UNIVERSITI PUTRA MALAYSIA

AN APPLICATION OF THE SYSTEM OF NATIONAL ACCOUNTS TO FOREST RESOURCE ACCOUNTING OF MALAYSIA

AHM. MUSTAIN BILLAH

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AN APPLICATION OF THE SYSTEM OF NATIONAL ACCOUNTS TO FOREST RESOURCE ACCOUNTING OF MALAYSIA

BY

AHM. MUSTAIN BILLAH

Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in the Faculty of Economics and Management University Putra Malaysia

February 2000

This Thesis is dedicated to my beloved family:

My Sweet Heart Daughters
Farah Billah (Binti)
Shazinath Billah (Srabanti)
My Beloved Wife
Dr. Maliha Parveen

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

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Chairman : Associate Professor Dr. Mohd. Shahwahid Hj Othman

Faculty : Faculty of Economics and Management

Malaysia is endowed with an extensive forest resource base. The forest area has declined by 23.0% over the last 25 years from 7,583 thousand ha in 1972 to 5,820 in 1996. Yet, the Peninsular Malaysia economy has grown 7.6% in 1974 to 8.8% in 1996 suggesting that the economy is growing sustainably. Nevertheless, there is a trend of forest conversion to make way for development. The share of forest resource rent (net price) of Peninsular Malaysia to its GDP has declined very rapidly from 0.5% in 1972 to 0.25% of GDP in 1996. This reduction implies wavering importance in relative terms but is not true in terms of absolute value.

The present system of national accounts (SNA), the concept of capital maintenance applies to physical capital only. Limited account is given to the contribution of natural resource and environment to economic activities. Despite

agreement among those who favour economic integrated accounts to incorporate natural capital directly into the SNA, no consensus has yet been reached to accomplish the task.

The study applies the user cost method in estimating the resource depletion in forestry. According to the user cost method, the annual forestry sector real adjusted gross domestic product (AGDP) increased for the study period. Despite, decreasing physical stock of forest resources income increased due to an appreciation of the real value of resource rent. However, the net price method provided contrasting findings. The user cost is considered to be the better method in the estimation of resource depletion as it unlike the net price method takes into account the future benefits foregone or gained. For the national economy, using both the methods, the study found that the trend of per capita real ANDP and AGDP increased almost three times over the last 25 years, indicating welfare increase.

Both the weak sustainability test (PAM>0) and the World Bank (1995) Genuine Saving sustainability test confirm the economic sustainability of Peninsular Malaysia with respect to forestry resource depletion. It is suggestive that enough resource rents are reinvested in the economy, particularly in human resource and infrastructure development.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk mendapatkan Ijazah Doktor Falsafah.

PEMAKAIAN SISTEM PERAKAUNAN NASIONAL DI DALAM PERAKAUNAN SUMBER PERHUTANAN DI MALAYSIA

Oleh

AHM. MUSTAIN BILLAH

Februari 2000

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Fakulti : Fakulti Ekonomi dan Pengurusan

Malaysia dianugerahkan dengan sumber hutan yang luas. Walaubagaimanapun, keluasan hutan telah berkurangan sebanyak 23% semenjak 25 tahun dahulu iaitu dari 7,583 ribu ha dalam tahun 1972 ke 5,820 ha dalam tahun 1996. Pada masa yang sama, ekonomi bagi Semenanjung Malaysia telah menunjukkan perkembangan yang berterusan dengan peningkatan sebanyak 7.6% dalam tahun 1974 kepada 8.8% dalam tahun 1996 memberi andaian bahawa ekonomi negara sedang meningkat dengan mampan. Hutan asli meliputi 56% dari luas tanah Semenanjung Malaysia. Namun begitu, terdapat satu tren di mana kawasan hutan telah dibuka untuk memberi laluan kepada pembangunan. Dengan mengambil pembalakan sebagai contoh, didapati peratusan sewa sumber hutan (harga bersih) kepada Keluaran Dalam Negara Kasar (KDNK) telah menurun secara

mendadak dari 0.5% dalam tahun 1972 ke 0.25% dalam tahun 1996. Penurunan ini menunjukkan berkurangnya kepentingan hutan secara relatif tetapi ini tidaklah benar dari sudut nilai absolut.

Di dalam Sistem Perakaunan Negara (SNA) yang sedia ada, konsep penyelenggaraan modal hanya diaplikasikan kepada modal fizikal sahaja. Kurang akaun yang mengambilkira sumbangan sumber asli dan alam sekitar kepada aktiviti ekonomi. Walaupun terdapat persetujuan di antara mereka yang memilih akaun yang berintegrasikan ekonomi untuk mangambilkira modal asli di dalam Sistem Perakaunan Negara (SNA), persetujuan belum lagi dicapai untuk memulakan langkah tersebut.

Kajian ini mengaplikasikan kaedah kos pengguna di dalam menganggarkan pengurangan sumber dalam sektor perhutanan. Berlainan dengan kaedah harga bersih, kaedah kos pengguna mengambilkira kehilangan faedah pada masa depan yang disebabkan oleh pengurangan sumber. Mengikut kaedah ini, Keluaran Dalam Negara Kasar Diubahsuai(AGDP) tahunan untuk sektor perhutanan didapati meningkat di dalam jangka masa kajian. Walaupun stok fizikal berkurangan bagi sumber hutan, pendapatan telah meningkat disebabkan oleh peningkatan nilai sebenar sewa sumber. Ini menyumbang kepada kemampanan sektor ini. Kaedah harga bersih pula memberi keputusan yang bertentangan dengan kaedah kos pengguna. Keluaran Negara Kasar Diubahsuai(ANDP) tahunan untuk sektor perhutanan didapati menurun dalam jangkamasa 25 tahun yang lepas menunjukkan keadaan ekonomi sektor yang tidak mampan. Kaedah kos pengguna dianggap lebih baik di dalam penganggaran pengurangan sumber kerana ia mengambilkira kehilangan faedah pada masa depan.

Kajian tentang kriteria pengukuran kebajikan untuk ekonomi negara dengan menggunakan kedua-dua kaedah menunjukkan tren ANDP dan AGDP benar per kapita meningkat lebih kurang tiga kali di dalam jangkamasa 25 tahun tang lepas. Ini menunjukkan terdapat perningkatan dalan kebajikan.

Kedua-dua ujian "Weak sustainability" (PAM>0) dan ujian "Genuine Saving Sustainability" Bank Dunia (1995) mengesahkan keadaan ekonomi yang mampan di Semenanjung Malaysia walaupun dalam keadaan sumber hutan yang berkurangan. Apa yang telah hilang dari segi kuantiti diganti balik dengan nilai tambah daripada usaha-usaha menanam balik pokok dan juga dengan menerokai penggunaan baru bagi ladang pokok pertanian. Selain itu, sewa sumber yang mencukupi telah dilaburkan kembali dalam ekonomi seperti pembangunan sumber manusia dan infrastruktur. Kajian ini mungkin dapat melahirkan polisi yang sesuai untuk pengurusan perhutanan mampan.

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LIST OF ABBREVIATIONS

A	Reserve Additions
AGDP	Adjusted Gross Domestic Product
ANDI	Adjusted Gross Domestic Investment
ANDP	Adjusted Net Domestic Product
A-P-F	Adelman-Pindyck-Fisher
AV	Average
CAI	Current Annual Increment
CBO	Congressional Budget Office
CLS	Closing Stock
CMAI	Culmination of Mean Annual Increment
CO	Current Production Expenditure
CRt	Current Resource Rent
dbh	Diameter at Breast Height
DE	Defensive Expenditure
DNC	Depreciation of Natural Capital
DX	Development Expenditure
Edt	Economic Depreciation
FR	Forest Reserve
GDI	Gross Domestic Product
GDP	Gross Domestic Product
GNP	Gross National Product
ha	Hectare
HRA	Harvesting Area
IEEA	Integrated Environmental & Economic Accounting
Kh	Human Capital
Km	Physical Capital
Kn	Natural Capital
m	Meter
m^3	Cubic meter
MAI	Mean Annual Increment
mc_{find}	Marginal Fining Cost
MC	Marginal Cost
mcx	Marginal Replacement Cost
MR	Marginal Revenue
MRC	Marginal Replacement Cost
NDI	Net Domestic Invesatment
NDP	Net Domestic Product
NNP	Net National Product

NP	Net Price
NPV	Net Present Value
NRA	Natural Resource Accounting
OS	Opening Stock
∂	Per unit Resource Rent
PFE	Permanent Forest Estate
Q	Quantity
SD	Sustainable Development
SEEA	Satelite Environmental Economic Accounting
SMS	Selective Management System
SNA	System of National Accounts
SSNNP	Sustainable Social Net National Product
St	Stock
SV	Stumpage Value
TGR	Timber Growth Rate
UNSTAT	United Nations Statistical Division
WRI	World Resource Institute

CHAPTER I

INTRODUCTION

Background of Natural Resource Accounting

During the last five decades, ever since the end of World War II, industrial countries have experienced impressive economic growth and have achieved high standards of living. The developing world, which is the home to three-quarters of the world's population has gained in purchasing power, life expectancies and literacy rates. However, inequitable distribution of income in low and middle-income countries prohibits large segments of society from enjoying development gains.

Economic activities that deplete the natural resources and degrade the environment likewise jeopardize development efforts. Often, these activities are the result of government policies, or actions by individuals, who fail to account for the true social value of natural resources. Such resources have long been undervalued, thereby reducing long-term productivity, damaging human health, and undermining development prospects. In short, the achievement of economic development objectives remains a challenge facing the human community as it approaches the twenty-first century.

When the natural capital of a country is depleted without the simultaneous investment of a portion of revenues into other assets, future generations are left with fewer resources to produce goods and services (Hicks, 1946). Income may be considered as the highest level of consumption attainable in a given period, which does not reduce consumption in future periods. The same holds true at the national level: Hicksian income is the maximum value that a nation can consume at the present time without impoverishing itself in the future.

It is generally accepted that income is a function of capital assets. A capital asset is any stock of value that has the potential to generate a stream of income to the owner. First type of capital assets includes such items as machines, factories, buildings, and infrastructure, known as physical capital. Stocks of physical capital generate flow of goods and services as the assets are used in the production process.

A second type of capital is known as natural capital.[1] Natural capital is defined as "the stock that yields the flow of natural resources - the forests that yield the flow of cut timber; the petroleum deposits that yield the flow of pumped crude oil; the fish populations in the sea that yield the flow of caught fish" (Daly, 1992).

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[1] Additional types of capital include human capital (i.e., the stock of knowledge, health and skills of the population, etc.) and social capital (i.e., civic institutions upon which functioning societies are grounded, popular participation in societal decision making, social cohesion, etc.) (Kellenberg, 1995).

The assignment of property right of natural capital is important before it can be used for any economic activity. Solow (1974) stressed that natural capital in any form in the ground is a capital asset to society and its owner has to be assigned property rights much like a printing press or a building or any other reproducible capital asset. Similarly, a forest falls into the category of natural capital. It may be built up over time through investing in silviculture and pest control, or it may be depleted through harvesting. Thus, forests derive their value principally through the final goods and services that are produced from it. Natural capital plays an integral role in the economic development of a nation by investing the resource rent into the economy.

In order to maintain a sustainable income one should calculate the Hicksian income and must account for maintenance of the capital stock. Capital needs to be maintained in order to sustain economic development. The calculation of income provides an indication of the amount that people can consume without compromising with present level of standard. On the basis of this principle, income can be defined as the maximum value of an asset that he can consume during a certain period, say in a year and at the end of the year he will remain as well off as the beginning of the year. In short, the main purpose of calculating income is to use as guide for prudent exercise (Hicks, 1946).

Accounting serves to separate from the proceeds accruing to owners that part which they could use to finance their families' current needs. Owners have to guard against consuming their capital because it is the source of their continued well being.

The accounting system was established as a backward-looking operation to gauge levels of income or profits for individuals and businesses. Accountants purge capital elements from receipts in order to arrive at a true measurement of income (El Serafy, 1989).

Maintaining capital intact is prudent. Thus, in order to account for income properly, a portion of current receipts must be used to repair, restore and maintain capital; to preserve its ability to produce goods and services in perpetuity. The decline in the productive capacity of capital is accounted for by a depreciation allowance, which amortizes the capital asset's value over its useful life. Like an allowance is made for the depreciation of physical capital, so must exist an accounting for the decline in productivity of natural capital. Hicks wrote that if an individual's receipts are derived from the exploitation of a wasting asset, liable to give out at a future date, the receipts are considered in excess of his income, the difference between them being reckoned as an allowance for depreciation. (Hicks, 1946).

Natural capital is indeed a "wasting asset" if it is non-renewable. If it is renewable, is not actually renewed through careful maintenance. Thus a depreciation allowance must be involved every time an exhaustible resource is extracted or if a renewable resource is used in an unsustainable manner.

System of National Income Accounts (SNA)

Information from national income accounts provides the most widely used indicator of economic performance, growth and economic development. The System of National Accounts (SNA) provides information to identify a country's assets and liabilities at particular points in time. The system also keeps track of transactions - such as purchases of goods and services, payments to wage and profit earners, import payments and export revenues for goods and services by measuring disparate goods and services using a common metric. The SNA has become the standard framework for measuring macroeconomic performance, analysing the trends of economic growth, and providing the economic counterpart of social welfare.

The work of Kuznets and Stone and the theories of Keynes heavily influence the SNA. Keynesian economists were preoccupied with the global economic depression of the 1930s and specifically were seeking to explain how an economy could remain at less than full employment for long periods of time.

In the beginning of 1940s, all countries in the world have used the national accounts. The national accounts reflect the aggregate consumption, savings, and investment and government expenditure as defined by the Keynesian macroeconomic model.

In the System of National Accounts (SNA) for the purpose of economic and environmental planning, the use and misuse of natural resources and the environment should be appropriately measured. Unfortunately, they are not. National accounts serve two purposes: (i) providing inputs to modeling economic valuations and (ii) monitoring of an economy's performance from measures such as gross domestic product (Glenn-Marie *et al*., 1994).

There are several reasons why the SNA may provide a misleading picture of long-term economic performance. The SNA only includes economic activities, which are valued at private cost rather than social cost; a zero valuation is placed upon certain essential goods and services. The concept of capital maintenance applies only to physical capital; limited account is taken of the contribution of the natural resources and environment to economic activity; and, finally, no account is taken of human or social capital (Harrison, 1992).

GDP represents the total monetary value of domestically produced goods and services in a given year for final use in private consumption, government expenditure, investment or trade. But GDP is a gross measure and it ignores the fact that the stock of capital in particular machinery is being used up during the production process. A better indicator is the Net Domestic Product (NDP) which deducts from GDP the value of the stocks of capital worn out or depreciation. However, NDP, as it is measured still ignores that in the process of production of economic goods natural capital also gets worn out, such as asset of forest and oil.

Presently national income accounts have been accused of partial "blindness" regarding new scarcities and degradation of natural resource endowments. These effects are caused by economic activities on natural resource endowment production and consumption, which if remains unchecked will unwillingly jeopardize the long run sustainability of these economic activities themselves. Consequently, the major deficiencies of the system of national accounts can be placed into two categories:

(a) Non-incorporation of the environmental effects of the economic activity. The environmental effects of the economic activity occur both upon the natural resources being exploited and upon the environment at large. Taking logging as an example, too much harvesting would cause degradation: one, on the reduction in the quantity and quality of log upon impact of felling trees to the ground and eventual use of inferior and damaged logs by logging industries. The other is the damage or injury of standing residual trees from the impact of felling trees.

(b) Neglect of services of unpriced inputs and unpriced outputs (Peskin, 1991). Unpriced inputs include natural resource and environment; unpriced outputs may include specific attributes of natural resources and environment such as clean and unpolluted air and water. These inputs and outputs influence production and consumption decisions in the same way as the services of man-made physical capital (Peskin, 1991).

In order to sustain economic growth, a country would have to reinvest enough of its earnings derived from its natural resource utilization and from other sectors to offset the decline in the natural wealth (El-Serafy, 1989). When natural resources are renewable, as in the case of forestry, the resource wealth can be regenerated and even increased over time if properly managed. At the national level, Net Domestic Product (NDP) is gross domestic product after deducting off depreciation allowances for man-made physical capital. It can be worthwhile to look at the need for Natural Resource Accounting (NRA) in order to incorporate the natural resource depreciation into the system of national accounts (SNA).

Problem Statement

Malaysia, like any other tropical country, has a natural advantage in the form of extensive forest base. But it is a resource that is dwindling with the current rapid pace of economic development. When talking of the supply in the forestry economics, there is a need for distinction between physical supply and economic supply. Physical supply is the total recoverable quantity of the resource in existence under given biological and technical conditions. The economic aspect involves, however cost-revenue considerations. It is a schedule showing the flow of resources that will be supplied at different price levels.

The supply has both a static and dynamic aspect. The static concept refers to the existing stock of trees. The dynamic aspect concerns the growth and mortality rate of trees that will affect supply at different periods in the future. These depend on the inherent characteristics of each species and on the environment, which, together with cost-revenue factors, can help to determine the optimal time path of harvesting of trees over one or more cutting cycles.

The rate of extraction is affecting the sustainability of the resource base. Total forest area and trend of physical forest resource in Peninsular Malaysia is declining. The forest area declined about 30% from 8,211 thousand ha in 1972 to 5,820 thousand ha in 1996.

Fortunately for the country, another 4.3 million ha are under tree coverage, with agricultural crops, mainly rubber and oil palm. Among these agricultural crops rubber wood has in recent years become an important timber material particularly for furniture and as such has joined the rank of renewable timber resources for the country.

The implications of the continuous depletion of natural resources like forest resources may reduce the country's long run economic growth. Considering the long run adverse consequences, the Peninsular Malaysia government had banned log export totally in 1985. As a result, the area logged and timber production both remained unchanged and forest rehabilitation activities were stepped up. The logged area decreased from 424 to 164 thousand hectares (ha) in 1972 and 1996 respectively (see Figure 1). The log production decreased from 8,920 thousand m^3 to 8,418 thousand m^3 during the same period (Forestry Statistics, 1972-96).

In order to meet the demand for rapidly growing domestic industries, there is a need for felling of more trees. The natural forest is the most important source of log input for the domestic primary wood processing industry of the country. Logging has been conducted from two sources of natural forest: those outside the Permanent Forest Estate (PFE) i.e. state land, which are meant for conversion into development projects and those inside the permanent forest estate.

The local processing of sawlogs into sawn timber, veneer and plywood increased from 11 million m^3 to 15 million m^3 in the years of 1990 and 1995 respectively in Malaysia. Similarly, the local wood-based industry experienced rapid expansion in which the utilization of sawn timber for the production of wood moulding and furniture increased from 0.72 million to 1.3 million m^3 in

Figure 1: Forest Area Logged ('000 ha) in Peninsular Malaysia

the year of 1990 and 1995 respectively. This represented about 13.7% of the total sawn timber produced in the above period (Seventh Malaysia Plan, 1996).

The intensity of forest resource extraction is also alarming for Malaysian forest resource depletion. An examination of annual rate of harvesting and regeneration in Peninsular Malaysia during the seventies indicates that the forest harvesting hectareages have been in excess of the annual coupes (Mohd. Shahwahid, 1991). This feature continued in the eighties. During the Fifth Malaysia Plan (1986-90) the total annual coupe during the period was 320,400 ha, but the actual harvested area was 544,696 ha, an excess of 224,296 ha or 70% more than the annual coupe set.

In order to curb this intensity of resource depletion the government is undertaking a massive programme of forest rehabilitation for the ongoing Seventh Malaysia Plan. About 1.5 million ha of forest will be treated, while 153,900 ha of degraded forestland will be reforested during the plan period. In addition, planting of high value trees, particularly teak, and other trees for pulp and paper will be encouraged (Seventh Malaysia Plan, 1996).

In national income accounts the depreciation is not recorded as an economic transaction, but is imputed to capture the declining income generating potential of an asset over time. It indicates the level of investment necessary for a country to maintain its productive capacity. The exploitation of natural resources and degradation of environment undoubtedly lessen an economy's productive capacity, particularly those developing economies, which rely heavily on resource extraction industries. This being the case, it is clearly inconsistent and misleading to deduct depreciation only of productive man-made capital, while ignoring the analogous depletion of productive natural capital. Malaysia cashed in a substantial portion of natural resource wealth of its natural wealth during the last three decades. This resource boom provided a large share of the fuel for the country's rapid economic expansion. With the exploitation of natural resources the country is attaining economic growth (Vincent *et al*., 1993).

The timber losses due to deforestation and degradation have exceeded the reduction in stocks due to commercial harvesting. These losses represent tremendous opportunity cost in terms of foregone export revenue and foregone raw materials for domestic down stream wood based industries.

However, in order to ensure the sustainable management of (forestry) resource stock, it is essential to estimate and determine the rate of forestry resource depletion. The present study aims at estimating the resource depletion and in formulating the forestry NRA framework for Peninsular Malaysia.

Objectives of the Study

The general objective of the study is to determine resource depletion and its linkage to sustainable economic growth.

The specific objectives of the study are therefore:

(1) To develop a NRA framework for forest resource sector in Peninsular Malaysia in order to account for changes in the physical stock of resources as well as changes in the values of forestry resource in Peninsular Malaysia.

(2) To incorporate the value of forest resource depletion into national and forestry sector accounts for Peninsular Malaysia.

(3) To examine whether enough reinvestment is made from derived earnings of the forestry resource in Peninsular Malaysia to maintain sustainable income.

(4) To make an economic sustainability test for the economy of Peninsular Malaysia.

Significance of the Study of Natural Resource Accounting

Globally there is increasing awareness that economic production cannot be measured without accounting for environmental concerns. While revenues derived from resource extraction have the potential to finance investments in industrial capacity, infrastructure, and education, a reasonable accounting representation of the process would recognize that one type of asset has been exchanged for another. If natural capital elements can be identified and purged from income measurements, a more accurate level of income would emerge which can better reflect economic performance and can provide an improved basis for policy prescriptions.

A system of natural resource and environmental accounts provides a framework for organizing the information required for effective policy. In their most basic form, NRA provides consistent inventory of resource stock and flow accounts may be developed for various resources, including a unique set of resources such as special ecosystems. In a more advanced form, natural resource and environmental accounts are used for analyzing and forecasting the impacts of changes in environmental policy. As an analytical tool, natural resource and environmental accounts link changes in policy to changes in human activity and resource depletion or growth.

As long as human activity is at the level below the regeneration capacity of natural environment, there is no secular decline in the quality of these resources. In order to maintain the above balance, a measurement of income incorporating degradation of the natural resources becomes necessary. This is the key point stressed by Daly (1989) and El-Serafy (1991). True income can be thought of as a maximum amount that can be consumed in a given period without reducing the amount of possible consumption in the future period. This concept encompasses not only current earnings but also changes in the assets: capital gains increase income; capital loss reduces income.

Present economic management requires that government should know the maximum amount that can be consumed by a nation without causing its eventual impoverishment. It is important, therefore, that national income be measured correctly to indicate sustainable income.

Organisation of the Study

The study consists of eight chapters. Chapter II describes the forest resource management and its status in Peninsular Malaysia. Chapter III reviews the literature regarding the estimation of resource depletion and its integration into national accounts. Chapter IV discusses empirical studies on methods of valuing natural capital depreciation. Chapter V develops the research method for NRA of Peninsular Malaysia. Chapter VI discusses the results of the empirical analysis and the measurement of the economic value of the natural capital depletion (forest resource) during the period of 1972 to 2026. Chapter VII integrates the value of natural capital depletion into the macroeconomic accounts and offers several indicators of sustainable development. The final chapter examines the policy options for sustainable management of forest resources in Peninsular Malaysia.

CHAPTER II

FOREST MANAGEMENT IN PENINSULAR MALAYSIA

Introduction

Malaysia is composed of three distinct and geographically separated regions: Peninsular Malaysia, Sabah and Sarawak. Peninsular Malaysia comprises 11 states and the Federal Territory of Kuala Lumpur (Figure 2). Peninsular Malaysia contains 40% of the nation's total land area but with 81% of the population. The other two states are located in East Malaysia on the northern part of Borneo.

There is a parliamentary form of government with an elective monarch. As regards to central executive affairs, there is a federal system of government responsible for certain matters, such as education, defense, international trade, public works and so forth. Legislative power is divided between the federal and the state legislative assemblies. Regulations pertaining to forestry matters timber allocations, revenue collection and land development are the affairs of the state governments.

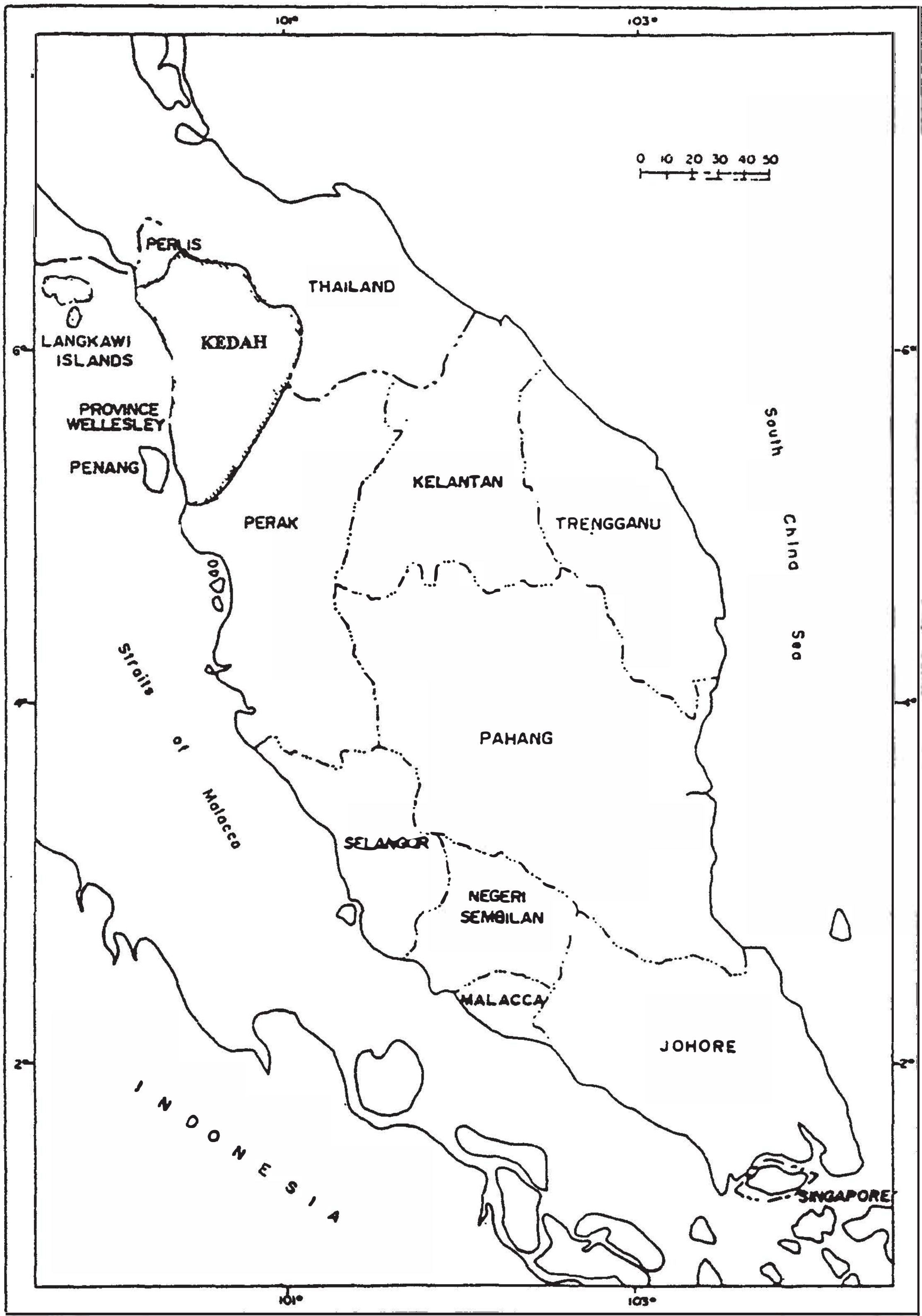

Figure 2 : Map of Peninsular Malaysia

Malaysia can be described as an open economy. The country has been endowed with diverse and vast natural resources such as tin, oil, natural gas and forests. In the early stages of economic development, the Malaysian economy was mostly dependent on agriculture and primary commodities, particularly tin, timber, rubber and palm oil. From 1980s the economy started changing structurally from primary and agriculture based exports to export of petroleum and manufacturing goods.

The economic growth in Malaysia has increased vigorously during the Sixth Malaysia Plan (1990-1995). The country achieved an average annual gross domestic product (GDP) growth rate of approximately over 8% during the same period (Seventh Malaysia Plan, 1996). A highly stable political environment and conducive investment opportunities have also helped Malaysia in achieving the impressive economic growth in the last few years.

Forestry sector has a vital role to play in the economic development of Peninsular Malaysia. Since the early 1960s the opening up of land development schemes for agriculture, the rise in the demand and the price of the tropical hardwood in the international markets, and the growth of wood-processing facilities in the country have facilitated the decline of the forest resource base. The growth in exploitation was not matched by sufficient regeneration of the resource in the country. Lowland dipterocarp forests were subject to rapid conversion during the 1960s and 1970s as a result of large scale conversion of land for agricultural development (Vincent & Yusuf, 1991; Awang Noor, 1994).

This led to a substantial depletion of forest resource in Peninsular Malaysia.

The government of Malaysia has formulated and implemented a good number of policies for managing these forests in order to preserve the interest of the present and future generations. Some of the forestry and environmental policies are pertinent to the framework of the present study.

An effective forest and environmental policy should be based on an understanding of the natural resource and human activities that generate environmental conflicts. Essential information about the systems includes the state, quality and quantity of resources. A system of NRA provides a framework for organizing the information required for effective policy.

Forest Management System in Peninsular Malaysia

Peninsular Malaysia is endowed with extensive complex ecosystems. The flora is estimated to comprise 75,0000 species of seeds plants of which 41,000 are woody (Chiew, 1986). Approximately, 2,900 species reach a diameter of 10 cm dbh while 1,680 species reach a diameter of 30 cm dbh (Whitemore, 1975), with 890 of these species being exploitable sizes with a dbh of at least 45cm. Under Malaysian Grading Rules a total of 408 species have been introduced in the international market.

Based on ecological and locational condition, forests in Peninsular Malaysia can be divided into the following categories such as Dipterocarp, Peat

Swamp and Mangrove Forest. Dipterocarp forests are more extensive and commercially more important (constituting about 4.4 million ha). In this forest, the family Dipterocarpaceae predominates the area, with many of the species from the genera Anisoptera, Dipterocarpus, Dryobalanops, Hopea, Shorea and Parashorea (Vincent and Yusuf, 1991; Awang Noor, 1994).

An overview of the forest management of Peninsular Malaysia shows that sustainable forest management practices have been developed since early 20th century in order to maintain forest regeneration ecologically, harvest yield economically and conserve them environmentally. In the early days silvicultural management system was concerned with felling over mature trees and trees that might compete with the favoured species.

In response to growing demand for the tropical hardwoods after the Second World War the Malayan Uniform System (MUS) has been formulated. MUS consists of removing the mature crop in one single felling of all trees down to 45 cm dbh for all species and releasing the selected natural regeneration of varying ages which are mainly the demanding medium and light hardwood species. About 5 to 7 years after felling, strip samplings used to carry out to verify the presence of regeneration and subsequently provide with suitable treatment. Hence, basically the MUS is the system for converting the virgin tropical lowland rainforest forest to a more or less even-aged forest, containing a greater proportion of commercial species (Wyatt-Smith, 1963).

The factors which made MUS a success included: (i) an adequately well-distributed stocking of seedlings of economic species at the time of felling, (ii) complete removal of all big size species to make them even-age forest, (iii) a few years left undisturbed for regrowth and (iv) at a regular interval linear sampling used to carry out to assess the status of regeneration of the left over seedlings.

The MUS was successfully applied in the lowland dipterocarp, but proved to be unsuccessful in the hill forest management because of insufficient stocking that result in poor regeneration. Furthermore, it caused soil erosion. Besides silvicultural and environmental factors, the monocyclic approach is found to be financially and economically less attractive. The longer rotation and single cycle of the MUS require larger forest base in order to practice sustained-yield forestry.

Considering the land scarcity and ever growing demand for timber, the Selective Management System (SMS) was evolved in order to meet the requirement of (i) flexible forest management system suitable to resource base condition and to the changes in the socio-economic and environment and (ii) optimization of forest management goal such as an economic cut, sustainability of the forest and minimum cost of forest development.

The SMS requires the selection of management (felling) regimes based on inventory data rather than arbitrary prescription to ensure ecological balance and environmental quality. Under the SMS, the cutting cycle was determined for 30 years, whereas under the MUS one has to wait a complete rotation of 55 years or more until the regeneration has grown into harvestable trees.

In order to determine the appropriate minimum cutting limits under the SMS, a Pre-Felling Inventory is to be carried out to provide reliable estimates of population parameters that are measured in terms of species size, composition, volume and topography, such as slope, elevation and soil types.

The conservation forest management approach under the SMS is expected to ensure the benefits like conservation of the dwindling forest resource, sustainability of resource base, minimizing reinvestment, preserving environmental quality, reducing excessive damage and wastage, and encouraging optimum utilization of the resource. In order to make the SMS a success, some things are required to be taken care of, such as species wise growth and mortality by carrying out growth and yield studies. Similarly, Pre-inventory and Post-inventory information may provide tree sizes under various intensities of selective logging, logging damage to residual trees in relation to diameter classes and ensure economic cut. Considering the existing resource base, ecological condition, and economic need, the forest management system of Peninsular Malaysia was revised over time.

Forest Status and Regulation

A good number of rules and laws have been formulated and enacted by the government. These include the Land Capability Classification (1965), the Protection of Wildlife Act (1972), the National Forest Policy (1978), the National Forestry Act (1984) Amendment (1993), the Wood Based Industries Act (1984) and the Industrial Master Plan (1985) and (1995). All these acts and policies have had great influence on development of forestry sector in Malaysia. Under the National Forestry Act (NFA) every state is required to prepare and implement forest management and working plan in the PFE.

The plan describes the area to be harvested, the species to be felled, the cutting limit and allowable cut to be prescribed, penalties for poor timber harvesting practices and so on. With this development, management and control of the forest resources has been systematically strengthened and upgraded.

Peninsular Malaysia conducted three national inventories for reserve forest with a view to manage forest resources in a sustainable manner. In the National forestry inventories, the reserve forest has been divided into eleven types as shown in Table 1.

Table 1: Area of Different Types of Forest in Peninsular Malaysia in Three NFI's

Strata of Forest	NFI-I Area in (ha)	Percentage	NFI-II Area in (ha)	Percentage	NFI-III Area in (ha)	Percentage
Superior Virgin Forest	827000	10.17	692814	10.31	430986	7.40
Good Forest	1149500	14.14	847987	12.62	578397	9.93
Medium Forest	1398000	17.19	1118923	16.65	635688	10.92
Logged over Forest	1267000	15.58	2260427	33.63	2759706	47.40
Damage Forest	1713500	21.07	487575	7.25	374717	6.44
Shifting Cultivation	260500	3.20	220491	3.28	151223	2.60
Poor Forest	412000	5.07	254951	3.79	184275	3.16
Mountain Forest	288500	3.55	278454	4.14	257455	4.42
Virgin Swamp Forest	464000	5.71	261883	3.90	180391	3.10
Logged over Swamp Forest	183500	2.26	38573	0.57	229063	3.93
Damaged Swamp Forest	167000	2.05	259406	3.86	40784	0.70
Total Area (ha)	8130500	100.00	6721484	100.00	5822685	100.00

Sources: National Forestry Inventory I (1972), II (1982), and III (1993)
NFI = National Forestry Inventory

Awareness has been growing regarding the protective role of forest. These are minimizing flash floods, soil erosion and siltation the influence of water balance and regulation of climate. Thus the need for soil conservation and genetic resource emerged. Sustainable management of forest is vital for successful agricultural, industrial and socio-economic development in order to maintain environmental stability and quality of life in general.

The forest has been divided into three categories with respect to their functions and objective: protective forests (environmental and amelioration such as water catchment), productive forest (timber production) and amenity forests (conservation and other services such as recreation and research). The changes in total natural forest area in Peninsular Malaysia are shown in Table 1. As the natural forests are depleting overtime, the plantation forest become increasingly important in order to meet the future log requirement. As of December 1996, 66,754 ha of plantation forest have been established under the compensatory forest plantation project (Forest Statistics, 1996).

The compensatory forest plantation project (1982) is aimed at planting fast growing hardwood species, which can be harvested based on a 15 year rotation. The main species identified for plantation include (i) *Acacia mangium* (ii) *Gmelina Arborea* and (iii) *Paraserianthes falcataria*. However, most of the established areas now consist of *Acacia mangium* due to its adaptability to almost all planting site.

In order to coordinate the development of the forestry sector in Peninsular Malaysia, the National Land Council (NLC) established the National Forestry Council (NFC) in 1971. The NFC serves as a forum for the federal and the state government to discuss and resolve the common problems and issues relating to the forestry policy, administration and management. A significant policy effect of the NFC was the formulation and acceptance of the National Forest Policy (NFP) 1978.

