF, per capita BC in Pakistan



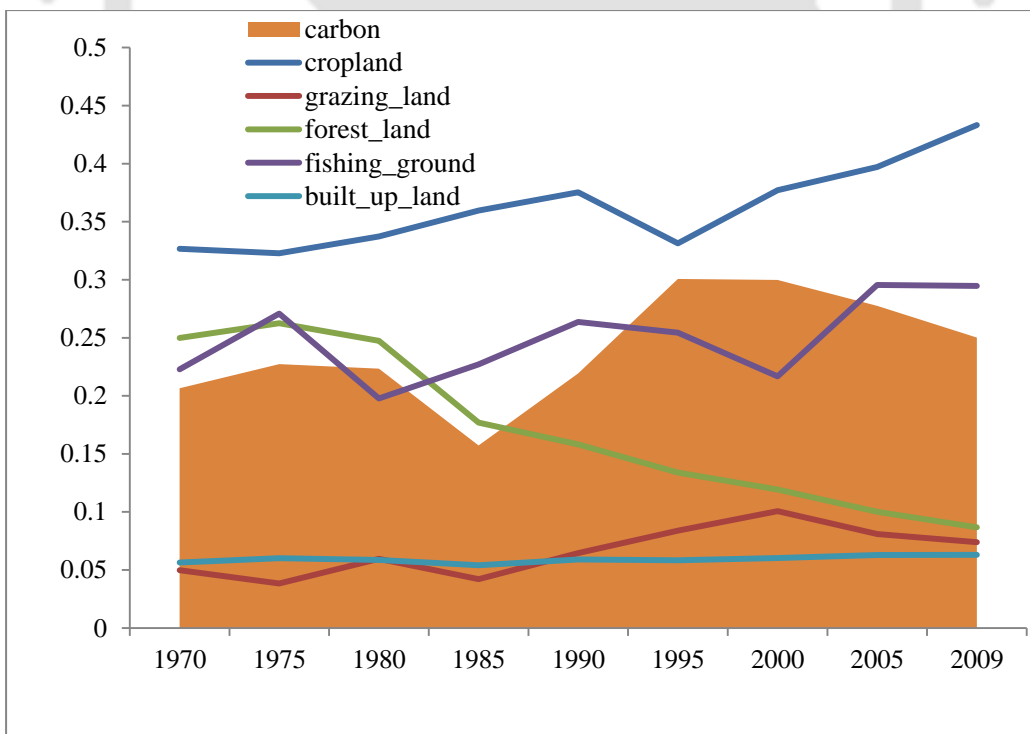
**Figure 4.9b Components of per capita ecological footprint in Pakistan**

Before 1970, Pakistan (Figure 4.9a) had a reserve in its biocapacity. But since 1970s, Pakistan had always ecological deficit ( $BC < EF$ ) till the end of the study period, during which it saw a significant increase in its population (9%) and a 22% increase in the average ecological footprint. This growing population has to cope with a fixed supply of natural resources, resulting in less available biocapacity per capita. A sharp increase in Pakistan's adjusted net savings is recorded between 2000 and 2005, after which it was dropped by 1.3%.

Like the other LMI countries, Pakistan too has cropland footprint as the highest contributor to the average per capita EF, however at a decreasing rate (Figure 4.9b). The most significant increase is noticed in the carbon footprint which indicates that Pakistan is also moving towards manufacturing-based economy.



**Figure 4.10a Trends of ANS, per capita EF, per capita BC in the Philippines**



**Figure 4.10b Components of per capita ecological footprint in Philippines**

In the Philippines (Figure 4.10a), the gap between per capita EF and per capita BC is widening very rapidly. Per capita EF has increased by 30% and per capita BC is decreased by 16.9% during the study period. ANS is increasing, but at a declining rate which leads to the conclusion that natural capital is not properly used in this LMI country.

Figure 4.10b shows that in the Philippines, the trends of components of EF are exceptional. There is a sharp increase in built up area land and also fishing ground. Biocapacity has decreased 44 per cent, due to rapid population growth and it's inherent policy bias which allows the country to heavily depend on exports of primary commodities like agricultural harvests and other natural resource-based (mining and forestry) products (UNIDO, 1999). These principal industries usually execute more liability on the environment. Further, the environmental vulnerability of the Philippines towards the effects of changing climate, including devastating typhoons result in destruction of buildings. So, people of the Philippines have to construct new houses very often which increase the build-up land footprint. Again according to Manila Bulletin, there is recorded a 75% overfishing in the Philippines (Kae Unite, 2015) which leads to increase the footprints of fishing grounds. Cropland has the largest footprint and there is a rapid intensification in the carbon footprint.

Trend analysis for the lower middle-income countries reflects that, LMI countries are characterized by a huge population, richness in natural resources, low per capita footprint and low but skewed consumption. Although, the per capita footprint of these countries are relatively small in comparison to HI and UMI group, but the EF has an increasing trend and the gap between the EF per capita and BC per capita is widening (*see* Figure 4.6a, 4.7a, 4.8a, 4.9a, 4.10a). However, the consumption pattern of a handful of people who has access to most of the resources has significantly contributed to increase the EF in most of the LMI countries (Marcotullio, 2001; Galli et al., 2012). All the LMI countries, except Indonesia, have overshoot their demand for nature ( $EF > BC$ ), thus all of them are ecologically deficit countries. The Figures 4.6b, 4.7b, 4.8b, 4.9b and 4.10b show that the cropland footprint is the significant contributor to ecological footprint in

the LMI group. However, carbon footprint is gradually increasing, which is mostly evident in the case of India, where cropland footprint is declining and share of carbon footprint in EF is increasing. The decline in cropland footprint indicates that the LMI countries are also in a transition phase moving from agriculture to industrialization. However, although with the growth of other sectors, the overall share of agriculture on GDP has decreased in these countries but agriculture still continues to play a dominant part in the overall economic scenario of the LMI group.

## 4.5 Summary

This chapter taking per capita ecological footprint as an indicator of humanity's demand for nature and adjusted net savings as the total stock of capital, analyzed the path of sustainability followed by selected Asian countries with different income groups. The chapter conducted a time series trend analysis of ecological footprint (along with the components of EF) and the biocapacity per capita to understand the status of natural capital of the selected countries. The findings of the chapter showed that the selected emerging countries of Asia has great variations in their demand for as well as supply of natural resources over the study period. However, in all the selected countries, since mid-1970s, the human demand has overshoot the available domestic resources, which has led to an environmental degradation. This overshoot since then has been growing and the countries continue to follow a 'weak sustainability' path by substituting natural capital by man-made capital.

From the above time series trend analysis, it is clear that all the 10 selected Asian countries are successful in managing their total capital stock which is revealed through the increasing trends of ANS over the time from 1970 to 2010.

The results basically established that the biocapacity of the selected Asian countries is under stress due to the present patterns of economic growth. Further, the study found, that between HI, UMI and LMI countries, the most pronounced disparity is in the carbon component. For the HI group the share of carbon

component in the EF is higher than the UMI and LMI groups. However, the share of carbon component in the upper and low middle-income group is gradually increasing while the share of other components – forest, grazing land – is falling, indicating a “transition from primarily biomass driven to fossil fuel driven societies” (Galli et al., 2012).

The only exception is Indonesia where there is still bio-reserve (as already discussed above). This can be measured by comparing what nature’s supply is and what the humanity demands from the environment. But this bio-reserve is getting depleting very fast and if this trend continues, very soon Indonesia’s per capita EF will cross its per capita BC (*see* Appendix 6).

Since the selected countries under this study are growing economically by substituting their natural capital into man-made capital and since their demand on nature, in terms of EF per capita, is also increasing; it is now necessary to see which are the factors that have the largest impact on the continuously increasing demand on nature. The next chapter hence performs econometric models using all the collected data to analyze the three panels of HI, UMI, and LMI group of countries.

## Chapter 5

# Underlying Factors Defining the Growth Patterns in Asia: A Panel Data Analysis<sup>15</sup>

---

### 5.1 Introduction

In Chapter 4, the time series trend analysis indicated that the relationship between environmental indicators (both SS and WS indicator) and economic growth for the ten selected Asian countries varies across income groups. It also showed that except Indonesia where the ecological footprint is still below its biocapacity, all the other countries, selected in this study, are following a weak sustainability path. To understand factors behind the weak sustainability path followed by the countries in three different income groups, a panel data regression analysis was carried out. It was carried out taking ecological footprint as a dependent variable, as it reflects the demand for nature, along with explanatory variables – (biocapacity, GDP, population, and urbanization), to examine the impact of these explanatory variables on EF. This section carries the results of the panel data analysis.

### 5.2 Panel data analysis

As discussed in the research methodology chapter (Chapter 3), a panel data analysis was carried out using additional variables using the equation given below

$$ef_{it} = \beta_0 + \beta_1(lnbc)_{it} + \beta_2(lngdpp)_{it} + \beta_3(lnpop)_{it} + \beta_4(lnpercenturbp)_{it} + \alpha_i + \varepsilon_{it}, \text{--- (A)}$$

First, Hausman test was performed to decide whether a fixed effect or a random effect model is the best for estimating the equation (A). The result of Hausman test is included in Table 5.1. An insignificant p-value of Hausman test statistic

---

<sup>15</sup> This chapter is under review in the Journal of Environmental Planning and Management, Paper ID: CJEP-2016-0151 titled “Sustainable Development and Natural Capital: A panel study of ecological footprint of Asia”.

indicates that a random effects specification may be inconsistent, and a significant p-value of the test suggests that the fixed effect model seems to be more suitable for that case. The result of Hausman test statistic (70.66 with  $p=0.001$ ) confirms that both estimators are consistent, but fixed effect estimates are more efficient in this case.

### ***5.2.1 Cross-sectional dependency test result***

The Stata command 'xtcsd' has been used to check if there is cross-sectional dependence in the regression models adopted in this study. The results are as follows.

*For fixed effect model:*

Pesaran's test of cross-sectional independence=0.456, Pr=0.6486

Average absolute value of the off-diagonal elements=0.357

The CD test accepts the null hypothesis of cross-sectional independence. The average absolute correlation of the residuals is 0.357, which is low. Hence, the evidence is not enough to suggest the presence of cross-sectional dependence in the fixed effect panel data model.

*For random effect model:*

Pesaran's test of cross-sectional independence=0.519, Pr=0.6034

Average absolute value of the off-diagonal elements=0.363

The CD test accepts the null hypothesis of no cross-sectional dependence. The average absolute correlation of the residuals is 0.363, which is again low. Hence, the evidence is sufficient to suggest absence of cross-sectional dependence in the random effect panel data model.

### ***5.2.2 Unit root test results***

Since the presence of cross-sectional dependence is rejected in the CD test in both FE and RE models, unit root test was performed to examine possible non-stationarity of variables used in the econometric analysis before investigating the

liaison between economic growth, environment, population and urbanization. A large number of non-stationary data can give spurious results because of existence of unit roots. Panel unit root tests assume independence of cross-sections (Baltagi, 2005). The results of the unit root test are reported in the Appendix 7. Decision of accepting or rejecting the null hypothesis of having unit roots is taken based on three methods. A series is considered to be stationary if majority of the methods reject the null hypothesis. However there are two benchmarks: i. if the series with a unit root is not differenced, the results will be spurious; ii. whereas, if a stationary series is transformed to a differenced one, the series losses its efficiency on account of the moving average error generated during differencing the series (Kennedy, 2008, pp. 309). So, utmost care is taken to have the best unit root results. All tests were estimated with a constant term and trend. Cross-section means were removed by subtracting. The three unit root tests LLC, IPS and ADF showed enough evidence that the studied variables are trend stationary at level. Only exception is recorded in the variable- *lngdpp* which is stationary at level only, not trend-stationary. So, conclusion can be drawn that all the studied variables are stationary at level and in all variables the null hypothesis on non-stationarity can be rejected.

The scatter plots of all the variables before and after logarithmic transformation are presented in Appendix 8(a) and 8(b) respectively for each income level.

### **5.3 Panel data estimation results**

Panel data yields valued evidence and makes the assessments across the countries because it combines cross-section (entities) of individual time-series. Panel data controls non-stationarity of data. Therefore, a panel data regression analysis was carried out using the fixed effect and random effect estimation technique, thus, permitting for more heterogeneity in the shape of growth - environment relationship. Both this estimation approaches control for unmeasured heterogeneity that the ordinary regression estimation ignores. The big advantage of the fixed effect estimator is that any potential correlation between the explanatory variables and the fixed effects is treated harmless and, therefore, their

correlations with the explanatory variables are wiped out from the equation to be estimated (within transformation, as discussed in Chapter 3). Without the within transformation, correlation between the explanatory variables and the fixed effects would bias the estimations. One disadvantage of using the fixed effects estimator is that the effects of time-invariant variables cannot be assessed (Barua, 2009). But this obstacle is overcome in the random-effects estimator which can also estimate all coefficients more efficiently as it uses both the cross-sectional (between) and time-series (within) variation of the data.

However prior to fixed or random, the coefficients of the explanatory variables are estimated through the pooled regression technique to have an overall idea about the behaviour of the explanatory variables towards the dependent variable. This regression assumes a constant intercept and slopes irrespective of country or time periods. The results of OLS regression are presented in Appendix 9. In this study with 10 countries and 41 years, the basic scheme is that ecological footprint is impacted and determined by biocapacity, GDP, population and urbanization. The pooled OLS hypothesizes that there is no difference in intercept and slopes across countries and time period. So, estimation is also conducted for each income group-HI, UMI and LMI, separately and presented in the same table.

### ***5.3.1 Fixed effect and Random effect estimation (overall)***

The Panel regression estimation method was applied for all the ten Asian countries running the models using the fixed effect and the GLS econometric technique with and without income level effects. The Hausman statistic was tested to see whether fixed effect or the random effect model fits the data best. Hausman test for the data confirms that  $x_i$  and  $\alpha_i$  are uncorrelated and so both estimators are consistent, but fixed effect estimates are efficient. The estimation results from both fixed effect as well as random effect estimation for ecological footprint per capita are reported in table 5.1. For comparison purpose, the both fixed as well as random effect results (with and without income level effects) are presented in the same table.

**Table 5.1****Fixed and Random effects regression results for all 10 countries**

<i>Variables</i>	<i>Fixed Effect</i>	<i>Random Effect without income level effects</i>	<i>Random Effect with income level effects</i>
Biocapacity per capita	0.0916** (0.016)	0.0807*** (0.002)	0.0771*** (0.002)
GDP per capita	0.4404*** (0.000)	0.462*** (0.000)	0.4303*** (0.000)
Population growth rate	0.0019 (0.919)	0.0217 (0.263)	-0.0014 (0.941)
Urbanization	-0.2634*** (0.000)	-0.2338*** (0.000)	-0.2399*** (0.000)
Income level	No	No	Yes***
Constant	-1.8484*** (0.000)	-2.1231*** (0.000)	-1.2174*** (0.000)
Number of observations	408	408	408
Number of countries	10	10	10
R <sup>2</sup> (within)	0.7025	0.7008	0.7021
R <sup>2</sup> (between)	0.8859	0.8956	0.9111
R <sup>2</sup> (overall)	0.8540	0.8631	0.8901
F- statistic	232.62*** (0.000)		
Wald chi <sup>2</sup>		1083.92*** (0.000)	1204.14*** (0.000)
Pesaran's test of cross sectional independence	0.698 (0.485)	1.981 (0.048)	1.153 (0.249)
Hausman statistic	70.66*** (0.001)		

p-values of the estimated coefficients are given in parentheses

\*\*\*, \*\* and \* indicate significant at 0.01, 0.05 and 0.10 (significance) level respectively

Both F statistics and Wald test results indicated that the results from FE and RE model, as well as the coefficients, are jointly significant at the 1% level.

Table 5.1 represents the parameter estimates for all the 10 selected Asian countries based on the model specification (A) where the per capita ecological footprint enters into its right as a dependent variable and is meant to account for environmental impacts of the explanatory variables. Both FE and RE (without income level effects) gave the same results for all the explanatory variables-*bc*, *gdpp*, *pop* and *percenturbp*. The results indicate the robustness of the two estimation techniques. All explanatory variables have a highly significant effect on the EF as expected.

For fixed effect model, F-statistics tells whether all coefficients are jointly equal to zero - i.e. the model as a whole is significant (Barua, 2009). The results are significant at 1% level. The Wald test result reported for EF per capita confirms that coefficients are jointly significant.

Findings from the FE and RE analyses in Table 5.1 yield multiple theoretically relevant relationships.

The effect of per capita GDP is statistically significant with a positive sign, is relatively strong in magnitude, and remains stable across both the models – FE and RE. The results indicate that a 1% increase in GDP per capita results in almost 0.4% of increase in per capita EF as a whole in all the three models. The effect of urban population is negative and statistically significant in all the three regression models. The results of all the three models suggested a 0.2% reduction in the overall EF per capita when urbanization increases by one unit. This result implies two possibilities. First more urbanized societies exhibit lesser levels of consumption and lesser demand for nature as found by studies like Martínez-Zarzoso and Maruotti (2011), Liddle (2013) etc. These studies have argued that urbanization improve the efficient use of infrastructure and other utilities by lowering energy use and emission. Second, out of the 10 selected countries only the HI countries are highly urbanized, other 8 countries have only 30-38% urbanization only. Turning to the bio-capacity, results from all the three models- the FE, RE (without income level effect), and RE (with income effect) show positively significant relationship between per capita biocapacity and per capita

footprint. This can be interpreted in two ways. The significantly positive relation of fixed effect implies that biocapacity do have much influence on the demand for nature in the selected Asian countries and a positive -significant relationship of the RE models with and without income effect may imply that biocapacity has indeed favourable effects on the increase in the levels of income for the selected Asian countries and this variable will have impact on the natural capital in the future also. The population growth rate was found insignificant in all the three models which suggests that population growth rate is declining in this whole region This result, however, unfolds the reality that all people do not demand equal amount of natural capital. In other words, consumption per capita in these countries is highly skewed. This also explored the truth that the selected Asian countries are heavily indebted by inequity in resource distribution.

All these results were based on all the 10 selected countries as a whole. But what is the pattern of the growth-environment relationship at the income levels? Below are the results of panel data analysis based on the three income groups-HI, UMI and LMI.

### ***5.3.2 Estimation results (based on income groups)***

To get a better picture of the impact of the explanatory variables on the dependent variable, income group specific regression analysis was performed by both FE and RE estimation techniques.

#### ***5.3.2.1 High-income group***

Table 5.2 shows the estimation results for the selected ten Asian countries, based on the HI panel to determine the relationship between each of the dependent variable *ecological footprint* and the independent variables, which are *per capita bc*, *per capita GDP*, *population growth rate* and *urbanization*. This panel consists of the two very high-income countries of Asia - Republic of Korea and Singapore.

**Table 5.2****Fixed and Random effects regression results for High-Income countries**

<i>Variables</i>	<i>Fixed Effect</i>	<i>Random Effect</i>
<i>Biocapacity per capita</i>	0.156* (0.084)	0.0058 (0.662)
<i>GDP per capita</i>	0.4456*** (0.000)	0.3169*** (0.000)
<i>Population growth rate</i>	0.0214 (0.428)	0.0174 (0.522)
<i>Urbanization</i>	0.4931** (0.024)	0.8130*** (0.000)
<i>Constant</i>	-4.8167*** (0.000)	-5.2689*** (0.000)
<i>Number of observations</i>	80	80
<i>Number of countries</i>	2	2
<i>R<sup>2</sup> (within)</i>	0.9097	0.9062
<i>R<sup>2</sup> (between)</i>	1.0000	1.0000
<i>R<sup>2</sup> (overall)</i>	0.5936	0.9420
<i>F- statistic</i>	186.43*** (0.000)	
<i>Wald chi<sup>2</sup></i>		1217.21*** (0.000)

p-values of the estimated coefficients are given in parentheses

\*\*\*, \*\* and \* indicate significant at 0.01, 0.05 and 0.10 (significance) level respectively. Both F statistics and Wald test results indicated that the results from FE and RE model, as well as the coefficients, are jointly significant at the 1% level.

From table 5.2 it was found that while GDP per capita has a statistically significant effect on EF per capita, for both FE model and RE model. The results are similar for FE model as well as RE model, indicating that GDP per capita will continue to play a significant role in driving the EF in the future in both the countries. Since 1970, there has been a tremendous growth in the countries, making them highly developed and free market economy of Asia. Both Singapore and Republic of Korea, with scanty natural resources were third-world nations with poor infrastructure and limited capital in the sixties (Singapore, 2015). Rapid industrialization, particularly export-oriented industries drove their economy and today the per capita GDP of Singapore as well as Republic of Korea is, in fact, higher than many developed countries. While GDP per capita of these countries increased by almost four times during the study period, this was accompanied by high EF per capita.

Urbanization is highly significant on EF per capita in both FE model and RE model for the HI group, it shows that urbanization has a positive relationship with EF per capita. Being highly urbanized, these countries have a high level of consumption based environmental demand (Galli et al., 2014), which drives the per capita EF. While population in both these countries are relatively small and the panel result also provide little evidence for population to be significant, high per capita energy intensive consumption of the people of Singapore and Republic of Korea offsets the benefits of a small population. As reported by the WWF (2010) “If every person in the world lived like Singaporeans, 4.1 planets would be needed to sustain our needs”.

In the case of biocapacity, the FE and RE models provide insufficient evidence that the supply of natural resources significantly affects the demand for it. A significant effect of supply of biocapacity as found in the fixed effect model was expected as these are resource poor countries and mainly dependent on importing resources for development purpose. So the country-wise differences are reflected in the model. But these two HI countries are adopting green growth strategies which may have affected the per capita EF as reflected through the RE model

estimation. As mentioned earlier, the footprint is mostly driven by carbon footprint in both the countries, while the footprints of other components have remained more or less same compared to carbon footprint since the 1970s.

The high economic growth of Singapore and Republic of Korea, led to substantial reduction in poverty and high human development, with Singapore ranking 11 and Republic of Korea 17 in the human development index<sup>16</sup>. However, all these achievements had a negative implication on natural capital as both the countries followed a weak sustainability path, which led to high consumption-based environmental impact. While Singapore have the seventh-largest ecological footprint in the world, Republic of Korea's demand on ecological resources increased from less than its own biocapacity in 1961 to almost eight times domestically available biocapacity in 2012 (GFN, 2014). Energy intensive lifestyle and unsustainable consumption patterns have contributed to the increasing carbon emissions produced per capita in both the countries as well as the ultimate driver of resource use. Attempts have been made in the recent past to invest in the natural capital through green growth strategies - reducing carbon emissions, integrating renewal energy and promote sustainable consumption - but we are yet to see the long run effect of such strategy on the EF per capita of Singapore and Republic of Korea.

### **5.3.2.2 Upper middle-income group**

The findings of both fixed and random estimation results for UMI countries are reported in table 5.3. The results from both the estimation (FE and RE) are similar which indicates the robustness of the results. Both fixed and random estimation results of Panel 2 show that only *gdpp* has statistically significant positive impact. *Pop* and *percenturb* has statistically significant negative impact.

---

<sup>16</sup> HDI includes life expectancy, education, and income per capita indicators.

**Table 5.3****Fixed and Random effects regression results for Upper Middle-Income countries**

<i>Variables</i>	<i>Fixed Effect</i>	<i>Random Effect</i>
<i>Biocapacity per capita</i>	-0.2078 (0.170)	0.3489*** (0.000)
<i>GDP per capita</i>	0.6652*** (0.000)	0.1735*** (0.000)
<i>Population growth rate</i>	-0.114* (0.058)	-0.2759*** (0.000)
<i>Urbanization</i>	-1.2205*** (0.000)	-0.0417 (0.778)
<i>Constant</i>	0.2148 (0.577)	-0.6249* (0.076)
<i>Number of observations</i>	123	123
<i>Number of countries</i>	3	3
<i>R<sup>2</sup> (within)</i>	0.7382	0.6768
<i>R<sup>2</sup> (between)</i>	0.0029	0.9972
<i>R<sup>2</sup> (overall)</i>	0.1581	0.8814
<i>F value</i>	81.76*** (0.000)	
<i>Wald chi<sup>2</sup></i>		876.77*** (0.000)

p-values of the estimated coefficients are given in parentheses

\*\*\*, \*\* and \* indicate significant at 0.01, 0.05 and 0.10 (significance) level respectively

Both F statistics and Wald test results indicated that the results from FE and RE model, as well as the coefficients, are jointly significant at the 1% level.

Table 5.3 showed that the effect of *gdpp* is positive and statistically significant for both the models. This result is similar to the HI group, and as expected. These countries set a classic example of rapid economic growth in less than a generation, which upgraded them from a low to upper middle-income economies. Being rich in natural resources, the growth in these countries was broadly been supported by the primary sector i.e. agriculture and harvesting of natural resources, which is evident from the large share of cropland and forest land footprint in the EF footprint (see Figure 4.3b, 4.4b, 4.5b of Chapter 4). Therefore, while this rapid growth is accompanied by a reduction of poverty and improved welfare but was achieved at the cost of degradation of natural capital. This also reveals that the countries followed a weak sustainability path by increasing the total stock of capital but at the cost of replacing natural capital by man-made capital.

The effect of the population is negative and significant on EF per capita of UMI group. This result is robust because it is invariant with both FE and RE models used in this study. There may be two reasons: one is the declining population growth rates in these countries, especially in China. China is also Asia's most populous country and hence it is not surprising to see that population has a highly significant impact on EF. The other may be the low EF per capita. The low level of ecological footprint per capita shows a contradictory result. The reason could be that while these countries particularly China has a large population, the consumption per capita is extremely skewed. For example, although China's per capita ecological footprint is 2.1 gha, which is lower than the global average of 2.7 gha, China's total Ecological Footprint is the largest in the world in view of its large population size (WWF, 2012). This means that only handful of people have access to most of the resources and those who have the access have played a significant role in increasing the ecological footprint of these nations (Marcotullio, 2001; Galli et al., 2012). The Gini coefficient, which indicates income inequality, is very high in all the three countries (China – 46.6, Thailand – 48.4 and Malaysia – 46.2), which further indicates that distribution of wealth as well as access to resources, are not evenly distributed. Economic inequality leads to an oversupply of environmental problems (Keshwan, 2017). Therefore while urbanization in

most cases seems to have a significant impact on EF (York et al., 2003; Jorgenson and Clark, 2011), but in the case of the selected UMI countries we found the effect of urbanization to be insignificant because the process of urbanization in these countries have not facilitated a fair distribution of resources and have been achieved by making significant compromises on the standard of living, which has kept the per capita EF low.

It is also important to mention here that these countries are biocapacity exporters. Being biocapacity rich, the domestic resources are used to meet not only domestic demand but also to meet global demand (Asici, 2013). Malaysia, China, and Thailand often export biocapacity embodied in primary / manufactured products to countries like Singapore, Japan, USA, Hong Kong, Australia etc. to meet their domestic demand. Therefore, a significant and positive effect of biocapacity on the domestic EF per capita of the UMI group was expected, as table 5.3 reveals, because natural resources of UMI countries constitute a fairly big share of exports (Muradian and Martinez-Alier, 2001). But as table 5.3 reveals, biocapacity is not positively related to ecological footprint in UMI group. In other words consumption of natural capital is not increasing because of biocapacity; rather there is a negative relationship between the two, though the relationship is not significant. In all the three UMI countries, since 1990s, there seems an upswing trend in imports of ecological footprint, but export is decreasing (based on GFN, 2014 data). This has helped in reducing the pressure on the domestic biocapacity of these upper middle income countries. Till 1990s, as stated by Jorgenson and Clark (2011), more available arable land allows these countries for developing their built infrastructure like rail and road transport, industries etc., which contributes to the ecological footprints of the countries nations as well. This randomness in biocapacity is reported in the RE model.

Although the EF of the UMI countries is high and has an increasing trend (e.g. Malaysia has an EF of 4.86 gha, which is as high as Singapore), but they lag behind the high-income group in terms of human development. The HDI ranking

of China, Malaysia and Thailand, which is 90, 62 and 93 respectively for the year 2014 (UNDP, 2015), is still very low compared to the HI group. The increasing share of carbon footprint of these countries is also a cause of concern and is likely to grow in the future. Urban household consumptions, capital investments and growth in exports are expected to be main drivers behind such increase (Galli et al., 2012). Although, UMI countries have adopted green development plans like - green development goals in China to reduce carbon footprint, investment in natural resources by conservation of ecosystem services in Malaysia and policy for sustainable use of natural resources in Thailand - but to pull themselves up from the middle-income trap to become a fully developed country, they will continue to focus on high economic growth irrespective of its impact on the natural resources. As such there is a possibility that the weak sustainability pattern of development is likely to continue, which might have an irreversible impact on natural capital in these biocapacity rich nations.

### ***5.3.2.3 Lower middle-income group***

**Table 5.4**  
**Fixed and Random effects regression results for Lower Middle-Income countries**

<i>Variables</i>	<i>Fixed Effect</i>	<i>Random Effect</i>
<i>Biocapacity per capita</i>	0.3141*** (0.000)	0.3197*** (0.000)
<i>GDP per capita</i>	0.1636*** (0.000)	0.3067*** (0.000)
<i>Population growth rate</i>	-0.1070*** (0.000)	0.0777*** (0.001)
<i>Urbanization</i>	-0.0100 (0.660)	0.0454 (0.224)
<i>Constant</i>	-0.9756*** (0.000)	-2.2026*** (0.000)
<i>Number of observations</i>	205	205
<i>No. of countries</i>	5	5
<i>R<sup>2</sup> (within)</i>	0.6096	0.3656
<i>R<sup>2</sup> (between)</i>	0.8083	0.9403
<i>R<sup>2</sup> (overall)</i>	0.7952	0.8951
<i>F value</i>	76.50*** (0.000)	
<i>Wald chi<sup>2</sup></i>		1706.10*** (0.000)

p-values of the estimated coefficients are given in parentheses  
 \*\*\*, \*\* and \* indicate significant at 0.01, 0.05 and 0.10 (significance) level respectively  
 The F-statistic is significant at the 1% level which suggests that the fixed effect model as a whole is significant. The Wald test result confirms that coefficients are jointly significant for all the three countries under this panel

The fixed effect estimation technique in table 5.4 indicates that the independent variables – *bc* and *gdpp* have positive and significant impact on per capita EF and *pop* has negative and significant impact of LMI group. *percenturbp* does not have any significant impact. The LMI group is experiencing an averaged GDP growth rate of 6% - 7% per annum, which has resulted in substantial increase in the per capita GDP of the LMI group. The economies of these countries are going through an economic transformation due to rapid industrialization. This is also because there has been a shift away of production from relatively more efficient centers of production, such as Japan, to relatively more resource-intensive centers of production like India and Bangladesh. With economic growth, these countries are slowly advancing towards development, urbanization and industrialization, which have resulted in significant changes in land use - converting agricultural land to non-agricultural purposes. This is also the reason for a sharp decrease in cropland footprint and a sharp increase in the demand for carbon uptake land in all the five LMI countries (see Figure 4.6b, 4.7b, 4.8b, 4.9b, 4.10b of Chapter 4).

Urbanization, which is negative and insignificant for the FE model, implies that urbanization has no positive impact on the EF per capita as average urbanization is only 30% as a whole for this group. This result is similar to Poumanyong and Kaneko (2010) and Sadorsky (2014) who surprisingly have noticed that urbanization decreases energy use in the low-income group. As a reason the authors explained that in low-income group, there could be possibility of switching from inefficient out-dated fuels to efficient modern fuels. However rise in population living in urban areas might be the driving variable of LMI group's demand for nature beyond the regenerative capacity of the biosphere (Galli et al., 2012). The biocapacity of the LMI group is positive and significant and this finding is somewhat similar to the findings of Jorgenson et al. (2011). Jorgenson et al. (2011) found that domestically available bio – productive land increases consumption opportunities. Hence in our study, since all the five lower middle-income countries are rich in biocapacity it provides them with larger arable land for development of built infrastructure, which contributes to EF as well carbon footprints. Urbanization's impact on EF per capita is negatively insignificant

should not be a matter of pride for these countries as it has been achieved by extreme compromises on quality of life. Any increase in prosperity of the urban population will lead to an increase in the footprint in the future (Sanyal et al., 2008).

While LMI countries have already reached its overshoot situation, the economic growth experienced by these countries has not consistently raised the average standard of living of all people. This is one of the reasons why the EF per capita is very low for these countries. The development has been extremely skewed, which indicates that while some citizens are enjoying a higher standard of living, the majority are not getting much benefit from this prosperity. Instead, poverty is mounting as an increasing number of people contest for an inadequate pool of resources (Poumanyvong and Kaneko, 2010). Indeed, the ecological footprint of many needs to be intensified in order to fulfil the basic needs of life, like sufficient nutrition, housing, electrical energy, hygiene, treatment and material goods.

A number of studies (Galli et al., 2012; Asici 2013; Cobbinah et al., 2015) have found that due to increasing demand on natural resources these countries have already placed an unprecedented demand for the provisioning services of the environment and is adding to the degradation of land and water properties. The weak sustainability path followed by these countries will have a big implication on the poor people of these countries as a large section of the population still depends directly on natural resource based livelihood like agriculture, fishing etc. The countries are also faced with multiple challenges such as low HDI ranking, multi-dimensional poverty, raising Gini coefficient and high gender inequality ratio. Hence economic growth will continue to have a prominent place in government agenda of these countries. If these countries follow the path of HI and UMI group, with the population pressure they have, the kind of economic and environmental consequences it may have seems to be the matter of concern.

## 5.4 Discussion on the findings

Regardless of the concern whether the analysis is for all countries combined or restricted to high-, upper middle- or lower middle-income countries, the effect of level of economic growth on the per capita ecological footprints of the selected 10 Asian countries increases consecutively.

Nonetheless, the findings question the validity of neoclassical economic theory's claims concerning the possibility of substitutability of natural capital by man-made capital and that growth will take care of the environment. The results suggest the similar results as Jorgenson and Clark (2011) have found. They have found that *“through time, economic development has become relatively more resource use intensive and thus increasingly environmentally taxing”* (page no. 239).

This study covers a long history of economic development and environmental consequences of the selected Asian countries. It appears that as time passes economic growth demand more supply of resources. Thus, the growth has become increasingly ecologically demanding. The results further suggest that the selected Asian countries, with their finite natural resources, are now facing the environmental consequences of their unprecedented economic growth. The analysis indicates that reverse movement has occurred in both HI countries and middle income countries.

These results authenticate elementary postulates of interaction between human housekeeping and nature's housekeeping. The outcomes, together with the stated effects of economic growth, biocapacity, urbanization and population, highlight the significance in considering the importance of ecological dynamics while concentrating on the environmental impacts of socio-economic conditions.

## Chapter 6

# Mainstreaming Natural Capital into Decision Making for Sustainable Development in Asia

---

### 6.1 Natural vs man-made capital

In the Rio+20 conference, all the participants - heads of State and Government and high-level representatives have renewed their obligation towards achieving sustainable development, and to ensure the campaign for economically, socially and environmentally sustainable future for the planet and for humanity (Rio+20, 2012). They also reaffirmed their responsibility towards the present challenges to sustainable development, especially in developing countries. The goal of sustainable development would not be achieved unless social sustainability, which is regarded as the “weakest” pillar of the SD concept (Lehtonen, 2004), is achieved. Achievement of economic stability and sustainable growth must ensure the “...*promotion of social equity, protection of the environment, enhancing gender equality and women's empowerment, equal opportunities for all, and the protection, survival and development of children to their full potential, including through education*” (Rio+20, 2012).

The socio-economic indicators are reflected in four primary dimensions in the Brundtland Report: safeguarding long-term ecological sustainability, satisfying basic human needs, and promoting intragenerational and intergenerational equity (Holden et al., 2014). These four dimensions are interlinked and one should not be prioritized over another. The Brundtland definition has already connected the development of the human society with the sustainability of the natural capital. The necessity of sustainable use of natural capital in order to make people empowered to think radically for the future generation is greatly endorsed by the Brundtland Report. As an argument, the report cited “*The loss of plant and animal species can greatly limit the options of future generations; so sustainable*

*development requires the conservation of plant and animal species” (WCED, 1987, pp. 13).*

As discussed in chapter 5, the selected Asian countries vary in terms of their socio – economic development. To get an in-depth understanding in this section we highlight the status of a few important socio-economic variables ( *see* Table 6.1) in the 10 countries. The indicators mentioned in table 6.1 are defined in Appendix 12. In order to compare the ecological and social sustainability of these countries, EF per capita of each country is also presented in the same table.

**Table 6.1**  
**Status of the indicators of sustainability in the selected Asian countries**

Countries	HDI rank	Life expectancy at birth	Mean years of schooling	Multidimensional poverty index (Headcount ratio <sup>17</sup> )	Gender equality index	Gini coefficient	GDP per capita (US\$)	EF
<b>High Income Countries</b>								
Korea	17	81.9	11.9	NA (15%)	0.93	30.2	28,440	5.6
Singapore	11	83	10.6	NA (23%)	0.98	46.4	55,182	5.34
<b>Upper-Middle-Income countries</b>								
China	90	75.8	7.5	0.023 (5.20%)	0.94	46.9	6,807	2.21
Malaysia	62	74.7	10	3.8%	0.94	46.2	10,538	4.86
Thailand	93	74.4	7.3	0.006 (1.6%)	1	48.4	5,779	2.37

<sup>17</sup> Headcount ratio: percentage of population living in multidimensional poverty. Data are not available for Republic of Korea, Singapore and Malaysia. So percentage of people below poverty line is considered from the source Central Intelligence Agency (US) <https://www.cia.gov/library/publications/the-world-factbook/fields/2046.html>.

Lower-Middle-Income country								
Bangladesh	142	71.6	5.1	0.196 (41.3%)	0.91	32.1	747.37	0.6
India	130	68	5.4	0.283 (53.7%)	0.79	33.6	1,233.94	0.91
Indonesia	110	68.9	7.6	0.066 (15.5%)	0.51	38.1	1,853.80	1.21
Pakistan	147	66.2	4.7	0.230 (52.1%)	0.72	29.6	813.70	0.77
Philippines	115	68.2	8.9	0.052 (11.0%)	0.58	43.0	1,662.07	1.3

Data sources: HDI data were collected from (UNDP, Table 2: Trends in the Human Development Index, 1990-2014, 2015); data on multidimensional poverty were collected from (Alkire et al., 2016); data for all other indicators were collected from World Bank (Bank, 2014); source of EF data are already mentioned in Chapter 3.

The table 6.1 indicates that both the high-income countries have high per capita EFs but at the same time they have high HDI ranks and they have been able to reduce their poverty substantially. Inequity in access to the resource is a concern which is reflected by high Gini coefficient. A high HDI and high ecological footprint, shows that they followed a weak sustainability path, by replacing their natural capital by man-made capital. So while they have a strong social and economic status, but the degradation of the environment is a major concern. As these countries do not have enough natural resources left, they need serious policies to restrict and alter the trend direction (Niccolucci et al., 2012) and preserve the natural capital for the wellbeing of the population. The middle and particularly the low-income groups still have a long way to go when it comes to socio-economic development i.e. man-made capital. The performance of indicators like Gini coefficient, poverty rates, HDI, gender equity, health, and education is very poor and is a cause of concern. Hence, they are also incompetent to generate policies to meet the necessities of sustainable development, as at present their priority lies in improving the quality of life for a most of the population which is currently living in deficiency of basic needs through higher economic growth. They are thus confronted with the dual challenge of achieving ecological as well as the socio-economic dimension of sustainable development.