The policy has been accepted by all states in Peninsular Malaysia. The NFP calls for the establishment of the Permanent Forest Estate (PFE), whereby a sufficient forest area have been designated for timber production, water regulations, environmental protection recreation, education, research and conservation; these are strategically located throughout the country and in accordance with the concept of rational land use.

Forest intended to be converted to other uses are termed as State Land Forest (SLF). The total natural forest area in Peninsular Malaysia was estimated to be 6.1 million ha, or 46.5% of the total land area (Forestry Department 1996). Out of this area, 4.7 million ha are PFE. Production forest covers an area of 2.8 million ha.

Forest based industrialization has grown rapidly during the past three decades. The tremendous growth of the forestry sector has developed it into a major contributor to foreign exchange and has established for the country a favorable image as the top producer of high quality tropical hard wood. In the 1960s and 1970s a large proportion of logs were harvested and exported. The banning of logs of some popular species for export began in 1972 and a total ban was imposed in 1985.

From early, 1980s the government encouraged the development of wood based processing industries. The Industrial Master Plan launched in 1985 provides the general industrial development objectives and strategies for sectors with promising growth potential; wood based industries are one of such sectors. Forest based industries grew rapidly during the period from 1961 to 1985.

Domestic demand and export expansions were the main factors that contributed to the growth of forest based industries (Vincent, 1986).

In order to enhance the effectiveness in the forestry enforcement, the National Forestry Act (1984) has been amended in 1993 and steps were taken to institute the preparation of EIA to protect the forest environment and biodiversity, in particular the logging of natural forest. The reduced impact logging (RIL) is encouraged, and helicopter logging is carried out in Sarawak (Seventh Malaysia Plan, 1996). These practices are encouraging the development of downstream processing industries and improving the timber concession policy. Sufficient funds are being made available for forest development projects to enhance research and development, carry out forest resource inventory survey and monitor the silvicultural and reforestation activities.

The expansion and sustainability of forest based industries in the long run depends mostly on sustained timber supply. The scheduled reduction in log production in Peninsular Malaysia is a major approach to maintain a sustained yield from the natural forests. The government has taken several measures to address the issue. These include the designation of Permanent Forest Estates, which are being managed under sustained yield; practicing sustainable forest management through selective management system (SMS); establishing plantation under the compensatory forest plantation project and encouraging the utilization of rubber (wood).

Changes in the Forest Resource

The National Conservation Strategy for Malaysia (EPU, 1993) shows that there is an increasing trend in timber harvest in the three regions from 1970 to 1989. In that study it was found that the harvest were fairly steady throughout the period in Peninsular Malaysia. The average harvests during this period were around 10 million m^3 /year. This trend continues to date, with a slight decline to 9 and 8 million m^3 for the year 1995 and 1996, respectively (Forest Statistics, 1996). By 1996 the area of unlogged forest remaining in Peninsular Malaysia was still more than 50% of that in 1972, declining from 8.2 million ha to 5.8 million ha (Forest Statistics, 1972-96). More timber is commercially extracted from the forest than it is being regenerated in Peninsular Malaysia.

After 1980 rubber stumpage was considered an economic good. This resource continued to decline as the land is converted to other land use at an average rate of 3% annually over the last 17 years. In terms of rubber log supplies, Ismariah and Norini (1994) and Mohd Shahwahid *et al.* (1995) have suggested that there would be no overall supply deficits in the short term until the end of the century and possibly even 10 years later. This will be possible, if the factor preventing utilisation of the full potential of rubber log supplies can be overcome. It is therefore very essential to manage the rubber wood sustainably like other types of forest resources.

Due to continuous economic expansion, the total installed wood processing capacities of mills in Peninsular Malaysia were 13.7 million m^3 for 1994-95 (Thai, 1998). There is no possibility of decline in it. In the Seventh Malaysian Plan (1996-2000), it was announced that the average annual coupe would decrease from 52 thousand in the Sixth Malaysia Plan (1990-95) to 45 thousands ha. for the Seventh Malaysia Plan (1995-2000). This reduction is expected to be more than 17%. It reflects that there will be a shortage of timber supply for Peninsular Malaysia in the future.

The Forestry Department in the year of 1980 projected that there would be a critical shortage of timber supply in Peninsular Malaysia by the end of 1990s. Hence the Forestry Department of Peninsular Malaysia launched the Compensatory Forest Plantation Project (CFPP) in 1982. The programme aimed at planting fast growing hardwood species, which can be harvested in a 15 year rotation. The main species identified for the plantation include (i) *Acacia mangium* (ii) *Gmelina arborea* (iii) *Paraserianthes falcataria*. However, most of the established areas now consist of *Acacia mangium* (86%) due to its adaptability to almost all planting site (Forestry Department, 1997).

Despite all the efforts undertaken by the Government to mange the forest resource of Peninsular Malaysia sustainably, a rapid declining trend of forest area (state land) and higher extraction of resource stock are observed as demonstrated in Table 2.

Table 2: Forest Resource Depletion by Area and Production of Logs

Year	Permanent Forest ('000 ha)	Stateland ('000 ha)	Total Forest Land ('000 ha)	Log Production ('000 m^3)
1972	3437.4	3518.2	6955.6	8920
1973	3358.1	3348.9	6707.0	9695
1974	3411.4	3295.4	6706.8	8628
1975	3448.5	3230.6	6679.1	7538
1976	2934.4	3653.1	6587.5	9831
1977	3164.5	3226.6	6391.1	9717
1978	2948.5	3288.9	6237.4	9418
1979	2933	2908.5	5841.5	10401
1980	3124.9	2632.6	5757.5	10453
1981	3083.3	2611.2	5694.5	10226
1982	3019.9	2604.9	5624.8	9840
1983	4830.5	1314.8	6145.3	10237
1984	5049.7	682.7	5732.4	9181
1985	5103.6	701.4	5805.0	7914
1986	5127.3	783.3	5910.6	8586
1987	4990.0	813.6	5803.6	10318
1988	4928.2	815.0	5743.2	12360
1989	4866.2	906.2	5772.4	13155
1990	4866.6	853.2	5719.8	12818
1991	4748.1	717.2	5465.3	12283
1992	4717.7	716.3	5434.0	13030
1993	4698.5	717.5	5416.0	11234
1994	4687.4	594.4	5281.8	11389
1995	4684.9	590.5	5275.4	9029
1996	4684.0	521.5	5205.5	8418

Source: Forestry Statistics Peninsular Malaysia (1972-1997)

Table 2 clearly demonstrates that total forest land area decreased from 6956 thousands ha in 1972 to 5206 thousands ha in 1996. This is because of depletion of state land forest substantially over the study period, where from harvesting takes place. An increasing trend of log production is also observed from 8920 thousand m^3 in 1972 to 11389 thousand m^3 in 1994, though strong conservation policy was able to curb the log production in the 1990s.

Conclusion

Sustainable forest management practices prevail in Peninsular Malaysia for long time. In the early days, silvicultural management system was concerned with felling over matured trees and favoured species. But in response to growing demand for tropical hardwoods Malayan Uniform System (MUS) was introduced after the Second World War. MUS failed in the management of hill forest because of insufficient stocking that result in poor regeneration. Considering the land scarcity and ever-growing demand for timber, Selective Management System (SMS) has evolved. Under this system 30 years cutting cycle is determined. Pre-felling inventory has to be carried out that covers tree sizes, compositions, volume and topography.

A good number of regulations and Acts have been formulated that have great importance on the management of forestry sector. In order to meet the growing demand for timber, Peninsular Malaysia launched the Compensatory Forest Plantation Project (CFPP) in 1982. This continuing project aims at planting fast growing hardwood short rotation species, which needs to be continued.

CHAPTER III

LITERATURE SURVEY ON RESOURCE ACCOUNTING

Estimation of Resource Depletion and Integration into National Accounts

Buildings and machinery deteriorate with use over time, hence any reduction in their value is treated as a depreciation in conventional national income accounting. In order to estimate net national product this depreciation value is subtracted from gross national product. Natural resources are also capital stocks like buildings and machinery, but their decline is not accounted for national accounts. Resource accounting corrects this discriminatory treatment by adjusting the depletion of natural resource capital as capital consumption. It includes any loss of value of natural resources caused by economic activities such as felling trees for development.

An appropriate method of measuring the national product or national income, which can be adjusted to account for natural resource depletion, thus is essential for understanding and measuring sustainable income.

Theoretical background of Sustainable Income

The National Income Accounting (NIA) provides an information framework suitable for analyzing the performance of an economy. The concept that underlies the calculation of national income will have significant implication in measuring welfare. The concept of income itself has various meanings and interpretations in economic literature. Classical economists defined income as the revenue or income that simply comprises rent, wages, and profit, which are returns to land, labor and capital (Smith, 1776 cited in Smith, 1937). Ricardo, Malthus, Karl Marx and other earlier classical economists predicted that the industrial economy would stagnate or collapse because of the lowering of rents and subsistence wages.

The classical school also predicted that the population would outstrip nature's power to provide sustenance. The theorists worried that this disparity would result in widespread famine. This school has regarded income as the return on three kinds of assets: (i) human resources, (ii) invested capital i.e. physical capital and (iii) natural resources.

Hicks (1946) highlighted the importance of capital maintenance in defining income. Income exists only after capital in the beginning period is maintained so that it can be used for the next periods. This definition is termed as sustainable income, or "Hicksian income". The Hicksian income corresponds to Adam Smith's notion of "net revenue," where cost of capital maintenance needs to be subtracted from the gross receipts of production in order to establish the amount, which can be spent on subsistence without depleting the capital stock (Smith, 1937). The national income account that fails to take into consideration the depreciation of natural resource will likely overstate the net national product.

According to neoclassical economists, income was only that portion of gross revenues, which could be spent while keeping capital intact. They modified the calculation of income by minimizing the role of natural resources. This is because the school of neoclassical economists (Hicks is one of them) of the late nineteenth century experienced unprecedented international trade as transport costs fell and inexpensive grains were imported from developing countries to the west. According to this school, capital was the more binding constraints on growth. As a result they ignored the present value of the income potential from their natural resources. The marginal product of natural capital is assumed to be zero. Thus, there is a dangerous asymmetry today in the way the national income is measured.

The current system of national accounts reflects the Keynesian Macroeconomic model that became dominant when the system was developed. The aggregate economics of Keynesian analysis - consumption, savings, investment and government expenditures - are carefully defined and measured, but Keynes and his contemporaries were preoccupied with the Great Depression and the business cycle, specifically with explaining how an economy could remain for long periods of time at less than full employment. The least of their worries was scarcity of natural resources. As Keynes' analysis largely ignores the productive role of natural resources, so does the system of national accounts. In fact, natural resource scarcity played little part in the 19th century neoclassical economics from which traditional Keynesian and contemporary theories are derived.

In the present changing circumstances the world's population is growing rapidly and technologies are expanding at an accelerated pace. Changing circumstances overcome the constraints of labor and capital. On the contrary, the natural resources and environment are becoming scarce due to accelerated growth of natural resources exploitation. If the value of natural resources is taken into account in national income accounting, the difference in the treatment of natural resource and other tangible assets will reinforce the false dichotomy between the economy and the "environment." This would lead policy makers to ignore or destroy natural resources in the name of economic development.

The present system of national income does not follow either the definition of income of classical economists or the neoclassical "Hicksian income". The System of National Accounts, from which indices such as the GDP and NDP are derived, are theoretically neutral and not aligned with any school of economic thought. The present calculation of NDP by subtracting the physical capital depreciation reflects the concept of "net income."

Many other early economists also contributed to the discourse to Hicks' credit with the concept of sustainable income stating that used up material and capital need to be adjusted with gross income in order to obtain net income (Marshall, 1961). In a similar vein, the discoveries of natural resources are to be included in the measure of income and wealth (Hewett *et al.*, 1938) as highlighted by Katz (1993).

Natural resources typically earn a return over what is required to cover the opportunity cost for using other inputs such as labor and capital to exploit them. This resource value is an economic surplus or rent (i.e. total revenue over total cost) that a country can either invest or spend for consumption or combination of both. The basic issue lies on how this rent can be allocated between investment and consumption in order to maintain economic sustainability.

Hartwick (1977) suggested a method, intending to provide for future generations, given that some stock of exhaustible natural resources are available. They can invest these competitive resources in reproducible capital in order to maintain their stream of consumption for indefinite future. This corresponds to "Hartwick rules" which calls for rents associated with resource scarcity to be invested in reproducible capital. Solow (1986) derived Harwick's rules to show that a country must maintain its total stock of all forms of capital. Any decrease in natural capital must be balanced by increasing the same amount of reproducible capital.

Maler (1991) developed a net National Welfare Measure (NWM). It shows that a NWM remains nondecreasing over time, an indicator of sustainable development. Thus sustainable income is defined as the maximum flow of consumption generated as a return or interest on the total wealth of a nation (Solow, 1992). Sustainable development requires that the total stock of capital should remain nondecreasing over time.

An adequate amount of revenue derived from the sale of non-renewable or renewable resources for maintenance and regeneration should be deducted to calculate Hicksian income. The seller, if he consumes rather than invests his capital, clearly have decreased his capital, his future revenue will be less well off after the sale.

The influence of measuring Hicksian income on recent studies is obvious. All studies carried out by Peskin (1981 and 1989); Repetto *et al.* (1989); El-Serafy (1989) and Hartwick (1990) apply the notion of Hicksian income conceptually and methodologically to estimate the sustainable national income.

Resource Rent and Sustainability

Hotelling (1931) demonstrated that current net price does indeed equal the user cost when markets for non-renewable resources are efficient. User cost refers to the present value of all future sacrifices (including foregone use, higher extraction cost, increased environmental costs) associated with the use of a particular unit of an *in situ* resource (Howe, 1979). In forestry the user cost measures the future benefits that are given up by felling forests (extracting resources) in the current period. Actual net prices might approximate user cost on average over time, but in any particular period market imperfections and supply constraints can cause current net prices to deviate from user costs. Prices for natural resources are notoriously volatile and cannot be accepted as indicating 'true' values of user cost (Solow, 1992), because it is highly influenced by short term price fluctuations. Market efficiency means resources are extracted optimally, whereby the discounted sum of resource rent is maximized. If the current and future net prices are not the same, the pattern of extraction over time is not optimal, because the net present value of aggregate resource rent can be increased by changing the allocation of extraction between present and future (Vincent *et al.*, 1997).

Current extraction should be increased if current net price exceeds discounted future net price, and future extraction should be increased if the opposite is true. Extraction levels can be adjusted until current and discounted future net prices are equal, which is until current net price equals user cost.

Marginal cost must be used in calculating net price because when resources are extracted optimally the discounted values of marginal, not average, cost of extracting resources, that are being equalized with prices across time periods. Using average cost to calculate net prices overstates user cost and therefore the depletion allowances, because average costs tend to be less than marginal costs in an attractive industry.

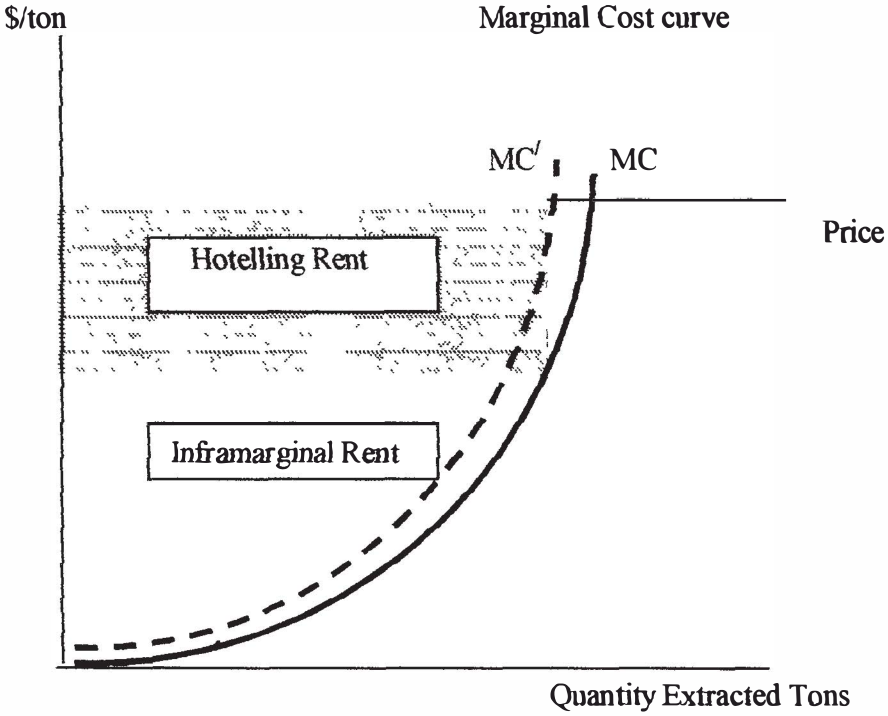

Figure 3: Components of Resource Rent

Source Adapted from Vincent *et al.* (1997)

Figure 3 shows an upward sloping marginal cost in a given period implying escalating costs per unit of output as production rises. For competitive market, production level is determined by the intersection of price and marginal cost curve. However, for natural resources, optimal production point falls to the left of this point, as a resource producer must take into account not only the direct production cost but also the opportunity cost associated with foregoing production in the future periods. The latter (opportunity cost) is termed as user cost. Since the user cost is not actually incurred by the present generation producer, so the total rent is above the MC curve (direct production cost), not above MC' curve (Figure 3).

The marginal cost curve can be decomposed as ($UC + MC = MC'$), in which UC is the user cost. The total resource rent is the area above the marginal cost curve (MC) and below the price line, but to the left of the production level. The total resource rent is divided into two components. The first, on the top are the rectangle given by the product of user cost and the amount produced. This rectangle is termed the total "Hotelling rent." The second component is known as inframarginal rent that can be used for consumption. Hartwick's Rule states that the total Hotelling rent must be reinvested in order to sustain consumption; inframarginal rent is the portion that can be consumed.

Sustainability Conditions

Sustainable development (SD) simply is defined as non-declining consumption per-capita or per unit of GNP or some alternative welfare indicators(s). This is how SD has come to be interpreted by a majority of the economists addressing the issue (Pearce *et al.*, 1990; Maler, 1991; and Turner, 1993). They added that non-declining stock of natural capital over time is a necessary condition for sustainability because of the sustainability limits in production process as well as other factors.

There exist two points in sustainability: weak and strong sustainability. The weak sustainability position does not single out the environment for special treatment; it is simply another form of capital (natural capital). Therefore, what is required under SD is the transfer of aggregate capital stocks no less than the one that exists now. Weak sustainability is based on the very strong principle of perfect substitutability between the different forms of capital. The strong sustainability implies a certain degree of decoupling of economy from the environment through technical change and reinvestment.

However, Solow (1993) speculated as to whether various types of capital substitute or complement one another. Economists generally consider several types of capital, including fixed capital i.e. physical capital (*Km*), natural capital (*Kn*) and human capital (*Kh)* in the production process. In order to maintain sustainability, it requires sufficient capital endowments from the present generation to future generations to endure production of essential goods and services. He added that sustainability refers to prosperity in general, or to the ability to care for future generations requires that a minimum standard of living in the present generation must be maintained (Solow, 1993).

The point of maintaining living standards at present levels as highlighted by Solow corresponds to the definition of "Hicksian income." Pearce and Warford (1993) also supported the view that keeping capital intact is imperative to ensure the present levels of consumption for future generations. The capital concepts enter into this intergenerational equity as follows: If the current generation leaves the next generation a stock of capital (K) that is not less than the stock currently possessed, then the next generation can use that stock to generate the same level of welfare as the previous generation did (Pearce *et al.*, 1993).

Pearce and Warford further argue that substitution of natural capital for human capital using the wealth of nature to improve human health and increase literacy rates, should be a goal of economic development. In that case it appears that non-renewable natural resources should be left untouched.

Hartwick (1977) addressed this dilemma, noting that non-renewable resources are wealth assets and therefore should be properly managed by the present generation. These efforts have the potential to provide income flows for future generation. For example, one might assume that a petroleum reserve represents a finite stream of future earnings whereas a bank account represents infinite streams of future earnings. Similar other example can be cited for forest resource, such as chopping trees one can deposit the net revenues into the bank and live off the interest thereafter. This way any finite stream of earnings must be equated to an annuity received every year into the future. In this manner, Hicks' "wasting asset" may generate income long after the exhaustible resource has been fully exploited (Repetto *et al*., 1989).

Weak Sustainability Approach

When a natural capital such as oil runs down, the stock of man made capital can be built as replacements. This result is very important for sustainable economic development. It arises in the Hartwick model that the aggregate production function for consumption good is a Cobb-Douglas one.

Theorists who allow for unconstrained elasticities of substitution between fixed capital and natural capital support an ethic known as "weak sustainability." They believe that an economy is weakly sustainable if it saves more than the combined depreciation of fixed capital and depletion of natural capital. That is $Z>0$ only if $S> (\partial_F + \partial_N)$, where Z is a sustainability index, S is saving, ∂_F value of physical capital depreciation, and ∂_N is the value of natural capital depletion (Pearce and Atkinson, 1993a). A value of $Z> 0$ implies weak sustainability. Investing resource rent in fixed capital in order to replace depleted natural capital is sufficient for calculating Hicksian income.

But there are many environmental assets, which may not have any substitutes such as bio-diversity or ozone layer. Any environmental economic analysis of development is seriously flawed once resource allocation and distribution objectives are augmented only by the consideration of scale. The scale is defined in materials balance sense. The scale of economic activity should be related to the regenerative capacities of the ecosystem that can provide inputs for the economy and to assimilate the waste flows from the economy. A desirable scale for the economic activity to a point that does not erode the environmental carrying capacity over time (Daly, 1992).

The technological assumptions as regard perfect substitutability of weak sustainability approach violate scientific understanding of the evolution of thermodynamic systems and ecological thinking of complementary of resources (Perrings, 1991 and Perrings *et al.*, 1992). Christensen (1989) stresses that natural capital and man-made capitals are in most cases complements rather than substitutes.

Strong Sustainability (Ecological Economic) Approach

A number of analyses from a variety of disciplines draw attention to the missing elements in the economic calculus of weak sustainability rule. The critics of conventional economics highlight that the full contribution of all component species and processes to the aggregate life-support service of ecosystems have not been captured in economic values (Erlich *et al.*, 1992). The Hartwick model thus does not apply to all resources when all tangible and non-tangible values are not accounted for. In forestry other than timber and tangible goods, it provides habitat and life support to the ecosystems.

According to the Strong Sustainability (SS) rule, it is not sufficient just to protect the over all level of capital. Some of the capital that is non-substitutable must be protected. The case of this strong sustainability rule is based on the combination of a number of factors: presence of uncertainty about ecosystem functions and their total service value and the irreversibility of some environmental resource degradation and / or loss.

Strong sustainability does imply the changing economic resource allocation over time in such a manner so that it does not affect the overall ecosystem parameters significantly. A certain degree of "decoupling" of the economy from the environment should therefore be possible through technical change and environmental restoration investment with a moderate growth rate.

A number of rules for sustainable utilization of natural capital have been outlined (Pearce *et al.*, 1993). Market failure and government intervention related to resource pricing and property rights should be corrected. Technological changes should be steered via an indicative planning system. The overall economic activity should be maintained within the carrying capacity limit of natural capital.

Approaches of Measuring Sustainability

Economic sustainability can be measured in ways (i) estimating the change in the total capital stock and (ii) estimating NDP appropriately as a long run measure of economic well-being. Both of them measure the impacts of resource depletion on human welfare in the long run. The two approaches require identical calculation so that the proving of one will prove the other (Vincent, 1997). The first one is derived from Hartwick's work (cited from Vincent, 1997) to estimate the net change in the capital stock as follows:

$$I_t^N = dK_t/dt + dH_t/dt + dR_t/dt \qquad [3.1]$$

In which I_t^N stands for net investment for period t. K_t, H_t, and Rt indicate the value of physical, human and natural capital stocks in period t respectively. Net investment capital is derived by subtracting depreciation from gross investment. Therefore, when $I_t^N = 0$, then a country just can sustain its consumption level. The consumption level of this country is possibly increasing only if $I_t^N > 0$, indicating a positive net investment which is known as theorm of "Hartwick's Rule" (see Appendix A).

According to Hartwick (1977, 1990), Hartwick and Hageman (1993) and Vincent (1997) appropriate sustainability measure is derived by the product of marginal rent and the change in the resource stock that equals the negative amount of resource extracted known as "Hotelling rent".

Dasgupta and Maler (1991) and Maler (1991) and Vincent (1997) applied this "Hotelling rent" concept to forestry like nonrenewable resource depletion by incorporating the growth of forest resource. The change in the resource value has an important implication for sustainable resource management. A proportion of the resource rent should be invested for management and regeneration of renewable resources.

The second way of the measuring sustainability is simulated from the work of Weiztman (1976) on NDP stating that NDP differs from GDP, where it includes net, not gross investment.

$$NDP_t = C_t + I_t^N \qquad [3.2]$$

where C_t is the consumption and I_t^N stands for net investment in man made physical capital. He also highlights that the change in the value of resource stock should be included in NDP (Dasgupta and Heal, 1979; Solow, 1986; Vincent, 1997). That is I_t^N in Equation [3.2] should be defined as in Equation [3.3] such as

$$NDP_t = dC_t/dt_t + (dK_t\ /dt_t + dH_t\ /dt_t + dR_t/\ dt_t) \qquad [3.3]$$

Weitzman's finding of NDP as a long run measure of sustainability and welfare equivalent to consumption is based on two assumptions. The first is that a country's growth path is optimal which may not be true, due to frequent market intervention and policy failures (Vincent, 1997). The second is that welfare is equal to consumption, which does not hold if NDP will not be equal to consumption (Dasgupta and Maler, 1995; Vincent, 1997).

In theory the two above mentioned measurement tests (Hartwick and Weitzman) are equivalent. NDP can rise only if the total capital stock increases, as $NDP_t = dk+dh+dr$, (where k is physical capital, h is human capital and r is natural capital) i.e. return on the total capital stock (Solow, 1986). However, in practice the result is different due to measurement errors, such as unrecorded benefits from natural capital and failure of investment to generate anticipated returns (Vincent, 1997).

In both the approaches the measurement error can take place when perfect substitutability assumption is violated. Replacing the extraction of some natural capital through reinvestment in reproducible capital may not guarantee in keeping the total capital stock intact. On the other hand, unrecorded benefits from some natural capital such as forestry as habitat and life support to the ecosystem and failure to make appropriate investment in order to compensate the loss or regeneration of the anticipated benefits may overstate the estimate of NDP.

Resource Depletion and Integration into System of National Accounts

The intention of natural resource accounting is to provide an idea of how a country is planning for its future. The core national income accounts have mishandled a major capital asset, even though it is as productive as physical capital. This inconsistency in the SNA is glaring, explainable only because natural resource had been abundant 50 years ago relative to population and economic activity. Nowadays the limits of these resources are well recognized. There is wide agreement for the need to figure out the true picture of net investment, the depletion of natural capital should be taken into account (UN, 1992). But controversy persists over exactly how to carry out this activity, particularly in the developing countries.

The 1993 Revision of SNA: Introducing the Satellite Accounts

The background of the evolution of natural resource accounting (NRA) may be summarized as follows. Discussions on NRA began following the publication of the 1987 report of the Brundtland Commission, Our Common Future. United Nations Conference for Environment and Development (UNCED) in its Agenda 21 (Chapter 8) at the Rio de Janeiro summit in 1992 called for the establishment of an integrated environmental and economic accounts as a complement to the United Nations system of national accounts. In 1992, the United Nations Environment Programme (UNEP) was given the mandate to develop guidelines for environmental accounting. This effort provided a further impetus for natural resource accounting (Landefeld and Carson, 1994). The Statistical Division of the United Nations formally approved a Revised Version of the SNA in February 1993. "The revision offers a clearer treatment of assets and their accounting, specifies what constitutes an economic asset in the system, and presents a revised classification of assets and a revised set of accumulation accounts" (Lutz, 1993).

The UN formed a multidisciplinary group of experts including economists, national accountants, environmentalists and others. They debated the issue for a decade. They examined whether the revised SNA should (a) modify the framework of the SNA in order to incorporate valuation of environmental degradation, environmental services and natural capital depletion, as well as expand the production boundaries of the SNA; or (b) maintain the conventional methods of national accounts calculation and incorporate the changes in natural capital in self-standing accounts that complement the SNA without any fundamental change. In procedure (a) resources and environmental changes are monetized and used to adjust conventional income measurements. This would produce integrated accounts. In procedure (b) changes are maintained in separate tables, which together with conventional accounts will form satellite account.

The multidisciplinary working group decided to exclude overhauling the SNA. The promotion of satellite accounts (i.e. separate accounts that describe the flow of resources material and energy underling any economic activity) was encouraged as a means to enable countries to evaluate the impact of economic activities on the environment without any modification of the core framework of the SNA. The revised SNA does not affect the continuous usage of the well-established time series market transactions (Bartelmus *et al.*, 1993).

The promotion of satellite accounts provides countries with supplementary accounts and indicators for natural resources and the environment. However, the revised SNA leaves many issues yet to be resolved. For instance, to what extent should the environmental degradation and natural capital depletion be covered for incorporation into the SNA. The existing production boundary was not expanded. In a similar vein, the revised SNA continues to exclude many phenomena that actually exist within the environment such as the loss of biological diversity or damage to the ozone layer (Kellenberg, 1995).

Approaches to Natural Resource Accounting

In a survey of natural resource and environmental accounting in industrialized countries, Peskin *et al.* (1990) highlighted several approaches adopted by these nations for resolving the deficiencies in SNA as regard to the treatment of natural resource and environment. These alternative approaches are presented below such as (i) physical resource accounting, (ii) depreciation of marketable natural resources and (iii) full environmental and natural resource accounting.

Physical Resource Accounting Approach

A practical suggestion in order to rectify the deficiencies with conventional economic accounts is to develop separate or satellite accounts that describe the flow of resource material and energy that underlie any economic activity. In principle, physical accounts shows depletion of natural resources and addition to the resource base through discovery and natural growth and also their transformation into goods and materials, some of which may go back to the environment as pollutants.

There are two approaches for obtaining physical accounts. The first one is stock accounting, which typically indicates an "opening stock." It shows any addition to the stock either through discoveries or growth, any subtraction due to exploitation or natural destruction, and finally a "closing stock." This type of physical accounting typically applies to non-renewable resources such as minerals or to renewable resources such as forestry or fishery. The other approach of physical accounting applies to environmental tracing of pollution sources and their flows to final disposition. These approaches have been implemented in the Norwegian and French systems.

There are many practical limitations associated with physical resource accounts. These include difficulty in collecting data on stock, identification of the stock of physical resources, changes in the stock, their transformation into products and material wastes and the practical difficulties determining what data to collect and in what detail. It is hard to find any common physical unit of measure that would permit aggregation comparison and difficult to determine what is important and what is not. Ignoring the problem of aggregation, it is very difficult to determine which non-monetary or physical unit of resource is appropriately meaningful for any natural resource accounts. For example, the reduction in the size of forest could be measured in terms of reduction in the number of trees, the number of trees of a particular species, the acreage or the stumpage volume of available trees.

In order to overcome the above problems a variety of measures need to be used. However, this may make the framework more complex and poses greater difficulties in making aggregations useful to policy makers (Hueting, 1989 and Tai *et al.*, 1996). In addition, Offsen and Lorentsen (1989) and Tai *et al.* (1996) pointed out that the more complex the framework, the greater will be the cost of data development and the higher is the probability that resource accounting cost will exceed the benefits of the efforts.

The World Bank study of Mexico noted that the most pressing problem in constructing NRA was the broad array of statistical data compiled by different public and private institutions for a variety of purposes (Tongeren *et al.*, 1993). The data from particular sources may be unreliable, whereas data from different sources are contradictory. For instance, forest growth, log prices, and extraction cost considerably vary in terms of location, species composition and types of forest.

On the other hand, summaries of the physical accounts do not provide policy makers to comprehend the impact of economic policies on natural resources and the environment, which is presumably the main purpose of the exercise (Repetto *et al.*, 1989).

There is a meaningful distinction between physical deterioration and loss of economic value. Only true economic value is incorporated in the national income accounts. Accounting should be made for both economic and biological reasons. Though a smaller forest may have less economic value in the short run, it might be biologically and economically more valuable than a larger forest in the long run (Peskin and Lutz, 1993) due to differences in time and variation of locations and types of forest.

Depreciation of Marketable Natural Resources

Another approach in modifying the SNA is to focus on their failure to depreciate natural resource and environmental assets. The depreciation calculations as prepared by Repetto *et al.* (1989) are based on estimates of changes in the physical stocks of natural resource times the difference between the average unit price and variable extraction cost of marketed resources over the accounting period. This approach does not cover non-marketed resources and services such as rivers, lakes that generate non-marketed environmental services, forests that provide habitat or recreation and life support to the ecosystems. This may also cause difficulties in most natural resources and environmental assets that are not traded in well-functioning markets and do not have observed market values to reflect long run, future economic productivity of the assets.

Marketed outputs of natural resource can lend only to the approximation of true economic depreciation (Landefeld and Hines, 1985). While physical depreciation of resource (e.g. natural forest) may imply that forest depreciate in value terms, it may not necessarily be the case when real prices increase over time. From both economic and biological point of view, the smaller physical forest may show a gain in economic value that it may show negative depreciation or "capital gain." This apparent anomalous behavior can arise because the value of resource depends not just on its short-term ability to generate output but also on its ability to generate the same value over its entire life.

This approach encountered the same limitations, since they are associated with the physical accounts because calculation of the depreciation of a natural resource would entail the estimation of changes in the physical stocks of the natural resources. Nevertheless, despite all the difficulties, this approach make sense especially in resource dependent developing countries, where resource problems may be quantitatively more important than environmental issues (Peskin and Lutz, 1991) in formulating their development strategy.

All through the investigations concerned with market value of natural resources such as in the case of forestry only timber value is incorporated. The value of non-timber forest products is yet to be addressed. The asset boundary pertinent to natural resources and the production boundary in economic activities need to be expanded in order to carry out more accurate estimate of national accounts.

Full Environmental and Natural Resource Accounts

The final approach to SNA is the most ambitious. It intends not only to accommodate all the elements of physical resource accounting and natural resource depreciation calculations as well as place monetary value on all physical entries. It has been used in the Dutch System (Hueting, 1989), United Nations Statistical Office Framework (Bartelmus *et al*., 1993) and the Peskin (1989) framework. These three approaches (such as (i) physical resource accounting, (ii) depreciation of marketable natural resources and (iii) full environmental and natural resource accounting) strive for monetary valuation. There are differences in coverage, presentation and valuation methods.

The principal problem in this approach is to assign a value on the services and any societal damages that may arise due to consumption of these services. There are a number of methods of doing this. However, many economists would prefer valuing the services at the consumers' willingness to pay for these services or to avoid damages. There is, however, a conceptual problem that has little to do with data and technique; namely, appropriateness of consumer sovereignty principle for determining societal valuations. Many justifiable fears are expressed concerning the willingness to pay technique, since many services of the resources and the environment that are important socially to be determined this way. In particular, the long term value of the services of resources and environment to society may be under appreciated by present day consumers, the long term ecological values of certain species or the opportunities for future generations to have the options to enjoy the gift of nature are examples. It may be necessary to find alternative valuation principle for these sort of natural resources and environmental services.

In conducting natural resource and environmental accounting, the ownership issues of the resources need to be addressed. This is because the value of private resource and public resource differs substantially. There is a limited environmental accounting carried out in the developing countries. Despite all conceptual differences and limitations of data it is worthwhile to begin by applying the existing techniques and using the available data.

Welfare Measurement: Adjusted GDP

NRA mainly aims at measuring the welfare of a nation appropriately, that would enable the policy makers to formulate more accurate policy prescription and to make an appropriate projection for the nation. Presently, a consensus is growing over time that the conventional calculations of national income are inappropriate and are rather misleading. In both of their studies of NRA Repetto *et al*. (1989 and 1991) criticized the usefulness of GDP in measuring the sustainability of economic output.

Devaranjan and Weiner (1990) made the adjustment of GNP to account for the nontradable resource related activities. Their model concentrated on benefits foregone due to non-optimal use of resources rather than actual revenue loss. The actual revenue loss is the main focus of El Serafy's model. In order to adjust the income foregone, the revenue loss resulting from non-optimal resource depletion or environmental degradation, is calculated and deducted from the conventional measurement of GNP as a penalty. This revenue foregone due to resource loss is considered as user cost of non-optimal resource utilization. The over-exploitation of resources decreases the productive capacity of the resources by that amount. This income foregone indicates the asset erosion resulting from non-optimal resource exploitation.

More specifically, Devaranjan and Weiner (1990) modify the GNP by subtracting an amount equal to the discounted shortfall between optimal and actual extraction.

$$Y_0' = Y_0 - \frac{(Y_1 - Y_1)}{(1+r)}$$

where

Y_0' = adjusted national income

Y_0 = current measured national income

Y_1 = future national income under optimal resource extraction

Y_1= future national income under current rate of resource extraction

r = social discount rate.