The countries are represented by large population, hence it is important to understand the link between poverty and environment as a large section of the community still depends on traditional livelihoods like agriculture, fishery, animal husbandry, dairy etc. and degradation of natural capital will threaten these livelihoods and will put poor and marginalised communities at risk by enhancing their vulnerability. Although the policy priorities currently lay elsewhere, but rising EF per capita and the declining BC also demands for measures to check the loss of environmental qualities like deforestation, degradation, soil erosion, etc. (Niccolucci et al., 2012).

As discussed elsewhere, man-made capital is not a substitute of natural capital, but is complements. In other words, man-made capital can be used to improve the status of the natural capital and vice versa. A country with high EF may have a high human development index which indicates that natural capital is successfully replaced by human or man-made capital. Also, a country with high demand on the BC may be successful in reducing inequity in society. Hence, there is a need to deeply understand the threats economic activities pose on natural resources and how it leads to resource limitation. Human wellbeing depends on the wellbeing of the natural capital and if natural capital is not integrated into socio – economic policies they may not be left with enough resources to support their productive activities.

## **6.2 Status of mainstreaming natural capital in Asia**

For mainstreaming natural capital, a country needs to first have an updated account of its natural resources. Although there have been some private efforts, like independent researches, NGOs, projects etc. for taking the stock of natural assets and resources, up until 21<sup>st</sup> century, the selected Asian countries had not initiated developing databases of their natural resources at the national level.

The selected HI countries have understood the benefits of conservation of natural capital. They have adopted green technologies to mitigate with the environmental

degradation such as climate change, pollution, deforestation etc. Both Singapore and Republic of Korea have claimed that they have been able to control environmental pollution, carbon emission and energy depletion. This claim is true to some extent as can be seen in the EF trends outlined in chapter 4. It is seen from figure 4.1b that carbon footprint is not increasing after 2005 in case of Republic of Korea. Similarly figure 4.2a show that there is a declining EF per capita trend in Singapore since 2008. But these two countries have already lost its natural resources and now they are only focusing on weak sustainability policies. They have not included EF accounts into their governmental plans. However Singapore has prepared the Sustainable Singapore Blueprint in 2015, where the country aims to reduce carbon footprint by considerably.

Among UMI countries, China started implementing national forestry and conservation policies, e.g. Sloping Land Conversion Programme (SLCP) since 1997-98 which involves many farmers (Daily, 2014). China has also established a new network of “ecosystem-function conservation area” (EFCAs) to focus on conservation and restoration of ecosystems. In 2014, Chinese Government has approved a new plan-Gross Ecosystem Product along GDP at all levels of the government. Investments in all these strategies are made targeting integrating people and environment by all people’s well-being by poverty alleviation, improved drinking, irrigation, maintaining hydropower, protecting biodiversity, climate stabilization to save grass land and forests to secure people from flood. Evaluating these programmes, especially the SLCP, it is seen that there is some success stories. Land conversion pattern has been changed and soil erosion has been decreased (Daily, 2014). The achievements are reflected in EF accounts too! There is a 15% increase in the total forest land biocapacity in China during last 20 years (1999-2009) (based on GFN, 2014 data).

The Philippines was the first among the selected LMI Asian countries which took initiative to mainstream natural capital into its national income accounting. From 1988, this country took methodologies such as Peskin approach (environmentally adjusted GDP estimates), System of Environmental-Economic Accounting, System of Natural Accounting etc. (Murty and Panda, 2016). In 2007, the

governments of six Asian countries including Indonesia, Malaysia, and the Philippines launched a framework called the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) to address threats to the natural capital of the Coral triangle<sup>18</sup> ecosystem (WWF, ADB, 2012). Under this initiative, investment is done to manage and protect designated seascapes, fisheries and marine natural resources. But this measure would be a vogue if the critical ecosystems are not understood scientifically. So to achieve the objectives of the CTI-CFF, member countries have tried to establish a sound scientific and knowledge base so that the global best practices can be shared and integrated towards decision making.

As already discussed in chapter 4 and 5, the Philippines is vulnerable to both natural calamities and environmental degradation. The country has not lost its total biocapacity during last 40 years under this study; but due to its increasing population and consumption, per capita available biocapacity has been reduced by 30.69% (based on GFN, 2014 data). In 2011, the government of Philippines started a multi-staged venture to analyze the country's limit imposed by its available natural resources and to identify opportunities for ecological footprint accounts for shaping policy making. To help in this initiative, the GFN published "a measure for resilience" in 2012. The report is adopted by the Cabinet Cluster on Climate Change Adaptation and Mitigation, which now is working for ensuring integrity of environment, climate change adaptation and mitigation strategies and measured by promoting sustainability of natural capital (GFN, 2016). The Philippines now has included EF as a national indicator.

The 2<sup>nd</sup> Asian LMI country under this study, having emphasizing on mainstreaming from strong sustainability perspective, is Indonesia. In 2010, the Ministry of Public Works published a report "Ecological Footprint of Indonesia". Djoko Kirmanto, the Minister of Public Works forwarded the report with this expression that this review is a:

---

<sup>18</sup> Coral Triangle is the planet's richest marine ecosystem, covering a vast ocean area that spans 6 Asia-Pacific countries- Indonesia, Malaysia, the Philippines, Papua New Guinea, Solomn Islands, and Timor-Leste (WWF and ADB , 2012).

*“perfect platform towards mainstreaming of sustainable development in Indonesia”* (Directorate General of Spatial Planning, 2010).

The objective of this review of EF of Indonesia is to inspire view while formulating policy of sustainable development and management in Indonesia and to promote well-being of both people and environment. The review report has recognized EF as a tool to be used to determine the sustainability of the natural resources and the environment.

The process of natural capital accounting is a process to value what environment has given to the society. India is lacking behind in preparing such account at the national level (Mali et al., 2016). However some progress has been observed at grass root level. For example, Mali et al. (2016) estimates the accounts and net present value of the forest resources of Kerala; Singh et al. (2009) explored the value and accounts of forest resources in Sikkim etc. (*see* Mali et al., 2016).

Like other capitals of production, natural capital also needs investment for its sustainable use. Till now, developing countries are only looking at natural capital from conservation point of view. It is hardly realized that by scientifically made investment, natural capital can be successfully mainstreamed for social sustainability by using it in improving social indicators. Although there are studies on the methodologies to accounting the environment, many Asian developing countries are unable to use them because of high cost of data collection, analysis and inefficiency in market formation (Mali et al., 2016). Implementation of environmental tax is another real life problem in these countries.

### **6.3 Challenges and barriers in the mainstreaming natural capital**

A key challenge for the selected region is to find such development path that enhances human development without much addition to ecological footprint (WWF

and ADB, 2012). The economic development strategies, policies, and programs of these countries, particularly in middle-income countries are focused mainly on rapid accumulation of physical capital, financial capital and human capital at the expense of natural resources, causing adverse impacts both on the present and on the future. Integration of natural capital in socio / economic policies is still in isolation from other forms of capital. There is a need to mainstream natural capital into decisions-making processes in these emerging Asian countries for long-term project focus, knowledge advancements, institutional involvements, and culture (Daily et al., 2011). There is a poor protection of natural capital in the selected Asian countries because in most of these countries neoclassical school of thought continues to dominate the decision-making procedure associated with economic growth. The neoclassical school of thought takes the services of natural capital for granted as they believe in the substitutability of natural resources by man-made resources as such the existing policies and institutions do not encourage or value management of ecosystems for service provision. The current price signals don't indicate sufficient value to encourage protection and provision of services. This is because the valuation of natural capital is done with a very reductionist approach (e.g value of the forest is equal to timber price in the market). While the government is slowly waking up and is able to understand the need to include natural capital in decisions related to economic growth, but how to integrate it, remains to be a major challenge. This is because unlike for economic goods and services, no ready tools to capture the actual value of natural capital is available. Unless such valuation techniques which can capture politically the complete value of the services provided by nature is developed, natural capital will continue to come as an add-on in the development decision and will not be able to take the center stage.

## Chapter 7

# Environment and Economic Growth: Conclusion and Looking Towards the Future

---

In this chapter, the main achievements and results of the research work are summarized and the areas needing future work are suggested.

### 7.1 Summary of the findings

Asia is one of the most emerging and fast developing economies of the world, and hence, the sustainable development path followed by Asian countries will definitely have a huge impact on the global economy. This study taking per capita ecological footprint as an indicator of human demand for nature analyzed the path of sustainability followed by selected Asian countries with different income groups. The study first conducted a time series trend analysis of ecological footprint per capita (along with the components of EF), biocapacity per capita and adjusted net savings to understand the status of natural capital and the total stock of capital of the selected countries. The findings of the analysis show that the selected countries vary greatly in both their demand for and supply of natural resources over time. All the selected countries have an increasing per capita ecological footprint and declining biocapacity indicating that they have overshoot their demand for the natural resource. The total stock of capital, i.e. adjusted net savings has an increasing trend which indicates that the total stock of capital is positive, but has been achieved at the cost of degradation of natural capital. Hence, based on the time series trend analysis, it can be concluded that the declining ecological reserves of all the selected countries —high, upper middle and lower middle-income — make them, in environmental terms, “weakly sustainable nations”.

The human demand had exceeded the global<sup>19</sup> biocapacity since the mid-1970s in all the selected Asian countries, which has led to an environmental degradation. This overshoot since then has been growing and the countries continue to follow a weak sustainability path by replacing natural capital by man-made capital. There is a possibility that growth-oriented development of these countries may further widen this gap. However, as Galli et al. (2012) have already pointed out, the major concern in these countries is the growing population, which has a positive relationship with resource utilization. The high population pressure in these countries has continued to put pressure on natural resources, especially in the case of lower middle-income group despite of declining population growth rates. Due to the large population size these countries may take a longer time to reach the per capita income of high-income countries and during that time, there could be irreversible damage to the natural resources of these countries. Increasing adjusted net savings and a steady increase in the ecological footprint per capita indicate that they are following a path of weak sustainability. It remains to be seen how long these countries will continue to move on this path, as at present the economies of these countries are mostly dependent on natural resource intense sectors (*see* Sachs and Warner, 1997; Coxhead, 2004).

The panel data analysis, across the income groups-high, upper middle and lower middle - identified the underlying factors driving the per capita EF in the selected Asian countries. The result indicates that economic growth is the common factor responsible for driving the per capita EF in all the three income groups of countries - high, upper middle and lower middle to have a significant impact on the natural capital. We found that high-income countries, showed a continuous increase in the per capita EF although they are endowed with low per capita BC. They have higher levels of consumption-based impacts, which drive the ecological footprint. They need serious policies to limit and change the direction of the trend (Niccolucci *et al.*, 2012). For these HI countries, along with GDP per

---

<sup>19</sup>It is meant that the per capita demand in the selected Asian countries has crossed the availability of natural capital per capita at the global scale (Appendix 13).

capita urbanization also plays a significant role in driving the per capita EF. Although HI countries have huge EF, to restore natural capital they are following green growth strategy by integrating natural capital into the decision-making process as we have seen in Chapter 6, and but we are yet to see its impacts on EF.

In the case of UMI countries, the panel data regression models found that GDP per capita is the significant contributor in driving the economic growth and also for putting pressure on the natural capital of these countries. Further for LMI countries, GDP per capita, and biocapacity are the significant contributors to the increasing trends of per capita ecological footprint. However when population growth rate is considered, it is found that its magnitude of influencing the environment has been declining as it is influenced by various factors like social institutions, government policies, technological changes, ecological conditions, individual behavior etc. (Jorgenson and Clark, 2010). All the selected upper middle and lower middle income groups are also following the same pattern of growth like the high income countries and have experienced a rapid transition from an ecological surplus to ecological deficient countries. Inequity in access to resource and benefits from economic growth continues to be a big challenge in these countries, which has resulted in poverty and low quality of life. Hence, they are also unable to develop policies to meet the requirements of sustainable development, as at present their priority lies in improving the quality of life for vast segment of population now living in poverty through higher economic growth. They are thus confronted with the dual challenge of achieving ecological as well as socio-economic dimension of sustainable development. Thus these countries are also following a weak sustainability path and will continue to do so as natural capital has not received much attention in the decision-making process.

Overall, the findings suggest that per capita ecological footprint can be influenced by multiple factors like economic growth, population and population growth rate, urbanization, consumption patterns, export demand etc. and it is therefore important to balance economic development and exploitation of natural resources. There is a need to deeply understand the threats economic activities pose on

natural resources and how it leads to resource limitation. To know these critical limits, realistic knowledge regarding interaction between natural capital and human well-being is required (Pelenc & Ballet, 2015). Human wellbeing depends on the wellbeing of the natural capital and if natural capital is not integrated in socio – economic policies they may not be left with enough resources to support their productive activities. Natural capital is crucial for the welfare of all species as well as for sustainable economic growth. But it is declining at an accelerated rate due to man-made activities in all the ten selected Asian countries. The selected Asian countries are faced with challenges of both environmental and social dimensions. Many of the Asian countries are facing the negative impacts of the monetary and financial crisis. Along with that, there are challenges due to climate change such as sea-level rise, natural resource depletion, environmental degradation, which could threaten food security, energy security and human safety. It is already seen in this study that economic growth which is demanding more from the domestic as well as global natural resources, is the major contributing factor in increasing per capita ecological footprint. So the growth strategies are to be revised in such a manner that natural capital can be incorporated into development and financial planning. The Philippines and Indonesia are only two countries among all the 10 selected Asian countries which are implementing Ecological Footprint accounts as a framework to mainstream their natural resources and to integrate it with the social wellbeing. However a Proper understanding of natural capital is a thrust area to attain SD goals in these countries.

## **7.2 Limitations and future research possibilities**

The limitations of this research in terms of data collection and methodological shortcomings have been discussed in Chapter 3 of this study. Also, the results may be biased by the way the countries are selected. Empirical examination of institutional indicators into the study could not be incorporated due to insufficiency of data and methodological issues, like their quantification. So, indicators to represent international treaties, conservational policies, technological

progress etc. might add explanatory power to the estimation result and may provide a better explanation for sustainability paths adopted by the selected Asian countries.

This study has analyzed the environmental impact based on income groups. This can also be treated as a limitation of this research work. There is a scope to analyze each and every country separately to get a clearer picture of each country's sustainable development challenges. Further analysis can be carried out at the country level, particularly in India, to understand the interstate disparity in ecological footprint. It will help to inform policy making. This study has focused on the EF as a whole. However, studies can be carried out to see the impact of each component of the EF – grassland, cropland, carbon etc. – to understand which component is and will be significant in future in driving the EF as they differ at the country level. Policy analysis from a political economy approach will be a useful contribution as it can help to understand how policies will include or not include natural capital in decision-making.

This research demonstrates, the path of weak sustainability is easy to follow; whereas the strong sustainability path is difficult and is considered to be anti-growth. But since some of the services of nature are non-substitutable, by mainstreaming natural capital into the decision making procedure can help countries to achieve sustainable development goal in all the three dimensions - economy, ecology, and society. It is believed that this study will help other researchers to think and act in this direction and will encourage them to take this work ahead.



## References

- Abou-Ali, H., Abdelfattah, Y.M. (2013). Integrated paradigm for sustainable development: A panel data study. *Economic Modelling*, 30, 334-342.
- ADB. (1997). *Emerging Asia: Changes and Challenges*. Manila: Asian Development Bank.
- Alkire, S., Jindra, C., Robles, G., Vaz, A. (2016). "Multidimensional Poverty Index 2016: Brief methodological note and results." OPHI Briefing 42.: Oxford Poverty and Human Development Initiative, University of Oxford.
- Aminuzzaman, S. (2010, July 5-9). Environment Policy of Bangladesh: A Case Study of an Ambitious Policy with Implementation Snag. *Paper presented to South Asia Climate Change Forum, organized by Monash Sustainability Institute*. Monash University, Australia.
- APFED. (2005). *Part I: Overview of the Asia-Pacific Region*. Asia-Pacific Forum of Environment and Development.
- APFED. (2010). *APFED II Final Report: Driving Innovation for Sustainable Asia and Pacific*. Asia Pacific Forum for Environment and Development.
- Asici, A. (2013). Economic growth and its impact on environment: A panel data analysis. *Ecological Indicator*, 24, 324-333.
- Ayres, R.U., Kneese, A.V. (1969). Production, consumption, and externalities. *The American Economic Review*, 59, 282-297.
- Azam, M., Khan, A.Q., Zaman, K., Ahmad, A., (2015). Factors determining energy consumption: Evidence from Indonesia, Malaysia and Thailand. *Renewable and Sustainable Energy Reviews*, 42, 1123-1131.
- Baltagi, B. (2005). *Econometric Analysis of Panel Data, Third Edition*. West-Sussex, England: John Wiley & Sons Ltd.
- Bank, W. (2014). *World Bank Indicators*. Retrieved June 16, 2014, from World Bank: <http://data.worldbank.org/indicator/SP.URB.TOTL>

- Bank, W. (2015). *Gross domestic product 2014, PPP*. Retrieved April 11, 2016, from World Development Indicators database: [http://databank.worldbank.org/data/download/GDP\\_PPP.pdf](http://databank.worldbank.org/data/download/GDP_PPP.pdf)
- Bank, W. (2015, July 02). *New Country Classifications*. Retrieved February 19, 2016, from World Bank: <http://data.worldbank.org/news/new-country-classifications-2015>
- Bank, W. (2015). *World Development Indicators*. Retrieved from Population data.
- Bank, W. (2016). *Industry, value added (% of GDP)*. Retrieved June 24, 2016, from The World Bank Working for a World Free of Poverty: <http://data.worldbank.org/indicator/NV.IND.TOTL.ZS>
- Bank, W. (2016a, April 11). *GDP ranking, PPP based*. Retrieved April 15, 2016, from The World Bank: Working for a World free of Poverty: <http://data.worldbank.org/data-catalog/GDP-PPP-based-table>
- Bank, W. (2016b). *Population growth (annual %)*. Retrieved April 02, 2016, from World Bank: Working for a World Free of Poverty: <http://data.worldbank.org/indicator/SP.POP.GROW/countries?page=1>
- Barnett, J., Lambert, S., Fry, I. (2008). The hazards of indicators: insights from the Environmental Vulnerability Index. *Annals of the Association of American Geographers*, 98(1).
- Barr, S. (2008). *Environment and Society: sustainability, policy and the citizen*. England: Ashgate Publishing Limited.
- Barua, A. (2009). *An Empirical Analysis of Water Pollution in India: Ph.D. Thesis*. London: Sustainable Research Institute, Leeds University.
- Barua, A., Khataniar, B. (2015). Strong or weak sustainability: A case study of emerging Asia. *Asia-Pacific Development Journal*, 22(1), 1-32.
- Beder, S. (2000). Costing the Earth: Equity, Sustainable Development and Environmental Economics. *New Zealand Journal of Environmental Law*, 4, 227-243.

- Begum, R.A., Pereira, J.J., Jaafarb, A.H., Al-Amina, A.Q. (2009). An empirical assessment of ecological footprint calculations for Malaysia. *Resources, Conservation and Recycling*, 53, 582-587.
- Borucke, M., Moore, D., Cranston, G., Cracey, K., Iha, K., Larson, J., Lazarus, E., Morales, J.C., Wackernagel, M., Galli, A. (2013). Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. *Ecological Indicators*, 24, 518-533.
- Boulding, K. (1966). The economics of the coming Spaceship Earth. In H. (. Jarrett, *Environmental Quality in a Growing Economy*. Baltimore: Hohn Hopkins University Press.
- Brander, J. (2007). Viewpoint: Sustainability: Malthus Revisited? *Canadian Journal of Economics*, 40(1), 1-38.
- Carson, R. (1962). *Silent Spring*. Boston: Houghton Mifflin.
- Castaneda, B. (1999). An index of sustainable economic welfare (ISEW) for Chile. *Ecological Economics*, 28, 231-244.
- Chang, N. (2012). The empirical relationship between openness and environmental pollution in China. *Journal of Environmental Planning and Management*, 55(6), 783-796.
- Cobbinah, P.B., Erdiaw-Kwasie, M.O., Amoateng, P. (2015). Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environmental Development*, 13, 18-32.
- Colander, D., Holt, R., Rosser Jr., B. (2004). The changing face of mainstream economics. *Review of Political Economy*, 16(4), 485-499.
- Common, M., Stagl, S. (2005). *Ecological Economics: An Introduction*. New York: Cambridge University Press.
- Costanza, R., Daly, H. (1992). Natural capital and sustainable development. *Conservation Biology*, 1, 37-45.

- Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387, 253-260.
- Coxhead, I. (2003 йил May). *Development and Environment in Asia: A Survey of Recent Literature*. University of Wisconsin-Madison.
- Coxhead, I. (2004). *International Trade and the Natural Resource 'Curse' in Southeast Asia: Does China's growth threaten regional development*. University of Wisconsin-Madison.
- Dahiya, B. (2012). Cities in Asia, 2012: Demographics, economics, poverty, environment and governance. *Cities*, 29, S44–S61.
- Daily, G. (1997). *Nature's Services: Societal Dependence on Natural Ecosystems*. (G. Daily, Ed.) Washinton, DC: Island Press.
- Daily, G.C., Kareiva, P.M., Polasky, S., Ricketts, T.H., Tallis, H. (2011). *Chapter 1 Mainstreaming Natural Capital into decisions In Natural Capital: Theory and Practice of Mapping Ecosystem Services*. (P. T. Kareiva, Ed.) Retrieved March 07, 2016, from Oxford Scholarship Online: <http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199588992.001.0001/acprof-9780199588992-chapter-1>
- Daily, G. (2014). Mainstreaming the values of nature for people into decision-making. *Sustainable Humanity, Sustainable Nature: Our Responsibility. Extra Series 41*, pp. 1-15. Vatican City: Pontifical Academy of Social Sciences.
- Daly, H. (1968). On Economics as a Life Science. *Journal of Political Economy*, 76, 392-406.
- Daly, H. (1990). Sustainable Development: From Concept and Theory to Operational Principles. *Population and Development Review*, Vol. 16, 25-43.

- Daly, H. (1996). *Beyond Growth: The Economics of Sustainable Development*. Boston Massachusetts: Beacon Press.
- Daly, H. (2005, September). Economics in a Full World. *Scientific American*, 100-107.
- Daly, H. and Farley, J. (2007). *Ecological Economics: Principles and Applications*. Delhi: Pearson Longman.
- Daly, H. E., Farley, J. (1994). *Ecological Economics, Principles and Applications* (1st ed.). Island Press.
- Dasgupta, P. (2000). Valuing Biodiversity. In S. Levin (Ed.), *Encyclopedia of Biodiversity*. New York: Academic Press.
- Dasgupta, P. (2010). The Place of Nature in Economic Development. In D. R. M. Rosenzweig, *Handbook of Development Economics, Vol. 5* (pp. 4977-5046). Amsterdam: Elsevier.
- De Hoyos, R.E., Sarafidis, V. (2006). Testing for cross-sectional dependence in panel-data models. *Stata Journal*, 6(4), 482-496.
- Dietz, S., Neumayer, E. (2007). Weak and strong sustainability in the SEEA: Concepts and measurement. *Ecological Economics*, 61, 617-626.
- Dinda, S., Coondoo, D. (2006). Income and emission: A panel data-based cointegration analysis. *Ecological Economics*, 57, 167-181.
- Directorate General of Spatial Planning. (2010). *Ecological Footprint in Indonesia*. Indonesia, Directorate General of Spatial Planning. Jakarta: Ministry of Public Works.
- Dobson, A. (2007, Nov 8). Environment sustainabilities: An analysis and a typology. *Environmental Politics*, 401-428.
- Ekins, P. (1993). 'Limits to growth' and 'sustainable development': grappling with ecological realities. *Ecological Economics*, 8, 269-288.

- England, R. (2000). Natural capital and the theory of economic growth. *Ecological Economics*, 34, 425-431.
- Erb, K. (2004). Actual land demand of Austria 1926–2000: a variation on ecological footprint assessments. *Land Use Policy*, 21, 247-259.
- ESCAP. (2007). *Statistical Yearbook for Asia and the Pacific*. Thailand: United Nations Publication.
- ESCAP. (2012). *Statistical Year Book for Asia and the Pacific*. United Nations Economic and Social Commission for Asia and the Pacific. Bangkok: United Nations Publication.
- Farina, A., Johnson, A.R., Turner, S.J., Belgrano, A. (2003). 'Full' world versus 'empty' world paradigm at the time of globalisation. *Ecological Economics*, 45, 11-18.
- Ferguson, A. R. (2002). The Assumptions Underlying Eco-Footprinting. *Population and Environment*, 23(3), 303-313.
- Figge, F. (2005). Capital Substitutability and Weak Sustainability Revisited: The Conditions for Capital Substitution in the Presence of Risk. *Environmental Values*, 14(2), 185-201.
- Fricker, A. (1998). The ecological footprint of New Zealand as a step towards sustainability. *Futures*, 30(6), 559-567.
- 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.
- Galli, A., Wackernagel, M., Iha, K., Lazarus, E. (2014). Ecological Footprint: Implications for biodiversity. *Biological Conservation*, 173, 121-132.
- Gao, J., Tian, M. (2016). Analysis of over-consumption of natural resources and the ecological trade deficit in China based on ecological footprints. *Ecological Indicators*, 61, 899-904.

- Geng, Y., Zhang, L., Chen, X., Xue, B., Fujita, T., Dong, H. (2014). Urban ecological footprint analysis: a comparative study between Shenyang in China and Kawasaki in Japan. *Journal of Cleaner Production*, 75, 130-142.
- Georgescu-Roegen, N. (1971). *The entropy law and the economic process*. Cambridge, MA: Harvard University Press.
- Getzner, M. (1999). Weak and strong sustainability indicators and regional environmental resources. *Environmental Management and Health*, 10(3), 170-176.
- GFN. (2014). *National Footprint Accounts, 2012 Edition*. Retrieved 2014, from Global Footprint Network: <http://www.footprintnetwork.org>
- GFN. (2016). *Philippines*. Retrieved October 31, 2016, from Global Footprint Network: [http://www.footprintwork.org/en/index.php/GFN/page/philippines\\_case\\_study](http://www.footprintwork.org/en/index.php/GFN/page/philippines_case_study)
- Goodland, R., Daly, H.E. (1996). Environmental Sustainability: Universal and Non-Negotiable. *Ecological Applications*, 6(4), 1002-1017.
- Gowdy, J. (2000). Terms and Concepts in Ecological Economics. *Wildlife Society Bulletin*, 28(1), 26-33.
- Gowdy, J.M., McDaniel, C.N. (1999). The physical destruction of Nauru: An example of Weak Sustainability. *Land Economics*, 75(2), 333-338.
- Greasley, D., Hanley, N., Kunas, J., McLaughlin, E., Oxley, L., Warde, P. (2014). Testing genuine savings as a forward-looking indicator of future well-being over the (very) long-run. *Journal of Environmental Economics and Management*, 67, 171-188.
- Greene, W. (2012). *Econometric Analysis* (7th ed.). Upper Saddle River, USA: Prentice Hall.
- Guha, R. (1999). *Environmentalism: A Global History*. Pearson.

- Gujarathi, D.N., Sangeetha. (2007). *Basic Econometrics*. New Delhi, India: Tata McGraw Hill.
- Haberl, H., Erb, K.H., Krausmann, F., 2001. (2001). How to calculate and interpret ecological footprints for long periods of time: the case of Austria 1926–1995. *Ecological Economics*, 38, 25-45.
- Hamilton, K. (1994). Green adjustments to GDP. *Resources Policy*, 20, 155-168.
- Hamilton, K., Clemens, M. (1999). Genuine savings rates in developing countries. *The World Bank Economic Review*, 13(2), 333-356.
- Hanley, N., Moffatt, I., Faichney, R., Wilson, M. (1999). Measuring sustainability: A time series of alternative indicators for Scotland. *Ecological Economics*, 28, 55-73.
- Hara, K., Uwasu, M., Yabar, H., Zhang, H. (2009). Sustainability assessment with time-series scores: a case study of Chinese provinces. *Sustain Sci*, 4, 81-97.
- Hardin, G. (1968). The tragedy of the commons. *Science*, 162, 1243–1248.
- Hartwick, J. (1977). Intergenerational equity and the investing of rents of exhaustible resources. *American Economic Review*, 67(5), 972-974.
- Hartwick, J. (1978). Substitution among exhaustible resources and intergenerational equity. *The Review of Economic Studies*, 45(2), 347-354.
- Hausman, J. (1978). Specification tests in econometrics. *Econometrica*, 46, 1251-1271.
- Hinterberger, F., Luks, F., Schmidt-Bleek, F. (1997). Material flows vs. ‘natural capital’ What makes an economy sustainable? *Ecological Economics*, 23, 1-14.
- Holden E., Linnerud, K., Banister, D. (2014). Sustainable development: Our Common Future revisited. *Global Environmental Change*(26), 130-139.

- Hossain, I., Tamim, M. (2006). *Energy and Sustainable Development in Bangladesh: Sustainable Energy Watch*. Bangladesh: Helio International.
- Hubacek, K., Guan, D., Barrett, J., Wiedmann, T. (2009). Environmental implications of urbanization and lifestyle change in China: Ecological and Water Footprints. *Journal of Cleaner Production*, 17, 1241-1248.
- Im, K.S., Pesaran, M.H., Shin, Y. (2003). Testing for the unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53-74.
- Islam, F., Shahbaz, M., Ahmed, A.U., Alam, M.M. (2013). Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis. *Economic Modelling*, 30, 435-441.
- Jorgenson, A. (2009). The sociology of unequal exchange in ecological context: a panel study of lower-income countries, 1975-2000. *Sociological Forum*, 24(1), 22-46.
- Jorgenson, A.K., Clark, B. (2011). Societies consuming nature: A panel study of the ecological footprints of nations, 1960–2003. *Social Science Research*, 40, 226-244.
- Kae Unite, B. (2015, August 16). *Overfishing observed in 75% of PH*. Retrieved June 6, 2016, from Manila Bulletin: <http://www.pressreader.com/philippines/manila-bulletin/20150816/281595239266301/TextView>
- Kalland, A., Persoon, G. (1998). An Anthropological Perspective on Environmental Movement. In A. P. Kalland (Ed.), *Environmental Movements in Asia* (pp. 1-43). Richmond: Curzon Press.
- Kaly, U., Pratt, C., Mitchell, J. (2004). *Environmental Vulnerability Index (EVI) 2004*. South Pacific Applied Geoscience Commission (SOPAC).
- Kennedy, P. (2008). *A Guide to Econometrics 6th edition*. Malden, USA: Blackwell Publishing.

- Keshwan, P. (2017). Inequality, democracy, and the environment: A cross-national analysis. *Ecological Economics*, 131, 139-151.
- Knoema. (2016, April 01). *Knoema*. Retrieved April 14, 2016, from IMF World Economic Outlook (WEO), April 2016: <https://knoema.com/IMFWEO2016Apr/imf-world-economic-outlook-weo-april-2016>
- Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Telberth, J., Jackson, T., Aylmer, C. (2013). Beyond GDP: Measuring and achieving global genuine progress. *Ecological Economics*, 93, 57-68.
- 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.
- Lardy, N. (2002). *Integrating China into the Global Economy*. Washington, DC: Brookings Institutions Press.
- Lawn, P., Clarke, M. (2010). The end of economic growth? A contracting threshold hypothesis. *Ecological Economics*, 69, 2213-2223.
- Lee, J-W, Hong, K. (2012). Economic growth in Asia: Determinants and prospects. *Japan and the World Economy*, 24, 101-113.
- Lehtonen, M. (2004). The environmental-social interface of sustainable development: capabilities, social capital, institutions. *Ecological Economics*, 49, 199-214.
- Levin, A., C.F. Lin, C. Chu. (2002). Unit root test in panel data: Asymptotic and finite sample properties. *Journal of Econometrics*, 108, 1-25.
- Liddle, B. (2013). Population, affluence, and environmental impact across development: Evidence from panel cointegration modeling. *Environmental Modelling & Software*, 40, 255-266.
- Maddala, G.S., Wu, S. (1999). A comparative study of ul data and a new simple testnit root tets with pane. *Oxford Bulletin of Economics and Statistics*, 61(Special Issue), 631-652.

- Mali, K.P., Singh, K., Kotwal, P.C., Omprakash, M.D. (2016). Strengthening forest resource valuation and accounting system: a case of forest resources of Kerala, India. In N. M. Ghosh (Ed.), *Nature, Economy and Society: Understanding the Linkages* (pp. 87-112). New Delhi: Springer.
- Malthus, T. (1798). *An Essay on the Principle of Population*. London: J. Johnson.
- Marcotullio, P. (2001). Asian urban sustainability in the era of globalization. *Habitat International*, 25, 577-598.
- Martínez-Zarzoso, I, Maruotti, A. (2011). The impact of urbanization on CO2 emissions: Evidence from developing countries. *Ecological Economics*, 70, 1344-1353.
- Max-Neef, M. (1995). Economic growth and quality of life: a threshold hypothesis. *Ecological Economics*, 15, 115-118.
- Mayer, A.L., Thurston, H.W., Pawlowski, C.W. (2004). The multidisciplinary influence of common sustainability indices. *Frontiers in Ecology and the Environment*, 2(8), 419-426.
- Meadows, D.H., Meadows, D.L., Randers, J., Behrens III, W.W. (1972). *The Limits to Growth*. New York: Universe Books.
- Miller, D. and Plasencia, O. (Eds). (2013). *Statistical Yearbook for Asia and the Pacific 2013*. ESCAP, Statistics. Thailand: United Nations Publication.
- Moldan, B., Janouskova, S., Hak, T. (2012). How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators*, 17, 4-13.
- Monfreda, C., Wackernagel, M., Deumling, D. (2004). Establishing national natural capital accounts based on detailed Ecological Footprint and biological capacity assessments. *Land Use Policy*, 21, 231-246.
- Montagna, J. (1981, 06 02). *The Industrial Revolution* . Retrieved 04 29, 2016, from Yale-New Haven Teachers Institute: <http://www.yale.edu/ynhti/curriculum/units/1981/2/81.02.06.x.html>

- Mori, K., Christodoulou, A. (2012). Review of sustainability indices and indicators: towards a new City Sustainability. *Environment Impact Assessment Review*, 32, 94-106.
- 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.
- Murty, M.N., Panda, M. (2016). Current status of environmental and economic accounting: review of some countries experiences and way forward for India. In N. M. Ghosh (Ed.), *Nature, Economy and Society: Understanding the Linkages* (pp. 51-85). New Delhi: Springer.
- Narayan, P.K., Narayan, S. (2010). Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. *Energy Policy*, 38, 661-666.
- Nations, U. (2003). *Handbook of National Accounting: Integrated Environmental and Economic Accounting*. United Nations.
- Neumayer, E. (2003). *Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms*. Northampton, M.A.
- Niccoluccia, V., Tiezzi, E., Pulselli, F.M., Capinerib, C. (2012). Biocapacity vs Ecological Footprint of world regions: A geopolitical interpretation. *Ecological Indicators*, 16, 23-30.
- Norton, B., Toman, M. (1997). Sustainability: ecological and economic perspectives. *Land Economics*, 73(4), 553-568.
- Nourry, M. (2008). Measuring sustainable development: Some empirical evidence for France from eight alternative indicators. *Ecological Economics*, 67, 441-456.

- Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics*, 40, 657-664.
- Ozcan, B. (2013). The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: A panel data analysis. *Energy Policy*, 62, 1138-1147.
- Panditchpakdi, S., Clifford, M. (2002). *China and the WTO: Changing China Changing World Trade*. Singapore: John Wiley & Sons.
- Pansuwan, A. (2009-2010). Industrial Decentralization Policies and Industrialization in Thailand. *Silpakorn University International Journal*, 9-10, 117-147.
- Park, H. M. (2011, October). *Practical Guides To Panel Data Modeling: A Step by Step Analysis Using Stata*. Retrieved August 01, 2014, from Public Management and Policy Analysis Program: <http://www.iuj.ac.jp/faculty/kucc625>
- Parker, P. (1998). An environmental measure of Japan's economic development: the ecological footprint. *Geographische Zeitschrift*, 86(2), 106-119.
- Pearce, D.W., Turner, R.K. (1990). *Economics of Natural Resources and the Environment*. Hemel Hempstead: Harvester Wheatsheaf.
- Pelenc, J., Ballet, J. (2015). Strong sustainability, critical natural capital and the capability approach. *Ecological Economics*, 112, 36-44.
- Pereira, L., Ortega, E. (2012). A modified footprint method: The case study of Brazil. *Ecological Indicators*, 16, 113-127.
- Pesaran, M. (2004). *General Diagnostic Tests for Cross Section Dependence in Panels*. Retrieved from No. CESifo working papers, No. 1229: <http://www.dspace.cam.ac.uk/handle/1810/446>
- Pillarisetti, J. (2005). The World Bank's genuine savings measure and sustainability. *Ecological Economics*, 55, 599-609.

- Pillariseti, J.R., van den Bergh, J.C.J.M. (2007). *Sustainable Nations: What do Aggregate Indicators Tell Us?* Amsterdam: Tinbergen Institute.
- Posner, S.M., Costanza, R. (2011). A summary of ISEW and GPI studies at multiple scales and new estimates for Baltimore City, Baltimore County, and the State of Maryland. *Ecological Economics*, 70, 1972-1980.
- Poumanyong, P., Kaneko, P. (2010). Does urbanization lead to less energy use and lower CO<sub>2</sub> emissions? A cross-country analysis. *Ecological Economics*, 70, 434-444.
- Redclift, M. (1988). Sustainable Development and the market: A framework for analysis. *Futures*, 20(6), 635-650.
- Redclift, M. (1992). The Meaning of Sustainable Development. *Geoforum*, 25(3), 395-403.
- Redclift, M. (2005, July 22). Sustainable development (1987-2005): an oxymoron comes of age. *Sustainable Development*, 13, 212-227.
- Rees, W. (2012). Carrying Capacity, Cognition and Collapse: Reflections on the Human Prospect. *ISEE*. Rio de Janeiro, Brazil.
- Rio+20. (2012 йил 12-June). *United Nations*. From United Nations Conference on Sustainable Development: <http://rio20.net/wp-content/uploads/2012/06/N1238164.pdf>
- Sachs, J. W. (1997). *Natural resources abundance and economic growth*. Cambridge MA: Harvard University.
- Sadorsky, P. (2014). The effect of urbanization on CO<sub>2</sub> emission in emerging economies. *Energy Economics*, 41, 147-153.
- Sanyal, S., Nagrath, S., Singla, G. (2008). *Chapter 1 the link between urbanisation and sustainability (In) the The Alternative Urban Futures Report Urbanization & Sustainability in India: An Interdependent Agenda*. WWF. Thomson Press.

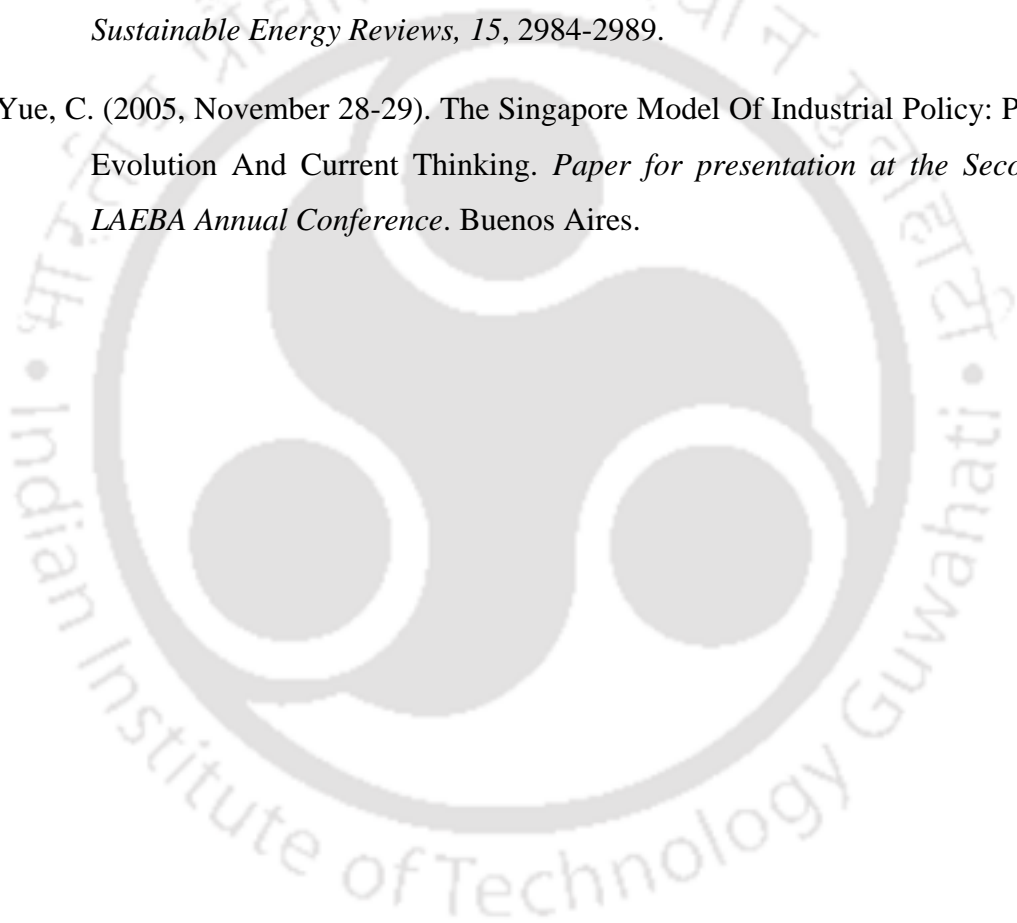
- Shahbaz, M., Loganathan, N., Sbia, R., Afza, T. (2015). The effect of urbanization, affluence and trade openness on energy consumption: A time series analysis in Malaysia. *Renewable and Sustainable Energy Reviews*, 47, 683-693.
- Shahbaz, M., Solarin, A.A., Mahmood, H., Arouri, M. (2013). Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. *Economic Modelling* 35 (2013) 145–152, 35, 145-152.
- Shengjuan, H., Jingping, Z. (2011). Research on the dynamic relationship of the Energy-Economy-Environment (3E) System-based on an empirical analysis of China. *Energy Procedia*, 5, 2397-2404.
- Shrestha, P. (2013, December). Economic development in South and East Asia: Empirical examination of East Asian development model. *Asia-Pacific Development Journal*, 20(2), 1-28.
- Singapore, E. (2015, May 16). *Our Economic History*. Retrieved April 27, 2016, from Future Ready Singapore: <https://www.edb.gov.sg/content/edb/en/why-singapore/about-singapore/our-history/1960s.html>
- Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K. (2009). An overview of sustainability assessment methodologies. *Ecological Indicator*, 15, 281-299.
- Sneddon, C., Howarth, R.B., Norgaard, R.B. (2006). Sustainable development in a post-Brundtland world. *Ecological Economics*, 57, 253-268.
- Solow, R. (1974). Intergenerational Equity and Exhaustible Resources. *Review of Economic Studies (Symposium)*, 29-46.
- Solow, R. (1986). On the Intergenerational Allocation of Natural Resources. *The Scandinavian Journal of Economics*, 88(1), 141-149.
- Solow, R. M. (1993). An almost practical step towards sustainability. *Resources policy*, 19, 162-172.

- Stern, D. (1997). The Capital Theory Approach to Sustainability: A Critical Appraisal. *Journal of Economic Issues*, 31(1), 145-173.
- Thiry, G., Cassiers, I. (2010, May). Alternative indicators of GDP: values behind numbers Adjusted Net Savings in question. *Applied Research in Quality of Life*, p. 2010.
- UN. (1997). *Glossary of Environment Statistics, Studies in Methods, Series F*. New York: United Nations.
- UNDESA. (2012). *World Urbanisation Prospects – The 2011 Revision*. New York, USA: United Nations Department of Economic and Social Affairs.
- UNDP. (2015). *Table 2: Trends in the Human Development Index, 1990-2014*. Retrieved February 16, 2016, from United Nations Development Programme: <http://hdr.undp.org/en/composite/trends>
- UNDP. (2016). *United Nations Development Programme*. Retrieved from Table 6: Multidimensional Poverty Index: developing countries: <http://hdr.undp.org/en/composite/MPI>
- UNEP. (2003). *Global Environment Outlook-3: Past, present and future perspectives*. United Nations Environment Programme. London: Earthscan Publications Ltd.
- UNEP. (2012, June 06). *GEO5-Summary for Asia and the Pacific Region: On the Eve of Rio+20*. Retrieved September 14, 2014, from United Nations Environment Programme: [www.unep.org/geo](http://www.unep.org/geo)
- UNEP. (2013). *Recent trends in material flows and resource productivity in Asia and the Pacific*. Bangkok: UNEP Division of Early Warning and Assessment.
- UN-ESCAP. (2011). *Statistical Yearbook for Asia and the Pacific 2011*. Economic and Social Commission for Asia and the Pacific, ESCAP Statistics Division. Thailand: United Nations Publication.

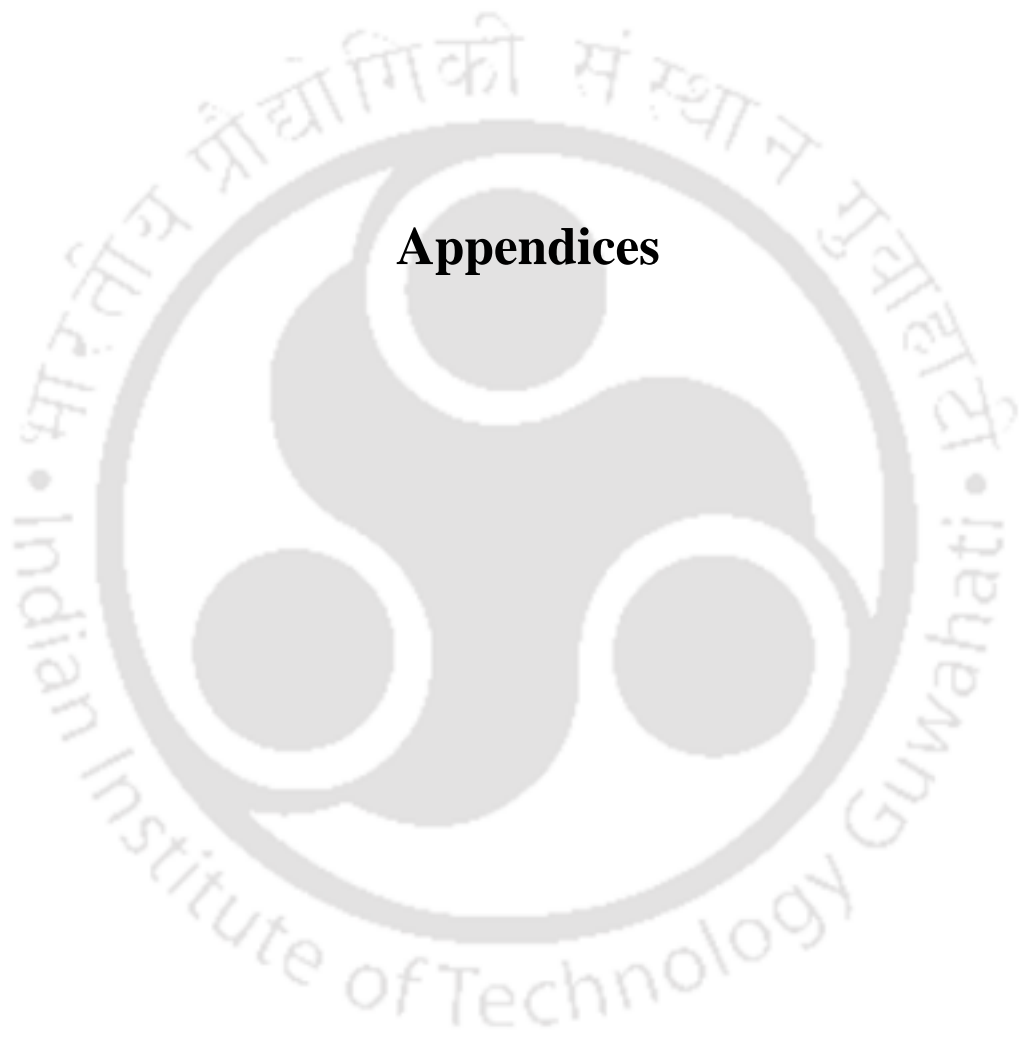
- UN-ESCAP. (2012). *Green Growth, Resources and Resilience: Environmental Sustainability in Asia and the Pacific*. Bangkok: United Nations and Asian Development Bank.
- UNESCAP and ADB. (2000). *State of the Environment in Asia and Pacific 2000*. New York: Economic and Social Commission for Asia and the Pacific and Asian Development Bank.
- UNESCO. (1997, November 12). *Declaration on the Responsibilities of the Present Generations Towards Future Generations*. Retrieved May 30, 2016, from United Nations Educational, Scientific and Cultural Organization: [http://portal.unesco.org/en/ev.php-URL\\_ID=13178&URL\\_DO=DO\\_TOPIC&URL\\_SECTION=201.html](http://portal.unesco.org/en/ev.php-URL_ID=13178&URL_DO=DO_TOPIC&URL_SECTION=201.html)
- UNIDO. (1999). *Industrial Policy and the Environment in the Philippines*. United Nations Industrial Development Organization.
- Uwasua, M., Yabar, H. (2011). Assessment of sustainable development based on the capital approach. *Ecological Indicators*, 11, 348-352.
- Wackernagel, M., Monfreda, C., Erb, K., Haberl, H., Schulz, N.B. (2004b). Ecological footprint time series of Austria, the Philippines, and South Korea for 1961-1999: comparing the conventional approach to an 'actual land area' approach. *Land Use Policy*, 21, 261-269.
- Wackernagel, M., Monfreda, C., Schulz, N.B., Erb, K-H., Haberl, H., Krausman, F. (2004a). Calculating national and global ecological footprint time series: resolving conceptual challenges. *Land Use Policy*, 21, 271-278.
- Wackernagel, M., Rees, W.E. (1997). Perceptual and structural barriers to investing in natural capital: Economics from an ecological footprint perspective. *Ecological Economics*, 20, 3-24.
- 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.

- Wang, Z. (2003). The impact of China's WTO-accession on patterns of world trade. *Journal of Policy Modelling*, 25, 1-41.
- WCED. (1987). *Our Common Future*. World Commission on Environment and Development. Oxford: Oxford University Press.
- Wooldridge, J. M. (2005). *Introductory Econometrics: A Modern Approach 3rd edition*. Thomson: Mason.
- WWF. (2006). *Living Planet Report*. Gland, Switzerland: WWF.
- WWF. (2008). *The Living Planet Report*. Gland, Switzerland: WWF International.
- WWF. (2010). *Living Planet Report 2010: Biodiversity, biocapacity and development*. Switzerland: World Wide Fund.
- WWF. (2012). *Living Planet Report 2012: Biodiversity, biocapacity and better choices*. Gland, Switzerland: World Wide Fund for Nature (formerly World Wildlife Fund).
- WWF. (2014). *Living Planet Report: Species and Spaces, People and Places*. Switzerland: World Wild Fund.
- WWF, ADB, GFN. (2012). *Ecological Footprint and Investment in Natural Capital in Asia and the Pacific*. UK: World Wide Fund for Nature and Asian Development Bank.
- WWF-CCICED. (2006). *Report on Ecological Footprint in China*. World Wide Fund on Nature (WWF) – China Council for International Cooperation on Environment and Development (CCICED).
- Yale Centre for Environment Law & Policy. (2010). *2010 Environmental Performance Index*. Yale Universty.
- Yang, L., Yuan, S., Sun, L. (2012). The Relationships between Economic Growth and Environmental Pollution Based on Time Series Data : An Empirical Study of Zhejiang Province. *Journal of Cambridge Studies*, 33-42.

- Yencken, D. (2000). Attitude to nature in the East and West. In D. F. Yencken, *Environment, Education and Society in the Asia-Pacific: Local traditions and global discourses* (pp. 4-27). New York: Routledge.
- York, R., Rosa, E.A., Dietz, T. (2003). Footprints on the earth: the environmental consequences of modernity. *American Sociological Review*, 68(2), 279-300.
- You, J. (2011). China's energy consumption and sustainable development: Comparative evidence from GDP and genuine savings. *Renewable and Sustainable Energy Reviews*, 15, 2984-2989.
- Yue, C. (2005, November 28-29). The Singapore Model Of Industrial Policy: Past Evolution And Current Thinking. *Paper for presentation at the Second LAEBA Annual Conference*. Buenos Aires.







## **Appendices**



## Appendix 1 Selection of Asian countries in various selection criteria of the present study

<i>Country</i>	<i>GDP per capita (2014)</i>	<i>Total population (2014)</i>	<i>Pop growth rate (2014)</i>	<i>CO<sub>2</sub> Emission (2011)</i>	<i>Urban pop (%) (2014)</i>	<i>Selected/Not selected (with justification)</i>
<i>Myanmar</i>	No data			0.200285		Not selected due to non-availability of data
<i>Korea, Dem. Rep.</i>	No data			2.987182		Not selected due to non-availability of data
<i>Singapore</i>	38087.82	5469700	1.29	4.320151	100	<b>Selected</b>
<i>Republic of Korea</i>	24565.61	50423955	0.41<1.15	11.84076	82.36	<b>Selection</b> is necessary with respect to huge economic expansion and high CO <sub>2</sub> emission
<i>Malaysia</i>	7365.24	29901997	1.47	7.898824	74.01	<b>Selected</b>
<i>China</i>	3862.92	1364270000	0.51<1.15	6.710302	54.41	<b>Selection</b> is necessary with respected to large economy, huge population and high CO <sub>2</sub> emission
<i>Thailand</i>	3768.79	67725979	0.41<1.15	4.534492	49.174	<b>Selection</b> is necessary with respected to huge economy, large population
<i>Sri Lanka</i>	2058.95	20639000	0.76	0.729921	18.32	Low Urbanization, less population, low CO <sub>2</sub> emission => <i>Not selected</i>

<i>Country</i>	<i>GDP per capita (2014)</i>	<i>Total population (2014)</i>	<i>Pop growth rate (2014)</i>	<i>CO<sub>2</sub> Emission (2011)</i>	<i>Urban pop (%) (2014)</i>	<i>Selected/Not selected (with justification)</i>
<i>Mongolia</i>	1882.38	2909871	1.76	6.915147	71.222	Very less population. Lowest in the country list=> <i>Not selected</i>
<i>Indonesia</i>	1853.81	254454778	1.26	2.303781	53.003	<b>Selected</b>
<i>Philippines</i>	1662.07	99138690	1.59	0.867845	44.488	<b>Selected</b>
<i>India</i>	1233.95	1295291543	1.23	1.662873	32.366	<b>Selected</b>
<i>Vietnam</i>	1077.91	90730000	1.13	1.971889	32.951	Low GDP, low urbanization => <i>Not selected</i>
<i>Lao PDR</i>	818.33	6689300	1.65	0.188911	37.551	Low GDP, less population, low CO <sub>2</sub> emission=> <i>Not selected</i>
<i>Pakistan</i>	813.71	185044286	2.10	0.941171	38.303	<b>Selected</b>
<i>Cambodia</i>	749.55	15328136	1.64	0.308073	20.514	Low urbanization, less population, low CO <sub>2</sub> emission => <i>Not selected</i>
<i>Bangladesh</i>	747.37	159077513	1.21	0.372017	33.516	<b>Selected</b>
<i>Nepal</i>	426.41	28174724	1.21	0.159474	18.243	Low urbanization, less population, low CO <sub>2</sub> emission => <i>Not selected</i>

## Appendix 2 Summary of the existing empirical studies on the relationship between environmental degradation and sustainable development

Study	Data type	Time Period	Study area	Methodologies	Indicators	Results
<i>Emission, energy consumption, economic growth nexus</i>						
(Ozcan, 2013)	Panel	1990-2008	12 middle east countries	Lagrange Multiplier test, panel cointegration test	Carbon emission, energy consumption, economic growth	CO <sub>2</sub> emission has declined with rise in income in only 5 countries
(Omri, 2013)	Panel	1990-2011	14 MENA <sup>20</sup> countries	Cobb-Douglas production function, Generalized Method of Moments (GMM)	CO <sub>2</sub> emission, energy consumption, GDP, trade openness, financial development, urbanization, total population, capital stock, total labor force	A bi-directional fundamental association between economic growth and CO <sub>2</sub> emission
(Narayan, P.K., Narayan, S., 2010)	Time series, Panel	1980-2004	43 developing nations	Panel cointegration test for long-run and short-run	GDP, CO <sub>2</sub>	In Middle Eastern and South Asian countries that carbon dioxide emission has declined with a rise in income.