In their (Devaranjan and Weiner) presentation the economy is modeled as one that depletes a non-tradable natural resource in two periods. Demand for resource is assumed to have constant elasticity. The optimal rate of resource extraction and pricing are assumed to satisfy the "Hotelling's Rule." Current and optimal future resource consumption thus needs to be calculated in order to get adjusted income.

Both the user cost approaches of Devarajan and El Serafy are similar in that they seek to account for long term cost on wealth effects of present economic activities and to charge them against the present revenues. Both the methods made assumptions pertaining to the profitability of resource-related activities over the lifetime of the resource. Regarding subsoil resource extraction and primary commodity production, any future technological change will affect profitability substantially. The estimations of resource depletion may therefore be widely different.

In fact there are good grounds for adjusting GDP. Deveranjan and Weiner (1990) is of the opinion that current estimate of GDP overstates the level of GDP when resources are not utilized optimally as a measure of long run welfare maximization. Their model of GDP adjustment was based on the difference between actual resource rents and hypothetical rents concerning optimal utilization. This is the idea mainly developed by Maler (1991) about shadow prices and NDP, i.e. ideally NDP need to be estimated using shadow prices that reflect marginal economic values along with optimal economic development path (Hartwick, 1993).

There are practical difficulties that arise in the application of Deveranjan and Weiner's (1990) model. First, in regard to the determination of the optimal utilization of resources, and second in quantifying the difference between actual and optimal rents (Vincent *et al*., 1997). The adjustment of GDP pertaining to non-market aspects of the environment is another problem. The environment also provides services that have value as development capital as well. For instance, environmental quality can influence human well being directly such as water and air pollution, similarly, the conversion of forest can cause the extinction of species and disturb the ecological balance valued locally and internationally (Vincent *et al*., 1997).

In the case where the definition of consumption includes direct environmental impacts, GDP accurately represents gross economic welfare (Maler, 1991; Dasgupta and Maler, 1991). However, in practice this is not the case. The Conventional GDP therefore seldom reflects the accurate benefits of economic growth when growth causes environmental degradation. In the conventional GDP calculation neither the benefit lost due to degradation of environment nor benefit gained due to improvements in environmental quality is incorporated. Therefore, both GDP and NDP are biased in identical directions, because NDP is derived from GDP (Vincent *et al*., 1997).

Daly (1989) has a similar suggestion along the same lines, the calculations of a measure; he calls it "sustainable social net national product" (SSNNP) which would subtract both natural capital depreciation and defensive expenditures from currently calculated GDP.

SSNNP = NNP - DE - DNC

Where

NNP = net national product as currently calculated

DE = defensive expenditure

DNC = the depreciation of natural capital.

The adjustments to GDP with natural resource depletion and environment degradation are therefore theoretically valid. In practice, these adjustments are more difficult to make. This is because they require additional information on optimal rate of natural resource extraction or value of environmental gain or loss due to a change in the environmental quality. This sort of information is hardly available in developing countries. For this reason, most applied studies in the developing countries have focused on macroeconomic implications of natural resource depletion (Vincent *et al.*, 1997).

The adjustment of GDP with resource depletion and environmental degradation has sound theoretical basis as a long run measure of sustainable income or welfare measure. But due to a lack of enough available information the present study like many other applied studies in many developing countries concentrates on macroeconomic implication of marketable natural resource depletion (timber). This leaves ample scope for adjusting GDP both at aggregate and sectoral level in the future, incorporating the benefits foregone from non-timber forest product and environmental services due to forest resource depletion.

This approach was adopted in many applied studies such as Equador (Kellenberg, 1995), Mexico (Tongeren *et al.*, 1993) and Papua New Guinea (Bartelmus *et al.*, 1992). In order to obtain more precise revised estimate of national income, the Thai forest resource accounting study adjusted both aggregate and forestry sector GDP in measuring the sustainability.

Net Domestic Product (NDP)

In the conventional national income accounts, it is well reconised that Net Domestic Product (NDP) indicates a better measure of national economic welfare than GDP. GDP equals the sum of (final) consumption and gross investment (GDP = C_f+Ig). Conventional NDP is calculated by deducting capital consumption from GDP. Hence, conventional NDP equals consumption plus net investment in physical capital (NDP= C+ I_n).

Weitzman (1976) argued that a true measure of NDP should take into account the changes in other capital stocks as well. Solow (1986) also highlighted this point. Especially he pointed that the development of human resource by education and training enhanced the state of knowledge, and benefits are derived from research activities through increased efficiency and productivity. In a similar vein natural resources "ought to qualify as capital" where derived revenues from natural resources can be used to generate reproducible capital. According to him, the true NDP is measured as maximum hypothetical consumption level that a country could maintain permanently with a given stock of capital at a point in time. Solow (1986) explained that NDP equals consumption only when net investment equals zero. This means there would be no change in the total capital stocks from one period to the next. The country cannot consume any more without reducing its total capital stock and therefore its output of goods and services available for consumption will fall.

The analysis indicates that a country can check whether its economic output is sustainable when consumption is compared with Adjusted Net Domestic Product (ANDP), where the latter (ANDP) is adjusted for both resource depletion and physical capital depreciation. If the consumption is lower than ANDP, net investment is obviously positive and there is potential for increasing consumption over time. When consumption exactly equals ANDP, the net investment is zero and there would be no potential for increasing consumption. Finally, when consumption is greater than ANDP, consumption invariably declines because net investment is negative (Solow, 1986; Vincent *et al.*, 1997). The current excess consumption would be met from dissaving or borrowing from future generations.

The above comparison considers that the adjusted aggregate GDP and NDP with the depletion of all types of natural resources would give better revised estimates of national accounts. The present study is focusing on only forestry resource depletion and two types of estimates of resource depletion (net price and user cost) are used. There are many potential natural resources, which contribute to GDP. The adjustment of aggregate national income only with forest resource depletion will not give much meaningful result. It is therefore, more appropriate to make the adjustment with GDP and NDP of that sector (forestry). This would reflect more accurate measurement of sustainable income.

The natural resource bases of Malaysia is quite large and diverge, the sectoral adjustment of forestry sector will give more sound and appropriate revised estimate of national income. A similar sectoral national income adjustment was made in the Thai forest resource accounting (Sadoff, 1993).

Adjustment of Investment

There is another method of measuring sustainability: adjusting net investment. When the net investment is adjusted with resource depletion, the per capita capital stock will decline. In order to maintain the sustainability the accumulated depreciation need to be reinvested for renewing the depleted resource used for some other capital improvement, as long as investment yields a net social output equal to that lost by resource depletion.

One paradigm is the reinvestment of depreciation of a building or machine. If a development activity destroys old forest or part of scenic river, the reduced value of the resource as a producer of utilities should be compensated by an investment. This investment will provide a stream of utilities equal to that, which was lost. The investment can be made in other forms by restoring the depleted natural resources like forestry and fisheries, creating man-made natural capital or improving human knowledge and skills for increasing the productivity of the resource base.

Many applied studies like in Indonesia and Costa Rica followed the adjustment of net investment to measure the sustainability. Other studies subsequently followed this approach including the UN and other individual studies like in Thailand (Sadoff, 1993), in Equador (Kellenberg, 1995) and in Malaysia (Vincent *et al*., 1997).

There are three practical difficulties concerning the above model consistent with sustainability. First, in the revised accounting system the inclusion of resource depletion as social cost will not necessarily imply that the private sector to save and reinvest social capital. Private sector may treat natural resource depletion as income available for consumption. Therefore, sustainability will require resource depletion to be taxed and reinvested by the state in a manner that will sustain output for future generations (Mikesell, 1992).

The second difficulty pertains to determining which social investment induced by the state will ensure that future generations receive the capitalized value of the resources depleted by the present generations. Suppose the taxed revenue is spent for the infrastructure development rather than in restoring depleted renewable natural resources or enhancing the productivity of natural capital. The extent to which physical resource can be substituted for natural capital in order to maintain rising national output can only be speculated (Mikesell, 1992).

The substitutability of physical capital for natural capital is quite limited (Daly, 1991). Unless raw material base is maintained, long run sustainability is impossible. In any case, substitutability requires that a substantial amount of resource depletion be reinvested in replenishing renewable resources, in increasing product output per unit of resource inputs or in increasing the end-use efficiency of resource-intensive products.

The third difficulty is that there is a certain limit in satisfying the demand for wilderness amenities and clean air. There is a point beyond which further degradation of environment cannot be compensated by higher per capita real income. There must be a limit beyond which natural environmental degradation cannot be allowed (Mikesell, 1992).

The shortcoming of national accounts in developed countries may be imperfect measures of the total stock of physical capital and its depreciation. But in developing countries like Malaysia resource related sectors have a larger share in the economy. It is therefore, worthwhile to carry out natural resource accounting (NRA) in developing countries (Vincent *et al.*, 1993). An appropriate portion of revenue derived from resource depletion requires reinvestment to be made in order to keep their capital stock intact. This effort may generate new capital through regeneration of renewable resources, enhancing reproducible physical capital and development of human resource to increase productivity and efficiency.

Alternative Economic Measure of Sustainability

Pearce and Atkinson (1993) proposed another measure of economic sustainability called indicator of weak sustainability. Their model is based on neoclassical assumption borrowed from Hartwick and Solow's approach that physical capital and natural capital are perfectly substitutable for each other. Pearce-Atkinson Measure (PAM) measures the value of capital depreciation against net savings. Net savings are obtained by deducting consumption and physical capital depreciation from gross domestic product.

If PAM is greater than zero the economy is judged to be sustainable. This will be positive if saving exceeds the sum of physical and natural capital depreciation. The purpose of this test is that if a country fails to qualify in weak sustainability test, it is for that country unlikely to pass a stronger test.

Atkinson and Proops (cited from Hanely *et al.*, 1993) adopted the PAM measure incorporating the exports and imports. In practice natural resources are not always perfect substitutes rather in many cases they are complementary to each other. The estimation of the depreciation of all natural resources is not always available in order to justify the substitutability.

World Bank (1995) introduced a similar measure of economic sustainability test named "genuine savings." This test measures the efforts to create new wealth in the nation. Vincent *et al.* (1997) observed that the World Bank (1997) analysis of "genuine savings" overestimated the resource depletion as it equated the total resource rent to genuine savings. In practice, the market imperfection and government intervention of resource pricing may distort the resource rent in developing countries.

Conclusion

The measurement of welfare and sustainability here is based on the assumption that total resource stock of the country is to be maintained intact. In order to estimate the resource depletion more appropriately, the market failure and government intervention related to resource pricing and property rights need to be addressed properly. The welfare measurement may be erroneous when perfect substitutability condition is violated, because of the failure to replace the loss of some natural capital appropriately. For example, natural capital, which is not substitutable, ought to be protected because of uncertainty about ecosystem functions, such as loss of forestry as habitat and life support to the ecosystems. The other reason for erroneous welfare measurement is the failure to make appropriate investment in order to compensate loss or regenerate the anticipated benefits. This is because of irreversibility of some resources such as extinction of plant and animal species.

Moreover the school of thermodynamic states that natural capital and physical capital in most cases are complementary rather than substitutable. The above considerations would provide more appropriate revised estimate of resource depletion and accurate measurement of sustainable income.

Total resource rent has two components the user cost that needs to be reinvested and inframarginal rent that can be used for consumption. According to Hartwick's rule the user cost must be reinvested in order to sustain consumption.

NDP represents the total capital stock of a country. By adjusting NDP a country can examine whether the economy is sustainable. If the consumption of a country is lower than ANDP there is a potentiality of increasing consumption over time indicating the sustainability of the economy.

The adjustment of GDP based on actual revenue loss (El-Serafy's model) is more practical than the adjustment based on the difference between actual resource rent and hypothetical resource rent concerning optimal utilization (Devaranjan's model). Hartwick's rule indicates that a country is investing enough resource rent in order to maintain its consumption if the investment is non-negative.

CHAPTER IV

EMPIRICAL STUDIES ON METHODS OF VALUING NATURAL CAPITAL DEPRECIATION

Resource Valuation Methods

This chapter considers the alternative methods of resource valuation within a theoretical framework, starting from Gray (1914) and Hotelling (1931) to the present. The estimates of the value of stocks and depletion of natural resources are based on a number of principles that underlie national income accounting in general and treatment of reproducible capital in particular.

Gray (1914) and Hotelling (1931) provided the basic understanding surrounding the economics of natural resources, their value and their optimal use. This long line of theoretical literature explores the valuation of non-renewable resource without necessarily placing resource valuation in the framework of the national accounts.

The Hotelling model, according to Solow (1974), is the fundamental principle of the economics of exhaustible resources and underlies the valuation techniques either advocated or actually used to measure the value of resources.

Latter researchers such as Landefeld and Hines (1985), Repetto *et al.* (1989), Stauffer (1986), Smith (1992) and the BEA (1994), adopted and operationalise this framework differently. The methods of resource valuations are critically explained below.

There are many valuation methods of natural resources but only Hotelling model has theoretical appeal to national income accounts (Slaper, 1995). Four valuation methods are attributed to the Hotelling model: (i) the net price, (ii) net rent, (iii) the net present value and (iv) the marginal cost methods. The sinking fund approach of El-Serafy is clearly different from either the Hotelling model or the replacement cost method models. The residual of prices less the extraction cost which can be seen from the Hotelling perspective as the resource rent is split between the resource rent (Serafy's user cost) and profits. The net revenue residual is allocated to resource rents and profits according to the interest rate. The lower the rate imposed by the accountant, the greater is the portion of the residual allocated to resource rent.

Finally, the transaction approach measures the change in the value of the asset due to aging. The value of the resource stock is measured based on market data. The opening and closing resource value is used to estimate the change, which is the value of depletion. Depletion is measured just like economic depreciation.

Evaluation of the Methods

Net Price Method (Depreciation)

The first method that applies Hotelling's framework is the net price (depreciation) method. On a per unit basis all non-capital cost are subtracted from this net price. The net price method simply portends the current year resource price, cost and quantities. The price and cost are assumed to remain at the same real level and production of quantity is assumed to remain along an optimal extraction path given current year's fixed stock of reserves.

The value of depletion in net price method subtracts both current and operating expenditures and cost of fixed capital (both depreciation and a normal rate of return) from market price. The formulation of this method can be stated as follows:

$NP = P - C - \pi K$

Where NP = Net Price

P is the price per unit of resource

C is the variable extraction cost per unit of resource

πK is the normal return to the fixed capital.

Standard calculations of national income impute and subtract the depreciation of physical capital from gross domestic product (GDP) to arrive at the net domestic product (NDP). Those who are in favor of Repetto's approach to natural resource accounting argues that the same should be done to account for natural capital depletion, to allow for the calculation of environmentally adjusted net domestic product (ANDP). It is important to make corrections of national accounts but not in direct and shortcut ways. The proper adjustment of domestic product would be a more meaningful indicator to economic wellbeing (Solow, 1993).

In order to calculate the economic value of natural capital depletion, physical accounts must be created. Changes in natural capital stocks are recorded in physical units appropriate to the particular resource. Regarding the forest resources, Repetto points out that the physical accounts may be expressed in hectares, tonnes of biomass, or cubic metres of timber although the last is probably the most important economic measure (Repetto *et al.*, 1989).

Depletion of forest resources expressed in purely physical terms hides important differences in composition, quality, age, and value among timber stands. However, accounting methods for renewable resources are not well developed. Renewable resources are more difficult to value for several reasons: (a) these resources often have a commercial value as well as an amenity or a recreational value; (b) ownership rights cannot always be established (e.g., ocean fish stocks); and (c) these resources have the potential to regenerate, so their use does not necessarily result in a net reduction in either the yield or value of the stock (Landefeld and Carson, 1994).

The relevant measure of value to be applied to physical changes in forest resources is the value of standing timber prior to any value added by processing. The economic rent from timber known as "stumpage value" equals its market value minus the costs of felling, extraction, transport, and milling, including a normal profit margin in each of these intermediate processes. Thus, depreciation of timber resources equals the difference between the stumpage value of the forest at the beginning and end of each accounting period. It should be reiterated that the economic stumpage value is calculated using border prices, which represent the opportunity cost to the economy.

Finally, with respect to forest resources, it should be noted that published studies to date using the net price method have accounted only for natural capital depletion in terms of commercial timber rather than the full extent of forest resources. This conservative accounting of forest resource is reflective only for a small portion of the true social costs of resource depletion (Sadoff, 1993). Moreover in the net price method timber account is based on timber actually produced or harvested. Valuation of the timber growth increment on uncultivated forestland is not necessary.

Studies by the World Resources Institute for forest and mineral resources follow the net price method for Indonesian and Costa Rican resource accounting. Van Tongeren *et al.* (1991) also used this method in Mexican petroleum and forestry resource accounting.

The net price method has several drawbacks that should be noted. First, ANDP equals conventionally measured NDP minus resource depletion plus resource discoveries, which are valued at the unit net rent. This valuation procedure is controversial. Repetto suggests that discoveries should be regarded at the full rental rate even though economic production has not taken place. He acknowledges that this is problematic. "The U.N. guidelines pointed out that large and sudden revaluation of subsoil assets as a result of (1) extensive new discoveries; (2) changes in technology increasing the range of exploitable reserves; or (3) changes in market conditions; could markedly affect estimates of current income if admitted into the flow accounts" (Repetto *et al*., 1989)

Accounting for the discovery of new reserves in this manner opens up the economic system to non-economic processes. This runs counter to the basic premise of the SNA in which national income and output depend exclusively on production. Well-defined economic processes may be overshadowed by erratic fluctuations caused by resource discoveries. Further, the calculation of net rent is based on the subtraction of average extraction variable cost. As long as marginal extraction costs are increasing, the use of average extraction variable costs in place of marginal will overestimate true economic depreciation (Hartwick, 1990). In practice the marginal extraction cost data is difficult, if not impossible to obtain.

Empirically it was found that net price method is easier and faster to use, but that the system tended to overestimate depreciation because it disregarded future tree growth and reflected inflated monopoly prices.

Net Rent Method

Landefeld and Hines (1985) use this method for the Bureau of Economic Analysis (BEA) study. On a per unit basis, all non-capital costs were subtracted from the total receipts, and from that difference the estimated value of fixed reproducible capital was subtracted to obtain a rent estimate per unit of oil in the developed reserve. No return to capital is assumed or subtracted from the net rent. The key difference between the net price and net rent is the capital component. The net price explicitly subtracts a rate of return to invested capital. The net rent method, like the net price method, simply portends the current year's resource price, costs and quantities. The prices and costs are assumed to remain at the same real level, and the production quantity is assumed to remain along an optimal extraction path given the current year's fixed-stock of reserves.

Net Present Value Method

Landefeld and Hines (1985), Born (1991), and the Bureau of Economic Analysis (BEA) (1994) have also implemented the Net Present Value (NPV) method. The NPV principle implies that the resource rent does not rise with the nominal interest rate. Hamilton (1993) also notes that the NPV approach may be preferable, given the lack of empirical evidence for Hotelling valuation.

The NPV model, like the net rent, is linked to the Hotelling resource rent valuation model and generates the same estimate for resource rent in the current period as the net rent method, but future revenues are discounted according to an assumed rate of return. The motivation for this approach stems from the Capital Asset Pricing Equation (*CAPE*). The CAPE values an asset as the sum of the expected discounted future net cash flows generated by that asset. While defining depreciation and /or depletion in terms of decline in the present value of the future receipts is generally accepted, the selection of the discount rate is controversial. Landefeld and Hines (1985) used a constant 10% real rate—the rate of return on private investment before taxes. The formulation of the NPV method follows the net rent method with the addition of the present value factor for annuity of N years:

$$NPV_t = \sum_{t=m}^{N} \delta_t Q_t /(1+i)^{m-t}$$

where δt is the per unit resource rent in the current (m) period. Q t is the expected quantity extracted each year over the life span of reserve and i is the discount rate. In this method depreciation can be measured by the decline in the present value of the asset between the opening and closing of the time period or $\partial t = V_t - V_{t+1}$. Using the method requires the forecasting of future prices, operating costs, production levels and interest rates to be forecasted over the life of the natural asset. This method was used in the case of fisheries for the WRI's Cost Rica case study Mayer (1993) and DNER's forest resources accounting of the Philippines Marian *et al.* (1991).

Under the notion of the Hotelling valuation principle, the NPV model was found wanting in its empirical validation (Miller and Upton, 1985b). The NPV model, like the net price and net rent, does not value economic activity associated with the production of the natural asset in the same way as other investment activity in the SNA's. Rather, it measures the holding gains (or losses).

The NPV model does not impute a return to invested capital. The model necessitates the selection of discount rate for future revenue streams. The model, does not assume that the stock of resources is fixed. This model, however, assumes present price is the best guess for future price and allows the possibility that the market price will rise less than the rate of interest. Unlike net price method the present value method, which is the more sound economic approach entailed more information and took more time to use.

Marginal Cost Approach

The marginal cost approach of Hartwick attempts to embrace the rudimentary principles of Hotelling model and extend it to account for reserve additions. Hartwick's (1990) valuation approach emphasizes the marginal cost component of the Hotelling model and uses marginal cost as the measure of Hotelling, or scarcity rent. Current scarcity rents on the net decrease in the resource stocks are subtracted from GDP i.e. ∂ (R_t -R_{t+1}), where R_t is the stock of resource at time t. Hartwick and Hageman (1993) have also presented an alternative model to the fixed stock Hotelling case whereby the resource rent is measured as price less the marginal cost of production less marginal finding cost: P - (mc_{prod} + mc_{find}). The Congressional Budget Office (CBO) used this formulation in 1993, in their study on green national income accounting. The specification of formula for marginal cost valuation of depletion per unit (δ) is

$$\delta = P - (CO+dK)/ (Q- DX/A)$$

where dK is the national income estimate for marginal cost valuation in the industry, CO is the current production expenditures, Q is the quantity production, DX is the development expenditures and A is the reserve additions, all in current period. This method is motivated by microeconomic theory, but measurement is impossible. The necessary data does not exist. Hence, empirical validation has not been done. One can do little more than assert that this formulation is true.

The marginal cost model, however, does value economic activity associated with the production of the mineral asset in the same way as the other investment activities recorded in the SNAs. It measures the economic activity of development expenditures used to produce mineral resources. Hotelling gains are not measured.

Replacement Cost Approach

The replacement cost approaches provide a more theoretically sound basis for valuing natural resources than the net price or net rent methods. The replacement cost method also fits well with an important view of capital valuation, namely, the replacement cost of capital. Adelman measures the scarcity of oil by its marginal cost of investment in discovery. This is because the marginal cost of production is the sum of (1) marginal production cost (or operating cost), which is small and correlated with (2) marginal capital cost, the amount that provides the necessary return on the investment required to expand production (Adelman, 1986b). Adelman more clearly stated that the cost of creating reserves by various methods should be approached equally at the margin. The total cost of creating new reserves through more intensive or extensive development of known pools can be marginal development cost (per unit), which should equal the market price net (per unit) of development cost (total).

Discovery, development and purchase all of them are competing investment outlets and alternative methods of acquiring reserves. If the operator chooses to develop known reserves more intensively, increased development cost is the penalty for using not holding. He should not incur a penalty greater than the value of undeveloped barrel i.e. user cost (Adelman *et al.*, 1993).

Although based on similar theoretical foundation, marginal replacement cost (MRC) model generates rent differently than Adelman's replacement cost technique. In the MRC model, price is equal to marginal cost of extraction plus marginal replacement cost.

$$P = \delta C/\delta Q + \delta X/\delta A = mc + \delta^{R}$$

Marginal discovery cost, $\delta X/\delta A$ is expressed as the proxy for resource rent δ^{R} In other words, the "user cost" of a barrel is its replacement cost. Sadoff (1993) and Kellenberg (1995) performed this operationlization of replacement cost for forest resource accounting of Thailand and Equador respectively.

The replacement cost model does value economic activities associated with the production of the resource in the same way that other investment activity is recorded in the SNA's. It measures the economic activity associated with investment in the development of new natural resources, and a small additional margin attributed to resource rent. This method fits the SNA's fixed capital analogy.

The replacement cost model does not impute an explicit return to invested capital. Implicit in the model, however, is a return to capital invested in the production of oil reserves. This necessitates discounting for future production. Central to the replacement cost model is that the stock of resources can be augmented by investment. There is no fixed stock. The replacement cost model also assumes that the current market price is the best guess for the future price. The role of price in the output market has both a direct, but muted, effect, and an indirect effect.

This method is theoretically different from any other methods. Replacement cost method measures the cost of restoring the resource to its previous state - not the actual change in present value terms. In the WRI Costa Rica case study, soils were valued in terms of the replacement cost of fertilizer. The UNSTAT has also used this approach to value changes in ground water (Mayers, 1992). This method is often inadequate for measuring the true cost of depletion. Fertilizer loss, for example is not really an adequate replacement for loss of soil quality due to erosion since it can only approximate the loss. The soil may be so severely degraded that no amount of fertilizer can restore the production capacity.

Marginal Replacement Cost Method

This is another form of replacement cost. The marginal replacement cost approach has been used by Pakravan (1984) to measure the user cost of Middle Eastern oil using aggregate data. At the margin, the owner of the oil reserves is indifferent between obtaining an additional unit of future production through abstaining from production now or through investment in development of an additional unit of reserves. This occurs, if the marginal cost of this investment does not exceed its marginal value (which is equal to the resource rent).

Thus, the shadow value imputed to an additional unit of proven reserves will be equal to the cost of producing that additional unit, cost which we can call the Marginal Replacement Cost (MRC) (Pakravan, 1984). Pakravan, like Adelman, finds that the marginal replacement cost of oil in the Middle East measured in pennies and compared them in relation to the output price measured in several dollars.

The MRC model also assumes that the present price is the best guess for the future price. Price does not rise with the rate of interest. The role of price in the output market is indirect. Future price expectations guide investment decisions, and in that way wellheed price influences the rent calculation.

Land Value Method

When markets are competitive, land prices should reflect the present value of natural assets that they contain. Thus if market values of transaction in land containing the resource stock are available, they can provide a basis for valuing the resource. "Land" is the one enduring asset of a permanent forest business" (Mathews, 1935). Forest productivity depends on the site of quality. It is the inherent vigor of the site that determines the potential productivity of the forest. In acquisition of the forest for production purposes, the basic quality of the land is consequently of utmost importance. Forestland takes its value from the crops it produces. Estimation of this value necessarily requires forecasting and appraising these crops over a considerable span of time.

The problem in basic outline is to determine the future income producing potential of the land itself. Four controlling factors are involved: (1) site quality, (2) the kind, intensity and cost of future management prescriptions (3) market value of the timber products and (4) time interval involved as measured by the rate of interest employed. If land purchases by resource extracting firms are similar to their purchase of fixed physical capital and other assets, then it may be possible to use data on land purchase to construct an investment series for valuing natural resources.

In theory, under condition of perfect competition, long run equilibrium is the price of physical capital or land should be equal to the present value of the asset. If one assumes the market for resource land roughly approximates perfect competition, one may simply use land purchase prices to produce an investment series. Once investment series are derived from land prices, estimates of natural resource stocks and their depletion can be constructed. The ultimate payment for use of the land is unknown. In order to overcome this difficulty it seems reasonable to assume that a firm should estimate future royalty payment and include the implicit cost of investing in land.

The land price method, as used by Landfeld and Hines (1985), was also criticized by Boskin *et al.* (1985). This method assumes that the entire value of the resource is paid to the landowner in the form of bonuses and royalties. Also the land price method is derived from private market transaction. National accounts are concerned on social value. Hence land prices understate value compared to their other estimates using gross wellheed prices. The Land price approach would be the perfect measure, if there were perfect markets, perfect information and perfect data. The case for using the land price approach is not strong (Slaper, 1995).

The land price model, however, does not value economic activity associated with the production of the natural asset in the same way as the other investment activity recorded in the SNA. Rather, it measures the change in value of an asset due to its use in the current period, together with holding gains (or losses) associated with price changes in the resource market such as petroleum reserve market.

El Serafy's User Cost Method

There are two main methods applied in the natural resource accounting of developing countries. These are the net price method (Repetto, 1989) and the user cost method (El Serafy, 1989). The Integrated Environmental and Economic Accounting (United Nations, 1993), or SEEA handbook mentions two concepts or analogies for viewing natural resources: fixed capital and inventory. The SEEA, which is a satellite counterpart to the System of National Accounts (SNA), presents two approaches for valuing the depletion (or depreciation) of natural resources: the net price method and the El Serafy's "user cost" approach.

The net price (depreciation) approach to natural resource accounting emphasizes actual depreciation of capital stock, in contrast to the user cost, which focuses on the discounted value of foregone future income. Standard calculations of national income impute and subtract the depreciation of physical capital from GDP in order to arrive at NDP. The rationale of measuring this depreciation is that the wear and tear of today will decrease the productivity of capital in the future. This will lead to a decrease in the future net income. Depreciation should signal the reinvestment necessary to maintaining economic productivity. This approach has been de facto endorsed by its inclusion in the SEEA.

El Serafy (1981) presented his method for dividing the proceed from the sale of an exhaustible asset, such as an oil reserve, into a portion that could be consumed and a portion to be reinvested. El Serafy's method calculates the proportion of true, perpetual or "sustainable" income to the proceeds from the extraction of a natural resource from a fixed stock. This method's calculation of the "depletion" of exhaustible resource was never proffered as a theoretical model but one that would measure the depletion of mineral assets as capital (Slaper, 1995).

El Serafy's methoh is a valid alternative to the net price approach. Stocks of natural resources can be easily treated as inventories in both physical and monetary terms. Conceptualizing natural resources as inventories gives rise to the possibility of, if not the preference for, using the El Serafy's method. El Serafy (1989) followed the proposal of Hicks (1946) in his attempt to derive "that part of the proceeds from a wasting asset that should be set aside and re-invested so that the yield on the investments would compensate for the dwindling resource" (El Serafy, 1991).

El Serafy calls the amount to be reinvested "user cost". He attributes his concept of user cost to Keynes: "user cost, in relation to capital equipment, {is} the maximum net value, which might have been conserved, if the equipment had not been used" (Keynes, 1936, quoted in El Serafy, 1991). Keynes views the concept as a link between the present and the future. User cost is the decline in the asset value due to its use in accounting.

The user cost component of natural resource related production must therefore be separated from standard calculations of national income in order to attain resource depletion-adjusted national income. The basic equation in netting out the user cost can be written as follows;

Resource Depletion Adjusted GDP = GDP - User cost.

User cost represents foregone future income, or as El Serafy (1989) has defined it the difference between total revenue and Hicksian income. It can likewise be thought of as that portion of current earnings that must be set aside for reinvestment in order to perpetually maintain an income stream which by virtue of natural asset erosion will no longer be available.

In El Serafy's model, he separated user cost from value-added both for non-renewable and renewable resources exploitative production. In the case of non-renewable resource he used the following formula. The finite series of revenue from derived from resource rent is changed into an infinite series of income flow.

The change in the capitalized value of the series form current period to next period yields "user cost" that can be obtained from the permanent stream of income. Deducting the user cost from total revenue separates the true sustainable income generated from the economic activity.

Mathematically it stands as follows (El Serafy, 1989):

$$X/R = 1 - \frac{1}{(1+r)^{n+1}}$$

Where

X = value-added or true income
R = total receipts, net of extraction costs
r = discount rate
n = number of period of extraction
X/R = ratio of the real value-added to total receipts
(1-X/R) = user cost

An advantage of estimating the El Serafy's user cost method is that it needs minimum data. In estimating the user cost this method requires total receipt obtained from resource sale, variable extraction cost, the time period for the resource extraction and the social discount rate. The model is however, very sensitive to changes in the discount rate and variable extraction rate.

In the case of renewable resources, El Serafy argues that an appropriate maintenance cost for sustaining the productivity of natural capital should be charged against the gross revenue of those activities, which deplete or degrade natural assets. If the asset is not properly maintained the costs, which would have been incurred in doing so, should be charged against income. "Quite often, the renewable resource is not restored to the same level of activity. As a result the value added that appears to be generated contains capital elements that should be removed. In this case those who estimate national income should impute capital consumption charge based on technically acceptable criteria against current receipts to obtain the true income from these activities" (El Serafy, 1989).

An appropriate maintenance of or reforestation cost should be charged against the gross revenues, which depletes forest resources. If the renewable resource is not sufficiently maintained the cost, which would have to be incurred in doing so, should be charged against income to obtain the level of Hicksian income (El Serafy, 1989).

Defining a 'resource' however is complex and arguably subjective due to externalities and option values. For example, should the areas of forest or the volume of wood be an appropriate criterion by which to measure forest depletion and hence required replacement? The decision to replace wood volume would maintain the forest's value as narrowly defined by the commercial timber, though forest clearly embodies values other than timber. The replacement of the forest areas would restore more, through the entire value of a natural forest.

In most cases data availability will be the practical difficulty of such questions, but standardization and comparability would be compromised as a consequence. Though the conceptual framework of El Serafy's user cost is based on the same theoretical basis, the methodologies employed to calculate user cost for non-renewable and renewable resource is markedly different. For non-renewable resource the calculation is essentially an accounting identity, driven by projected commodity prices and the social discount rate. For renewable resources such as the Thailand forest resource accounting (Sadoff, 1993) the user cost is calculated based on the cost of forest regeneration. However, this is not necessarily the correct way of doing it. This is because reforestation gives fast growing and high yielding forest whereas natural forest represents divergent species, slow growing with low yielding types of forest.

Theory of Resource Depletion

The basic theory of resource depreciation measurement follows that of Marshall (1936) and Hicks (1946). Income (regardless whether it originates from marketed capital such as machines, timber or non-marketed capital such as natural forest and its amenities) is defined as the sum of the current and potential future additions to wellbeing. More specifically, current additions to well being are defined as consumption and gross income is consumption plus gross investment. Gross investment is the addition to capital that will allow for increasing both future income and maintenance of current income.

Net income is simply consumption plus net investment, where net investment is gross investment less that portion of capital investment just necessary to maintain current level of consumption, which is conventionally called depreciation. However, as defined by economists, depreciation also equals the change in the value of initial capital stock over the accounting period. In the measurement of resource depreciation, it is useful to distinguish between economic definition of depreciation, or value depreciation and physical depreciation.

The relationship between income and change in the value depreciation can be shown as follows: A society's capital has value presumably because it generates a stream of goods and services i.e. income. Let V_0 represents this value of the resource (capital) at the beginning of the year, while Qt represents the services generated (that is gross income) at the subsequent t year. Thus Q_1 is gross income at the end of year 1.

In national income accounts, investment is divided into non-residential structure and producers' durable equipment and changes in resource stock inventories. Resource managers invest in new plant and equipment because they believe it to be profitable. The return to investment plant and equipment is spread over a number of years. For example, a manager may expect profit from a particular project to accrue over a five year span.

Prediction about expected profit over time complicates decision making about investment because profits received in the near future are worth more than profit received in more distant future. Managers cannot, therefore, simply add profit for various years and compare total profits with the cost of investment projects. They must use a more comprehensive approach applying present value method to determine whether a project is profitable. The general formula for present value principle calculates present value of future income stream. By future income stream is meant a series of income accruing over time.

According to Peskin's (1989) resource depreciation measurement theory, and Clark and Munro's (1978) assertion forest resource stock is quite similar to fish population or biomass. Forest resource like physical capital yields a sustainable consumption flow through time. The value of forest stock (V_0) is the present value of potential future net benefits. The theory of investment relates V_0 to the following present value of Q.

$$V_0 = \frac{Q_1}{(1+i)} + \frac{Q_2}{(1+i)^2} + \cdots + \frac{Q_n}{(1+i)^n} + \quad [4.1]$$

where i is the interest rate. V_1 is the value of V at the end of year 1, and at the beginning of year 2. It is simply the series of $Q_2 \ldots\ldots Q_n$, discounted to the year 1. Alternatively, V_1 is simply V_0 compounded to the next year by (1+i) minus net benefit in year 1 (Q_1).

$$V_1 = \frac{Q_2}{(1+i)} + \frac{Q_3}{(1+i)^2} + \ldots\ldots + \frac{Q_{n+1}}{(1+i)^n} + \ldots$$

Equation (4.1) can be written:

$$V_0 = \frac{Q_1}{(1+i)} + \frac{V_1}{(1+i)} = \frac{Q_1 + V_1}{(1+i)} \qquad [4.2]$$

From which follows:

$$V_0 + iV_0 = Q_1 + V_1$$

$$Q_1 = iV_0 + (V_0 - V_1) \qquad [4.3]$$

The term V_0-V_1, representing the loss in the value of the initial stock after year 1 is by definition, the value depreciation occurring in year one. Gross income is defined as consumption (C) plus investment (I^G). By definition net income equals consumption (C) plus net investment (I^N) and net investment (I^N) equals gross investment (I^G) less depreciation (D). Equivalently, net income (I^N) equals gross income less depreciation (D). It follows from Equation [4.3] that, since Q_1 is gross income at the end of year 1, the term iV_0 can be identified with net income. Thus Equation [4.3] can be rewritten as

$$Q_1 = C_1 + I^N_1 + D_1 \qquad [4.4]$$

Where C_1, I^N_1 and D_1 are consumption, net investment and depreciation in year 1 respectively. In other words

Gross income = Net income + (Value) depreciation

= Consumption + Net investment + (Value) depreciation

= Consumption + Gross investment

One reason for which depreciation exists is because of reduction over time in the physical ability of capital to generate consumable services. This loss in physical ability or physical depreciation may also lead to a loss in the value of the capital stock or value depreciation. That is value depreciation may be caused by physical depreciation. However, value depreciation may also be caused by other factors. For example, the value of capital may fall due to a change in taste and consumption for those items produced by the capital or simply because of a change in interest rates. Thus it is quite possible that an asset that remains physically intact (or even grows) can depreciate.