<sup>20</sup> MENA: Middle East and North Africa

(Shengjuan, H., Jingping, Z., 2011)	Time series	1983-2009	China	Vector Autoregressive Regression model, Vector Error Correction model, Johansen cointegration test	Total energy consumption, industry waste gas, GDP	Environmental pollution has a adverse impact on economic growth, energy consumption has a positive impact on growth
(Dindaa, S., Coondoo, D., 2006)	Panel	1960-1990	88 countries	Panel cointegration test	Per capita GDP per capita, CO <sub>2</sub> emission per capita	A bi-directional causal relationship between GDP per capita and emission per capita
<b><i>Finacial development, population, energy consumption nexus</i></b>						
(Islam, F., Shahbaz, M., Ahmed, A.U., Alam, M.M., 2013)	Time series	1971-2009	Malaysia	Dynamic Error Correction model, Vector Error Correction Model, Granger causality test	GDP, populaion, financial development	Economic growth increases the demand for energy. The impact of population on energy consumption is positive
<b><i>Natural resource availability, economic growth, and the environment</i></b>						
(Abou-Ali, H., Abdelfattah, Y.M., 2013)	Panel	1990–2007	62 countries	Resource Curse Hypothesis model and the EKC model	GDP, education, trade, CO <sub>2</sub> emission, capital formation, FDI, average fertility rate	The technique, adopted by some countries to deal with sustainability, is negatively affecting the environment

<i>Trade and environmental degradation</i>						
(Chang, 2012)	Time series	1981-2008	China	Vector Autoregressive Regression tests	Foreign trade export, foreign trade import, inward Foreign Direct Investment, industrial pollutants- sulphur, sold waste, wastewater,	There is a positive relationship between openness and economic growth; but negatively related with the environment
<i>Weak sustainability</i>						
(Greasley et al., 2014)	Time series	1765–2000	Great Britain	The Engle–Granger method follows the OLS regression	consumption per capita, real wages, population,	ANS can be a sustainability indicator up to 100 years
(You, 2011)	Time series	1980–2004	China	Structural vector autoregression framework and the generalized impulse response function	Electrical energy, GDP, GS (or ANS)	Increasing energy consumption weakens China's sustainability in terms of falling GS rates; energy efficiency increases the country's GS significantly. That is, renewable energy consumption encourages sustainable development for both environment and economy.
(Uwasua, M., Yabar, H.,	Panel	1970-2007	71 countries	IV regression	GS, Wealth, GDP, Institution, population	In the long run, the quality of institution, population growth, and natural resource abundance

2011)						have significant impact on capital accumulation. Increasing GS does not ensure sustainable development.
(Hamilton, K., Clemens, M., 1999)	Time series	1970s-1993	103 developing countries	GS estimation by current-value Hamiltonian function	Extended domestic investment, depreciation, current spending on education, gross domestic investment, net savings	Trends of GS are negative in many countries, particularly in Sub-Saharan Africa. Increasing the coverage of natural resources and pollutants would decrease the estimated levels of GS
<b><i>Population, resource consumption, international trade- Strong sustainability</i></b>						
(Jorgenson, 2009)	Panel	1975-2000, 5-year interval	66 lower income countries	GLS random effect model	Global biocapacity per capita, population, EF per capita, weighted export flows, GDP per capita	There is a direct relationship between exports and consumption in the study region
(Jorgenson, A.K., Clark, B., 2011)	Panel	1960-2006	53 countries including Asian countries	Panel random effect models	EF, GDP per capita, Arable land per capita, total population, military personnel, military expenditures	Political-economic factors, ecological milieu, and structural associations between nations -all influence the resource consumption habits of the societies
(Wang, Ben-C., Chou, F-	Time series	1994-2007	Taiwan	Time series trend analysis	EF, BC, ecological deficit	EF and ecological deficit of Taiwan have enlarged, and consumption and production

Yi, Lee Y-Jaan, 2012)						have exceeded nature's carrying capacity
(Parker, 1998)	Time series	1961- 1995	Japan	Comparison of economic and ecological footprint trends	GDP, EF	Japan's economy has expanded in size and EF increased almost double to over 6 hectares of productive habitat per person. This has placed pressure on the environment
<b><i>Both weak sustainability and strong sustainability</i></b>						
(Hanley, N., Moffatt, I., Faichney, R., Wilson, M., 1999)	Time series	1980- 1993	Scotland	Trend analysis of both weak and strong sustainability indicators	GNNP, GS, EF, environmental space, net primary productivity, ISEW, GPI	Unsustainable in 'weak' sense and marginally unsustainable in 'strong' sense
<b><i>Others</i></b>						
(Hara, K., Uwasu, M., Yabar, H., Zhang, H., 2009)	Time series scores	2000, 2005	All provinces of China	Calculating sustainability index scores	22 socio-economic, environmental and resources	Sustainability index improved in many provinces mainly due to socio-economic component, but environmental component has deteriorated in some provinces

### Appendix 3 Selection procedure of indicators for Weak and Strong sustainability

<i>Indicator</i>	<i>Type</i>	<i>SS/WS</i>	<i>Policy relevance High/Medium/Low</i>	<i>Relevant to RQ</i>	<i>Data availability</i>	<i>Simplicity</i>	<i>Validity</i>	<i>Accurate and affordable data</i>	<i>Applicability in sustainability</i>	<i>Reliability</i>	<i>Robustness</i>	<i>No. of indicators covered</i>	<i>Source</i>	<i>Analysis</i>	<i>Accepted/ Rejected</i>
GNNP	Market-based	WS	M	Y	N	Y	Y	N	Y	N	N	8	Nourry, 2008; Mota et al., 2010	Hamilton (1994) has argued that neither GNNP, nor its growth rate produces right policy indications on SD. Further it has later been pointed out that, since GNNP is an prompt measure, it cannot conclusively indicate whether the economy is on a WS path (see Dietz and Neumayer, 2007)	Rejected

<i>Indicator</i>	<i>Type</i>	<i>SS/WS</i>	<i>Policy relevance High/Medium/Low</i>	<i>Relevant to RQ</i>	<i>Data availability</i>	<i>Simplicity</i>	<i>Validity</i>	<i>Accurate and affordable data</i>	<i>Applicability in sustainability</i>	<i>Reliability</i>	<i>Robustness</i>	<i>No. of indicators covered</i>	<i>Source</i>	<i>Analysis</i>	<i>Accepted/Rejected</i>
GS or ANS	Market-based	WS	H	Y	Y	Y	Y	Y	Y	Y	Y	9	Hamilton and Clemens, 1999; Nourry, 2008; Mota et al., 2010; Asici, 2013; Kubiszewski, et al., 2013; Greasley et al, 2014	A necessary, although not sufficient, condition for all measures to attain WS is to measure the maximum amount of produced output that can be consumed at some point in time while maintaining constant wealth with a simple policy signal. According to this overall saving rule, total net capital investment is not allowed to be persistently negative. GS applies this rule (Hamilton, 1994; Dietz and Neumayer, 2007)	Accepted

<i>Indicator</i>	<i>Type</i>	<i>SS/WS</i>	<i>Policy relevance High/Medium/Low</i>	<i>Relevant to RQ</i>	<i>Data availability</i>	<i>Simplicity</i>	<i>Validity</i>	<i>Accurate and affordable data</i>	<i>Applicability in sustainability</i>	<i>Reliability</i>	<i>Robustness</i>	<i>No. of indicators covered</i>	<i>Source</i>	<i>Analysis</i>	<i>Accepted/ Rejected</i>
ISEW	<i>Socio-political</i>	W S	M	Y	N	Y	N	N	Y	Y	N	20	Nourry , 2008, Castaneda, 1999	More appropriate to measure quality of life (Asici, 2013) rather than the quality of environment	Rejected
GPI	<i>Socio-political</i>	W S	M	Y	N	N	N	Y	Y	Y	N	25	Lawn and Clarke, 2008, Posner and Costanza, 2011; Kubiszewski et al, 2013	Same as above	Rejected

<i>Indicator</i>	<i>Type</i>	<i>SS/WS</i>	<i>Policy relevance High/Medium /Low</i>	<i>Relevant to RQ</i>	<i>Data availability</i>	<i>Simplicity</i>	<i>Validity</i>	<i>Accurate and affordable data</i>	<i>Applicability in sustainability</i>	<i>Reliability</i>	<i>Robustness</i>	<i>No. of indicators covered</i>	<i>Source</i>	<i>Analysis</i>	<i>Accepted/ Rejected</i>
SEEA*	Market-based	Partly WS, partly SS	H	Y	Y	N	N	Y	Y	N	N	--	UN, 2003; Dietz and Neumaier, 2007	Contains a variety of definitions, methods and procedures. Economic and ecological scales are incompatible.	Rejected
EF	Ecology/Environment-based	SS	H	Y	Y	Y	Y	Y	Y	Y	Y	06	Parker, 1998; Wackernagel et al., 2004a, 2004b; Lambers et al., 2008; Nourry, 2008; Hubacek et al., 2009; Galli et al., 2012; Wang et al., 2012	Main focus is natural resource use by human. Data on resource use are usually available (Mayer et al., 2004).	Accepted

<i>Indicator</i>	<i>Type</i>	<i>SS/WS</i>	<i>Policy relevance High/Medium /Low</i>	<i>Relevant to RQ</i>	<i>Data availability</i>	<i>Simplicity</i>	<i>Validity</i>	<i>Accurate and affordable data</i>	<i>Applicability in sustainability</i>	<i>Reliability</i>	<i>Robustness</i>	<i>No. of indicators covered</i>	<i>Source</i>	<i>Analysis</i>	<i>Accepted/ Rejected</i>
ESI	<i>Ecology/Environment - based</i>	Partly WS, partly SS	M	Y	No. only for 2001 & 2005	N	N	N	Y	N	N	21	Pillaris etti and van den Bergh, 2008	ESI take only partly the viewpoint of strong sustainability, as the summarized outputs are provided by a composite index that is based on weak sustainability (Mori and Christodoulou, 2012)	Rejected
EPI	<i>Ecology/Environment - based</i>	SS	M	N	N	Y	--	N	N	N	N	25	Yale Centre for Environment Law & Policy, 2010	Are based on undertaken policies (Singh et al., 2012; Asici, 2013). So, not relevant to RQ. Data are also not available	Rejected

<i>Indicator</i>	<i>Type</i>	<i>SS/WS</i>	<i>Policy relevance High/Medium /Low</i>	<i>Relevant to RQ</i>	<i>Data availability</i>	<i>Simplicity</i>	<i>Validity</i>	<i>Accurate and affordable data</i>	<i>Applicability in sustainability</i>	<i>Reliability</i>	<i>Robustness</i>	<i>No. of indicators covered</i>	<i>Source</i>	<i>Analysis</i>	<i>Accepted/ Rejected</i>
EVI	<i>Ecology/Environment - based</i>	SS	H	N	N	Y	--	N	N	N	N	50	Kaly et al., 2004; Barnett et al., 2008	Assess the likelihood of potential damages caused by only the environmental problems (Asici, 2013) and ignores man-made activities. So, not relevant to RQ	Rejected

\*SEEA is an accounting tool comprised of many variables rather than one indicator

## Appendix 4(a) Input data to the Ecological Footprint and Biocapacity calculation

<i>Component</i>	<i>Dataset</i>	<i>Description</i>	<i>Source</i>
<b>Cropland</b>	Production of primary agricultural products	Data on physical quantities (tonnes) of primary products produced in each of the considered countries	FAO
	Production of crop-based feeds used to feed animals	Data on physical quantities (tonnes) of feeds, by type of crops, available to feed livestock	FAO
	Production of seeds	Data on physical quantities (tonnes) of seed	FAO
	Import and Export of primary and derived agricultural and livestock product	Data on physical quantities (tonnes) of products imported and exported by each of the considered countries	FAO
	Import and Export of non-agricultural commodities	Data on physical quantities (kg) of products imported and exported by each of the considered countries	COMTRADE
	Livestock crop Consumption	Data on crop-based feed for livestock (tonnes of dry matter per year), split into different crop categories	FAO, Haberl et al. (2007)
	Cropland yields	World average yield for 164 primary crop products	FAO
	National yield factors for cropland	Country specific yield factors for cropland	Concerned country

<i>Component</i>	<i>Dataset</i>	<i>Description</i>	<i>Source</i>
<b>Forest land</b>	Production of primary forestry products as well as import and export of primary and derived forestry products	Data on physical quantities (tonnes and m <sup>3</sup> ) of products (timber and wood fuel) produced, imported and exported by each country	FAO
	Forest yields	Defined as the average annual volume over a given reference period of gross increment less that of neutral losses on all trees to a minimum diameter of 0 cm (d.b.h.)	UNECE and FAO (2000), FAO (1998)
<b>Fishing ground</b>	Production of primary fishery products as well as import and export of primary and derived fishery products	Data on physical quantities (tonnes) of marine and inland fish species landed as well as import and export of fish commodities	FAO
	Fish yields	World-average yields for fish species. They are based on the annual marine primary production equivalent	Gulland (1971), Fishbase Database available at <a href="http://www.fishbase.org">www.fishbase.org</a> , Pauly and Christensen (1995)

<i>Component</i>	<i>Dataset</i>	<i>Description</i>	<i>Source</i>
<b>Carbon up-take land</b>	Carbon Uptake land yield	World average carbon uptake capacity. <i>Carbon uptake land is the only forest land assumed currently by the Ecological Footprint methodology</i>	IPCC (2006), Khatiwala et al. (2009)
	Carbon dioxide emissions by sector	Data on total amounts of CO <sub>2</sub> emitted by each sector of a country's economy	International Energy Agency (IEA)
<b>Urban land/Built-up land</b>	Built-up/infrastructure Areas	Except for data drawn from CORINE for European countries, all other data sources only provide total area values	CORINE, FAO, Global Land cover (GLC) (2000), Sustainability and the Global Environment (SAGE) at University of Wisconsin
<b>Grazing land</b>	Grazing land yields	World average yield for grass production. It represents the average above-ground edible net primary production for grassland available for consumption by ruminants	Monfreda (personal communication), 2008. SAGE at University of Wisconsin, Madison
<b>EQF</b>	Equivalence Factors (EQF)	EQF for crop, grazing, forest and marine land. Based upon the suitability of land as measured by the Global Agro-Ecological Zones model	FAO and IIASA (2000).

(Adapted from Borucke et al., 2013)

## Appendix 4(b) National Footprint Accounts (NFA)'s accounting framework

Flows of appropriate production (t/ha)		Land appropriation in terms of world average yield (wha)		EQF		Ecological Footprint (gha)
$\frac{\text{Agricultural products}}{\text{World crop yields}}$	=	Cropland	X	Cropland	=	Cropland footprint
$\frac{\text{Livestock products}}{\text{World grass yields}}$	=	Grazing land	X	Grazing land	=	Grazing land footprint
$\frac{\text{Fishery aquaculture products}}{\text{World fish yields}}$	=	Fishing ground	X	Fishing ground	=	Fishing ground footprint
$\frac{\text{Timber products}}{\text{World forest yields}}$	=	Forest land	X	Forest land	=	Forest footprint
$\frac{\text{CO}_2 \text{ emissions}}{\text{Carbon uptake factor}}$	=	Carbon up-take land	X	Forest land	=	CO <sub>2</sub> footprint
Built-up surfaces	=	Built-up land	X	Cropland	=	Infrastructure footprint
						<b>Total Ecological Footprint</b>
Production area (ha)		Land in terms of world productivity (wha)		EQF		Biocapacity (gha)
$\frac{\text{Cropland area } X}{\text{Cropland } YF}$	=	Cropland	X	Cropland	=	Cropland BC
$\frac{\text{Grazing land area } X}{\text{Grazing } YF}$	=	Grazing land	X	Grazing land	=	Grazing land BC
$\frac{\text{Marine or inland water area } X}{\text{Fishing } YF}$	=	Fishing ground	X	Fishing ground	=	Marine/inland water BC
$\frac{\text{Forest area } X}{\text{Forest } Y}$	=	Forest (net annual increment)	X	Forest land	=	Forest BC
$\frac{\text{Infrastructure area } X}{\text{Cropland } YF}$	=	Cropland	X	Cropland	=	Cropland BC
						<b>Total Biocapacity</b>

Source: Borucke et al. (2013)

## Appendix 5 Calculating Adjusted Net Saving

<i>Variable</i>	<i>Description</i>	<i>Sources</i>
GNS	Gross Net Savings is the difference between GNI and public and private consumption plus net current transfer. The formula is  $GNS = GNI - Private\ consumption - Public\ consumption + net\ current\ transfer$	WDI, OECD, UN, IMF, International Financial Statistics
D <sub>p</sub>	Depreciation of physical capital is the replacement value of capital used up by the process of production. Data is extracted directly from UN sources. Otherwise estimated by regression	UN
NNS	It is the difference between GNS and the consumption of fixed capital and its formula is  $NNS = GNS - D_p$	
EDU	Public current expenditure on education is used as an indicator to represent human capital which includes wages and salaries and excludes capital investments in buildings and equipment. Data is taken directly from UNESO. Otherwise average is taken for any missing year's data or assumed to be a constant share of GNI	UNESCO
ED	Energy depletion is the ratio of present value (PV) of rents of coal, crude oil, and natural gas, discounted at 4%, to exhaustion time of the resource. Price refers to international price. The formula is  ED = PV/exhaustion time Rent = production volume x unit resource rent Unit rent = unit price - unit cost Exhaustion time = min	OECD, British Petroleum, IEA, International Petroleum Encyclopedia, UN, World Bank, national sources

<i>Variable</i>	<i>Description</i>	<i>Sources</i>
MD	<p>Mineral depletion is the ratio of present value (PV) of rents of tin, gold, lead, zink, iron, copper, nickel, silver, bauxite, and phosphate, discounted at 4%, to exhaustion time of the mineral resource. Price refers to international price. The formula is</p> $MD = PV / \text{exhaustion time}$ <p>Rent = production volume x unit resource rent  Unit rent = unit price - unit cost  Exhaustion time = min</p>	USGS Mineral Yearbook, UNCTAD monthly Commodity Price Bulleting, World Bank, national sources
NFD	<p>Net forest depletion is the product of unit resource rents and the excess of round wood harvest over natural growth. It only includes timber values and does not include the loss of non-timber and nonuse forest benefits. The formula is:</p> $NFD = (\text{round wood production} - \text{increment}) \times \text{average price} \times \text{rental rate}$	FAOSTAT forestry data base, World Bank, FAO, UNECE, WRI, country-specific sources
COD	<p>CO<sub>2</sub> damage includes social cost of permanent damage by CO<sub>2</sub> emission represented by a conservative Figure of \$20 marginal global damages per ton of carbon emitted. The formula to calculate COD is</p> $COD = \text{emissions (tons)} \times \$20 \times 20 \times (12/44) \times 1000$	WDI
PMD	<p>PM<sub>10</sub> damage is the willingness to pay (WTP) to avoid mortality and morbidity attribute to particulate estimates. It is calculated by</p> $PMD = \text{disability adjusted life year lost due to PM emissions} \times WTP$	WDI

<i>Variable</i>	<i>Description</i>	<i>Sources</i>
ANS*	Adjusted Net Saving is the total stock of country comprised of both human and natural capital minus depreciation value of natural resources. So it is the Net national savings plus education expenditure minus energy depletion, mineral depletion, net forest depletion, carbon di oxide damage, particulate emission damage, i.e.  $ANS=NNS+EDU-ED-MD-NFD-COD-PMD$	

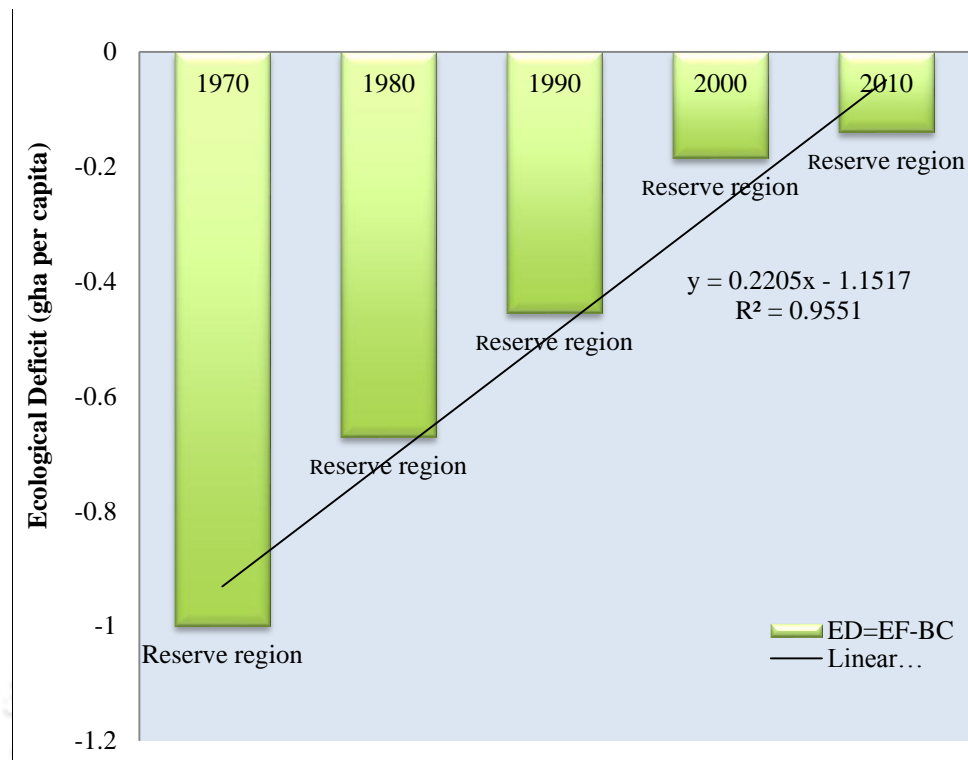
\* ANS without PMD can also be estimated

Source: World Bank, 2014

World Bank collects data from the following sources:

*“FAO: Food and Agriculture Organization; IEA: International Energy Agency; IMF: International Monetary Fund; OECD: Organisation for Economic Co-operation and Development; UN: United Nations; UNCTAD: United Nations Conference on Trade and Development; UNECE: United Nations Economic Commission for Europe; UNESCO/; United Nations Educational, Scientific and Cultural Organization; USGS: US Geological Survey; WDI: World Development Indicator; WRI: World Resources Institute; WTP: Willingness to pay”*

## Appendix 6 Ecological deficit in Indonesia



Reserve region is that where  $ED=EF-BC \leq -0.1$

Source: CCICED-WWF, 2006.