Moreover (in contrast to physical depreciation), value depreciation, V_0-V_1 need not necessarily be positive i.e., V_1 could in principle exceed V_0. It should be noted, however, that conventional practice is to define depreciation as non-negative and to refer to the case where V_1 exceeds V_0 as a capital gain. Peskin (1989) decomposed value depreciation into two components the portion of difference between V_0 and V_1 that is due to actual physical depreciation and the portion that is due to other causes such as change in interest rate or price. The latter, if positive, is termed "capital gain" and if negative is termed "capital loss". Thus, if physical depreciation is D_p and capital gain (or loss) is G, this decomposition of value depreciation requires that

$$V_1 - V_0 = D_p + G \qquad [4.5]$$

Value depreciation = physical depletion minus capital gain, or plus capital loss. Of course, physical depletion must be valued in order to make this computation possible. How the units of physical loss should be valued and what prices should be used is a matter of controversy. As the choice of valuation methods affects the measure of physical depletion, it has important implication for national accounting. However, if the focus is on value depletion, the implication of choosing among alternative capital prices can be avoided by estimating value depletion instead of by successive application of Equation [4.1]. One should, however, prefer the application of Equation [4.5].

Timber is a natural form of capital whose depletion due to capital loss from harvesting, fire and damage or gain from reforestation should be adjusted with GDP along with depletion of physical capital, when calculating NDP. In order to make this adjustment, it requires theoretically sound methods and data to apply those methods. Vincent (1997) examined the analytical foundations of such methods by reviewing estimation methods for non-renewable resources. Then the standard net depletion method for timber resources was reviewed, which generalizes methods for non-renewable resources without taking into account the time lags that occur in the real world between timber harvests.

This omission tends to cause the net-depletion method to overstate both the decrease in capitalized forest value that occurs when mature forest is logged and increase that occurs as immature forest regenerate. In this study alternative methods are introduced, based on the familiar Faustman model of optimal forest management that avoids the biases.

Measurement of Depreciation for Nonrenewable Resources

The capitalized value is used in estimating natural resource depreciation, which is the discounted sum of the net returns (resource rent) that generates over time. Economic depreciation reflects the changes in the capitalized value from one period to the other. Conversely, when resource extraction is greater than regeneration, the capitalized value declines, reflecting the capitalized value is positive over time. When capitalized value rises, especially in the case of growing renewable resources like forestry and fisheries, it indicates that the capitalized value is negative over time. In the case of nonrenewable resources when prices of extracted resource rise significantly, the capitalized value also may rise (Vincent, 1997). If the capitalized value declines over time the economic depreciation would be positive and vice versa. The fundamental equation of asset equilibrium (Hartwick and Hageman, 1993 and Vincent, 1997) states that realization of current resource rent decreases capitalized value (the depreciation indicates a positive value). On the other hand, the discounting back the stream of future rents towards the present increases capitalized value (depreciation reflects the negative value). Therefore economic depreciation is less than current resource rent (EDt < CRt).

Hartwick (1997) derived indirect method to continuous time switching from discrete in the discounted sum for estimating economic depreciation. According to Hartwick (1997) capitalized value of the resource is a continuous function. This continuous time economic depreciation is analogous to discrete economic depreciation of nonrenewable resource. Under an optimal natural resource extraction situation Hotelling's r-percent rule holds (Hartwick and Hageman, 1993). Thus economic depreciation refers to the quantity extracted times marginal, not average, rent. Hartwick terms this product as Hotelling rent.

Vincent (1997) derived the economic depreciation in continuous-time with respect to resource rent. El Serafy (1989) and Hartwick and Hageman (1993) proposed using the discrete-time counterpart of continuous-time formula to estimate economic depreciation.

Net Depletion Method for Timber Resources

Maler (1991) derived a model for renewable resource adapted from nonrenewable resource such as forestry by modifying the state equation and including growth of the resource stock:

$$dS(t)/dt = g(S(t)) - q(t) \qquad [4.6]$$

On simplification, the derivation of economic depreciation based on marginal revenue (MR) is as follows:

$$D(t) = [p - C^{/}(q(t))]\,[q(t) - g(S(t))] \qquad [4.7]$$

The economic depreciation equals the marginal rent times net depletion of the resource. The net depletion is defined as the difference between current harvest and current growth. Repetto *et al.* (1989) have also applied this method that differs only as regard multiplying net depletion with average rent, such as based on average revenue (AR)

$$D(t) = [p- C\ (q(t)) / q(t)]\ [q(t) - g(S(t))\ ] \qquad [4.8]$$

In both the approaches, the current harvest and current growth is the products of the same net price either marginal or average rent. Both the methods will provide identical value, when the cost function is linear in the quantity of resource extracted.

From the state equation for forestry resource i.e. $dS(t)/dt = g(S(t)) - q(t)$, it is indicated that resource growth is immediately available for harvest. In reality, timber typically takes several decades to be matured for harvesting. For every hectare of forest the discrete-time capitalized value for nonrenewable resources can be written as follows (cited from Vincent, 1997):

$$V_H(t) = (1+i)^{t-T}\ [pq(T) - C(q(T))\ ] / [1-(1+i)^{-T}\ ] \qquad [4.9]$$

where t is the current age and T is the harvesting age of the forest that maximizes $V_{(0)}$ (capitalized value for t=0). In other words, T is the age of forest resource for optimal rotation: the forest is to be harvested every T years, without any interruption in production. All trees on the harvest are assumed of same age, and all standing timber is harvested after attaining the maturity. In this expression it is also assumed that land remains permanently in forest use.

Previous Studies of Natural Resource Accounting in Developing Countries

A summary of the NRA conducted in the developing countries applying different method for different countries and resources is described in Table 3 below.

Table 3: Natural Resource Accounting Conducted in Developing Countries

Countries and Resources	References	Time series	Adjustment of GDP, NDP and Methods used
Costa Rica Forest Soil Fisheries	WRI Repetto *et al.* (1991)	1970-80	ANDP declined by 5% Net Price Replacement Cost Net Price Method
Indonesia Petroleum Forest Soil	WRI Repetto *et al.* (1989)	1971-84	ANDP declined by 9% Net Price Net Price Replacement Cost Method
Mexico Forest Soil Water Air	UN Tongeren *et al.* (1993)	1980-91	ANDP decline 6-13% Net Price and User Cost Replacement Cost Avoidance Cost (MC) to reduce pollution to acceptable level Same as for water
Papua New Guinea Gold, Copper and Silver Forest	UN Bartelmus *et al.* (1992)	1986-90	AGDP decline by 3.7-10.3% User Cost User Cost
Thailand	Sadoff (1993)		AGDP declined by 1.45% and ANDP declined by 2.27%
Malaysia Forest Minerals Fisheries	Vincent *et al.* (1993 and 1997) Tai *et al.* (1996)	1971-1989 1969-93	Per capita GDP growth 3.7% and ANDP 3.2% (Net Price) Net Price Use Cost
Philippines Forestry Fisheries`	DNER, Marian *et al.* (1991) Padilla *et al.* (1994)	1971-88 1948-91	ANDP declined by 6.2% in Net Price and by 0.22% PV method.
Equador Forestry Petroleum	Kellenberg (1995)	1970-90	ANDP declined by 4% (1971-90) AGDP declined by 0.7% in 1990

The Indonesian NRA found that the share of world export increased from 1% in the 1960s to 31% in 1980s. That caused the forest resource depletion substantially. The net price (depreciation) method was applied to the studies of Indonesia and Costa Rica. This method was essentially consistent with the new UN guidelines. The major difference is that the World Resource Institution (WRI) methodology is limited to natural resource depletion and has focused on adjusting major economic indicator rather than reforming the entire national account framework.

The Thailand NRA study found that the immediate losses of forest resource depletion appear to be rational with respect to the country's development strategy (Sadoff, 1993). The Indonesian and Costa Rican studies called for downward adjustment of GDP. The time period and scope of the study were different from the Thai and UN study. The Thailand study showed that the country has made relatively more successful transition away from the natural resource exploitative activities. The revenue derived from the resource exploitation has been invested in such a way that this shift has occurred while sustaining overall rates of economic growth.

The first UN study conducted within the framework of existing national accounts was the Mexican and Papua New Guinea study that called for the analysis of the degradation of environmental services. In Papua New Guinea forestry resources have clearly been depleted. To what extent exploitation exceeds regeneration at the national level remained uncertain. As a result no depletion allowance was calculated for the forestry sector (Bartelmus *et al.*, 1992). If the actual forest resource depletion were calculated, the AGDP would have been much lower than the findings of the present study.

Criteria for Selection of Methods

There two are main grounds that can be considered for choosing the methods. One is the sound theoretical basis and the other is availability of data. The choice of methods for the valuation of natural resources depends on the type of resources. In the case of valuation of forest resource, two methods are used in applied studies, the net price method and user cost method. But the user cost method is the more appropriate and sound economic approach. The difference between the present year and future year capitalized value gives the user cost. The user cost measures the future benefits foregone due to felling trees in the current period. This method is widely used in many applied studies such as the UN studies, Philippines, Equador, Thailand and Malaysia.

The other criteria for choosing the user cost method are the availability of the following information. (1) The species-wise domestic log price data for Peninsular Malaysia. A comparison of FOB log prices for the neighboring region Sarawak showed that despite the log export ban, they reflect the economic price. All other applied studies like Indonesia (Repetto *et al.*, 1989), Thailand (Sadoff, 1993) and Equador (Kellenberg, 1995), except Malaysia

(Vincent *et al.*, 1997) used the average FOB prices for logs. (2) Logging cost data for the year 1985,1992 and 1996. Where 1996 logging cost data were obtained from primary survey in nine compartment of Peninsular Malaysia (Mohd.Shahwahid *et al.*, 1996). (3) The discount rate is assumed on the basis of the finding of total productivity growth rate of Malaysian and is not merely based on arbitrary assumption. (4) There are many forest growth studies carried out in Peninsular Malaysia. Considering species wise forest growth rates the future forest growth rate is taken into account based on the FAO study for all species. (5) Unlike other studies the present study takes into account the net volume. The net volume is estimated species wise by adjusting with a reduction factor (Forestry Department Field Manual, 1997). (6) The species-wise time series data for actual log production is used in the study. The present study estimated the user cost for value of timber resources. The present study applied both the methods in order to examine the disparity between user cost and net price method in the estimation of resource depletion. Unlike other studies, to estimate user cost the present study considers the next cycle forests yield that accounts for the future benefits foregone due to felling forest in the current period.

Conclusion

The net price method, which is applied in the Indonesian, Costa Rican studies, measures the current benefits foregone due to felling trees. It simply portends the current year's price, cost and quantity. The production of quantity is assumed to be along an optimal extraction path given the current year fixed stock of reserves. In practice, changes in the market condition could markedly affect the resource value, which may avoid the real value of resource depletion. The best alternative method for forest resource accounting is the user cost method as it takes care of future benefits foregone due to resource depletion.

CHAPTER V

RESEARCH METHOD

Measurement of Physical Stock Change of Forestry Resource

This Chapter develops the methodological framework to derive forest resource accounts and their link with the sustainable economic growth. On the basis of current forest management system the present study attempts to examine how the forest resource depletion will affect the economic sustainability of Peninsular Malaysia. Subtracting of forest resource depletion from conventional national income accounts gives a new trend of income. The following principles and framework were discussed for the forest resource accounting of Peninsular Malaysia.

(i) Physical stock and flow of timber, natural and plantation forest including rubber wood during an accounting period.

ii) Value accounts and measurement of forestry resource stock, flow and depletion in monetary terms.

iii) Adjustment to national and forest sectoral accounts and also adjustment to an aggregate net domestic investment.

iv) Make economic sustainability test for Peninsular Malaysia.

The forest resource accounting framework presented below is followed to estimate resource depletions and adjustments of the national accounts of Peninsular Malaysia.

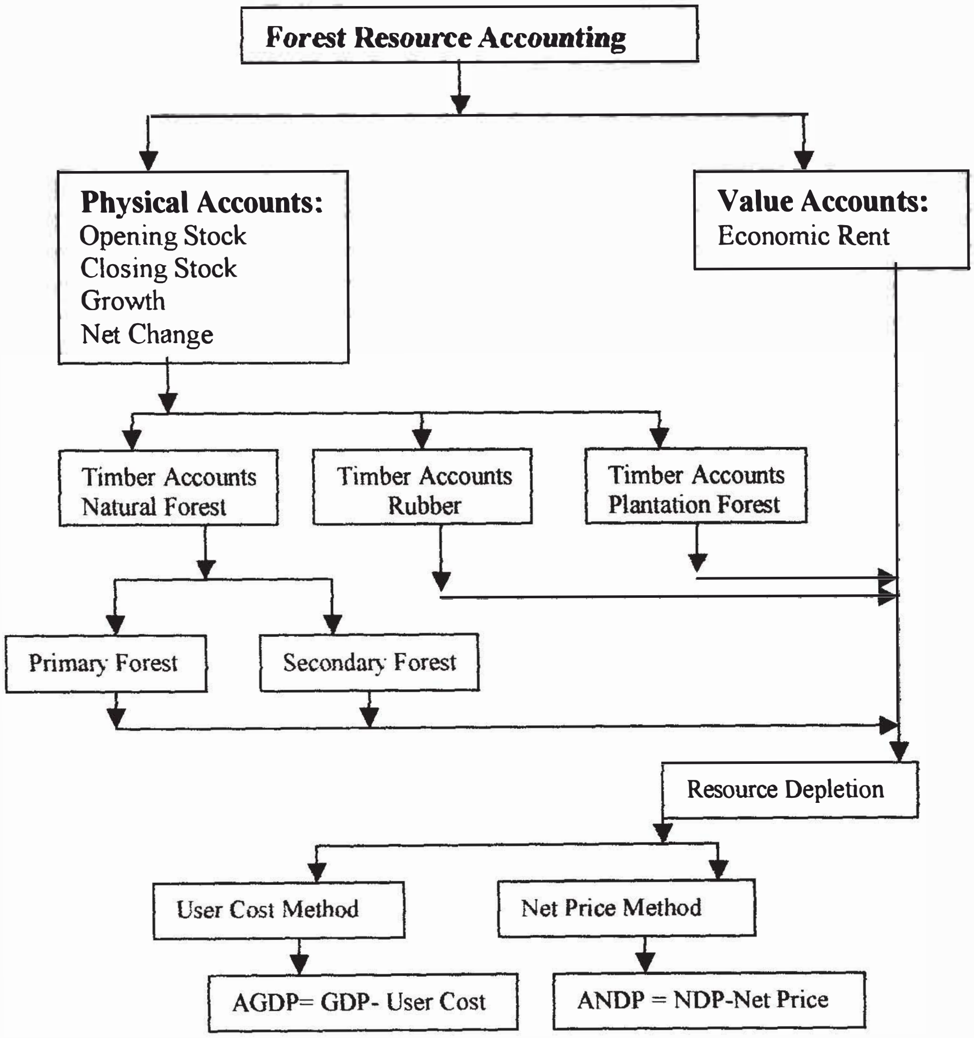

Figure 4: Forest Resource Accounting Framework

The theory and experience of El Serafy (1989, 1991) and (Vincent, 1997) are incorporated in the user cost approach for computing the depletion of forest of Malaysia as explained criteria for the selection of method in the Chapter Four. This is because of availability of species-wise log price, logging cost, species-wise actual log production and forest growth data. This method incorporates potential future benefits foregone or gained due to resource depletion.

In order to show the effects of methodological differences on resource depletion estimates, the net price method is also used. Unlike the user cost method, this technique takes into account the benefits foregone for the current period only. This method is applied by Repetto *et al*. (1989 and 1991) in estimating NRA for Indonesia and Costa Rica.

This study incorporates the natural resource accounts with the existing national accounts framework of Malaysia, using concepts developed for the UN Handbook on Integrated Environmental and Economic Accounting (IEEA).

The present study focuses in more detail the depreciation accounts for the natural forest resources, rubber resources and forest plantation of Peninsular Malaysia. In the `resource accounts, the study considers the growth and price differentials amongst different groups of species for natural and plantation forest. This does not apply to rubber wood because of single species.

The following section describes the formula developed in this study as shown in Figure 4.

Physical Accounts

Natural Forest

The physical accounts of forestry resource are used to keep track of the areas of forest and stocks of timber. This is because the changes in areas affect changes in the timber stocks. In forest resource accounting the areas and stocks are accounted separately for primary (or virgin) and secondary (or logged over) forests. The forest areas are estimated in unit of hectares (ha) and the stocks are recorded in m^3. Timber stock refers to the volume of wood in standing trees of commercial and partially commercial species with a diameter at breast height (dbh) 30 cm or greater (as stated in the national forestry inventories). The net volume estimation of wood is obtained by multiplying the gross volume with a deduction factor 0.70 to take into account potential damages during operation and defects (Forestry Department Peninsular Malaysia, 1997).

The accounting principle is that the opening stock plus all growth or addition (such as natural growth and reforestation) minus all extraction or harvesting and deforestation (conversion of land use) equal closing stocks. The areas and stocks are recorded separately for primary or virgin forests and for secondary forests.

The opening area of forest resource is the area at the beginning of a particular year (equals the forest area at the end of the previous year). The closing area indicates the area at the end of the same year (equals the forest area at the beginning of the following year). An addition to the opening area (or stock) can originate from new gazettement (or growth of initial stock), reforestation and afforestation and gazettement of forest reserves. Depletion of the forest stock can be classified into log production (harvesting), natural degradation (i.e. fire, insect infestations) deforestation by human action and degazettement of forest reserves. The main resource accounting principle is followed from Repetto *et al.* (1989) and Vincent *et al.* (1993).

The physical accounting of forest resource assumed that primary forest (virgin) is always logged before it is deforested.[1] The declining of the primary forest is assumed only due to logging (area logged) that leads to conversion of unlogged forest i.e. area deforested (area transferred to logged forest or other land uses for development purposes such as agriculture / urban development). Logged over forests can expand in area if the area transferred from primary forest due to logging exceeds the area of logged forests converted to other uses such as for agricultural development or urban development (area deforested). Thus the physical accounting identity for the primary and secondary forest area can be stated in Table 4.

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1 The loss of virgin forest is also due to shifting cultivation as found in many countries. But this practice does not occur in Peninsular Malaysia.

Table 4: Accounting Identity for Primary and Secondary Forest Area

	Primary Forest (ha)	Secondary Forest (ha)
A. Closing Area	$CLAPF_T$	$CLASF_T$
B. Opening Area	$OAPF_T$	$OASF_T$
C. Area Logged	$ALPF_T$	
D. Area of Secondary Forest Deforested		$ADSF_T$
E. Area of Primary Forest Harvested		$AHPF_T$
F. Net Change in Gazetted Area	$NCPF_T$	$NCSF_T$

Note:

Physical Accounting Identity for Primary Forest Area at time t ($CLAPF_T$) is defined as A = B – C + F while the Physical Accounting Identity for Secondary Forest Area at time t ($CLASF_T$) is defined as A = B – D + E + F.

The Physical Accounting Identities of timber stock for primary and secondary forest are stated below:

The virgin forest growth rate is equal to mortality rate resulting in zero net change (Vincent and Binkely, 1992). When an area of primary forest is harvested, some portions of the timber stock on it is lost (quantity harvested). The residual stock retained in the area is recategorised as harvested primary forest. This stock of resource is also lost when forestland is used for some development purposes such as agriculture and urban development (quantity destroyed by deforestation). But this loss accounted for, since harvesting occurs prior to conversion. The stock may be reduced for other reasons such as fire damage, illegal felling and typhoon (other reduction in stock).

In secondary forest, timber stock can increase for two reasons. The first is from timber growth following felling. The second source is from the gazettement of stateland into permanent forest reserves and the transfer of primary to secondary forest. A net change is the difference between the closing stock of any given year and closing stock on the preceding year. The accounting identity for the primary and secondary forest stock can be described in Table 5.

Table 5: Accounting Identity for Primary and Secondary Forest Stock

	Primary Forest Stock (m^3)	Secondary Forest Stock (m^3)
A. Closing Stock	$CLSPF_T$	$CLSSF_T$
B. Opening Stock	$OPSPF_T$	$OPSPF_T$
C. Newly Gazetted Area	$NGPF_T$	$NGSF_T$
D_S. Quantity Transferred to Secondary Forest		$QTSF_T$
D_P. Quantity Transferred from Primary to Secondary Forest	$QTPF_T$	
E. Quantity Harvested under Sustained Yield Management	$QHPF_T$	$HQSF_T$
F. Quantity Destroyed by Deforestation Following Harvesting PF or Deforestation in SF	$QDPF_T$	$QDSF_T$
G. Other Reduction in Stock such as Fire Damage and Illegal Felling	$ORPF_T$	$ORSF_T$
H. Timber Growth During Accounting Period (Natural Growth, Growth from Silvicultural Treatment)		$TGSF_T$

Note:

Physical Accounting Identity for Primary Forest stock at time t ($CLSPF_T$) is described as A = B +C -Ds -E -F -G while the Physical Accounting Identity for Secondary Forest Stock at time t ($CLASF_T$) is defined as A = B +C+ D_p -E- F-G +H.

The procedures followed for the physical accounting of plantations forest and rubber wood are illustrated below:

Forest Plantation

Current year closing area for the plantation forest is equal to the sum of the opening area plus new planting or replanting area less harvesting area. The change in stock equals {(new planting or replanting area) less harvesting area} times timber growth. The closing stocks are equal to the opening stocks plus change in stocks. The physical accounting of plantation forest is as follows:

Current Year Area Accounts

The plantation forest area changes over time due to new planting, replanting and harvesting. The physical accounting identity for plantation forest area is explained in Table 6.

Table 6: Accounting Identity for Plantation Forest Area

	Forest Plantation area (ha)
A. Closing Area	CLA_T
B. Opening Area	OPA_T
C. New Planting or Replanting Area	NPA_T
D. Harvesting Area	HA_T

Note:

Physical Accounting Identity for Plantation Forest Area at time t (CLA_T) is defined as A = B +C -D.

Current Year Stock Accounts

Similar to plantation forest area, its stock also changes over time due to forest growth and new plantation and harvesting. In this study it is assumed that plantation begins in the first year. The current stock accounting identity for plantation forest is illustrated in Table 7

Table 7: The Current Stock Accounting Identity for Plantation Forest

	Plantation Forest Current Stock
A. Change in Stocks (m3)	ΔS_T
B. New Planting or Replanting Area	NPA_T
C. Timber Growth Rate (m^3/ha/year)	TG
D. Harvesting Area (ha)	HA_T

Note:

Physical Accounting Identity for Plantation Forest Current Stock at time t (ΔST) is described as A = B*C -D*C. Similarly, the closing stock accounting identity for Plantation Forest is described in Table 8.

Table 8: The Closing Stock Accounting Identity for Plantation Forest

	Closing Stock (m^3)
A. Closing Stocks (m^3)	CLS_T
B. Opening Stocks (m^3)	OPS_T
C. Change in Stocks (m^3)	ΔS_T

Note:

Physical Accounting Identity for Plantation Forest Closing Stock at time t (CLS_T) is defined as A = B +C

Rubber wood

Current year closing area equals the opening area plus new plantings plus replanting less harvesting area. The opening area equals the area after planting t years (t may be any year) * timber growth rate (m^3/ha/year) * number of years. The physical accounts of rubber are as follows:

Current year Area Accounts

Like plantation forest area, rubber resource area also changes over time due to new planting, replanting and harvesting. The current area accounts identity for rubberwood is explained in Table 9.

Table 9: Accounting Identity for Rubberwood Area

	Rubberwood Area (ha)
A. Closing Area	CLA_T
B. Opening Area	OPA_T
C. New Plantings	NPA_T
D. Replantings	$RPLA_T$
E. Harvesting Area (part of uprootings is harvesting area)	HA_T

Note:

Physical Accounting Identity for Rubberwood Area at time t (CLA_T) can be defined as A = B +C +D -E.

Current Year Stock Accounts

Like plantation forest stock, rubber resource stock also changes due to planting, replanting, growth and harvesting. The current and closing stock accounting identity for rubberwood is demonstrated in Table 10.

Table 10: Accounting Identity for Rubberwood Stock

	Plantation Forest Current Stock
A. Change in Stocks (m3)	ΔS_T
B. New Planting at time t and	NPA_T
C. Timber Growth Rate (m^3/ha/year)	TG
D. Uprooting Area (ha)	URA_T
E. Closing Stocks	CLS_T
F. Opening Stocks	OPS_T

Note:

Physical Accounting Identity for Rubberwood Current Stock at time t (ΔS_T) is and described as A = B*C -D*C. Physical Accounting Identity of Closing Stock for Rubberwood at time t (CLS_T) is defined as E= F+ A.

In short, the change in stocks equals {(New Planting + Replanting Area) times (timber growth rate} less (uprooting area times timber growth rate). The closing stocks equal the opening stocks plus change in stocks.

Opening Stock

In order to estimate the areas of growing timber stock of natural forest three inventory data sets were used for Peninsular Malaysia. The areas for 1972 in the accounts were based on the first forestry inventory, which was completed in 1971-72. The opening areas for 1982 were based on the second forestry inventory, and similarly the opening areas for 1993 were based on the third forestry inventory, the remaining years between them were computed as straight line averages between three benchmark years of the three inventories.

The physical stock of the natural forest resources and any changes in those stocks during an accounting period is measured in cubic meter (m^3). Commercially and partially commercially forest as reported officially in forestry inventories were considered for valuation of forest resource depletion. For the computation of opening stock data for plantation forest and rubber wood were obtained from the Forestry Department and the Department of Statistics respectively.

Estimation of Stumpage Value

In order to derive the forest resource account, it is necessary to make the valuation of resources in its monetary terms. This is measured in terms of stumpage value. To estimate the stumpage value or resource rent the residual value technique was used, which is the difference between selling prices and production costs (also comprises margin for profit and risk) (Davis, 1966).

Stumpage value can be calculated for each species of log actually harvested using the following formula:

$$S_i = V_i \ (P_i - C - Pm_i) \qquad [5.1]$$

where

S_i = Stumpage value according to species group

V_i = Volume of timber according to species group

P_i = Log price according to species group

C = Average variable logging cost per cubic metre

Pm_i = Profit margin

i = An index according to species group

i = (1,2,3, ……………., n)

The stumpage value (S_i) of a standing tree is equal to the volume of timber in the forest (Vi) times the difference between the price (P_i) that concessionaires receive, and the logging cost they incurred to mill i.e. the extraction cost (C) for those logs and profit margin for running and managing the business. A site's potential stumpage value (SV_i) is found by aggregating the resource value of all species on the site.

$$SV = \sum_{i=1,}^{n} S_i \qquad [5.2]$$

where

SV = Total stumpage value per ha.

$\sum S_i$ = Summation of individual stumpage unit value according to species group i .

The following information was used for the estimation of stumpage value such as log prices, variable extraction cost and forest growth rates.

Log Price for Natural Forest

The log prices used in the calculation of stumpage value were obtained from MASKAYU. The Malaysian Timber Industry Board (MTIB) publishes monthly data on commercial domestic log prices in MASKAYU. MASKAYU reports prices for three regions - East Coast, Central and West Region. The domestic log prices paid by mills (in RM per m^3) are reported for 21 individual species and species group. These reported mean log prices by species are provided by miller's and logger's association in each region. From those monthly data, the average annual log prices were calculated for a given year. It should be noted that the reported log prices are the average prices for trees greater than 55 cm.

The use of domestic log prices as a shadow price of log under log export ban policy needs some justification. If logs are freely exported then either the domestic log price or FOB price can be used as an estimate of economic value of log. In the Indonesian case (Repetto *et al.*, 1989) and the Natural Accounting of Thailand (Sadoff, 1993) FOB export price of log was used.

The use of FOB export price is normally most suitable especially in the presence of export restrictions, whereby the domestic log price will generally under estimate the economic value. In this case export price for similar timber from the neighbouring region can be used to estimate the economic value (Vincent *et al*., 1993).

A restricted log export ban was imposed in Peninsular Malaysia since 1972. This was gradually followed by a complete export ban in 1985. A comparative analysis of FOB log prices from Sarawak and domestic log prices from Peninsular Malaysia of similar species is made. This is done to verify if indeed, the domestic log prices for Peninsular Malaysia undervalue their free market prices. In Sarawak there is no log export ban, logs are freely exported to Peninsular Malaysia and other countries. In order to make a comparative study the time series FOB price data for a few major species group such as Meranti, Kapur, Keruing and Sepetir were obtained from published source of Sarawak and FAO forest product prices.

The comparative study of major species showed that in the case of Meranti the domestic prices of log in Peninsular Malaysia was lower than the FOB log price of Sarawak during the period of 1980-87. The species used in this study are shown in Appendix B, Table 27.

The examination of the degree of variation showed that the domestic log prices of Meranti was lower by 7% than that of the FOB log price of Sarawak between 1980 and 1987. However, the stagnating log production and the high demand for logs have led the Meranti log prices to rise relative to 1987 from 3% to 47% between 1988 and 1994 respectively.

Similarly the domestic log prices of Kapur, Sepetir and Keruing were lower by around 8-14% than that of the FOB log prices of Sarawak between 1980 and 1987. Nevertheless, due to the stagnating log production and the high demand for logs have led the Kapur log prices to rise relative to 1987 from 13% to 25%, Sepetir from 35% to 57% and Keruing from 14% to 49% between 1988 and 1994 respectively (Appendix B, Table 28 provides more details).

Before the year of 1985, there was a partial log export ban in Peninsular Malaysia. This caused the domestic log price to be lower than that of the FOB prices of Sarawak. These trends continued until 1987. After 1988, there were increasing demand for logs in the domestic economy because of economic expansion. This led to a tremendous increase of log prices in Peninsular Malaysia. The domestic log price increased by 8-10 % in the year of 1988 over the FOB log price of Sarawak for the above said species. This trend continued to increase more than 50% for the year of 1994. The domestic log prices for Peninsular Malaysia continue to its increasing trend in the subsequent periods. The substantial rise of domestic of log prices from the year 1988 outweighed the impacts of partial log export ban occurring in the early 1980's.

The comparative study of domestic log prices of Peninsular Malaysia and FOB price of Sarawak showed that due to the growing demand for logs, the domestic prices have substantially risen higher than that of the Sarawak FOB log prices. Thus, it is felt that the domestic log prices could provide a better reflection of the supply and demand situation in the log market.

The usage of these domestic log prices has also been done by others. In the forest resource accounting study (Vincent *et al*., 1993) the domestic log prices for Peninsular Malaysia were used. In another study (Vincent *et al*., 1997) they also used domestic log price for Peninsular Malaysia in estimating the forest resource rent.

Logging cost data was obtained from Forestry Department Head Quarters, Peninsular Malaysia for 1985 (RM60) and 1992 (RM72). Cost structure data for 1996 is obtained from the study (Mohd.Shahwahid and Awang Noor, 1996) for Peninsular Malaysia. A detail break down of logging cost is shown in Appendix B and Table 29.

Log Price, Cost and Yield for Plantation Forest and Rubber

All prices and cost used in the analysis of this study are at 1978 price. Information from the Department of Forestry reported in the Table 11 was used in this study.

Table 11: Log Price, Cost and Yield of Plantation Forest (RM at 1978 price)

	A.magium [a]	*Teak* [b]	*Hevea* [c]	*Pine* [d]
Yield at rotation	150m^3/ha	150m^3/ha	184m^3/ha	150m^3/ha
Average timber growth	10/m^3/year	10/m^3/year	12.3/m^3/year	10/m^3/year
Planting Cost	RM654/ha	RM2291/ha	RM2793/ha	RM471/ha
Weeding Cost maintenance and thinning	RM565/ha	RM1412/ha	RM2559/ha	RM13/ha
Harvesting and marketing	RM20.21/ha	RM10.48/ha	RM10.46/ha	RM22.58/ha
Log price at maturity	RM78.45/m^3	RM313.81/ m^3	RM49.46/ m^3	RM45/ m^3
Rotation	15 years	15 years	15 years	15 years

Sources:
(a) Thai *et al.* (1997)
(b) Krishnapillay *et al.*(1998)
(c) Najib Lotfy *et al.* (1997)
(d) Forestry Department HQ (1998), Peninsular Malaysia.

In order to calculate the stumpage value for rubber resource (timber), a time series actual log price is used from rubber statistics (Department of Statistics, (1972-96). The nominal logging cost RM 24.5 and 28.40 for the year 1993 and 1995 were obtained from the Department of Statistics. These logging cost were used to generate logging cost for the study period applying the GDP deflator. The nominal logging cost was deflated as 1978 real logging cost for the calculation of stumpage value.

Growth of Natural Forest

Stumpage growth rates vary for different types of forest and species. The virgin forest growth rate is equal to the mortality rate resulting in a net change of zero, if no logging is done (Vincent and Binkley, 1992). The growth rate of logged over forest where forest grows naturally after felling and plantation is taken into consideration in this study.

Economists usually assume that the function relating to timber volume to age (q(s)) has either a concave or logistic shape (Hartwick, 1993 and Vincent, 1997). In the case of logistic shapes, it is usually assumed that the inflection point occurs at a relatively young age. Data from actual forest generally supports these assumptions (Vincent, 1997). Hence, for most ages in the case of logistic function $q'(t) > q'(T)$: the timber growth rate (the current annual increment to foresters) declines as the forests grow to maturity. Given the volume-age relationship, the volume of physical depreciation is underestimated for a very young forest (up to age 13 years) but beyond that volume depreciation is over estimated (Vincent, 1997).

The growth and yield relationship of forest stands are based on the concept that the growth and yield for stands of a given species or mixed species are determined by the following factors. (i) the age of the forest stand (ii) the productive capacity of the area which are affected by biotic, edaphic and climatic factors, known as site quality (iii) the condition of the stand density (iv) silvicultural treatment efforts (v) inherent genetic variability of a species (e.g., crown size, crown exposure and so forth.)

The different types of immature hill forest for (less than 10 years after logging, assuming under SMS's 30 year cutting cycle) Peninsular Malaysia has an overall average growth rate of 2.80 m^3/ha/year at dbh 10 cm and above, 6 years after logging (Chu Sang and Ashari, 1992), (see Table 12). This overall average growth rate (2.80 m^3/ha/year) is greater than the findings of 2.15 m^3/ha/year by Borhan (1984) at 10 dbh cm and above, 4 years after logging at Labis forest reserves, Johor Baru.

Another study conducted by Ashari (1997) for logged over forest 4 years after logging at Sungai Lalang Forest Reserve (FR) showed an overall growth rate of 1.15 m^3/ha/year for 10 cm+ dbh. A comparison of standing volume between before and after harvesting of different study areas clearly reveals that different stand volume compositions were mostly responsible for different growth rates at different sites. However published figures from UNDP/ FAO (1978) show that the gross volume growth was 2.20 m^3/ha/ year for marketable commercial species and 2.75 m^3/ha/year for all species having diameters greater than 30 cm dbh for Malaysia.

A study of the upper hill of Balau Hill in Peninsular Malaysia, illustrated that the average growth rate 13 years after logging is 1.37 m^3/ha/year for total dipterocarps, 0.50 m^3/ha/year for meranti (MER), and 0.87 m^3/ha/year for non-meranti (NMER) (see Table 13). It is 3.54 m^3/ha/year for non-dipterocarp, where it is 1.49 m^3/ha/year for LHW, 1.63 m^3/ha/year for MHW, 0.23 m^3/ha/year for HHW and is 0.19 m^3/ha/year for misc. species with an over all average growth rate of 4.90 m^3/ha/year at 15 cm and above dbh (Ashari and Dahlia, 1994).

In another study at Gunung Tebu Forest Reserves in Terenggannu , an overall average of growth rate of 0.94 m^3/ha/year at 15 cm dbh and above, was found 14 years after harvesting (Yong, 1990). The study shows a very poor growth rate in comparison with that of Balau Hill area. Balau Hill (229-508 m elevation) is higher than that of Gunung Tebu FR (15-304 m). The time span for both the studies is almost the same; 13 years and 14 years, respectively. In Gunung Tebu the general poor volume growth of the study area is attributed to poor site conditions, poor pre-felling stocks and the lack of silvicultural treatments to help enhance growth (Yong, 1990) as shown in Table 13. The World Bank Malaysian Forestry Sub-sector study (1991) states that the expected annual growth rate of the selectively logged over forest of commercial species (dipterocarp) varies between 1.5 and 3.0 m^3/ha/year.