Here ED denotes the Ecological Deficit (Ministry of Public Works Indonesia, 2010)

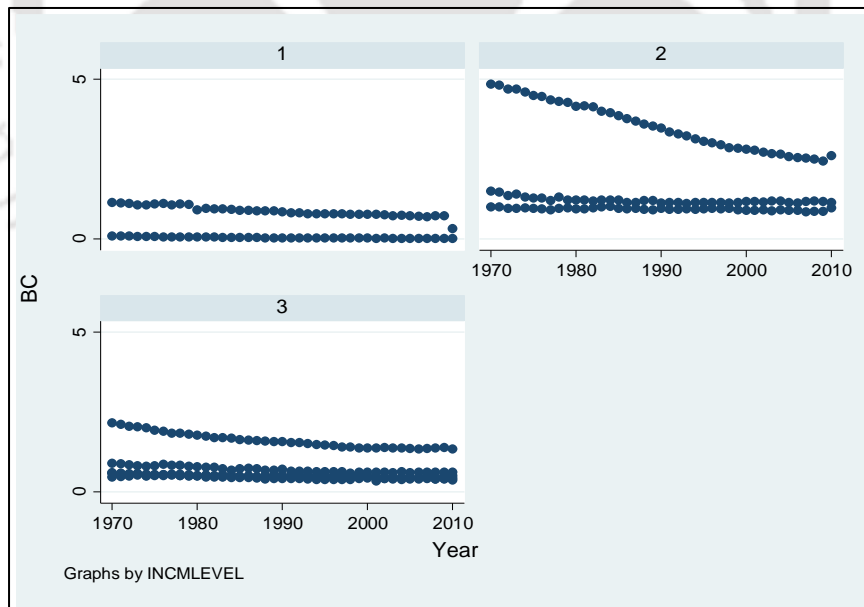
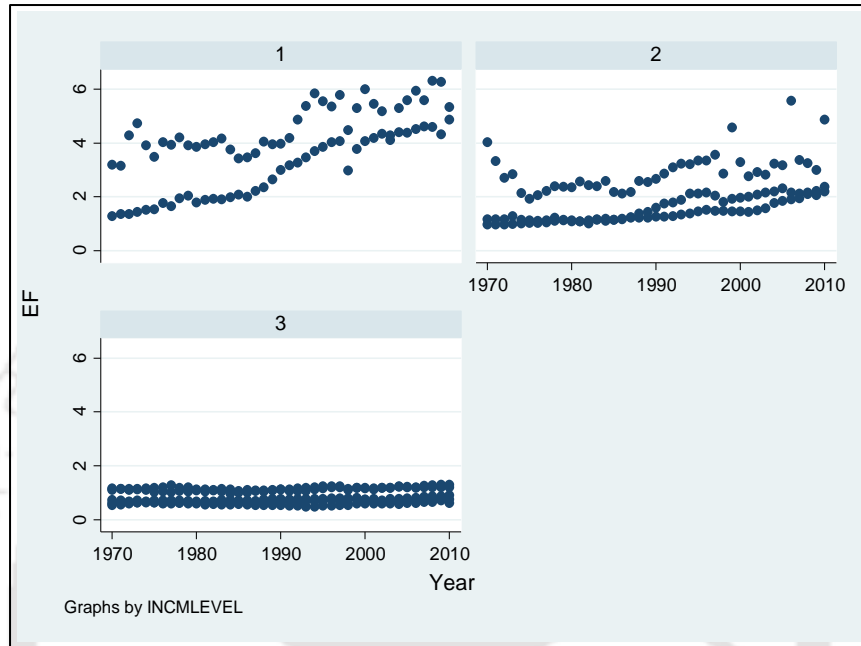
## Appendix 7 Unit Root Test Results

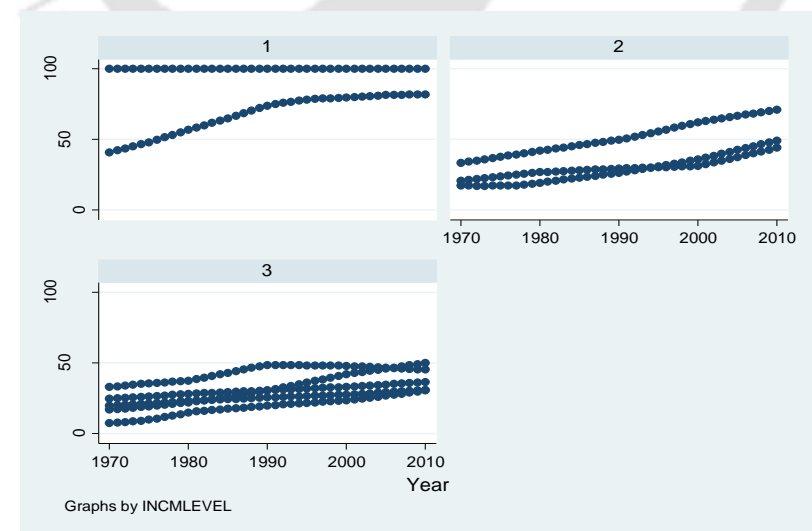
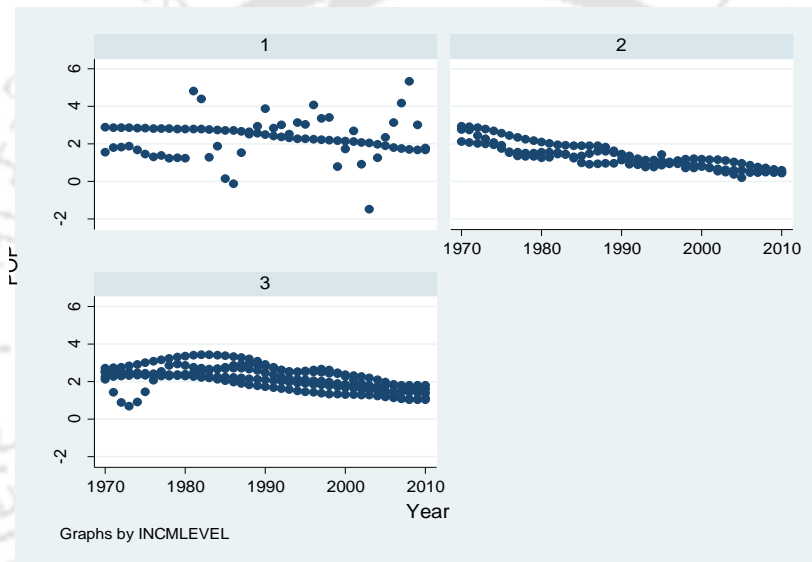
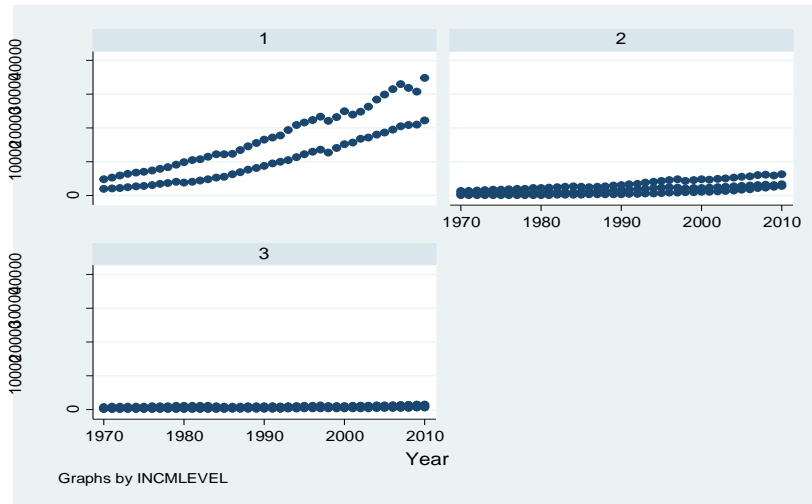
Variables	Levin-Lin-Chu	Im-Pesaran-Shin	Augmented Dicky-Fuller
<i>lnef</i>	-7.811 (0.152)	-3.251*** (0.000)	67.299*** (0.001)
<i>lnbc</i>	-7.876 (0.697)	-3.123*** (0.000)	62.407*** (0.000)
<i>lngdpp</i>	-5.678* (0.088)	-1.4594 (0.758)	56.649*** <sup>a</sup> (0.000)
<i>lnpop</i>	--	-2.936*** (0.000)	47.677*** (0.001)
<i>lnpercenturb</i>	-6.820*** (0.001)	-0.649 (1.000)	61.733*** (0.000)

<sup>a</sup> cross-sectional means are subtracted, but no trend was considered  
p-values of the estimated coefficients are given in parentheses  
\*\*\*, \*\* and \* indicate significant at 0.01, 0.05 and 0.10 (significance) level respectively

## Appendix 8 (a) Scatter plots of each variable before logarithmic transformation

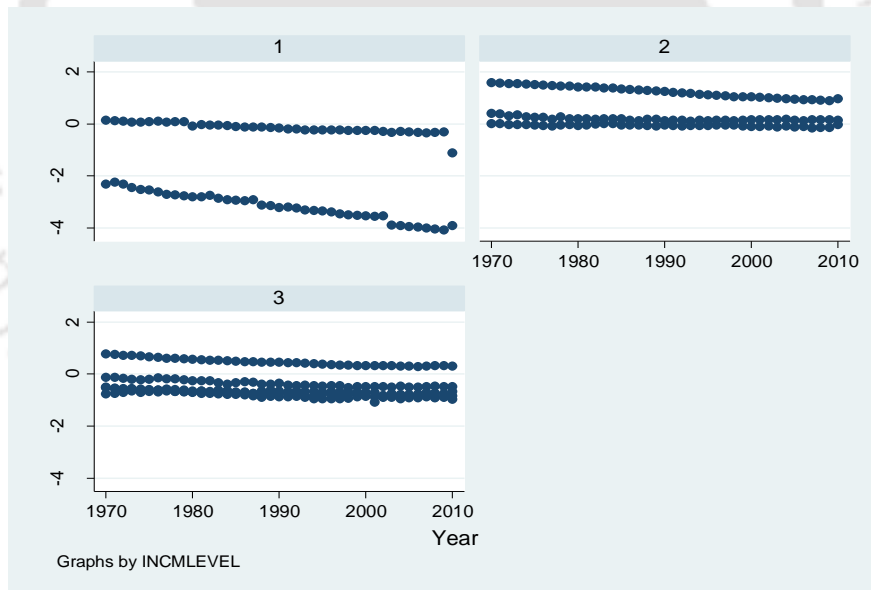
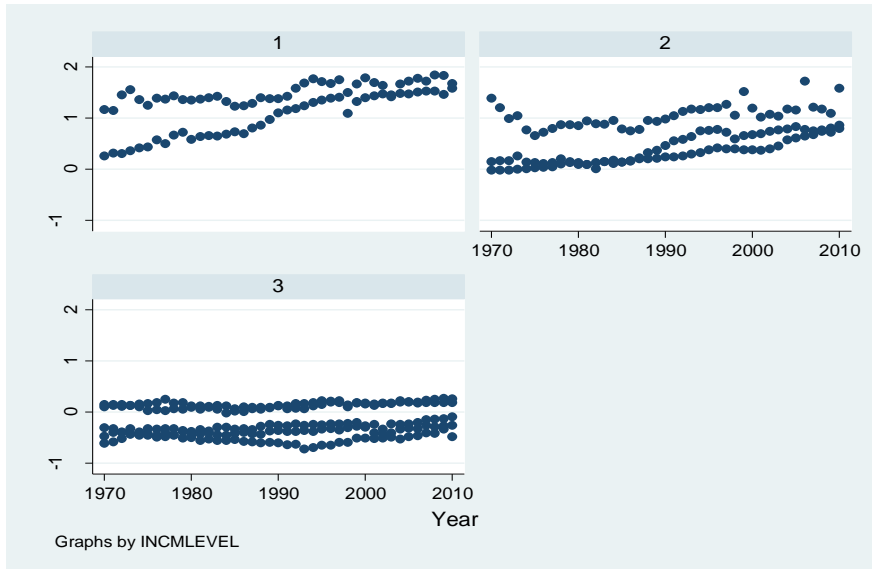
Income level: 1=HI, 2=UMI, 3=LMI

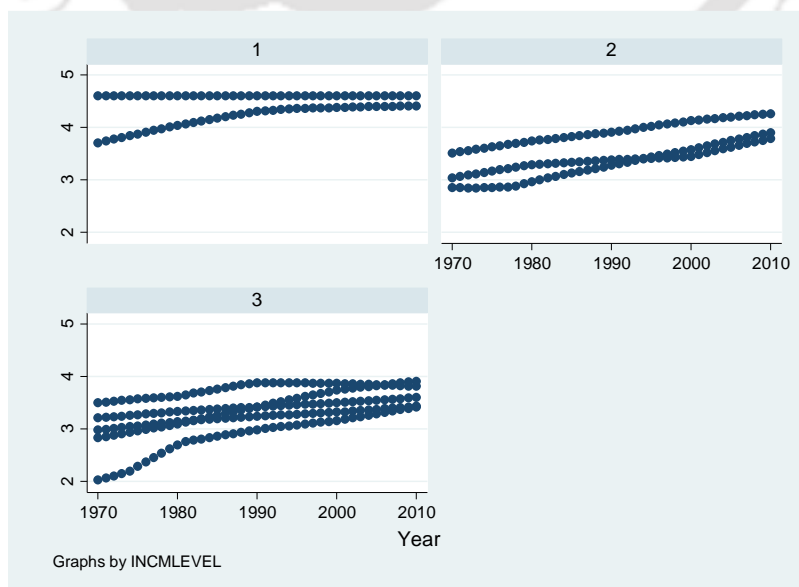
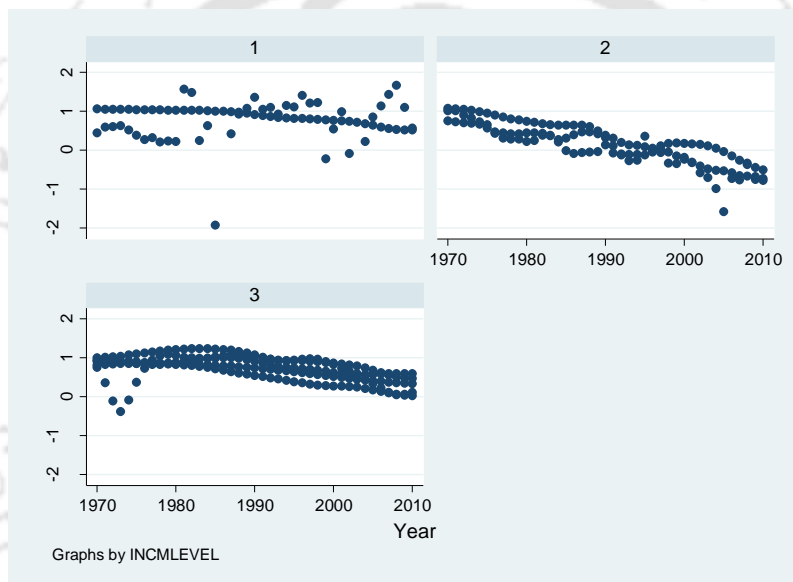
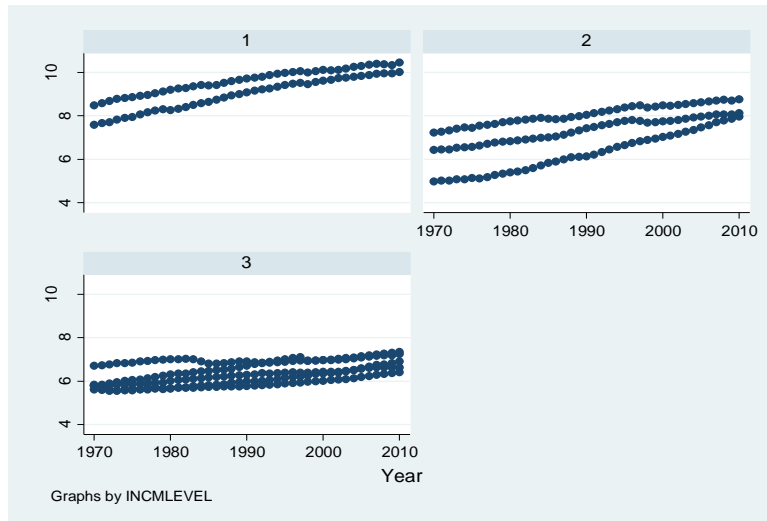




## Appendix 8 (b) Scatter plots of each variable after logarithmic transformation

Income level: 1=HI, 2=UMI, 3=LMI





## Appendix 9 Result of pooled OLS regression 1970–2010

Dependent Variable is the per capita EF

<i>Variables</i>	<i>Overall</i>	<i>High income</i>	<i>Upper middle</i>	<i>Lower middle</i>
<i>Biocapacity per capita (lnbc)</i>	0.0648*** (0.000)	0.0058 (0.664)	0.3489*** (0.000)	0.3197*** (0.000)
<i>GDP per capita (lngdpp)</i>	0.3252*** (0.000)	0.3169*** (0.000)	0.1735*** (0.000)	0.3067*** (0.000)
<i>Population growth rate (lnpop)</i>	-0.1155*** (0.000)	0.0174 (0.524)	-0.2759*** (0.000)	0.0777*** (0.001)
<i>Urbanization (lnpercenturbp)</i>	0.0916* (0.065)	0.8130*** (0.000)	-0.0417 (0.778)	0.0434 (0.226)
<i>Income level (incomelevel)</i>	-0.2517*** (0.000)	(omitted)	(omitted)	(omitted)
<i>Constant</i>	-1.6628*** (0.000)	-5.2689*** (0.000)	-0.6249* (0.078)	-2.2026*** (0.000)
<i>Number of observations</i>	408	80	123	205
<i>Number of countries</i>	10	2	3	5
<i>R<sup>2</sup></i>	0.9085	0.9420	0.8814	0.8951
<i>Adjusted R<sup>2</sup></i>	0.9074	0.9389	0.8774	0.8930
<i>Root MSE</i>	0.2034	0.1055	0.1460	0.09257
<i>F- statistic</i>	798.20***	304.30***	219.19***	426.53***

*p-values of the estimated coefficients are given in parentheses*

\*\*\*, \*\* and \* indicate significant at 0.01, 0.05 and 0.10 (significance) level respectively

This pooled OLS model fits the data well for all the countries, high, upper middle and lower middle groups at 0.05 significance level.  $R^2$  of all the four panels suggest that the pooled model accounts for 80-90% of the total variance in the ecological footprint per capita of countries. The pooled estimates suggest a positive and significant link between economic growth ( $lngdpp$ ) and demand for natural capital ( $lnef$ ) and between supply of natural capital ( $lnbc$ ) and demand for natural capital ( $lnef$ ) in all the countries, irrespective of income groups. However population and urbanization showed different impacts. While population growth doesn't show any significant impact on EF per capita for the whole group, and for the high income countries, it has negatively significant impact in the upper middle income group, and positively significant impact for lower middle countries. On the contrary, urbanization impact on the  $ef$  per capita is insignificant for all the panels except the overall and the high income countries.

The pooled regression model also gave the impact of income levels of the countries on the ecological footprint. In the overall group of all the ten countries, income has a significant negative impact. Since the income level ranges from high to low (1 to 3), the marginal effect of reduction in income level results in reduction of the average EF per capita of the countries.