Table 12 : A summary of Total Gross Volume Increment (m^3 / ha/ yr) of Trees 10 cm dbh and Larger by Species Groups at Several Forest Reserves in Peninsular Malaysia ogging Year after 4 and 6 years.

Species groups	Diameter class 10 cum + Labis FR J. Baru (1)	Diameter class 10 cm + Sungai Lalang FR S'gor (2)	Diameter class 10 cm + Legong FR Pahang (3)	Diameter class 15 cm + Balau Hill Forest Trengganu (4)	Diameter class 10 cm + Senliing- Inas and Angsi FR.N.Semb (5)
MER	0.19m^3/ ha/ yr	.07 m^3/ ha/ yr	.16m^3/ ha/ yr	-.208m^3/ ha/	0.09 m^3/ ha/ yr
NMER	-.80	-0.03	-.17	.083	.16
Total Dip	-0.63	-	-		.25
LHW	1.53	-0.34	-.97	-.530	1.43
MHW	0.07	0.06	-.52	-.562	.73
HHW	0.57	0.09	-.52	.070	.46
Misc	-	.60	-2.52	.323	-.07
Total NDip	-2.77	-	-	-	
NDCOM	-	-1.84	-2.79	-	
Pioneer-SPS	-	2.55	-2.09	-	
All species	2.15	1.15	-3.67	-1.468	2.80
Altitude	100-500m	300-915m	75-230m	229-508m	160-293m
Year after	04 years	04 years	04 years	04 years	6 years

Sources:
(1) Borhan (1984)
(2) Ashari (1997)
(3) Ashari (1997)
(4) Yong (1992)
(5) Chu Sang *et al.* (1992).

Note:
MER = Mernati Group of species
NMER = Non Meranti group of species
LHW = Light Hardwood
MHW = Medium Hardwood
HHW = Heavy Hardwood
NDCOM = Non-diptercarp commercial species.

Table 13: A Summary of Total Gross Volume Increment (m^3 / ha/ yr) of Trees 15 cm dbh and Larger by Species Groups at Several Forest Reserves in Peninsular Malaysia Logging after 13 and 14 years.

Species groups [1]	Diameter class 15 cm + (1) Gunung Tebu FR	Diameter class 15 cm + (2) Balau Hill Forest
MER	0.01 m^3/ ha/ yr	0.50m^3/ ha/ yr
NMER	0.13	0.87
TotalDip	0.14	1.37
LHW	0.38	1.49
MHW	0.31	1.63
HHW	0.20	.23
Misc	-0.08	.19
TotalND	0.80	3.54
All spec.	0.94	4.90
Altitude	15-304m	229-508m
Year after logging	14 years	13 years

Sources:
(1) Yong (1990)
(2) Ashari *et al.* (1994)

Note: [1] Refer to Table 12 for definition.

Growth Rate Used for Natural Forest

A comparison of standing volume before and after harvesting of different study areas clearly reveals that different standing volume composition were mostly responsible for different growth rates at different sites. However published figures from UNDP/ FAO (1978) illustrates that gross volume growth for marketable commercial species was 2.20 m^3/ha/ year and 2.75 m^3/ha/year for all species having diameters greater than 30 cm dbh for Malaysia. In this study the net growth rate used is obtained by multiplying the gross growth rate by 0.7 as used by the Forestry Department, (Forestry Fieldwork Manual, 1997) i.e. (2.75*0.7 =1.925 m^3/ha/year).

Growth Rates for Forest Plantation and Rubber Holdings

The growth in timber stock volume in the rubber estates and smallholdings are assumed to increase $8.8m^3$/ha/year and $7.2m^3$/ha/year respectively (Naimah *et al.*, 1993; Ismariah, and Norini, 1994, and Mohd. Shahwahid *et al.*, 1995).

The average timber growth rates of $10m^3$/ha/year, $10m^3$/ha/year, $12.3m^3$/ha /year and $10m^3$/ha/year are assumed for *Accacia magium* (Thai *et al.*, 1997), *Teak* (Krishnapillay *et al.*, 1998) *Hevea* (Najib Lotfy *et al.*, 1997) and *Pine* (Forestry Department HQ, 1997) respectively (Table 13).

Estimation of Forest Resource Depletion

The Monetary account approach places monetary value on changes in the physical assets. The study adopts the user cost method in estimating the resource depletion. In order to examine the methodological differences and estimated results of the two methods, the study also applies the net price method in estimation of the resource depletion. This method unlike the user cost method takes into account the current benefits foregone due to resource depletion.

User Cost Method

The user cost in the case of forestry is defined as the future benefits that are given up by felling trees in the current period. Prior to harvesting virgin forest its natural regenerative capacity remains unchanged. The net growth is assumed at a steady state. Only, when the virgin forest is harvested, there is the loss of productive capacity that signifies a diminished level of natural capital. Hence, it is inappropriate to apply a user cost to an area in which natural regeneration has not been compromised (Sadoff, 1993).

There are several ways of estimating the "user cost" or foregone future benefits. Forests can be maintained in terms of land area, wood volume or value of timber resources. If a land area approach is adopted, one hectare (ha) of deforested land would need to be replaced with one hectare (ha) of plantation forests. This method was adopted in a study of the forestry sector in Thailand (Sadoff, 1993). However, the value of wood on a one-hectare (ha) plot of plantation forest may be greater than the value of wood on a one-hectare plot of natural forest. Thus reforesting on a hectare for hectare (ha) basis not only maintains the volume of commercial timber but also increases the value of commercial timber. This approach may lead to an over estimation of the "user cost" (Kellenberg, 1995).

A second option is to replace the net change in the value of timber resources with an equivalent value of forest plantations. This approach is adopted in a study of the Equadorian forestry sector (Kellenberg, 1995). However, the replacement of natural forest by forest plantation is not realistic as well. Natural forests are quite mixed and diverse in species composition and tree sizes. The rotation period for natural forests is usually higher than the plantation forests of fast growing species. The timber volume in plantation forests is much higher owing to the fast growing and high yielding species are planted. The growth and yield of plantation forest is at least 5-8 times higher than that of the natural forests. The Equadorian study also did not mention how to standardize this high variation of growth, yield and differences of their diameter sizes and their prices.

The present study estimated user cost using the species wise actual log production. The species wise stumpage prices (RM/m^3) for annual production of log was obtained using the real prices and average logging cost (1978 base year). The potential stumpage value was projected up to the second cutting cycle to capture potential benefits for the second cycle of the natural forest, where by after 1996 the next 30 year cutting cycle is taken into account based on the Selective Management System (SMS) assumption. The incorporation of the second cycle is necessary to capture the low productivity expected in the subsequent cycle. The total potential benefits foregone (opportunity cost) is then capitalized back to the year under consideration from 2026 to obtain the capitalized value. During this period, the occurrence of resource (forest) depletion is determined which is the portion of revenues, which would need to be set aside and reinvested each year to maintain the forest resource.

The capitalized value, which capitalizes future returns, is most commonly used method for valuing sustainable forest harvest (Klemperer, 1996; Manley and Bell, 1992; NZIF, 1996). For a forest, the estimation of the change in capitalized value from one period to the next relates largely to the time cost of money and the fact that an investor is one year closer to harvest. The value of the forest inventory at any point in time is based only on the expected returns at harvest and the waiting period.

$$CV_t = \sum_{t=m}^{n} \frac{SV_t}{(1+i)^{m-t}} \qquad [5.3]$$

Where CV is the sum of discounted flow of future net benefits (rents from forest resource) over t periods starting in period m and discounting at rate *i* (i.e. Capitalized value). The discount rate is assumed to be 6% based on the total productivity growth rate of Malaysia for 1996. Then capitalized value is thus estimated for 55 years until the end of the second cutting cycle after 1996. The difference between the present years capitalized value from the following year gives the "user cost." The formula is as follows

$$USC_{(t)} = CV_{(t)} - CV_{(t+1)} \qquad [5.4]$$

Where $USC_{(t)}$ is the user cost in year t;

$CV_{(t)}$ is the capitalized value in year t calculated as the discount sum of rents in year t until end of the second cutting cycle;

$CV_{(t+1)}$ is the capitalized value in year (t+1) calculated as the discount sum of rents in year (t+1) until end of the second cutting cycle.

The economic depreciation can be defined as the difference between two opposing forces: the realization of current resource rent, which decreases the capitalized value (depreciation tends towards a positive value) and shifting of discounted stream of future rent towards the present, which increases capitalized value (depreciation tends towards a negative value). Hence, the economic depreciation would be less than current resource rent. This may be interpreted as the value of depreciation (or appreciation) or the user cost.

In order to estimate an individual hectare (ha) of forest, the formula of capitalized value in perpetuity developed by Vincent (1997) was used: $VH(t) = (1+i)^{t-T} [pq(T) - C(q(T))] / [1-(1+i)^{-T}]$ (Equation 4.9 in Chapter Four). Where t was the current age of the forest and T is the harvest age that maximizes V(0). In this study, T was assumed 30 years under Malaysian Selective Management System (SMS): the forest is harvested every 30 years, with no intervening production. q(s) now represents both timber harvest and standing timber stock: all trees on the harvest are of the same age, and all standing timber is harvested at maturity. This expression assumes that land remains permanently in forest use.

Estimation of Resource Depletion by Net Price Method

In the present study, taking the national forestry inventory data as the benchmark, and intrapolating between two inventories, a time series physical account has been constructed. This account reflects the net change in the fully and partially harvestable timber resource on an annual basis accounting for any addition and reduction to natural forest stocks (as stated in the national forestry inventories). While additions arise from natural growth in forests, reductions arise from logging, damage to other trees during logging operations, clearance for agriculture and fire. The net change in the potential forest volume is valued at the stumpage price.

The physical yield from forestry resource is expressed in monetary terms as a resource value. The calculation of stumpage value is given by the formula [5.1] was used for estimation of forest resource depletion under net price method. In the following formula the growth of secondary forest and stock in the permanent forest area have been taken into account.

$$SV = (FOR_{PF} * Stock_{PF} * ANP) - (LP_i * NP_i) + (FOR_{SF} * \text{growth rate}) * ANP \qquad [5.5]$$

Where

SV = Stumpage value (RM)

FOR_{PF} (ha) = Primary forest opening area for the following year (ha).

$Stock_{PF}$ =Stock of primary forests i.e. the average stock (m^3/ha) from

NFI-1, NFI-2 and NFI-3.

ANP = Average net price (RM/m^3).

LP_i = Actual log production by species (m^3).

NP_i = Net price for the reported volume of annual log production by species (RM/ m^3).

FOR_{SF} = Secondary forest in the permanent forest reserves (ha).

ANP = Average net price (RM/m^3).

PF =Primary forest (ha).

SF = Secondary forest (ha).

The net price for plantation forest and rubber wood for given year is calculated as follows;

$$DNPPF = LP_{i\,t} - Pc_t * (1+r)^t - Hc_t * (1+r)^t - Wc_{t-m} * (1+r)^{t-m} - Tc_{t-n} * (1+r)^{t-n} - Pm_t. \qquad [5.6]$$

where

DNPPF = Discounted net price for plantation forest

LP_i = Log Price by species in current year

Pc = Plantation and establishment cost occurring in year 0

Hc = Harvesting Cost occurring in current year

Wc =Weeding Cost

Tc =Thinning Cost

Pm = Profit margin

t = the current year

m = The year for weeding

n = The year for Thinning

r = Discount rate

NPR = Lp- Hc- Pm [5.7].

Where

NPR = Net Price for Rubber Wood

Lp = Log Price

Hc = Harvesting Cost

Pm = Profit Margin

Weeding and thinning activities do not apply to rubber wood production. This is because rubber plantation establishment and maintenance are mainly done for latex production.

Projection for Second Cycle

A projection (natural forest) for the second cycle of the next thirty years is made, based on the following assumptions. The average annual change in real log price and logging cost has been calculated for the last 25 years (as shown in Figure 5 and Appendix B Table 30). The annual change in real logging cost and the annual changes in real log price are averaged at 1.21% and 4.56% respectively.

The high real log prices are not expected to continue hence dampening world log prices. Using the 1996 log price and logging cost as base, next 30 years log price and logging cost were projected to increase by 1% per year. Similarly, the log production was projected from average annual percentage change of the last 25 years (0.5%) taking the log production of the year 1996 as a base (see Appendix B, Table 30).

A projection for rubber resource (timber) accounting from the year 1997 to 2026 is made, corresponding to a second cycle projection for natural forest. The following assumptions are used in making a projection for the physical and monetary accounts for rubber timber resource.

The timber volume stock in the estate and smallholdings is assumed to increase 8.8 m^3/ha/year and 7.2 m^3/ha/year respectively (Naimah, 1993). The average annual percentage growth rates for new plantings, replantings and closing area for estates would be –20%, -2% and –5% respectively (Webb *et al.*, 1997). A similar decreasing trend would prevail for smallholdings such as new plantings, replanting and closing area would be 13%, 1.5% and 1% respectively.

The annual growth rate of real log price and logging cost is assumed to increase by 2.5% and 2% respectively during the projected period (*Naimah et al.*, 1993). A time series for real log price and logging cost is derived, calculating a simple growth rate by using 1997 price and cost as a base. This assumption is based on an annual increase of real logging cost (2.1%) over the last 17 years. The change in average log price over the 17 years was variable, and the average growth rate was –6% per annum. This may not be realistic for the future projection.

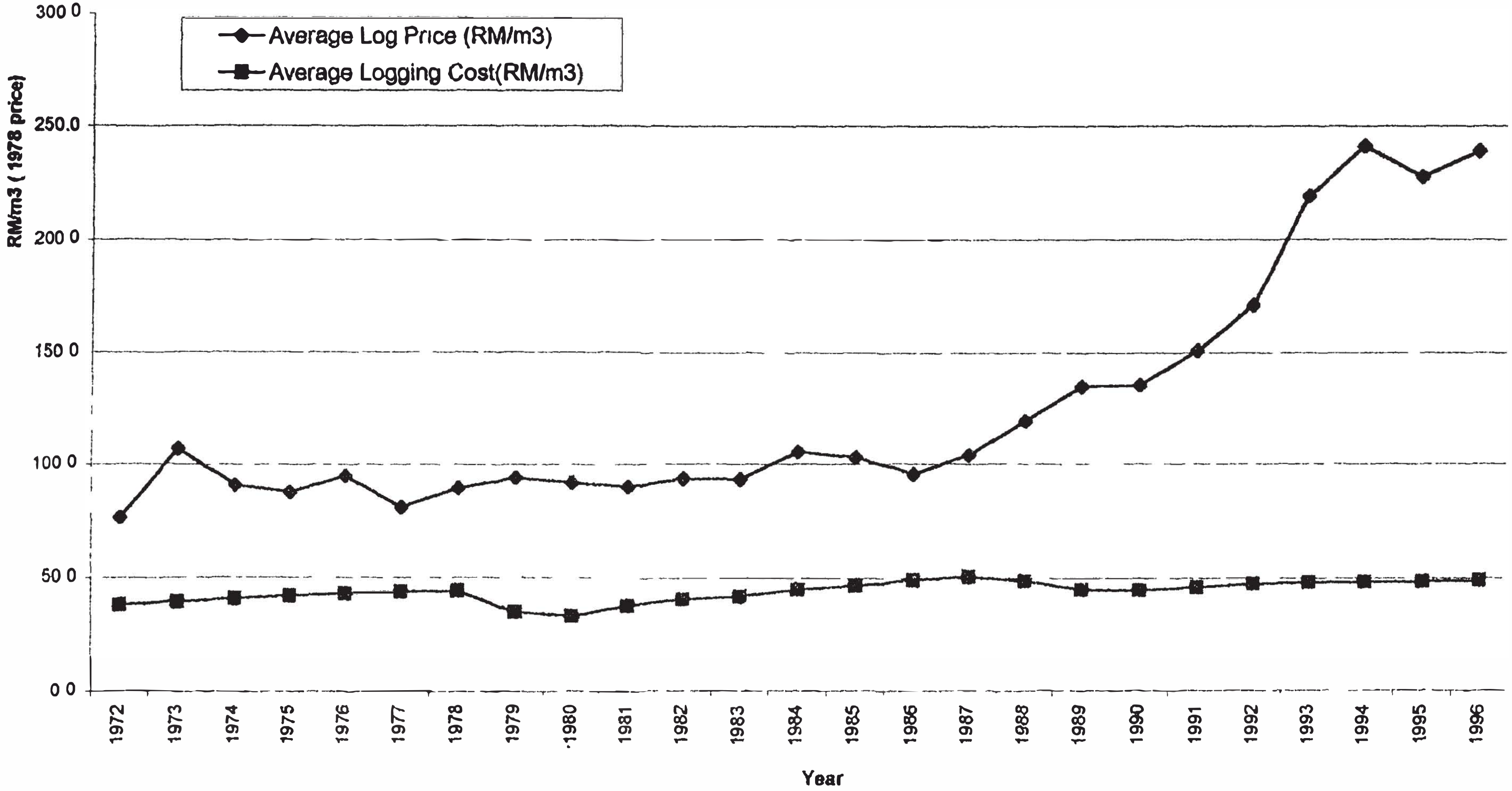


Figure 5: Average Log Price and Logging Cost for Natural Forest

Sensitivity Analysis

Considering the current economic downturn of the Southeast Asean economy any particular assumption would not be realistic. The contribution of natural forest is more than 98% of the whole in the forestry sector, as compared to plantation and rubber timber. The sensitivity analysis was conducted only for the projection of natural forest. The variation of price and cost was assumed at 0% change, 1% increase and 1% decrease and the discount rate was assumed to change at 4%, 6% and 8%.

Adjustment for Resource Depletion on GDP: User Cost Method

The measurement of Adjusted Gross Domestic Product (AGDP) is obtained by deducting user cost from GDP. Similarly Net Domestic Investment (NDI) is obtained by deducting physical capital depreciation from gross domestic investment. Adjusted Net Domestic Investment (ANDI) is calculated by subtracting user cost from net domestic Investment. The following formulae were used for adjusting GDP and Net Domestic Investment (NDI):

GDP = C+I

AGDP = GDP-User Cost

GDI = Gross Domestic Investment

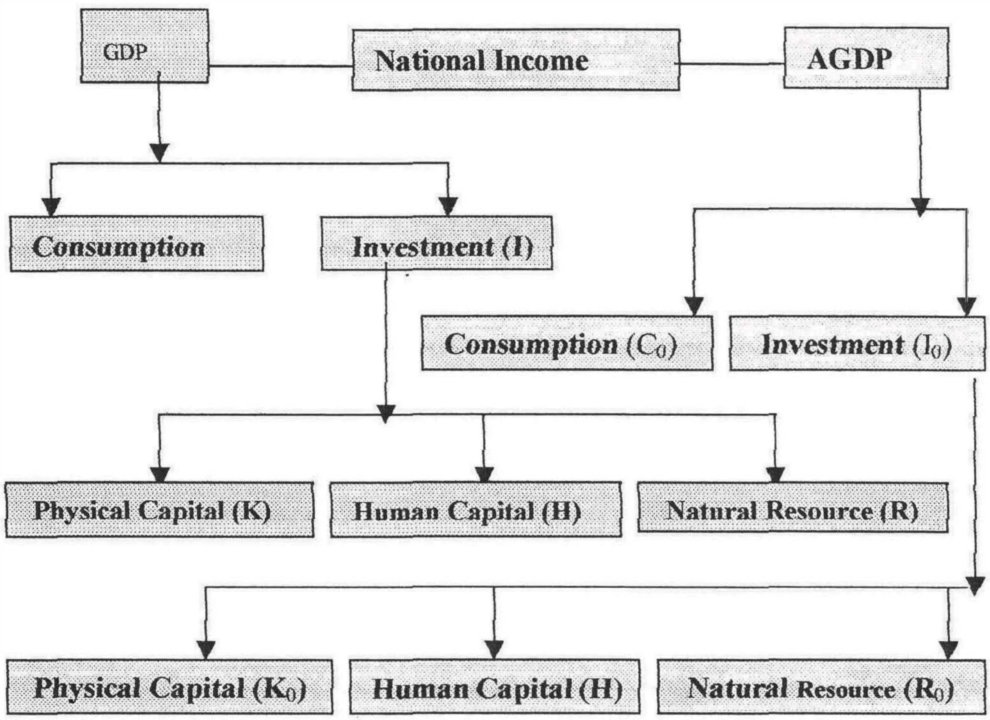
NDI = GDI-K

ANDI = NDI- User Cost

Where

GDP	=Gross Domestic Product
C	= Consumption
I	=Gross Investment
GDI	= Gross Domestic Investment
NDI	= Net Domestic Investment
K	= Depreciation of Physical Capital
ANDI	= Adjusted Net Domestic investment.

National account adjustment under the user cost method, where future benefits foregone or obtained have been taken into account can be depicted diagrammatically by a flow chart as follows:



where
GDP = C+I
AGDP = GDP-User Cost = (C_0+I_0)
Co = Consumption after from Adjusted Income
Ko = K-Depreciation of Physical Capital
Ro = R-User Cost i.e. Natural Capital after user is deducted

Figure 6: National Accounts Adjustment: User Cost Method

AGDP being less than GDP, this occurs only as long as the user cost is positive. When the user cost is negative, it means natural capital is appreciating, for example, the rate of growth of value for natural resource is greater than the rate of value of extracted renewable resources. In that case AGDP is greater than GDP. The increasing trend of AGDP over time indicates the sustainable growth of the economy. Conversely, adjusting with resource depletion, the declining AGDP over time indicates a unsustainable economic growth. There would be a similar corresponding impact on adjusted investment.

Adjustment for Resource Depletion on NDP: Net Price Method

The depletion of natural resources has great implication for Malaysia's long-run growth and its sustainability. In the case of net price method for adjusting national accounts, resource depletion is deducted from Net Domestic Product (NDP). In order to obtain Adjusted Net Domestic Investment (ANDI) resource depletion is to be subtracted from net domestic investment (i.e. ANDI= NDI-Net Price). This method is used to compare resource depletion adjustment with that of user cost method, which is more defensive method for estimating forest resource depletion. The net price method does not account for the future benefits foregone or obtained due to resource depletion.

When NDP is adjusted with net price, the increasing trend of adjusted NDP over time refers to sustainable economic growth. On the other hand, the declining trend of ANDP over time indicates the unsustainable economic growth. This applies to the case of adjusted investment as well. The following formulae are used for adjusting NDP and NDI:

NDP = GDP-DPC

ANDP = NDP-Net Price

ANDI = NDI-DNC

where

GDP =Gross Domestic Product

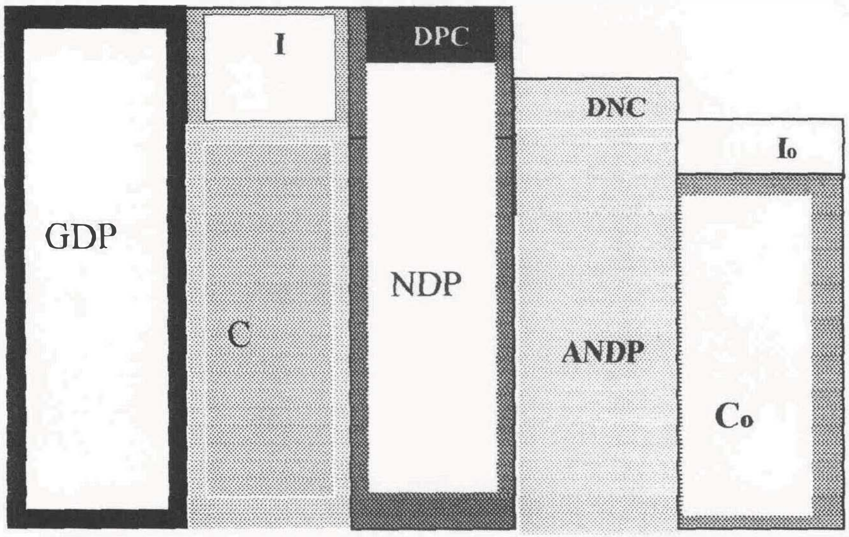
DPC = Depreciation of Physical Capital

NDI = Net Domestic Investment

ANDI = Adjusted Net Domestic investment.

DNC = Depletion of Natural Capital (Net Price)

Diagrammatically an adjustment of Net Domestic Investment (NDP) and Net Domestic Investment (NDI) using net price method is presented below.



where
GDP = Gross Domestic Product, Where GDP = C + I
I =Gross Investment
C =Consumption
NDP =Net Domestic Product, Where NDP = GDP-DPC
DPC =Depreciation of Physical Capital
ANDP = Adjusted Net Domestic Product, Where ANDP = NDP - DNC
DNC = Depletion of Natural Capital
Co =Consumption after Depreciation Adjustment
Io =Investment after Depreciation Adjustment
ANDP = Co + Io

Figure 7: National Accounts Adjustment: Depreciation Method

Source: Adapted from Stanley Fischer and R. Dornbusch (1988) by the author (1999)

In order to make national accounts adjustment the data for GDP and NDP Peninsular Malaysia and forestry sector data were obtained from the Annual Yearbook of Statistics Malaysia (1972-97). The data at national level fixed physical capital and consumption were obtained from the National Accounts Statistics (1972-97). Data for population of Peninsular Malaysia is also obtained from the Annual Yearbook of Statistics Malaysia (1972-97). The adjusted net investment was determined by subtracting physical capital depreciation and natural capital depletion from the physical capital (gross fixed capital formations). The data on depreciation were obtained from the Department of Statistics' Annual Report of the Financial Survey of Limited Companies (1972-97).

Sustainability Measure

A new measure of economic sustainability, formulated by Davis Pearce, offers a warning regarding the nation's future (Pearce and Atkinson 1993b). The weak sustainability refers to the case where the assumption of perfect substitutability is considered. The Pearce-Atkinson measure (PAM) is defined as

$$PM = \left(\frac{S}{Y}\right) - \left(\frac{\partial M}{Y}\right) - \left(\frac{\partial N}{Y}\right)$$

where

S = Savings

Y = National income

M =Reproducible capital

N = Natural capital

δ = Depreciation

Pearce's indicator of sustainability plots the value of natural capital depletion (forestry) against net savings with each of the two magnitudes expressed as a percentage of GDP. Net savings refer to the amount available for domestic investment after adjustment has been made for depreciation of fixed physical capital in Peninsular Malaysia. Pearce defines the 45^0 line as an indicator of marginal or "knife-edge" sustainability (where net savings equal natural capital depreciation). The data for national income, savings, reproducible capital were obtained from Annual Yearbook of Statistics, Malaysia (1972-97).

World Bank (1995) reported a similar measure of economic sustainability known as "genuine savings". This can defined as follows:

$$GS = GDP - (PC_b + PC_p + Km_d + Kn_d)$$

where

GS = Genuine savings

GDP = Gross domestic product

PC_b = Public consumption

PC_p = Private consumption

Km_d =Physical capital depreciation

Kn_d =Natural capital depreciation.

This measure is computed as GDP minus the sum of public and private consumption, physical capital depreciation and natural capital depreciation. The "genuine savings" indicator serves as a measure of the efforts to create new wealth (World Bank, 1995b; Kellenberg, 1995). Although an optimal level of "genuine savings" for developing nations is not provided, negative "genuine savings" indicate that the economy is in unsustainable path. The data for GDP, public, private consumption was obtained from Annual Yearbook of Statistics, Malaysia (1972-97). The data on depreciation were obtained from the Department of Statistics' Annual Report of the Financial Survey of Limited Companies (1972-97).

CHAPTER VI

EMPIRICAL ANALYSIS: RESULTS

Taking the national forestry inventory data as benchmark, and interpolating between two inventories, a time series physical account have been constructed. This account reflects the net change in the fully and partially harvestable timber resource (as mentioned in national forestry inventories) on an annual basis accounting for addition and reduction to natural forest stocks. (Appendix C, Table 31).

The additions arise from natural growth in the logged over forests (column 5 logged over opening area) and through new gazettment of forestland. The reductions arise from conversion of forestland through logging and clearance for agriculture and degazettment of permanent forest during the study period (column 13 net change in the permanent forest). A detail accounts for physical stock and economic depreciation of forest resource of Peninsular Malaysia is presented below.

Physical Accounts of Forest Resource

Area Accounts

The natural forest contributes about 98% of the total timber supply to the economy. There are two main factors responsible for declining the forest resource stock. One is the extraction of forest stock exceeding its regeneration. The other is conversion of forestland for agriculture and other development activities such as urbanization and construction. During the study period (1972-96) it is observed that natural forest declined about 30% from 8.2 million ha in 1972 to 5.7 million ha in 1996 (Figure 8).

Rubber holdings area also declined over time but less rapidly than that of natural forests as observed from Figure 8. Rubber area declined about 18% from 1.7 million ha in 1980 to 1.4 million ha in 1996. This was due to conversion for other agricultural purposes such as oil palm plantation.

On the other hand, the area for plantation forest showed an increasing trend from 3 thousand ha in 1983 to 35 thousand ha in 1996. This is because of compensatory forest plantation programme during the study period (Table 14).

Stock Accounts

To examine the physical depletion of natural forest resource of Peninsular Malaysia closing stock accounts of its timber resources is computed. Like the area accounts, a similar declining trend of timber stock is also observed (Figure 9). Conversion of forest land for agricultural and other development activities and other excessive logging caused timber stocks to decline 33% from 547.2 million m^3 in 1972 to 368.3 million m^3 in 1996.

There are two kinks in the declining trends of the closing stocks between 1981-82 and 1992-93. These two periods resemble the beginning of second and third national forestry inventory. The second national forestry inventory reported a lower per hectare resource stock than the first national forestry inventory. While the third national forestry inventory showed a higher per hectare resource stock than the second national forestry inventory. There is clear declining trend in the resource stock over the study period (1972-96) due to decline in the forest area as shown in Figure 9 (Appendix C Table 31a).

Figure 9 also showed that rubber wood stock declined over time from 234.1 million m^3 in 1980 to 188.0 million m^3 in 1996. This was also because of declining rubber holdings area for other development purposes as shown in Table 14.

Conversely, the timber stock for plantation forest increased during the study period (Table 14). This is due to an expansion of compensatory plantation area and increasing growth of newly plantation forest.

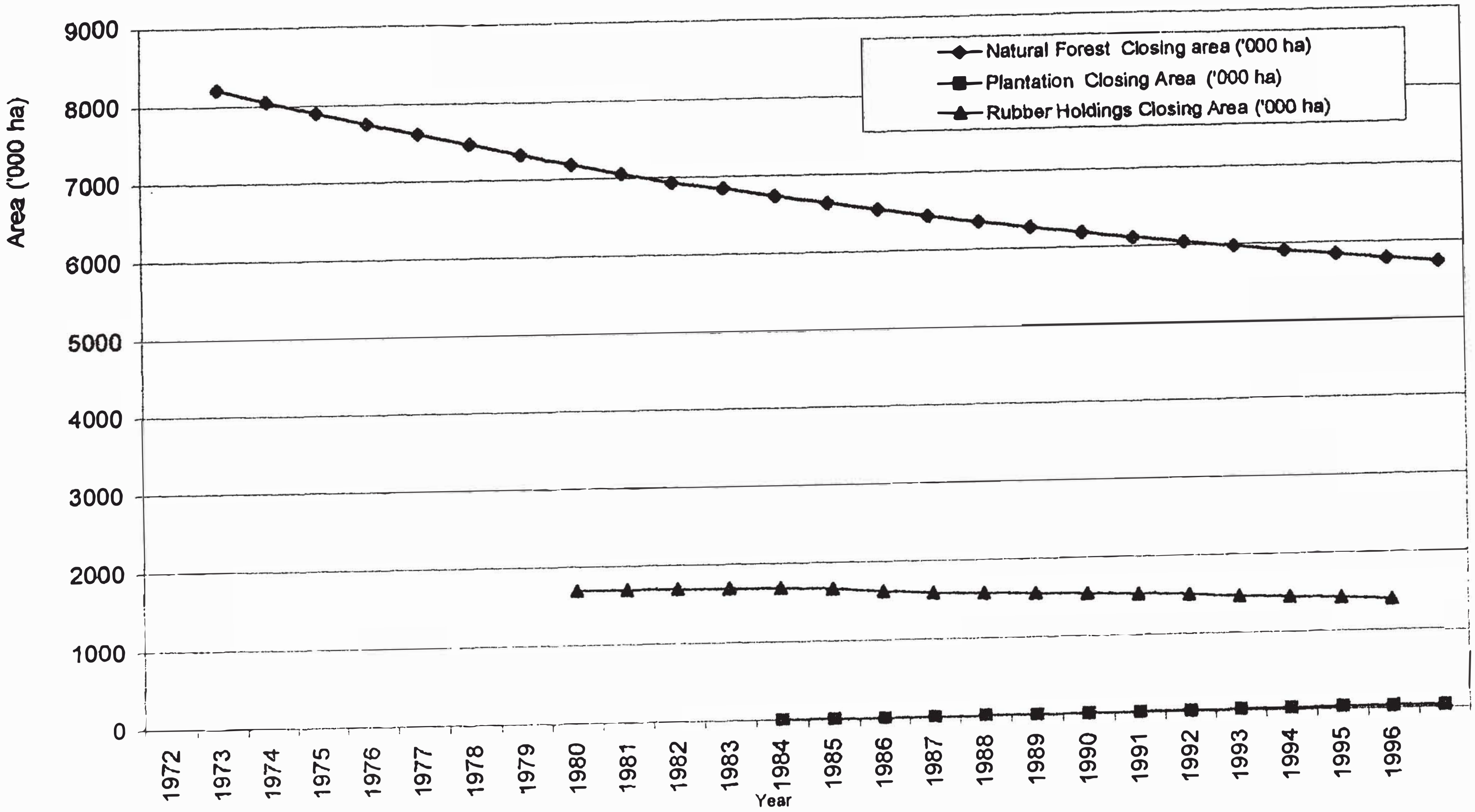


Figure 8: Closing Area of Forest in Peninsular Malaysia

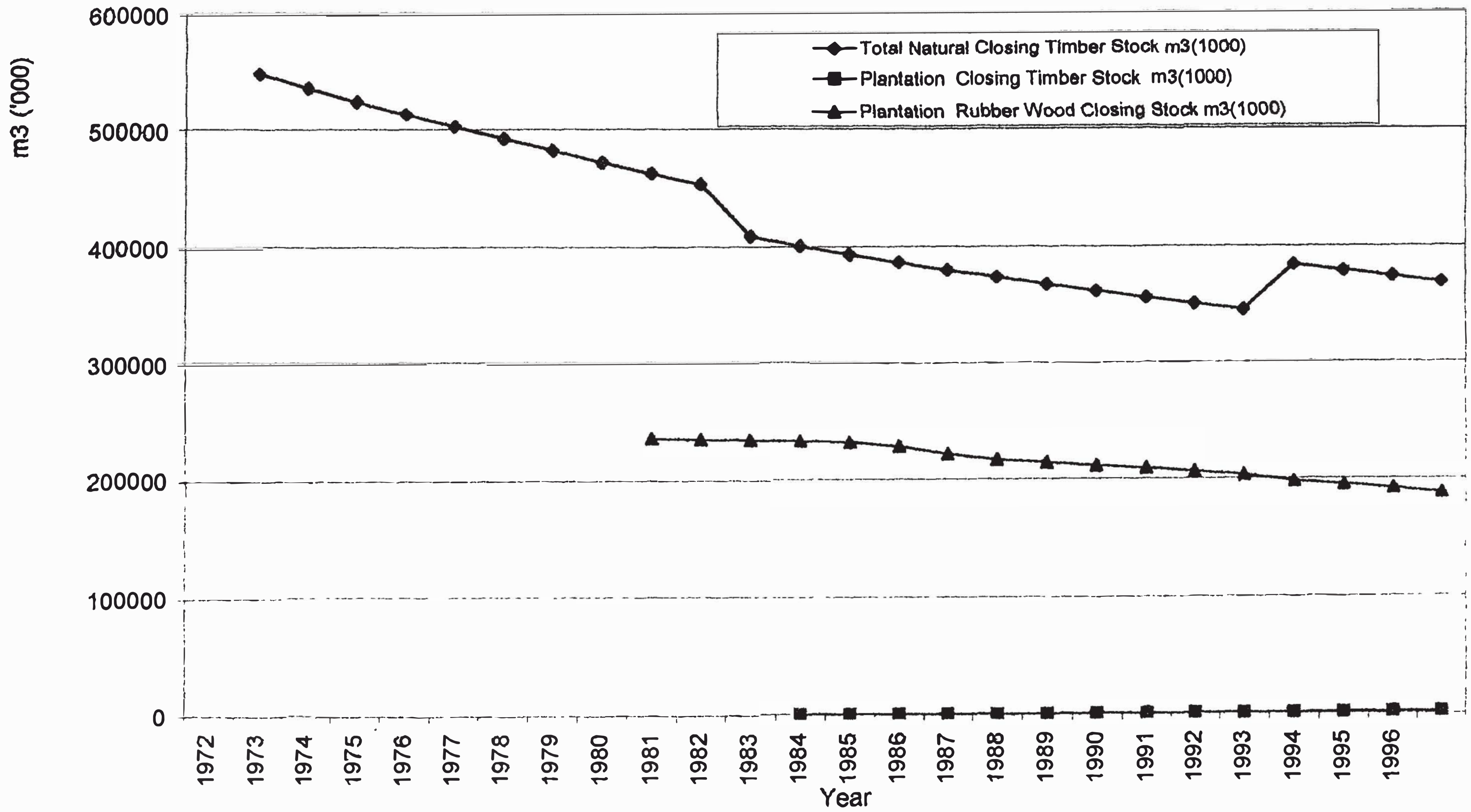


Figure 9: Closing Stocks of Forest Resource in Peninsular Malaysia

Table 14: Physical Accounts of Forest Resource of Peninsular Malaysia

	Natural Forest Closing area	Total Natural Forest Closing Timber Stock	Plantation Forest Closing Area	Plantation Forest Closing Timber Stock	Rubber Holdings Closing Area	Rubber Wood Closing Stock
Year	('000) ha	m^3('000)	('000 ha)	m^3('000)	('000) ha	m^3(000)
1972	8211	547183				
1973	8053	535626				
1974	7900	524366				
1975	7750	513397				
1976	7604	502710				
1977	7461	492299				
1978	7322	482155				
1979	7187	472271				
1980	7054	462639			1697	234128
1981	6925	453254			1696	233547
1982	6845	408375			1693	232821
1983	6737	400661	0	0	1691	232445
1984	6635	393237	0	3	1685	231095
1985	6537	386134	1	9	1663	227527
1986	6444	379340	2	28	1618	220961
1987	6355	372845	3	63	1586	216344
1988	6270	366638	6	118	1569	213841
1989	6190	360709	12	239	1551	211212
1990	6113	355048	15	395	1536	208972
1991	6041	349646	19	580	1517	206102
1992	5972	344493	24	821	1500	203473
1993	5906	383779	29	1112	1461	197643
1994	5844	378368	32	1432	1442	194858
1995	5786	373214	34	1764	1420	191618
1996	5730	368308	35	2072	1395	188021

Source: Appendix C Table 31a.