Thus the regression equations are:

$$lnef_{overall} = (-1.6628) + (0.0648)lnbc + (0.3252)lngdpp + (-0.1155)lnpop + (0.0916)lnpercenturbp + (-0.2517)incomelevel$$

In case of zero biocapacity per capita, zero GDP per capita, zero population and zero urbanization, each country is expected to have decreasing EF of 1.6628 units of per capita ( $p < 0.000$ ). For one unit increase in biocapacity per capita, the per capita ecological footprint is expected to increase by .0648 units, holding all other variables constant ( $p < 0.000$ ). Whenever GDP per capita increases by ten units, the per capita ecological footprint will increase by 0.3252 units, holding all other variables constant ( $p < 0.000$ ). The income level has a negative impact as reported by the pooled OLS estimation technique. One unit decrease in the income level

(since income level ranges from 1 to 3; 1=high, 2=upper middle, 3=lower middle), decreases the per capita ecological footprint by 0.2517 units ( $p < 0.000$ ).

$$\begin{aligned} \mathbf{lnef_{high\ income}} = & (-5.2589) + (0.0058)\mathbf{lnbc} + (0.3169)\mathbf{lngdpp} + (0.0174)\mathbf{lnpop} \\ & + (0.8130)\mathbf{lnpercenturbp} \end{aligned}$$

In HI countries, biocapacity per capita has no significant impact on the per capita ecological footprint ( $p < 0.664$ ). Whenever GDP per capita increases by ten units, the per capita ecological footprint will increase by 3.169 units, holding all other variables constant ( $p < 0.000$ ). The population growth rate has a positive impact as reported by the pooled OLS estimation technique. But it is also not significant ( $p < 0.524$ ). Urbanization has highly positive significant impact on the per capita *ef* in these high income countries. 1% increase in urban population can actually cause an increase of 0.8130 units in per capita EF in this HI group.

$$\begin{aligned} \mathbf{lnef_{UMI}} = & (-0.6249) + (0.3489)\mathbf{lnbc} + (0.1735)\mathbf{lngdpp} + (-0.2759)\mathbf{lnpop} \\ & + (-0.0417)\mathbf{lnpercenturbp} \end{aligned}$$

In case of UMI countries, if there is zero biocapacity per capita, zero GDP per capita, zero population and zero urbanization, each upper middle income country is expected to gain 0.6249 units reduction in its per capita ecological footprint ( $p < 0.078$ ). However for one unit increase in biocapacity per capita, the per capita ecological footprint is expected to increase by 0.3489 units, holding all other variables constant ( $p < 0.000$ ). Whenever GDP per capita increases by ten units, the per capita ecological footprint will increase by 1.735 units, holding all other variables constant ( $p < 0.000$ ). Population growth rate has a negatively significant impact as reported by the pooled OLS estimation technique. One unit increase in the population growth rate decreases the per capita ecological footprint by 0.276 units ( $p < 0.000$ ). Urbanization has no significant impact on the per capita *ef* in the upper middle income countries too.

$$\begin{aligned} \mathbf{lnef_{LMI}} = & (-2.2026) + (0.3197)\mathbf{lnbc} + (0.3067)\mathbf{lngdpp} + (0.0777)\mathbf{lnpop} \\ & + (0.0434)\mathbf{lnpercenturbp} \end{aligned}$$

In case of LMI countries, if there is zero biocapacity per capita, zero GDP per capita, zero population and zero urbanization, each upper middle-income country is expected to gain 2.2026 units reduction in its per capita ecological footprint ( $p < 0.000$ ). However, for one unit increase in biocapacity per capita, the per capita ecological footprint is expected to increase by 0.3197 units, holding all other variables constant ( $p < 0.000$ ). Whenever GDP per capita increases by ten units, the per capita ecological footprint will increase by 3.067 units, holding all other variables constant ( $p < 0.000$ ). Population growth rate has a positive impact as reported by the pooled OLS estimation technique. One unit increase in the population growth rate increases the per capita ecological footprint by 0.0777 units ( $p < 0.001$ ). Urbanization has a positive but insignificant impact on the *ef* of lower middle income countries.

Although this model fits the data well, there might be question if each country has different initial per capita demand on natural capital. That is, each country might have its own Y-intercept that is significantly different from those of other countries. Also the error terms might vary across countries. Unobserved heterogeneity problem was not solved by the pooled OLS. So, special regression models were required in this study. The former question suspect fixed effects, whereas the latter asks if there is any random effect.

## Appendix 10 Panel data output tables-Pooled regression

### Overall 10 countries

Source	SS	df	MS	Number of obs =	408
-----+				F( 5, 402) =	798.20
Model	165.126993	5	33.0253987	Prob > F =	0.0000
Residual	16.6327154	402	.041374914	R-squared =	0.9085
-----+				Adj R-squared =	0.9074
Total	181.759709	407	.446584051	Root MSE =	.20341

lnef	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lnbc	.0648762	.0104796	6.19	0.000	.0442746	.0854778
lngdpp	.3252374	.0245982	13.22	0.000	.2768802	.3735946
lnpop	-.1154952	.0221462	-5.22	0.000	-.159032	-.0719583
lnpercenturb	.0916494	.0496089	1.85	0.065	-.0058758	.1891746
incmlevel	-.2516978	.0225131	-11.18	0.000	-.295956	-.2074396
_cons	-1.662817	.1429319	-11.63	0.000	-1.943805	-1.38183

### High Income group

Source	SS	df	MS	Number of obs =	80
-----+				F( 4, 75) =	304.30
Model	13.5485806	4	3.38714514	Prob > F =	0.0000
Residual	.834813576	75	.011130848	R-squared =	0.9420
-----+				Adj R-squared =	0.9389
Total	14.3833941	79	.18206828	Root MSE =	.1055

lnef	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lnbc	.005806	.0133011	0.44	0.664	-.0206911	.0323032
lngdpp	.3169257	.0256005	12.38	0.000	.2659269	.3679245
lnpop	.0173556	.0270981	0.64	0.524	-.0366265	.0713378
lnpercenturb	.8130384	.105173	7.73	0.000	.603523	1.022554
_cons	-5.26886	.3549399	-14.84	0.000	-5.975936	-4.561783

### ***Upper Middle Income group***

Source	SS	df	MS	Number of obs = 123		
Model	18.6817208	4	4.6704302	F( 4, 118) = 219.19		
Residual	2.5142655	118	.021307335	Prob > F = 0.0000		
				R-squared = 0.8814		
				Adj R-squared = 0.8774		
				Root MSE = .14597		
lnef	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
L nbc	.348895	.0429428	8.12	0.000	.2638566	.4339334
lngdpp	.1734537	.0364579	4.76	0.000	.1012571	.2456504
lnpop	-.2758693	.0570281	-4.84	0.000	-.3888004	-.1629381
lnpercenturb	-.0417254	.1477593	-0.28	0.778	-.3343289	.2508782
_ cons	-.6248828	.3517215	-1.78	0.078	-1.321387	.0716214

### ***Lower Middle Income group***

Source	SS	df	MS	Number of obs = 205		
Model	14.6210369	4	3.65525923	F( 4, 200) = 426.53		
Residual	1.71397138	200	.008569857	Prob > F = 0.0000		
				R-squared = 0.8951		
				Adj R-squared = 0.8930		
				Root MSE = .09257		
lnef	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lnbc	.3196668	.0153457	20.83	0.000	.2894067	.3499269
lngdpp	.3066772	.0304102	10.08	0.000	.2467114	.3666431
lnpop	.0776992	.0232414	3.34	0.001	.0318696	.1235287
lnpercenturb	.045391	.0373615	1.21	0.226	-.028282	.1190639
cons	-2.202559	.1103747	-19.96	0.000	-2.420206	-1.984912



Random-effects GLS regression                      Number of obs    =    408  
 Group variable: concode                            Number of groups =    10

R-sq: within = 0.7008                              Obs per group: min =    39  
           between = 0.8956    avg =    40.8  
           overall = 0.8631    max =    41

Random effects u\_i ~ Gaussian                      Wald chi2(4)       = 1083.92  
 corr(u\_i, X)       = 0 (assumed)                      Prob > chi2       = 0.0000

	lnef	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
lnbc		.0807196	.0257507	3.13	0.002	.0302492	.1311901
lngdpp		.4619747	.0207427	22.27	0.000	.4213198	.5026296
lnpop		.0216603	.0193586	1.12	0.263	-.0162819	.0596025
lnpercenturb		-.2338354	.041984	-5.57	0.000	-.3161226	-.1515482
_ cons		-2.123126	.1260556	-16.84	0.000	-2.37019	-1.876061
sigma_u		.0957765					
sigma_e		.11489004					
rho		.4100119	(fraction of variance due to u_i)				

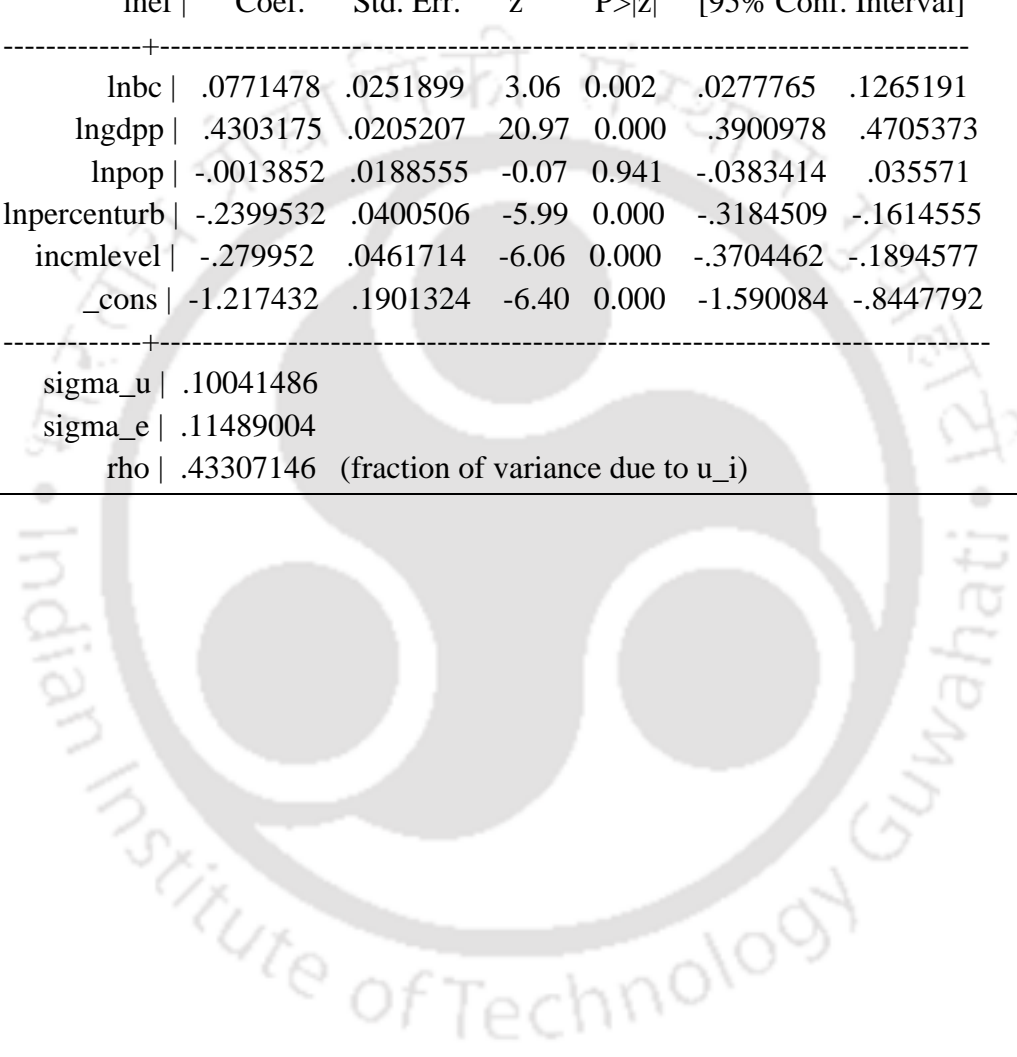
R-sq: within = 0.7021  
 between = 0.9111  
 overall = 0.8901

Obs per group: min = 39  
 avg = 40.8  
 max = 41

Random effects u\_i ~ Gaussian  
 corr(u\_i, X) = 0 (assumed)

Wald chi2(5) = 1204.14  
 Prob > chi2 = 0.0000

	Inef	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
lnbc		.0771478	.0251899	3.06	0.002	.0277765	.1265191
lngdpp		.4303175	.0205207	20.97	0.000	.3900978	.4705373
lnpop		-.0013852	.0188555	-0.07	0.941	-.0383414	.035571
lnpercenturb		-.2399532	.0400506	-5.99	0.000	-.3184509	-.1614555
incmlevel		-.279952	.0461714	-6.06	0.000	-.3704462	-.1894577
_cons		-1.217432	.1901324	-6.40	0.000	-1.590084	-.8447792
sigma_u		.10041486					
sigma_e		.11489004					
rho		.43307146	(fraction of variance due to u_i)				



**Fixed effect and random effect (High Income group).**

Fixed-effects (within) regression	Number of obs = 80
Group variable: concode	Number of groups = 2
R-sq: within = 0.9097	Obs per group: min = 39
between = 1.0000	avg = 40.0
overall = 0.5936	max = 41
	F(4,74) = 186.43
corr(u_i, Xb) = 0.0334	Prob > F = 0.0000

---

lnef	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lnbc	.155993	.0891455	1.75	0.084	-.0216333	.3336194
lngdpp	.4456328	.0796793	5.59	0.000	.2868684	.6043973
lnpop	.0214299	.0268677	0.80	0.428	-.0321051	.074965
lnpercenturb	.4931462	.2146116	2.30	0.024	.0655233	.9207691
_cons	-4.816723	.4396899	-10.95	0.000	-5.692824	-3.940622

---

sigma_u	.35535566
sigma_e	.10419042
rho	.92083874 (fraction of variance due to u_i)

F test that all u\_i=0: F(1, 74) = 2.90 Prob > F = 0.0927

Random-effects GLS regression	Number of obs = 80
Group variable: concode	Number of groups = 2
R-sq: within = 0.9062	Obs per group: min = 39
between = 1.0000	avg = 40.0
overall = 0.9420	max = 41
Random effects u_i ~ Gaussian	Wald chi2(4) = 1217.21
corr(u_i, X) = 0 (assumed)	Prob > chi2 = 0.0000

---

lnef	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
lnbc	.005806	.0133011	0.44	0.662	-.0202637	.0318757
lngdpp	.3169257	.0256005	12.38	0.000	.2667497	.3671018
lnpop	.0173556	.0270981	0.64	0.522	-.0357557	.0704669
lnpercenturb	.8130384	.105173	7.73	0.000	.6069031	1.019174
_cons	-5.26886	.3549399	-14.84	0.000	-5.964529	-4.57319

---

sigma_u	0
sigma_e	.10419042
rho	0 (fraction of variance due to u_i)





## Appendix 12 Social indicators to measure social sustainability

- (a) *Human Development Index (HDI)*: This social indicator is included in this study to measure human development in the selected Asian countries. It is a composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living (see <http://hdr.undp.org/en/content/human-development-index-hdi>).
- (b) *Life expectancy at birth*: Another measure for social sustainability. Number of years a new born infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life
- (c) *Mean years of schooling*: This is used an indicator of knowledge in the calculation of HDI by the UN. Mean years of schooling is measured as an average number of years of education received by people aged 25 or more. The raw data is converted from education attainment levels using official durations of each level.
- (d) *Multidimensional Poverty Index (MPI)*: It is an index of intensity of multidimensional poverty at the household level. The index recognizes deficiencies across the same three dimensions as the HDI (health, education and living standards) and shows the number of people who are multidimensionally poor (suffering deprivations in 33% or more of weighted indicators) and the number of deprivations with which poor households typically contend with (see <http://hdr.undp.org/en/content/multidimensional-poverty-index-mpi>).

- (e) Gender equality index: This is an important indicator for social sustainability. Gender equality index assesses the extent to which the country has installed institutions and programs to enforce laws and policies that promote equality for men and women in education, health, the economy, and protection under the law.
- (f) *GINI index* (World Bank estimate): Gini index processes the extent to which the income distribution (or, in some cases, consumption expenditure) among individuals or households within an economy departs from a perfectly equal distribution. The index uses a Lorenz curve which plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. Thus, a Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.

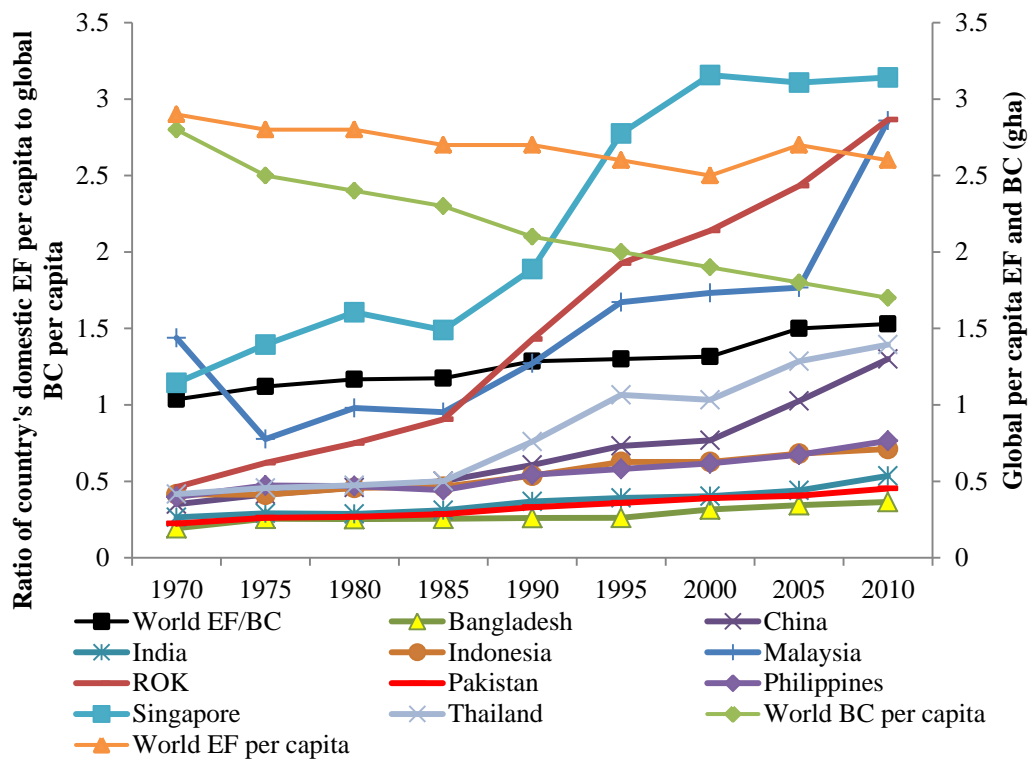
## Appendix 13 Ecological Footprint of each country at global scale

Ecological footprint of a country is a composite measure of per capita consumption i.e. how much pressure does each person of the country puts on its natural capital in terms of production, export and import. Through export, domestic EF goes to other countries and through import, it enters into the concerned country. So, EF is not a country-specific matter only. In this era of globalisation, through per capita EF consumption, each person of each country is actually putting pressure on the global ecosystem. In other words, even if in a country, per capita EF is less than its per capita domestic<sup>21</sup> (country's) BC, that EF may not be less than the global per capita BC. So, to have an idea about the comparative position of the selected Asian countries on dependence on global natural resources, an index EF/BC is used which is the ratio of country's domestic EF per capita to the global BC per capita. This index has been successfully used by (Wackernagel et al., 2004b) and a modified version by (Gao and Tian, 2016). Then the index for each selected country was compared to the ratio of global demand from the available global biocapacity. The world ecological footprint per capita serves as a comparison for all countries on an average basis (Wackernagel et al., 2004b).

Figure A.1 shows the ecological footprint of each country (domestic demand) in comparison with global available per capita biocapacity. While at the global level, the per capita ecological footprint has remained largely unchanged since 1990, different patterns of change were found in the three income groups. The high-income countries —Republic of Korea and Singapore — have increasingly high ratio of domestic EF to global BC, that is a very high demand for global natural resources, compared with upper and lower middle-income countries.

---

<sup>21</sup> Domestic BC - The biocapacity, available for each person within the geographical boundary of the country.



**Figure A.1 The ratio of Domestic Ecological Footprint (per capita) to Global Bio-capacity (per capita), 1970-2010**

Among the upper middle income countries, Malaysia's ratio is increasing very rapidly and is increasing more rapidly than the global demand. All the other UMI as well as the LMI countries' ratio of domestic EF per capita to global BC per capita are still below the global level. This showed the global demand has increased more rapidly than the upper middle and lower middle income countries.