Natural Forest Accounts: User Cost and Net Price Method

As discussed earlier that the user cost shows the future benefits foregone or gained due to resource depletion. The second cycle projected (1997-2026) benefits foregone have been capitalised back, in order to examine the effects of forest resource depletion of the current period. Following the Malaysian Selective Management System (SMS) assumption, a 30 year's cutting cycle is assumed for the present study.

The trend of user cost under the scenario of 1% price and cost increase and at 6% discount rate showed that the user cost was negative all the way for the last 25 years, signifying the appreciation of resource value.

Observing the micro trend with in the period it is found that in the early 1970s the user cost was high because of the higher extraction of logs. With the reduction in log production into the second half of the 1970s and the 1980s owing to the introduction of log export restrictions, the user costs declined further. Despite the total log export ban, from the year 1986 onward the user cost started to increase till the year 1993 where it became positive because of economic expansion and the growing demand from the wood processing industries. From the year 1994 again the user cost started to decline and remained negative to the year 1996 as shown in Figure 10 and Table 15.

Considering the present economic situation sensitivity analysis have been conducted. Two other scenarios for log price and logging cost changes have been simulated at 0% change and 1% decrease in the price and cost. For each of the price and cost change scenario, two different discount rates have been simulated at 4% and 8%.

Similar trends were observed in the case of the other two scenarios with no change in price and cost and at 1% decrease in the price and cost using all three discount rates as shown in Table 15 and 16 respectively. From the different discount rate scenarios, it is observed that the lower the discount rates the higher the depletion of resources over the years.

The net price method accounts for the benefits foregone or obtained for the current period due to resource depletion. Unlike the net price method, the user cost method takes into account the current benefits foregone or gained due to resource depletion. In order to make a comparison with the results of user cost method, forest resource depletion is estimated applying the net price method. The resource depletions estimated were negative for five years over the study period, particularly in 1976, 1978 and 1991 when the resource values appreciated because of higher addition into the permanent forest reserve through new gazettement and lower conversion of forestland. Conversely, due to the higher conversion of permanent forest and log production resulted in higher value of resource depletion for the years of 1977, 1980, 1983 and 1990 onward as shown in Figure 11 (Appendix C Table 31). The price change is another factor responsible for resource value to vary (Appendix B Table 30).

The above findings exposed the limitations of the net price method by ignoring the future benefits foregone or obtained. Thus the net price method provides an improper indicator of resource depletion.

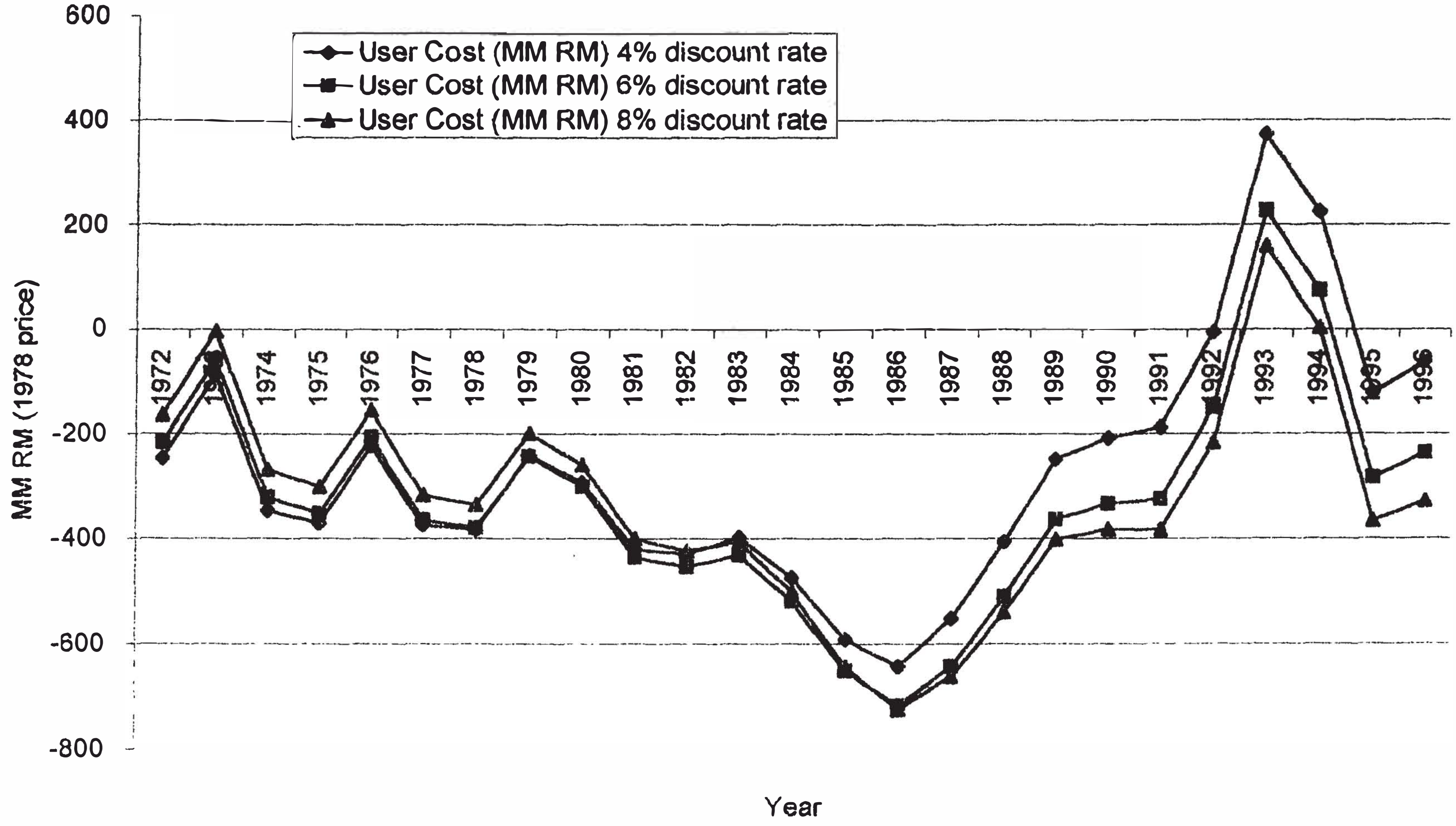


Figure 10: User Cost for Natural forest at 1% Projected increase in Cost and Price

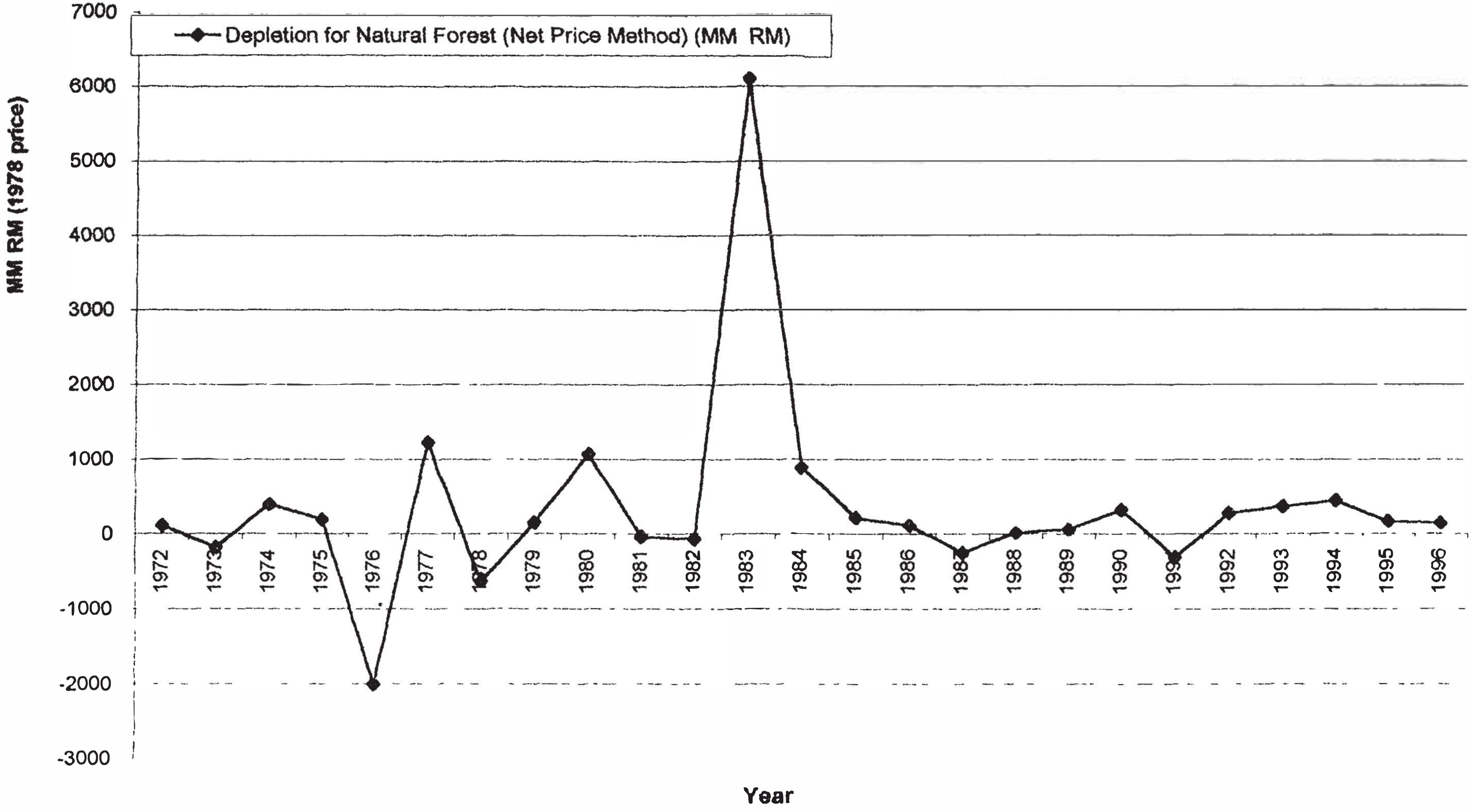


Figure 11: Depletion for Natural Forest (Net Price Method)

Table 15: User Cost for Natural Forest at Projected 1%increase of Price and Cost under 3 Rates of Discount

Year	User Cost (MM RM) 4% discount rate	User Cost (MM RM) at 6% discount rate	User Cost (MM RM) 8% discount rate
1972	-292	-247	-183
1973	-137	-93	-26
1974	-397	-357	-291
1975	-423	-389	-325
1976	-277	-246	-182
1977	-431	-407	-345
1978	-442	-425	-366
1979	-303	-290	-232
1980	-357	-351	-295
1981	-487	-490	-439
1982	-499	-511	-466
1983	-470	-492	-452
1984	-550	-584	-552
1985	-670	-718	-698
1986	-723	-789	-781
1987	-637	-719	-724
1988	-494	-591	-608
1989	-340	-448	-475
1990	-303	-424	-460
1991	-287	-420	-468
1992	-108	-252	-308
1993	267	119	61
1994	114	-40	-104
1995	-237	-404	-481
1996	-182	-364	-453

Table 16: User Cost for Natural Forest at Projected 0% price and Cost Changes under 3 Rates of Discount

	User Cost	User Cost	User Cost
	(MM RM)	(MM RM)	(MM RM)
Year	4% discount rate	6% discount rate	8% discount rate
1972	-245	-216	-164
1973	-89	-59	-4
1974	-346	-321	-268
1975	-370	-351	-301
1976	-222	-206	-155
1977	-374	-364	-316
1978	-383	-380	-335
1979	-241	-242	-199
1980	-293	-300	-259
1981	-421	-437	-400
1982	-429	-454	-423
1983	-398	-432	-406
1984	-475	-520	-502
1985	-592	-651	-644
1986	-642	-717	-723
1987	-552	-643	-661
1988	-407	-510	-540
1989	-249	-363	-402
1990	-208	-333	-382
1991	-188	-325	-383
1992	-5	-150	-216
1993	373	227	160
1994	225	74	3
1995	-121	-284	-366
1996	-62	-235	-328

Table 17: User Cost for Natural Forest at Projected 1% Decrease of Price and Cost under 3 Rates of Discount

Year	User Cost (MM RM) 4% discount	User Cost (MM RM) 6% discount rate	User Cost (MM RM) 8% discount rate
1972	-198	-184	-144
1973	-40	-26	17
1974	-295	-286	-245
1975	-318	-314	-276
1976	-167	-166	-128
1977	-317	-322	-287
1978	-324	-335	-304
1979	-179	-195	-165
1980	-229	-250	-222
1981	-354	-383	-360
1982	-360	-398	-381
1983	-326	-372	-360
1984	-400	-456	-452
1985	-513	-583	-590
1986	-561	-646	-666
1987	-468	-567	-599
1988	-319	-430	-473
1989	-157	-278	-329
1990	-113	-243	-303
1991	-89	-229	-298
1992	97	-49	-125
1993	480	335	259
1994	336	188	110
1995	-6	-163	-250
1996	58	-107	-203

Plantation Forest Accounts: User Cost and Net Price Method

As discussed earlier user cost accounts for benefits foregone or obtained due to resource depletion. For plantation forest the calculation of user cost showes that it appreciated during the initial years as the plantations are adding biomass. This can be seen by negative values as shown in Figure 12 (Table 18). In absolute terms, this appreciation increased in the first cutting cycle years (1983-98) as no biomass is extracted and timber is harvested from mature stands only. Growth in the remaining stands and new replanting have added timber biomass to replace harvested stands. Theoretically had planting and harvesting areas been equal, it is expected that the rates of depletion to be constant and zero. Annual plantings in Peninsular Malaysia were not equal owing to delays in work contract approvals. The higher value of depletion relative to natural forest is because of higher cost of plantation establishment, maintenance and relatively lower logs prices than that of natural forest.

For comparison, applying the same assumptions of user cost, the resource depletion is calculated under the net price (depreciation) method. The net price method does not take into account the future benefits foregone or obtained due to resource depletion. But like the natural forest the different valuation methods gave different results for resource loss. The measure of resource depletion is shown in Figure 13 (Table 18). The annual resource loss initially was negative but gradually became positive over time.

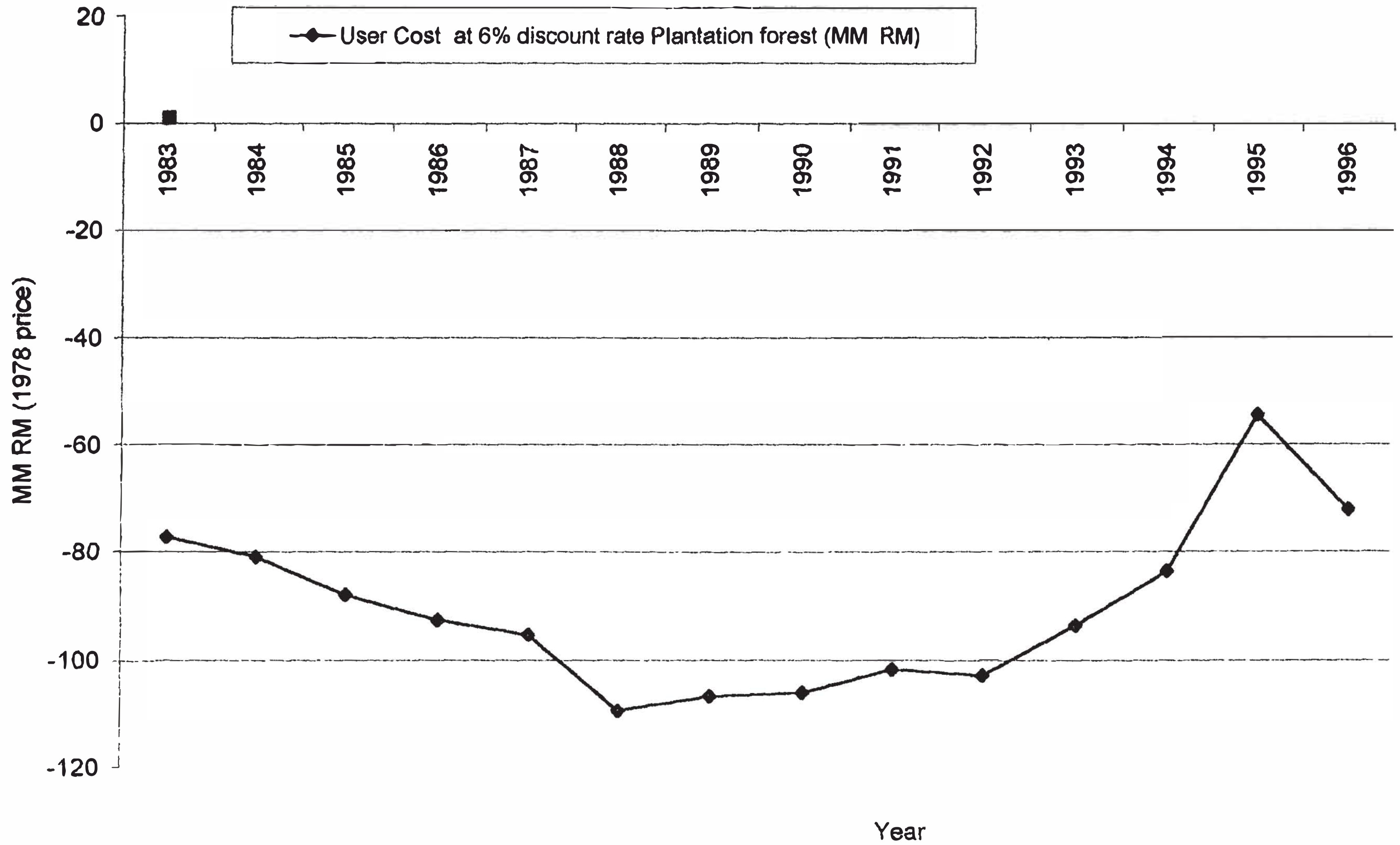


Figure 12: User Cost for Plantation Forest

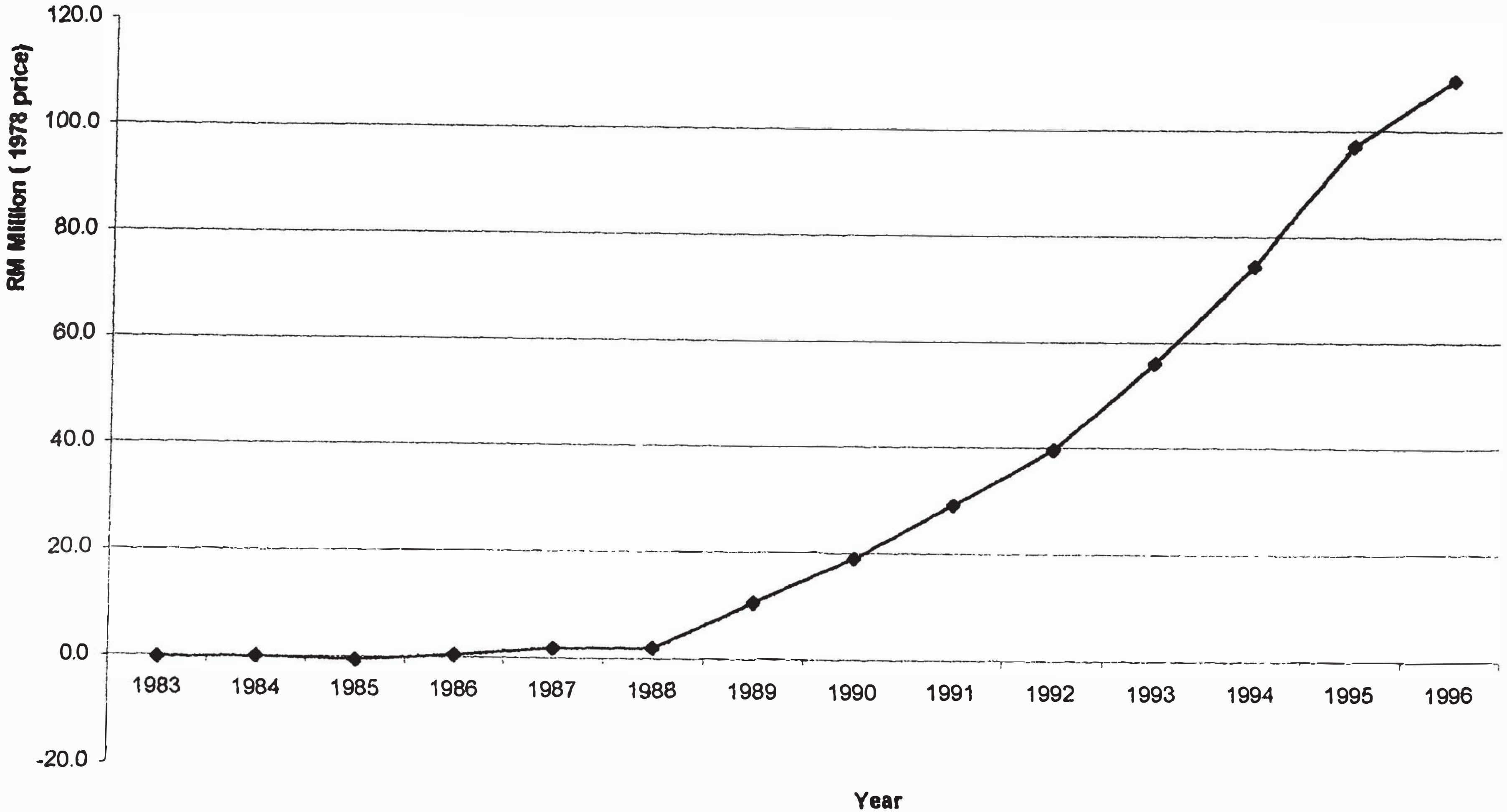


Figure 13: Depletion of Plantation Forest (Net Price) Method

Table 18: Plantation Accounts for Peninsular Malaysia

year	Harvestable Area (ha)	Cumulated Planted Area (ha)	Timber Harvested (m^3)	Cumulated Timber Stock (m^3)	Total Rent RM MM	User Cost RM MM	Ratio: User cost to Total Rent
1983	0.0	0	0	0	-0.2	-77	346.22
1984	0.0	299	0	3,004	0.0	-81	2134.94
1985	0.0	552	0	8,549	-0.6	-88	150.36
1986	0.0	1,916	0	27,795	0.4	-93	-218.17
1987	0.0	3,487	0	62,821	1.9	-95	-50.80
1988	0.0	5,515	0	118,218	2.0	-109	-54.23
1989	0.0	12,049	0	239,248	10.6	-107	-10.05
1990	0.0	15,472	0	394,661	19.0	-106	-5.58
1991	0.0	18,500	0	580,491	29.1	-102	-3.49
1992	0.0	23,952	0	821,085	39.6	-103	-2.60
1993	0.0	28,926	0	1,111,644	56.0	-94	-1.67
1994	0.0	31,938	0	1,432,459	74.6	-84	-1.12
1995	272.0	33,830	41,004	1,764,081	97.1	-54	-0.56
1996	230.0	34,947	34,670	2,071,875	109.5	-72	-0.66

Rubber Resource Accounts: User Cost and Net Price Method

It is discussed earlier that user cost measures the benefits foregone or obtained due to resource depletion. From the calculation of rubber wood depletion, it was observed that the exception of 1992, the user cost during the initial years from 1980-95 was negative after which it started to be positive and rising.

Prior to 1995 rubber holdings were replanted after timber harvesting when the trees matured. But in the second half of the nineties much old rubber holding were converted to the planting of oil palm and converted to other development projects. The user cost thus appreciated beginning 1995 as shown in Figures 14 and Table 19.

The net price method does take into account the benefits foregone due to resource depletion. In the net price (depreciation) method, the same assumptions are incorporated as used for the calculation of the user cost. But the calculation of net price yielded different results, because of methodological differences as shown in Figure 15 and Table 19. Figure 15 shows that the resource loss increased over the period, which is the reverse of the result of user cost. This again confirmed the reliability of the user cost method.

Prior to 1995 the timber asset value of rubber holdings was appreciating. After 1996 it depreciates. The annual rents realized from timber production still exceeded additions to the stocks. Overall, several conclusions can be made of the rubber resource in Peninsular Malaysia:

(a) Annual real rents grew throughout the eighties and nineties as utilization of rubber log in the wood based industries increased.

(b) Beginning the middle of the eighties, the rate of depletion in rubber resource stocks rose steadily as land areas planted with rubber declines. Consequently, the proportions of annual depletion over annual rent have grown.

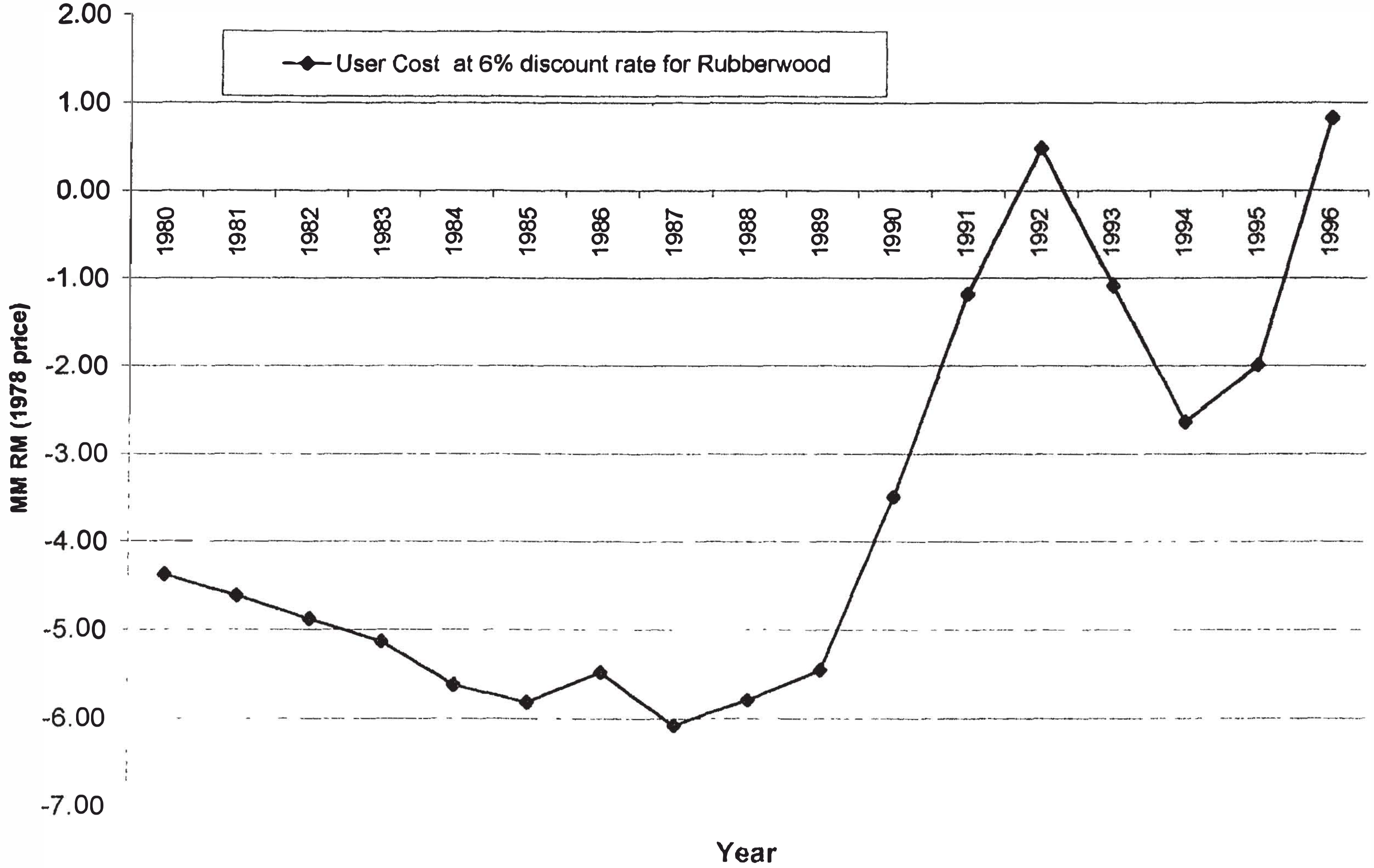


Figure 14: User Cost for Rubberwood

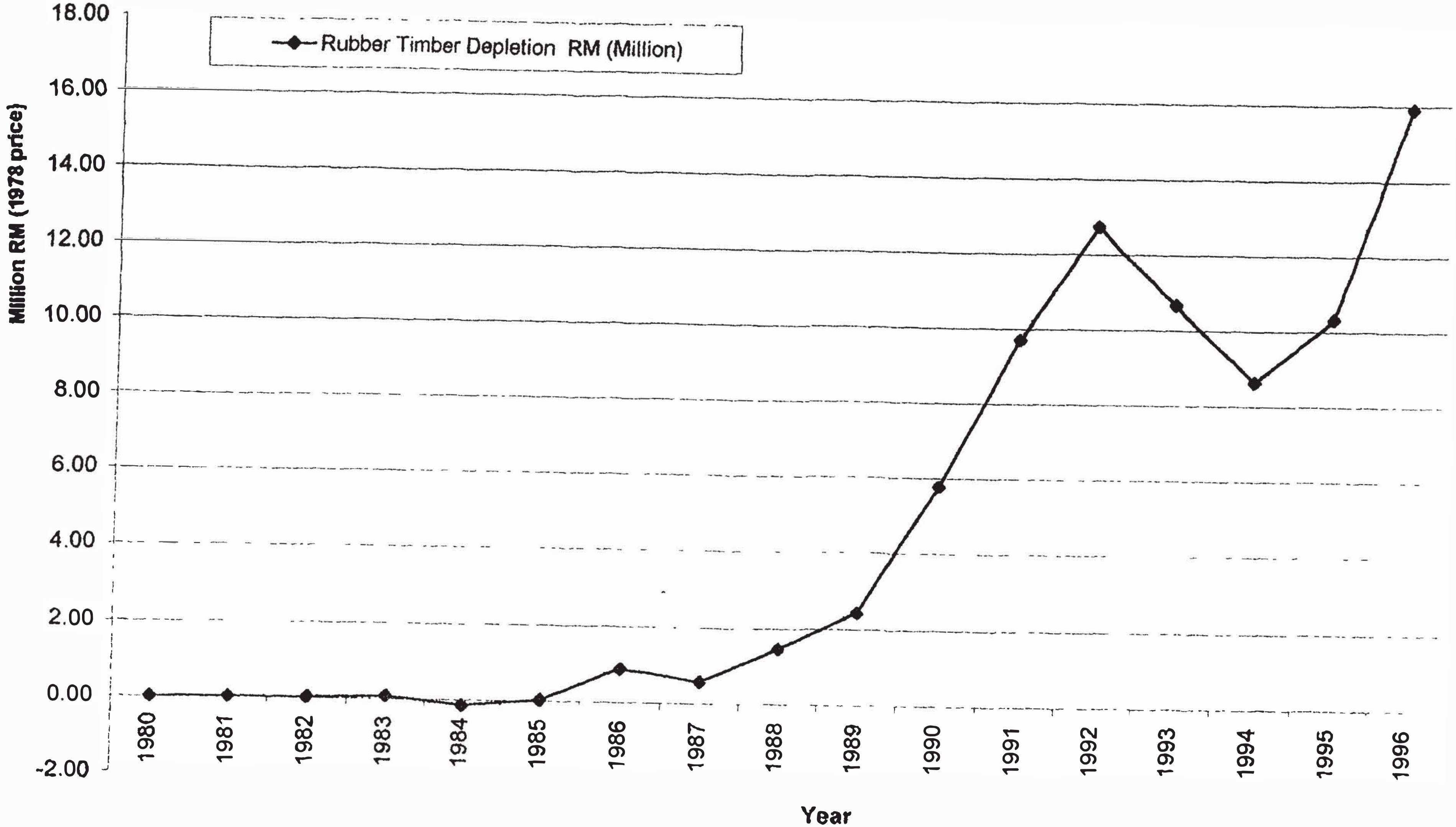


Figure 15: Rubber Wood Depletion (Net Price) Method

Table 19: Rubberwood Accounts for Peninsular Malaysia

Year	Closing Area (Thou ha)	Closing Stock Thou m³	Harvest Thou m³	Total Rent MM RM	User Cost MM RM	User cost to Total Rent
1980	1697	234128	3	-0.01	-4.38	846
1981	1696	233547	10	0.02	-4.61	-231.3
1982	1693	232821	30	0.04	-4.87	-128.4
1983	1691	232445	101	0.08	-5.13	-62.7
1984	1685	231095	400	-0.13	-5.63	42.6
1985	1663	227527	595	0.04	-5.82	-154.5
1986	1618	220961	696	0.87	-5.48	-6.3
1987	1586	216344	898	0.57	-6.07	-10.6
1988	1569	213841	1274	1.45	-5.79	-4.0
1989	1551	211212	1166	2.44	-5.46	-2.2
1990	1536	208972	1300	5.77	-3.50	-0.6
1991	1517	206102	1543	9.70	-1.18	-0.1
1992	1500	203473	1867	12.72	0.48	0.0
1993	1461	197643	1667	10.66	-1.09	-0.1
1994	1442	194858	1358	8.62	-2.64	-0.3
1995	1420	191618	1550	10.32	-1.99	-0.2
1996	1395	188021	1550	15.91	0.83	0.1

CHAPTER VII

INCORPORATING NATURAL CAPITAL DEPLETION INTO THE SYSTEM OF NATIONAL ACCOUNTS (SNA)

The Malaysian economy was growing rapidly during the last three decades because of a stable political system and generously endowed natural resources that provide a special advantage in economic development. Natural resources like forestry have been and continue to be economically important in Malaysia, but their physical natural stocks are declining over the last two decades. Therefore an adjustment for forest resource depletion (user cost) is made on the national income accounts of Peninsular Malaysia. In order to make a comparison, Net Domestic Product (NDP) is also adjusted with resource depletion computed by applying net price method.

Adjustment For Resource Depletion: User Cost Method

The user cost approach explicitly separates capital consumption from recorded income and production to isolate a true sustainable income stream. The premise of this approach is that revenues from resource based activities include a component, which represents the final sale of a natural asset, a component that is not value-added, rather disinvestment.

In the case of renewable resources like forestry, El Serafy (1989) suggests that future income stream can be maintained by replacing resources removed in each period. This replacement cost should be charged against current income as a user cost. Where maintenance fails to occur, the costs that would have been incurred in doing so should be imputed and excluded from Gross Domestic Product (GDP).

Per capita income is one of the important criteria for measuring the welfare. Despite the higher growth rate of the GDP (7.27%) than that of Adjusted Gross Domestic Product (AGDP) (7.19%) for the last 25 years, the average per capita AGDP was found to be increasing over the study period from RM 2,697 in 1970s to RM 5,686 in 1990s as demonstrated in Table 20. This indicates that the welfare of the economy increased over the study period.

Table 20: Average Per Capita Real GDP and AGDP

Income/ Year	1972-80 (Real) RM Per capita	1981-90 (Real) RM Per capita	1991-96 (Real) RM Per capita	Annual Average (1972-96)
GDP	2664.06	3572.84	5675.39	3750.3 (7.27%)
AGDP	2697.16	3619.18	5686.02	3783.3 (7.19)

Source: Estimated from Table 35 (Appendix D)

The Thai (Sadoff, 1993) and Equadorian (Kellenberg, 1995) studies adjusted aggregate GDP with user cost in order to measure sustainability of the economy. Unlike Malaysia, the Thai study found, the AGDP significantly lower than the GDP. The Equadorian study found a slight declining trend in AGDP during the period 1973-83. But their over all trend of aggregate AGDP increased over time, indicating the sustainability of the economy. Similar adjustment is also made in the UN studies such as Mexico.

Adjustment for Resource Depletion: Net Price Method

For a comparison, an adjustment of national accounts with net price method is presented. With the net price Peninsular Malaysia experienced slower Adjusted Net Domestic Product (ANDP) growth rates from 9.2% in 1973 to 8.5% in 1996 than that experienced by conventionally measured Net Domestic Product (NDP) from 9.8% to 8.5% for the same period. This can be attributed to the depletion of the forest resource during the period.

The average annual growth rates of GDP, NDP and ANDP are shown in Table 21. In the late 1970s the growth rate of ANDP was lower (6.64%) than that obtained by GDP (6.89%) and NDP (6.81%). The average growth rate of ANDP in 1980s became higher (6.36%) as compared to NDP (5.80%) because of the lower log production during the early part of this decade and due to economic depression in 1985-86. Thus there was a decrease in the value of forest resource loss that resulted in the appreciation of the growth rates of ANDP over the decade. But once the trend of ANDP is compared between two decades, the average growth rate of ANDP in the 1980s could not maintain with that in the 1970s, suggesting that the economy was not sustainable.

The increased log production along with price appreciation led to the value of resource depletion to be higher in 1990s. Despite higher resource depletion the growth rate of ANDP increased over the decade as compared to the previous decade from 6.36% in 1980s to 10.70% in 19990s, reflecting the economic sustainability. The over all average annual growth rate of ANDP over the last 25 years maintained an increasing trend (7.38 %) that showed that the economy was sustainable.

Table 21: Average Annual Growth Rate of Real GDP, NDP and ANDP

Income/ Year	1972-80 Change in %	1981-90 Change in %	1991-96 Change in %	Average Annual % Change (1972-96)
GDP	6.89	6.07	9.77	7.27
NDP	6.81	5.80	10.01	7.19
ANDP	6 64	6.36	10.07	7.38

Source: Estimated from Table 32 (Appendix D)

As discussed for the user cost method, per capita income is one of the most important criteria for welfare measurement. When depletion of forest resource is measured using net price (depreciation) method and adjusted with conventional NDP, it shows that the average per capita ANDP decreased as against the average per capita NDP during the study period in Peninsular Malaysia as demonstrated in Table 22. But the trend of average per capita ANDP over time increased from RM 2,583 in 1970s to RM 5,305 in 1990s suggesting that the welfare of the country increased over the study period.

Table 22: Average Annual Per Capita Real NDP and ANDP

Income/ Year	1972-80 Real RM Per capita	1981-90 Real RM Per capita	1991-96 Real RM Per capita	Annual Average (1972-96)
NDP	2585	3414	5322	3574
ANDP	2583	3355	5305	3545

Source: Estimated from Table 33 (Appendix D).

A similar increasing per capita ANDP was found in another study (Vincent *et al.*, 1997) for the period 1970-90, whereby ANDP grew 3.4% per year as against 3.8% increase of GDP per year for Peninsular Malaysia. The Equadorian (Kellenberg, 1995) and Thai studies (Sadoff, 1993) also found the trend of aggregate ANDP to increase over time. But in Equador a significant depletion of natural capital took place between 1973-83 and new discoveries of oil led to natural capital appreciation in the mid-1980s. Despite these new discoveries, the trend of ANDP declined after 1987 onward. The Indonesian study found that the trend of ANDP declined in the early 1970s, it started to increase afterwards having a wide margin with GDP increase.

Adjusted Net Domestic Investment (ANDI): User Cost and Net Price Method

In order to put Hartwick's Rule into practice the present study examines the status of net investment in the country. The trend of gross physical investment and user cost of Peninsular Malaysia is shown in Figure 16.

From Figure 16 it is observed that user cost as against the gross fixed investment (national) was also negative over time, signifying that the user cost as a percentage of gross domestic investment appreciated. This varied from –6.24% of gross domestic investment in 1972 to –0.52% in 1996 (see Appendix D, Table 28). This implies that resource rent is very important for sustainability with respect to investing it in reproducible capital, which is financed from all sources of natural resource exploitation. This investment should be at least as large as the capital value of resource depletion.

The trend of resource depletion under the net price method and gross investment is shown in Figure 17. In the Figure, it is observed that gross investment in 1987 declined. Gross fixed investment increased during the rest of the period.

From Figure 17 it is observed that the loss of resource rents also remained unchanged over the study period (1972-96) with a high decreasing trend in 1976 and substantial increasing in the year 1983. Thus the resource rent under net price (depreciation) method as a percentage of total gross investment declined from 2.24% in 1972 to 0.60% in 1996 for the economy (see Appendix D, Table 36).

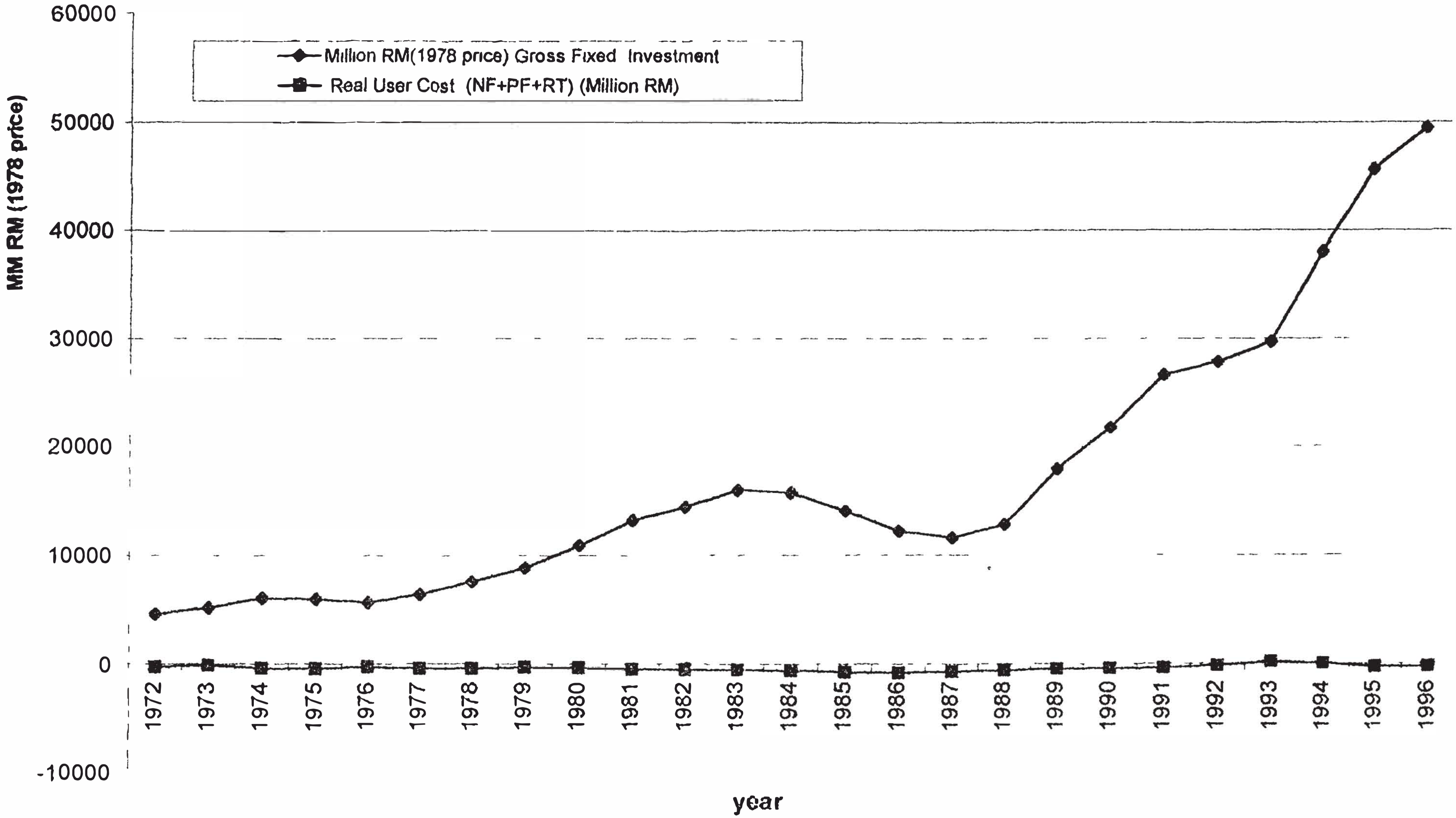


Figure 16: User Cost and Gross Fixed Investment

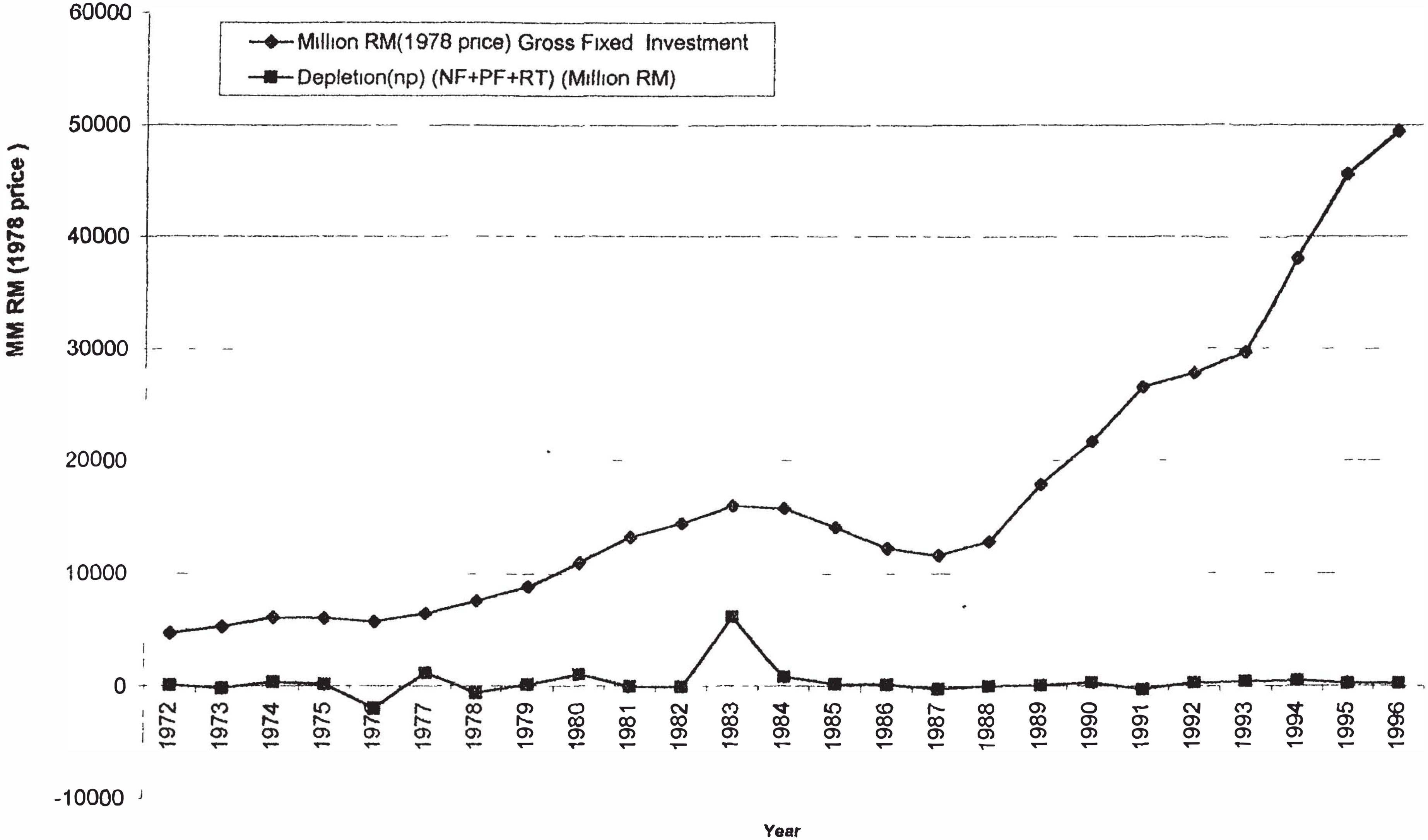


Figure 17: Resource Depletion (net price) and Gross Fixed Investment

Two other important criteria for measuring welfare are per capita investment and consumption. In order to examine these criteria per capita Net Domestic Investment (NDI) and Adjusted Net Domestic Investment (ANDI) under both the methods are presented below.

The measurement of resource depletion by adopting the user cost method found that the average per capita real adjusted net investment appreciated over time. The average ANDI was higher (RM1,097) than NDI (RM1,064) as shown in Table 23. Figure 18 demonstrated that per capita adjusted net investment (ANDI) was increasing over time except for the years 1976, 1985 and 1986. A comparison of per capita GDI, NDI and per capita ANDI (USC) is shown in Figure 18 (Appendix D, Table 36).

It can be stated that when the national income adjustment is made with the user cost method per capita adjusted net investment increased by three folds from RM 610 to RM1,948 during the study period. Once this amount of per capita investment is positive, the economy has expanded its per capita total capital stocks.

Table 23: Average Annual Per Capita Real NDI and ANDI under User Cost Method

Income/ Year	1972-80 RM Per Capita	1981-90 RM Per Capita	1991-96 RM Per Capita	Annual Average (1972-96)
GDI	656.46	1136.21	2292.0	1240.49
NDI	577.39	977.58	1938.24	1064.07
ANDI	610.49	1023.92	1948.86	1097.07
Consumption	2007.60	2436.63	3383.40	2509.40

Source: Estimated from Table 36 (Appendix D)

Under the user cost methods the Thai study (Sadoff, 1993) found that aggregate ANDI was lower than the aggregate net investment but the trend increased over time. The Equadorian study (Kellenberg, 1995) also found that the user cost Adjusted Net Investment (ANDI) increased initially but started to decline after 1978 onward.

Similarly, under the net price (depreciation) method the average per capita investment is given in Table 24. In this study the conventional net investment is determined by subtracting physical capital depreciation from physical capital (gross fixed capital formations) and ANDI is determined by subtracting natural resource depletion from NDI.

Table 24: Average Annual Per Capita Real NDI and ANDI under Net Price Method

Income/ Year	1972-80 RM Per Capita	1981-90 RM Per Capita	1991-96 RM Per Capita	Annual Average (1972-96)
GDI	656.46	1136.21	2292.01	1240.49
NDI	577.39	977.58	1938.24	1064.07
ANDI	575.21	918.24	1921.85	1035.61
Consumption	2007.60	2436.63	3383.40	2506.40

Source: Estimated from Table 36 (Appendix D)

When forest resource depletion was estimated adopting the net price (depreciation) method and adjusted with gross domestic investment, per capita welfare decreased. The annual average per capita real ANDI (RM1,035) decreased as compared to that of NDI (RM 1,064). A comparison of per capita Gross Domestic Investment (GDI), Net Domestic Investment (NDI) and per capita Adjusted Net Investment (ANDI) under the net price method is shown in Figure 19 (Appendix D, Table 36). Figure 19 shows that the per capita ANDI was increasing over time with a deviation for the years 1977, 1983, 1985 and 1986, where it declined.

A more detailed, it can be stated that despite the average per capita adjusted net investment being lower under the net price (depreciation) method as compared to net investment for Peninsular Malaysia, the over all per capita ANDI increased by three and half times from RM 575 in the 1970s to RM1,921 in the 1990s.

The Indonesian study (Repetto *et al.*, 1989) found that the trend of aggregate ANDI (net price method) decreased from 1973-80, and increased after 1980 onward. Under the net price method the Thai study (Sadoff, 1993) found that aggregate ANDI was lower than the aggregate net investment but the trend increased over time. The Equadorian study (Kellenberg, 1995) found different pictures, under the net price method aggregate ANDI was found very fluctuating over time.

The above analysis clearly depicts that under both the methods the per capita ANDI of Peninsular Malaysia was increasing over time with a small deviation in several years, indicating the sustainability of the economy.

According to Hartwick's Rule the economy is in a position to sustain per capita consumption since the per capita value of stocks increased in Peninsular Malaysia during the study period. Thus, despite the physical depletion of the country's forest resources, per capita consumption levels appear to be sustainable for Peninsular Malaysia during the study period because of reinvestment is taking place in the other setor of the economy. In another study Vincent *et al.* (1997) found that the total per capita capital stock of Peninsular Malaysia increased during the 1970s and 1980s.

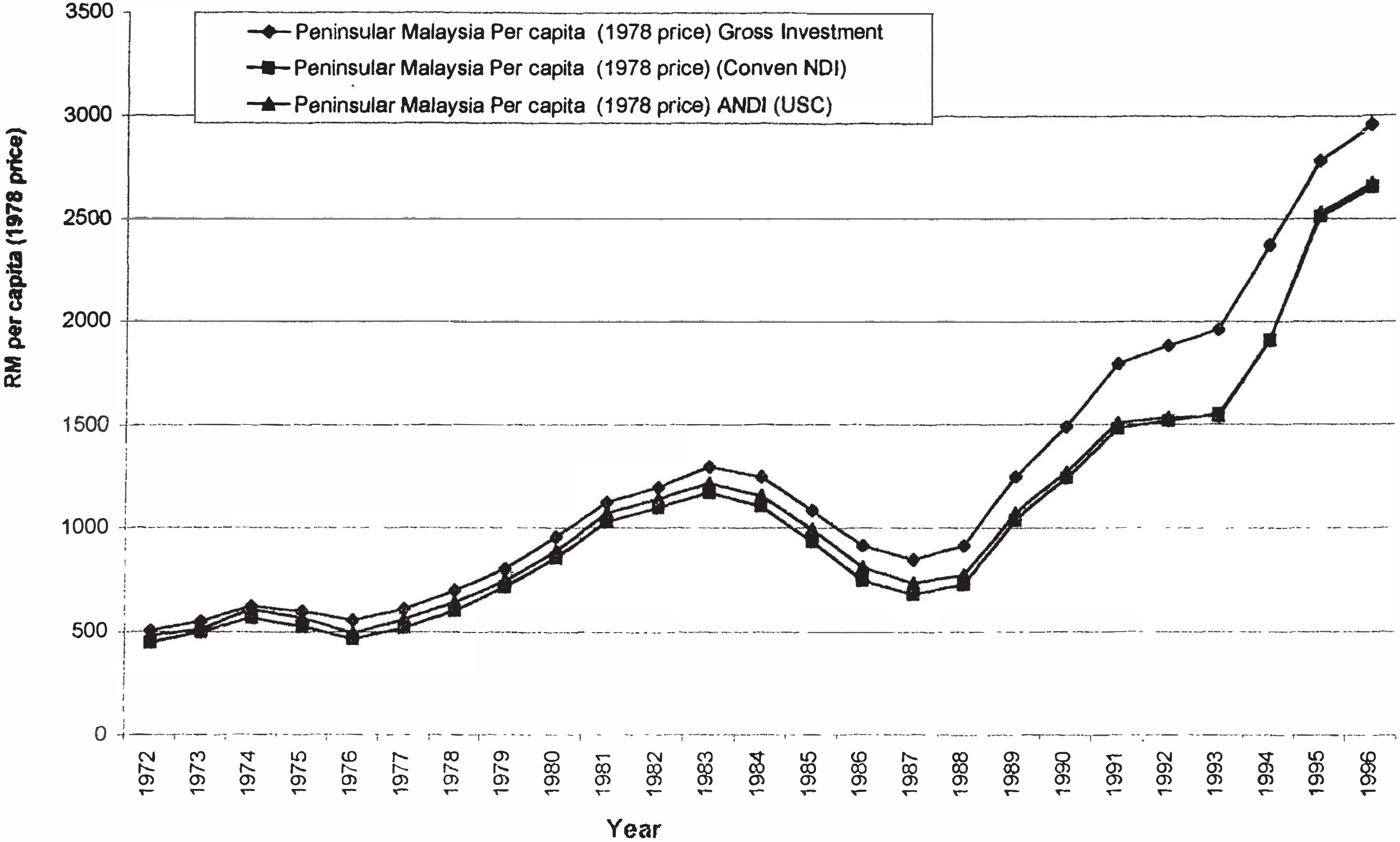


Figure 18: Per capita Adjusted Investment (User Cost) In Peninsular Malaysia

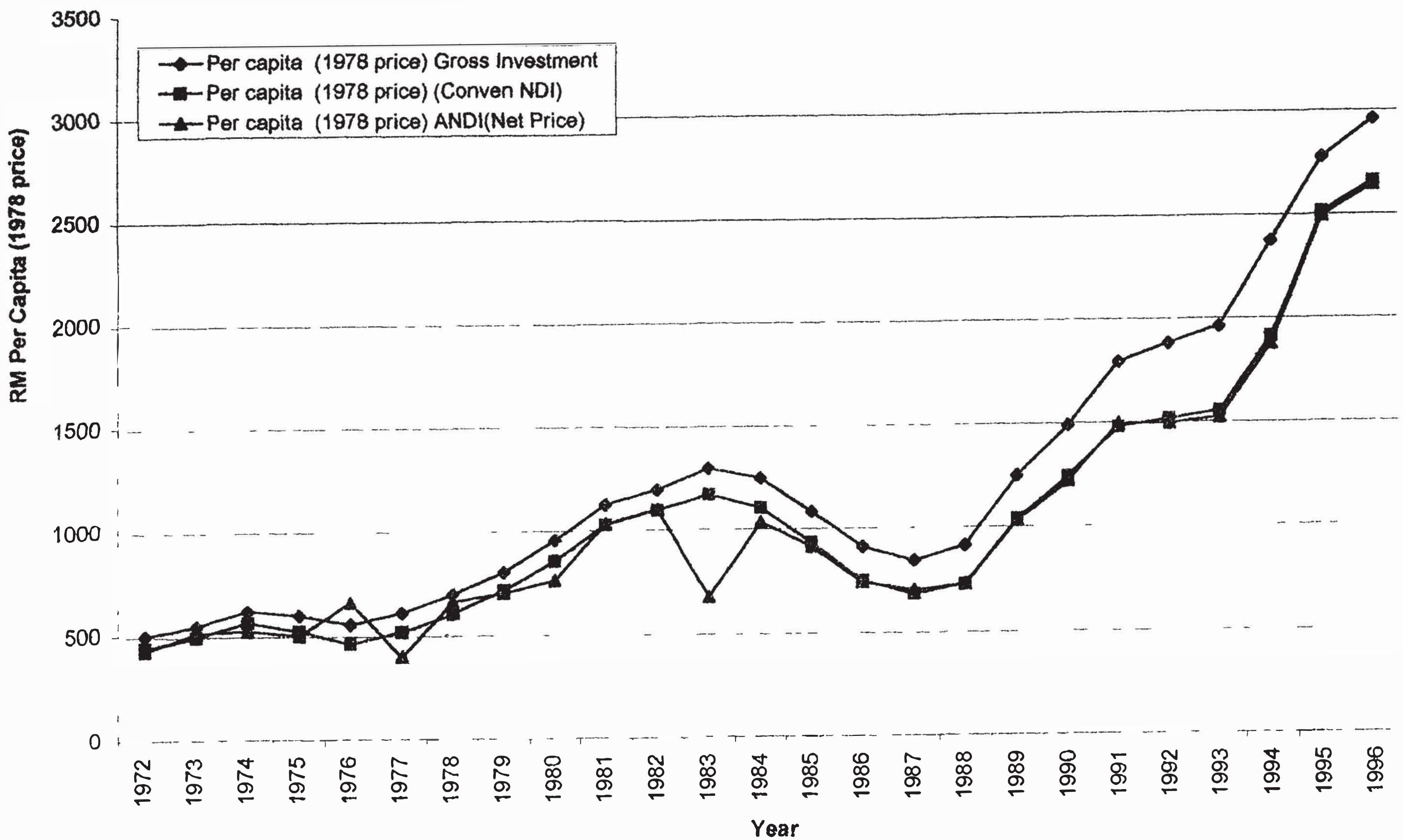


Figure 19: Per Capira Adjusted Invesment (Net Price) in Peninsular Malaysia

NDP and Consumption

A comparison of per capita NDP with per capita consumption will provide a check for the finding on the sustainability of the economy. Once net investment is truly positive, the per capita NDP should exceed per capita consumption. If this does not hold good, estimates of per capita adjusted net investment may be biased upward.

A pattern of changes is depicted in Figure 20 (Appendix D, Table 35) drawn using per capita GDP, AGDP (user cost method) and consumption. The result shows that AGDP and GDP increased over time, except for the years 1985 to 1987, due to economic recession. The pattern of per capita consumption also increased over time.

The pattern of changes in the value of per capita conventional NDP, adjusted NDP (net price method) and consumption are demonstrated in Figure 21 (Appendix D, Table 33). The result shows that the per capita consumption was less than the budget constraint imposed by adjusted NDP under net price (depreciation) method.

Applying both the methods in measuring the depletion of forestry resource in Peninsular Malaysia, it is found that the economy is growing in a sustainable fashion.

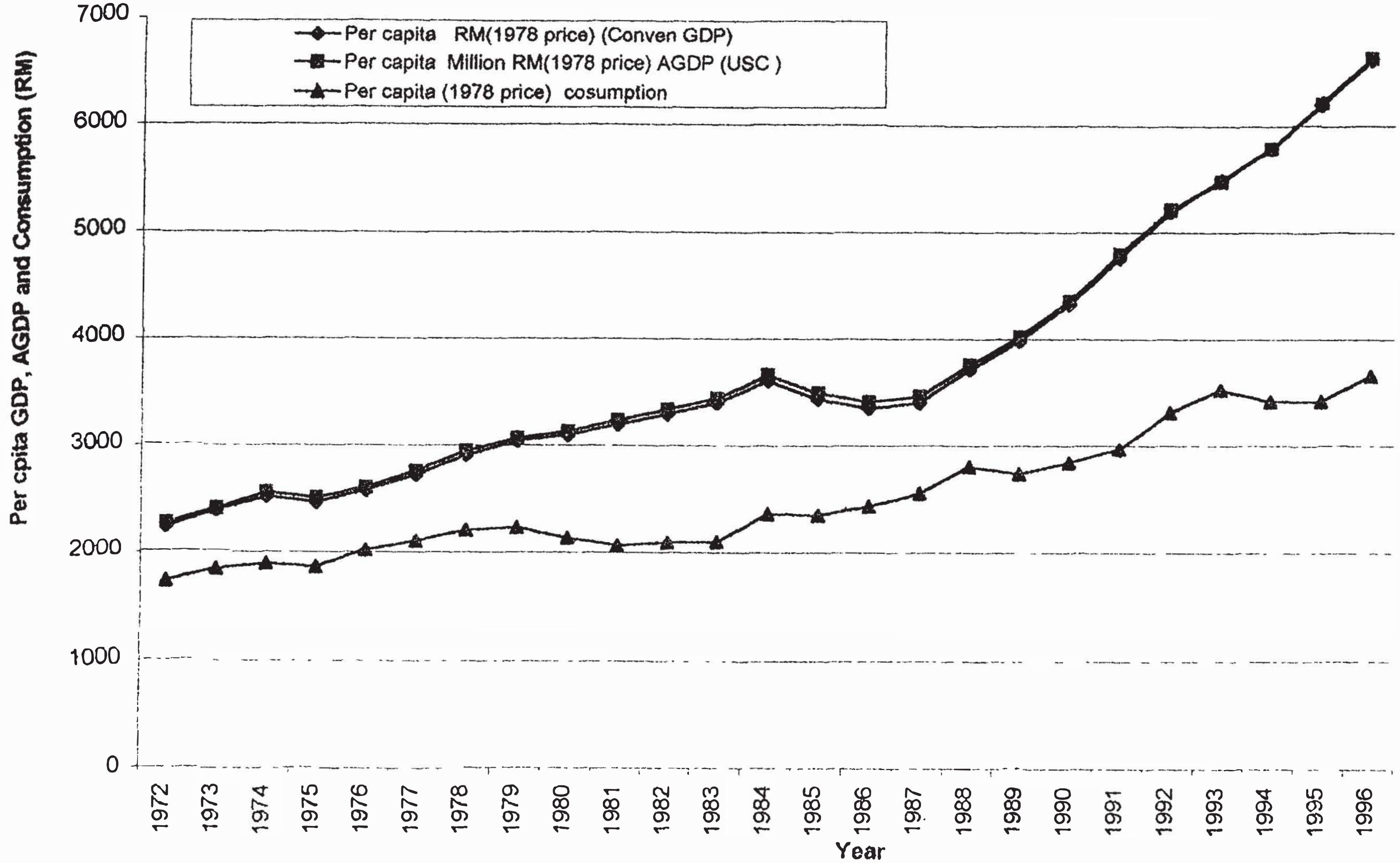


Figure 20: Per Capita GDP, AGDP and Consumption

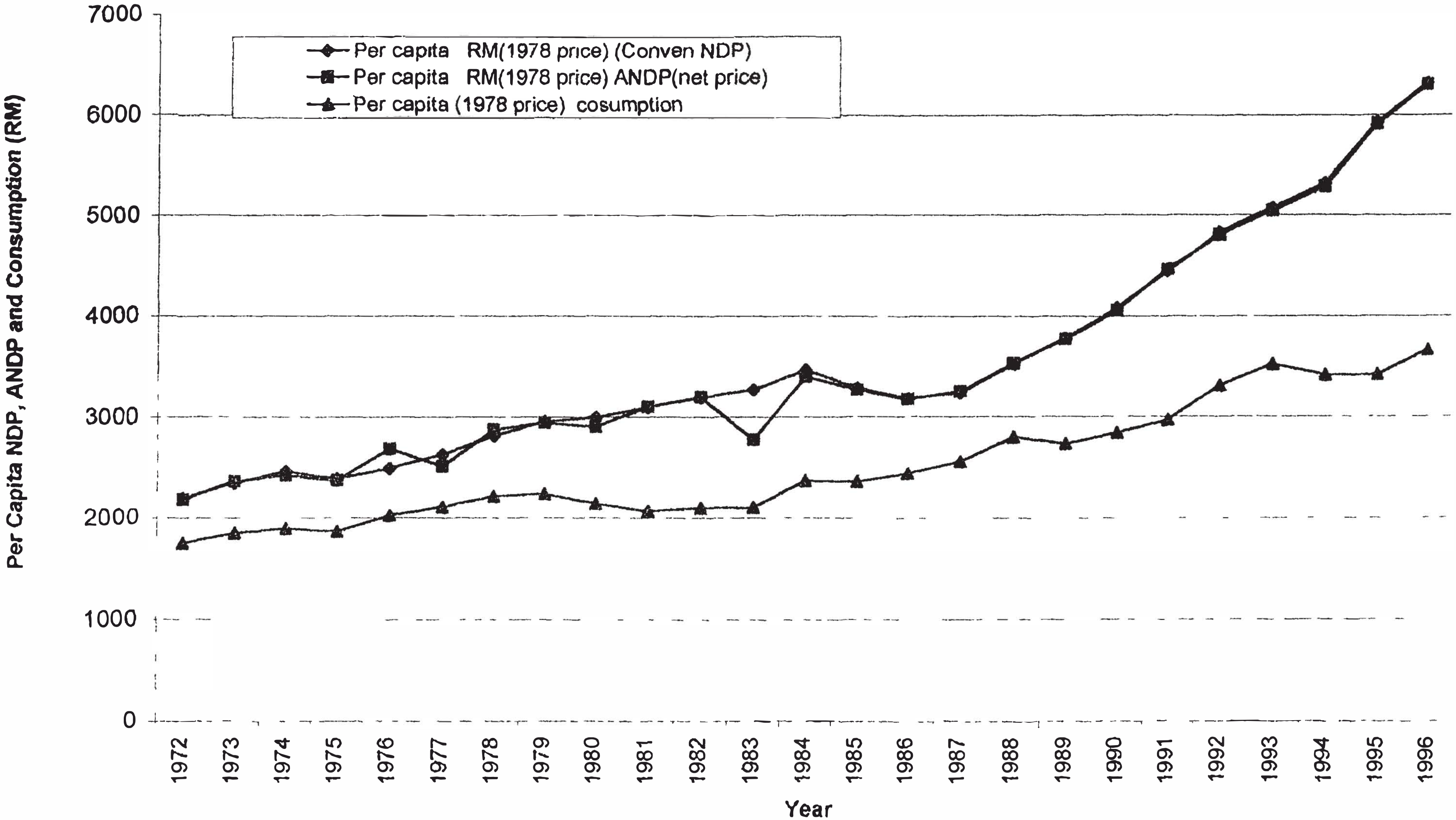


Figure 21: Per Capita NDP, ANDP and Consumption

Alternative Measures of Sustainability

In order to measure economic sustainability of Peninsular Malaysia. Two alternative sustainability tests have been carried out for the study period. One of these is called Pearce and Atkinson Measure (PAM) test and other one is known as genuine savings test.

In a weak sustainability test developed by "Pearce and Atkinson" (1993b) applying the under user cost method it showed that net savings as a percentage of GDP for the study period (1972-96) is higher than that of resource depletion, except for the years 1973 and 1993. For rest of the years net savings as a percentage of GDP lie above the knife-edge sustainability (45^0) line representing the sustainability of the economy as shown in Figure 22 (Appendix D, Table 37).

The net price method provides a similar picture for economic growth and its sustainability of Peninsular Malaysia except for the years 1977 and 1983. During the other years net savings as a percentage of GDP lie above the knife-edge sustainability (45^0) line indicating the sustainability of the economy as shown in Figure 23 (Appendix D, Table 37).

The above analysis demonstrates that regardless of natural resource accounting methods used, the aggregate economy of Peninsular Malaysia was sustainable all the way despite continued physical forest resource depletion.

When World Bank's (1995) genuine savings sustainability test is applied for the study period, a similar trend like that of Pearce's sustainability indicator is observed. According to the user cost method, the declining trend of genuine savings prevailed for the years of 1976, 1984-1988 and 1993, as shown in Figure 24 (Appendix D, Table 38).

In the net price method, genuine savings fell sharply in the years of 1977, 1983, 1988 and 1993, as shown in Figure 25 (Appendix D, Table 38).

Unlike other studies, the Equadorian study has also carried out the alternative sustainability test. In the case of the Pearce's indicator of sustainability, the study found that when national income was adjusted with user cost and net price method, in general the economy was found unsustainable. In the case of genuine savings sustainability test, the genuine savings of Equador fell below zero in ten of the twenty years (net price method). The genuine savings declined considerably after 1978 when national income was adjusted with user cost.

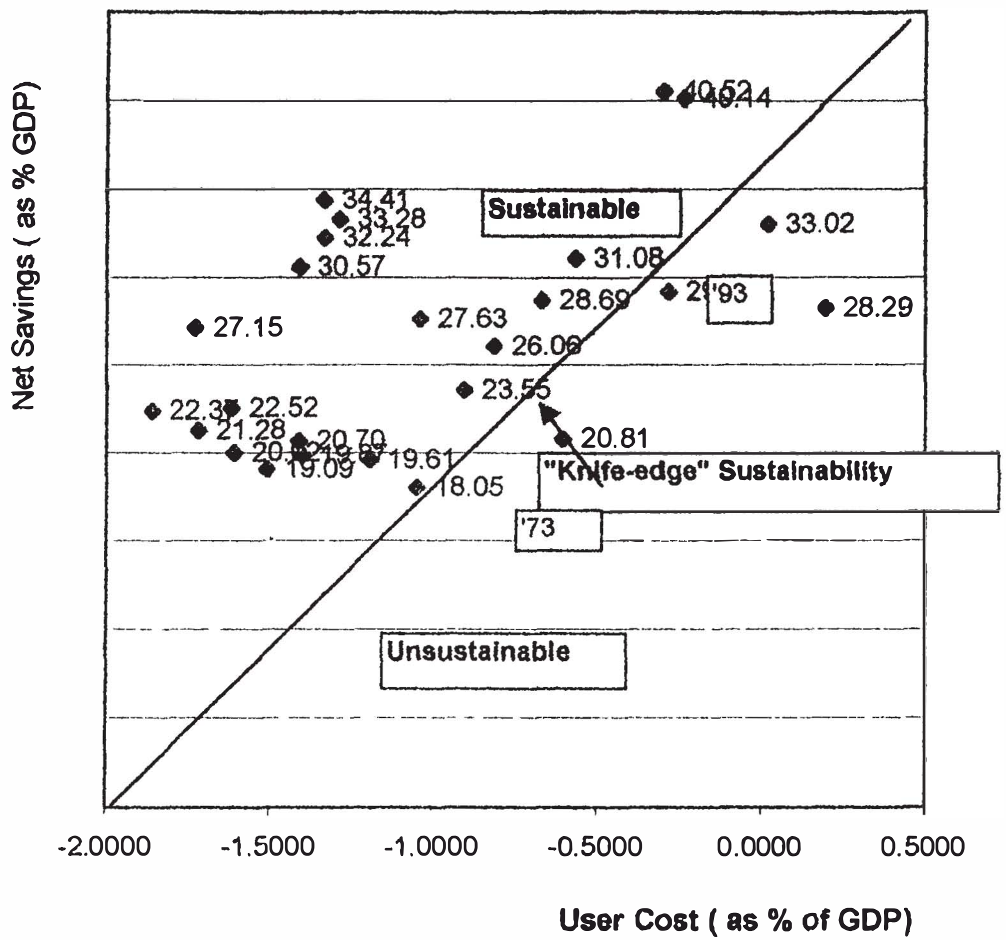


Figure 22: Pearce's Indicator of Sustainability:User Cost Method

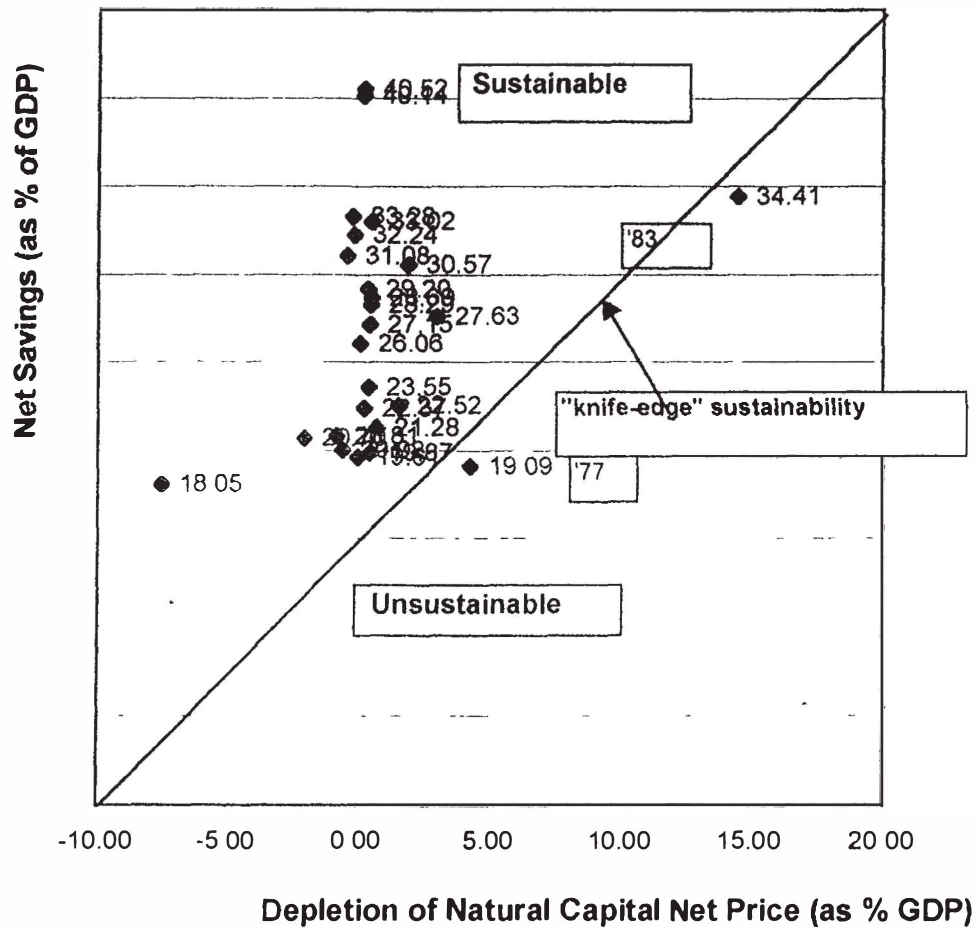


Figure 23: Pearce Indicator of Sustainability: Net Price Method

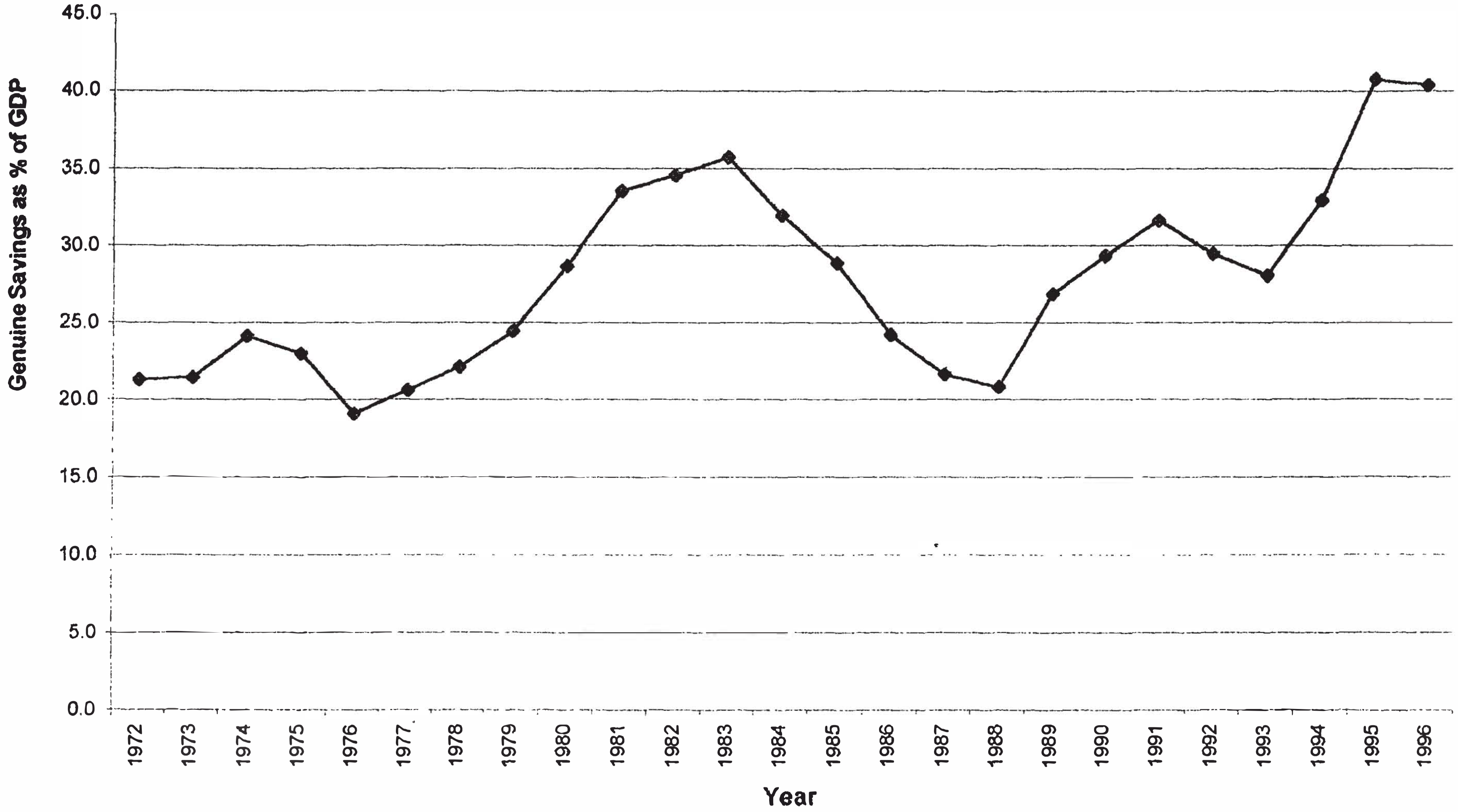


Figure 24: Genuine Savings as % of GDP (USC) Method

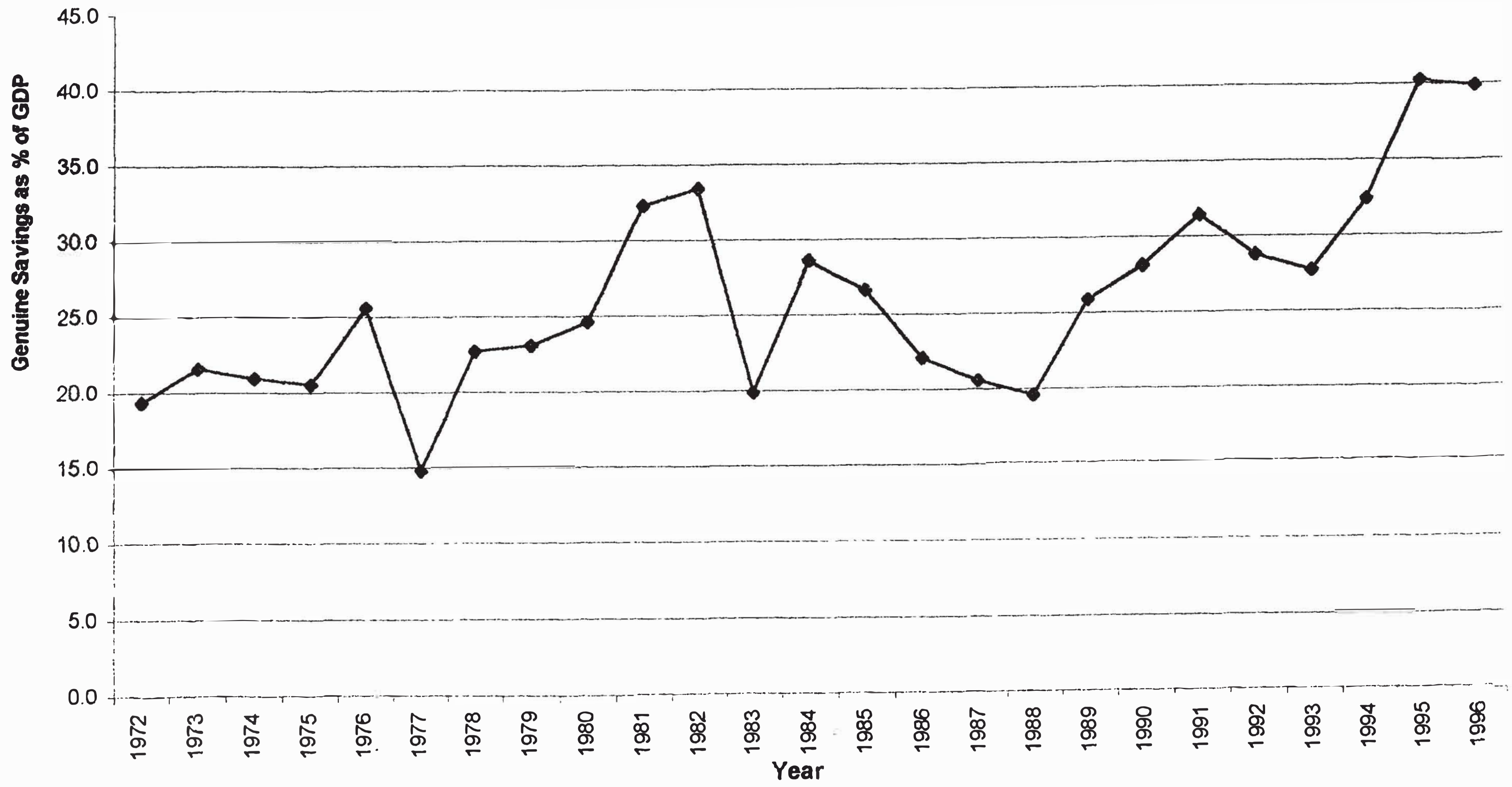


Figure 25: Genuine Savings as % of GDP (net price) Method

Forestry Sector Income Adjustment: User Cost and Net Price Method

The contribution of forestry sector to national level GDP is less than one percent in Peninsular Malaysia. The adjustment of forestry sector income with forest resource depletion will provide more accurate adjusted national income accounts. The forestry sector income adjustment is made with user cost. In this study, forestry sector GDP refers to gross value added of that sector and NDP represents gross value added after deducting from physical capital depreciation of the forestry sector. ANDP of the forestry sector indicates the NDP of that sector when it is adjusted with forest resource depletion. In order to make a comparison, the forestry sector national income adjustment is also made with resource depletion, applying the net price method.

The value of forest resource depletion (timber, rubber and plantation) as calculated applying user cost and net price method (Appendix-D, Tables 39 and 40) would normally be subtracted from the forestry sector GDP and ANDP to arrive at the forestry sector AGDP and ANDP respectively.

A comparative trend of GDP and AGDP is demonstrated in Figure 26. When the user cost method is adopted to measure the resource depletion, it (USC) decreased from 47% of the forestry sector GDP in the year 1972 to approximately 32% in the year 1996, signifying that AGDP appreciated over time, as shown in Figure 28 (Table 25). This indicated that the economy was sustainable despite the physical depletion of forest resources.

Table 25: Average Annual Forestry Sector Real GDP and AGDP (Million RM)

	1972-80	1981-90	1991-96	Annual Average (1972-96)
GDP	664	715	769	709
AGDP	1004	1321	935	1115 (11%)
User cost	-341	-606	-166	-405

Source: Estimated from Table 39 (Appendix D

The value of forest resource depletion was subtracted from forestry sector income in order to determine the user cost-adjusted forestry income in each period. After making an adjustment of GDP with user cost it is found that average annual AGDP increased by 11% compared to that of the 1970s as shown in Table 25. This implies that under the user cost method at sectoral level national income appreciated over the last 25 years. This reflected that the economy was sustainable at the sectoral level as well. This is because of the user cost method takes into account the benefits obtained from the appreciation of resource value and reinvestment is made in the forestry sector such as plantation programme.

Forestry sector income is also adjusted, using the net price method of resource depletion. A comparison is made with conventional NDP and ANDP (net price) as shown in Figure 27. ANDP was found to decrease over all the years, even it (on average) was negative during the 1980s, indicating that the welfare decreased over the last 25 years and demonstrating as though that the economy was not sustainable. This is shown in Table 18 below.

Table 26: Average Annual Forestry Sector Real NDP and ANDP (Million RM)

	1972-80	1981-90	1991-96	Average Annual Change
NDP	643.83	683.94	720.71	678.31
ANDP	610	-57.12	460	307.10 (-50%)
Resource Depletion	33.51	741.06	260	371.01

Source: Estimates from Table 40 (Appendix D

Using the net price method, it is found that the average annual capital depletion in the forestry sector increased from 3% to 33 % of the sectoral GDP in the 1970s to 1990s respectively (Figure 29). The net price method reflected the high rates of resource depletion, whereas the physical capital depreciation in Peninsular Malaysia varied around 2-4 % of Forestry sector GDP, over the last 25 years.

In contrast to 11% average annual increase in AGDP, the average annual ANDP of the forestry sector decreased by 50%, indicating the non-sustainability of the economy at forestry sector level, as shown in Table 26. This is due to methodological differences in the net price method that does not take into accounts the future benefits foregone due to resource depletion.

Hence, the usage of the adjustment of income parameters by net price method adjusted resource depletion can lead to misleading diagnosis owing to the failure to take into account of the future benefits. User cost resource depletion is theoretically a better measure than net price. As a result the appropriate income parameter adjustment for resource depletion ought to be based on user cost estimated resource depletion.

Only the Thai forest resource accounting (Sadoff, 1993) made resource depletion adjustment with forestry sector national income adopting the user cost method. Unlike Peninsular Malaysia, the AGDP of Thai forestry sector was lower than GDP. The trend of AGDP decreased from 1970-82, after 1982 it increased and became close to the trend of GDP in 1990s. As expected, in the case of the net price method ANDP was substantially lower than GDP but the trend was increasing till 1982, and declined afterwards, which was opposite to the trend of AGDP adjusted by the user cost.

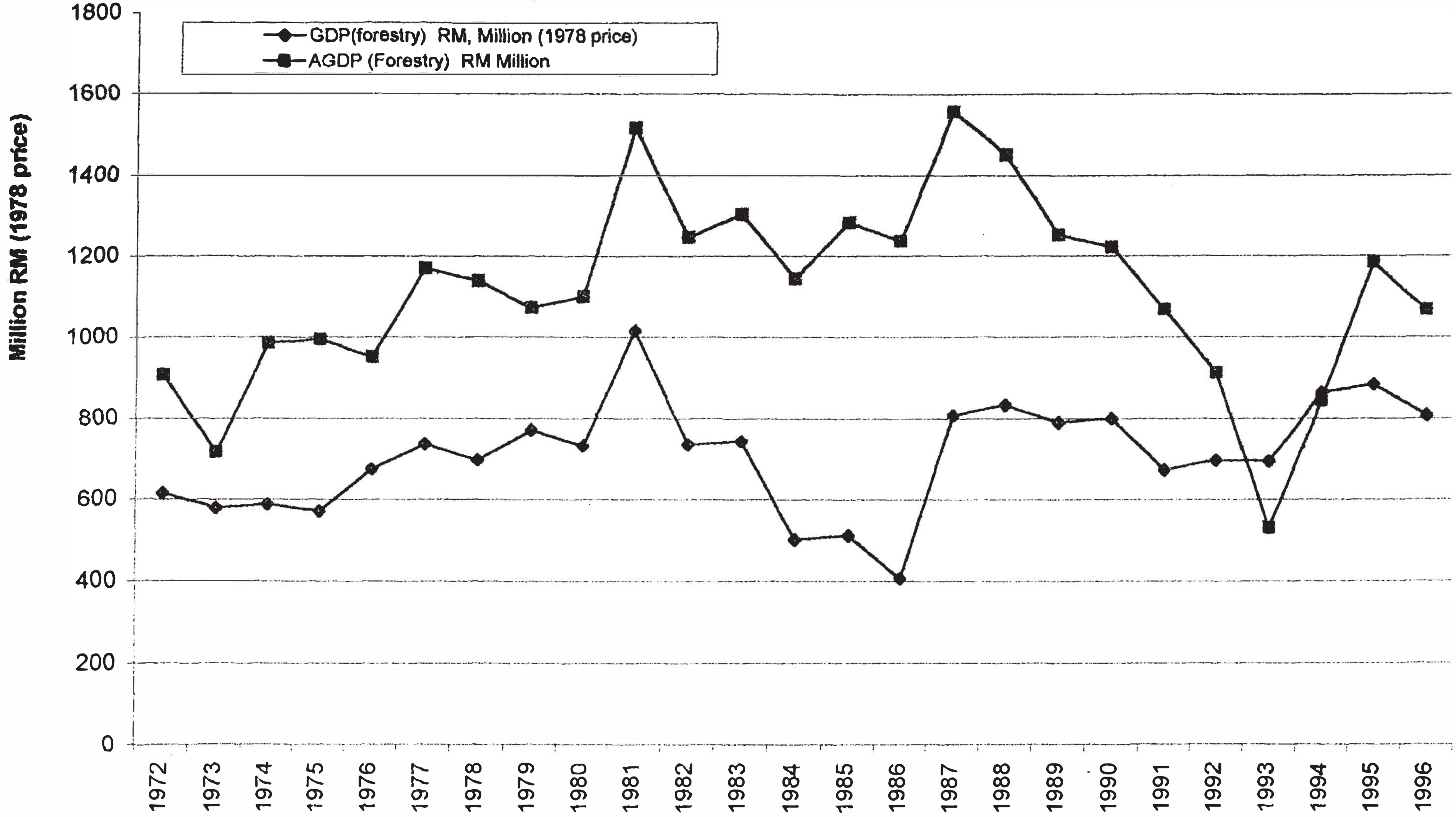


Figure 26 : Change in Forestry Sector GDP and AGDP

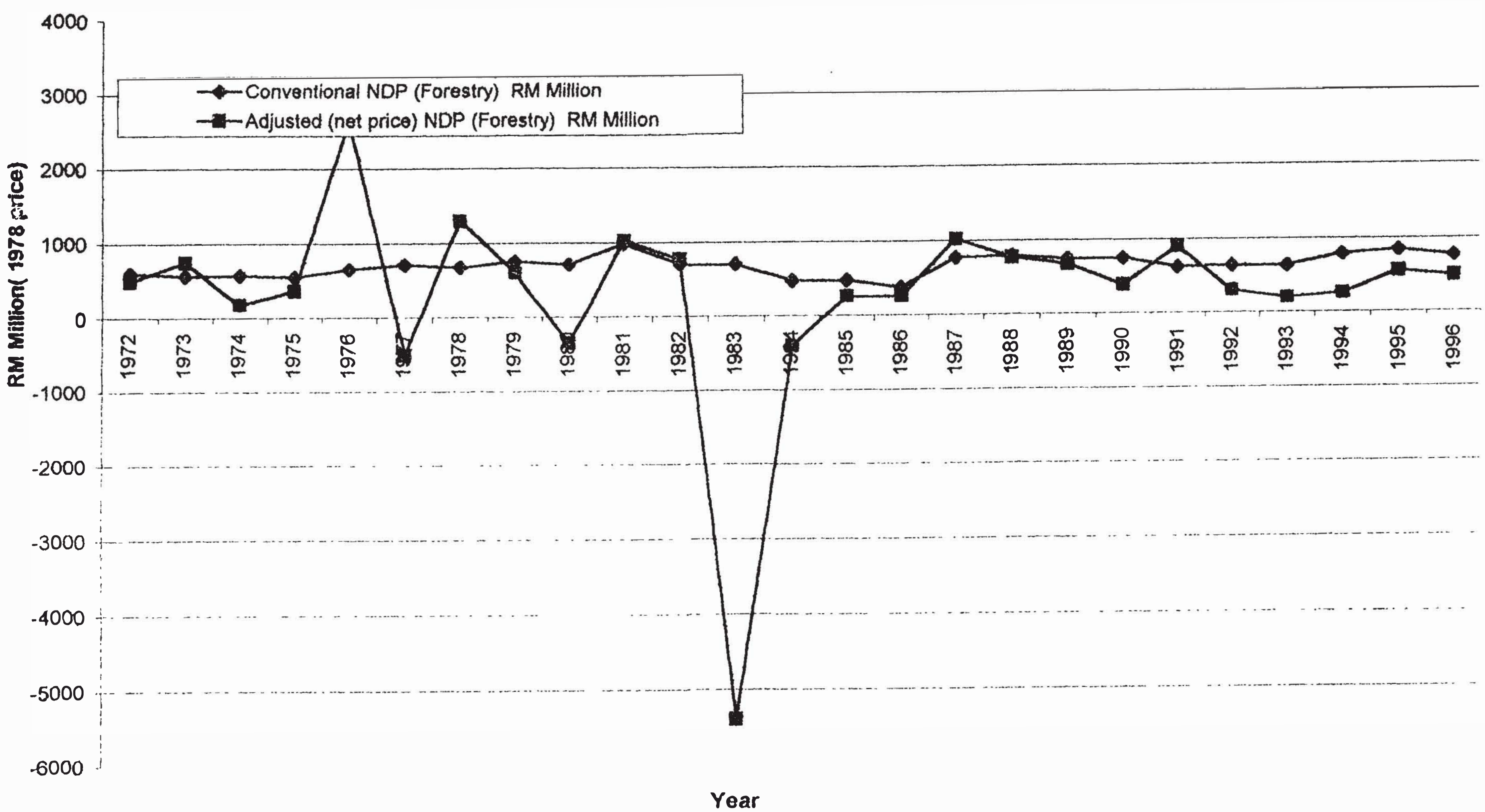


Figure 27 : Change in Forestry Sector NDP and ANDP

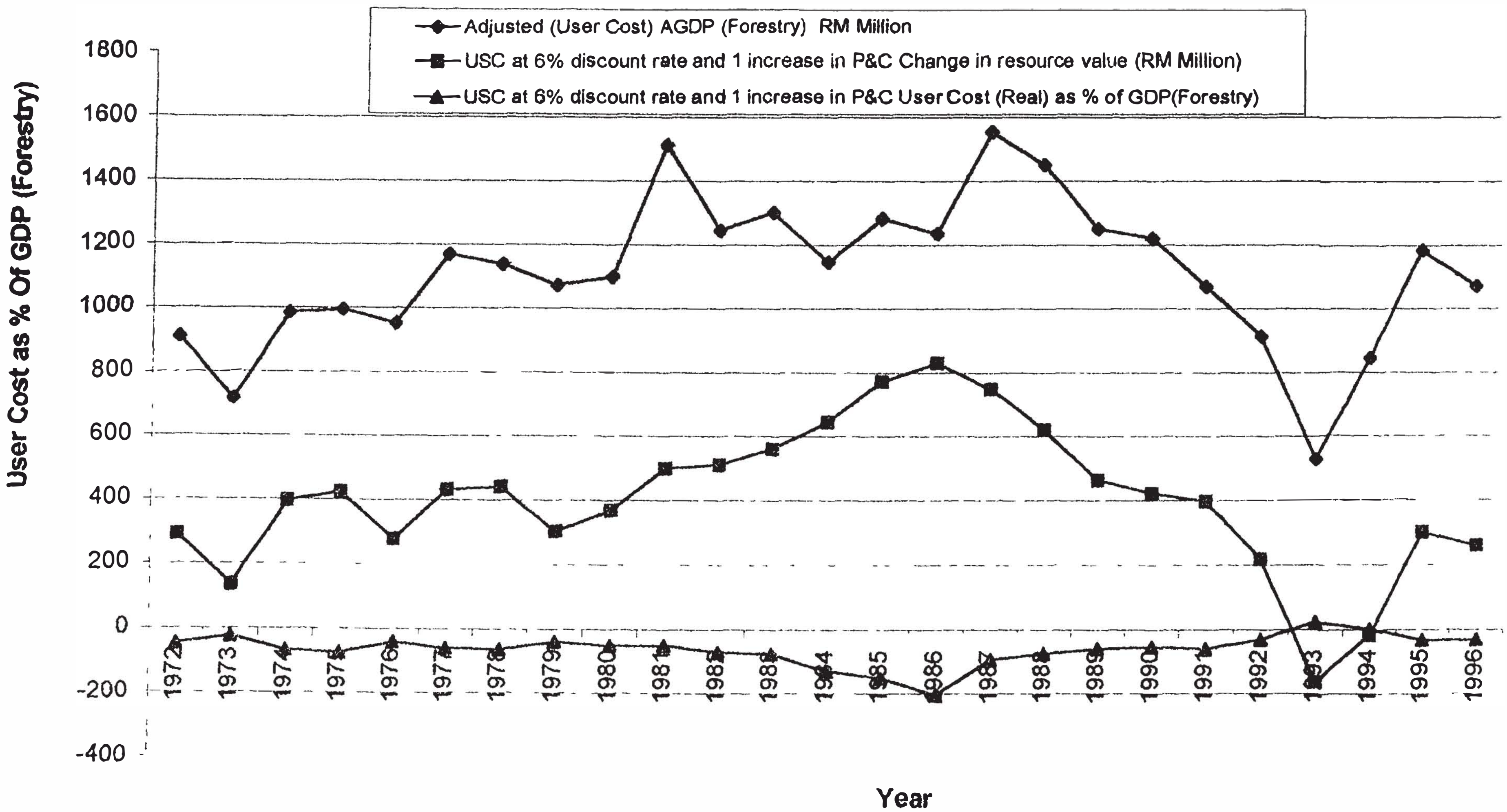


Figure 28: User Cost as % of GDP (Forestry)

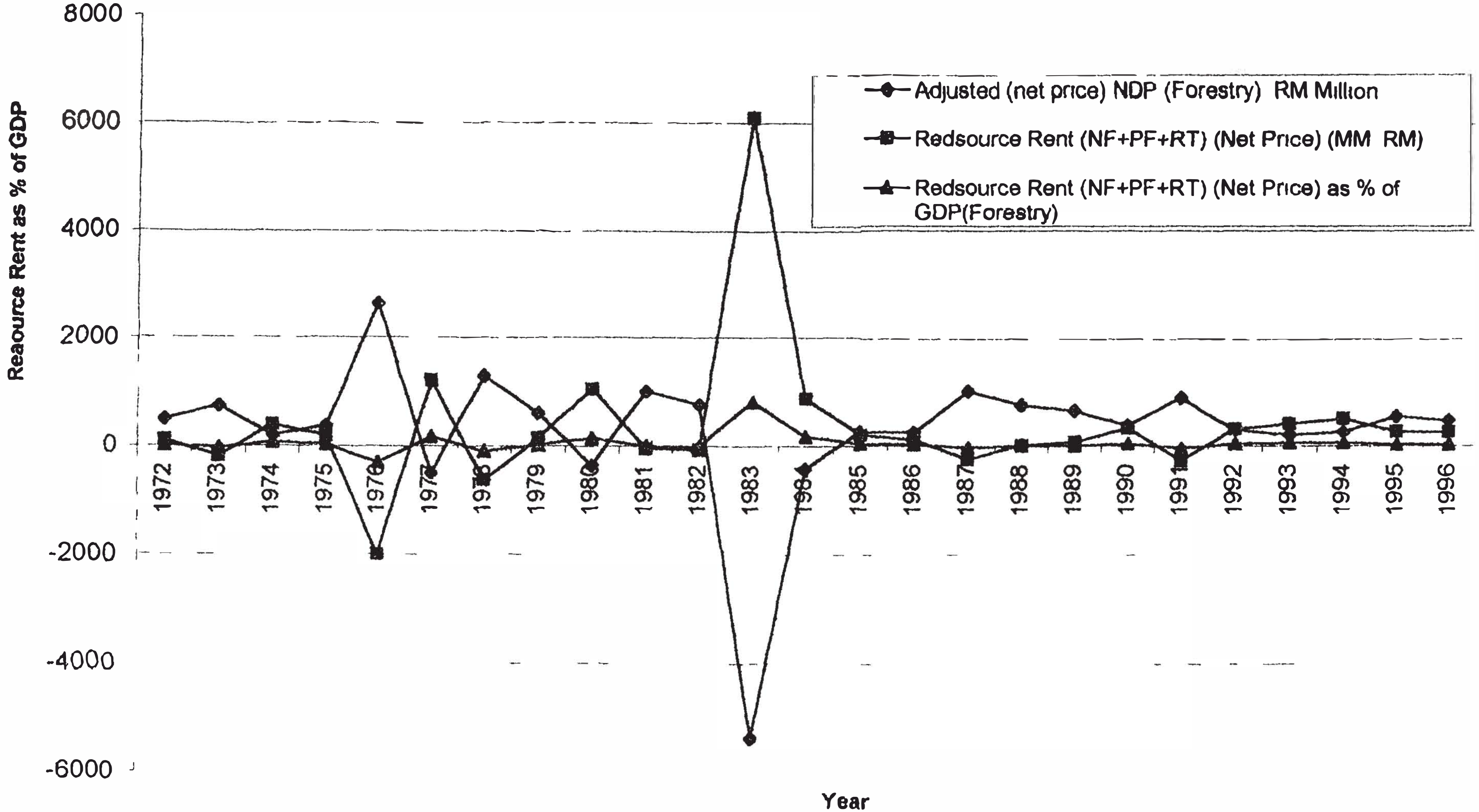


Figure 29: Resource Rent (Net Price) as % of GDP (Forestry)

CHAPTER VIII

DISCUSSION AND CONCLUSION

An accounting of forest resource is conducted to examine how timber resources depletion affects sustainable economic growth of Peninsular Malaysia. The study focuses on how the contribution of forest resource has an effect on national income accounts. The study also attempts to examine whether enough reinvestment is made from the derived earnings of the forestry resource in Peninsular Malaysia to offset the decline in natural wealth.

One theoretical question still remains unresolved, with regard to the standard approaches used for the estimation of resource depletion, which natural resource accounting methods permits a better understanding of the issue that resource dependent countries are facing.

The user cost method of computing résource depletion is applied in the present study, which showed that the per capita adjusted national income increased over time in a sustainable manner for Peninsular Malaysia.

For comparison, the same adjustment is made using net price method and it is found that adjusted national income increased over time under net price method as well. This occurred despite net price method misleading resource depletion assessment. Likewise, both the methods demonstrated that the per capita adjusted net domestic investments also increased overtime.

The annual value of resource depletion under the net price method was higher than that under the user cost method. The latter method (user cost) claimed declining capital elements as natural resource consumption allowance increases. The resource depletion can be smaller or negative for renewable resources if regrowths are greater than extraction in the long term. As a result, the net price resource depletion adjustment forestry sector income was significantly lower than the user cost adjusted income.

In the early 1970s, the depletion of forest resource was higher under both methods. This indicates that the high domestic and export demand for Malaysian timber has stimulated the intensity of harvesting, both in terms of area and yield. This results in substantial increase in resource depletion. With the introduction of the log export restriction beginning in the 1970s, which lead to a total ban from 1985, domestic demand for logs progressively picked up raising prices and resource value.

The user cost was negative during the study period signifying that the resource value was appreciating. This is because the user cost considers the future real value increase of forest resource and reinvestment of resource rent in the economy. Whereas in the net price method the resource depletion was positive during the study period except for the years 1976, 1978 and 1991.

From 1988 onwards in both the methods, the value of resource depletion increased because of economic boom and expansion of wood processing industries, which in turn stimulated the demand for wood. The physical log production also correspondingly increased from 9 to 11 million m^3 for the year 1987 and 1994 respectively.

Theoretical review and empirical finding suggest that the user cost approach appears to be more appropriate method of measuring the forest resource depletion. The integration of national income accounts following the user cost approach would bring the system more closely in line with proper economic definitions of production and capital depreciation. This method divides the proceeds from the sale of assets such as forestry resource into a portion that could be consumed and the portion that needs to be reinvested (El Serafy 1989, 1991). The net price method on the other hand, accounts for the whole proceeds as resource depletion.

NRA permits the nation to understand the economic cost of changing forest policies, which affects the forest resource stock and the environment. If more accurate information could be obtained or generated, more accurate results could be derived. This would help policy makers to adopt a more sound and environment friendly policy prescriptions and reap the benefits in the future. Thus, the natural resource depletion adjustment clearly shows that the resource related incomes and cost of resource depletion or benefits of resource appreciation in the existing national income accounts are not properly reflected.

The most compelling lesson from this study is the importance of standardizing the valuation method in natural resource accounting. If the cost and benefits of resource use policies can be prescribed by the choice of valuation technique or data, the natural resource accounting without standardized valuation methodology may not provide a consistent analytical framework for the economic valuation of natural resources. This can be seen by the dissimilar results obtained on the magnitude of resource depletion or appreciation when the two alternative methods are used.

Policy Implications

The resource depletion adjustment of the present study indicates that the failure to account for the cost of deforestation in standard measures of Gross Domestic Product (GDP) has led to an underestimate of the levels of national income in Peninsular Malaysia. Following the user cost approach, the Adjusted Gross Domestic Product (AGDP) through resource value appreciation yielded an upward adjustment at an average per capita AGDP (RM 3,783) as against that of conventional GDP (RM 3,750) for the last 25 years, indicating an increase of national welfare. The net price approach called for a declining trend of per capita adjusted net domestic product (RM 3,545) as against that of conventional net domestic product (RM 3,574).

The study also illustrated that the magnitude of resource depletion under the two approaches varies substantially. The user cost as a percentage of GDP varied from -1.4% to -0.2% in 1972 and 1996, respectively. Where as the percentage of resource depletion under net price method varied between 0.5% to 0.25% for the same period. The higher percentages obtained under the net price method due to is emphasis on the value of natural resource flow, where as the user cost focuses on losses or gains in future income resulting from the current exploitation of natural capital productivity.

The trends of AGDP, ANDP and adjusted net domestic investment (ANDI) in both the methods adjusted for forest capital depletion provided a good indicator of economic sustainability for Peninsular Malaysia. The Pearce and Atkinson Measure (PAM) and "Genuine Savings" indicator of sustainability further affirmed these findings.

The weak sustainability test of Pearce and Atkinson (cited from Christenson 1993) found that Burkina Faso, Ethiopia, Indonesia, Madgascar, Malawi, Mali, Nigeria and Papua New Guinea are unsustainable (PAM$<$0), Mexico and the Philippines are classed as marginal (PAM $\cong$ 0). The Costa Rica, Germany, Hungary, Japan, the Netherlands, Poland and the USA all passed the weak sustainability test (PAM$>$0). The investigation of the present study also found that Peninsular Malaysia has also met the weak sustainability test (PAM$>$0).

The findings of the present study covering only forestry suggest that Peninsular Malaysia made a successful transition away from natural resource exploitative activities towards reproducible capital related production. The revenues generated from forest resource extraction have been channeled and invested in such a way so that the over all economic growth rate was sustaining over the last 25 years.

The physical loss in terms of quantity is being compensated by the value increase in value-added production supported with efforts at forest rehabilitation and discovery of new utilization from agricultural tree plantation.

The investigation of the present study also suggests that when resource value is appreciating over time; there is high potentiality of extracting more logs from the forest until a zero rate of resource depletion is attained. But the decline of natural resources will also affect a country's productive capital stock once the rate of depletion is positive.

A sustainable economy demands an ecologically balanced environment for which there is a need to maintain the carrying capacity of the environment. In order to maintain this balance, the threshold level of the resource should not be exceeded. Therefore, development strategies and resource management programs have to be designed in such a manner so that the optimal rate of extraction of timber is ensured without exceeding the threshold level.

The investigation of the present study is based on the valuation of timber resources only. Renewable resources like forestry have many potential values such as minor forest products, environmental and amenity services, carbon sequestration, soil conservation, protection of catchments area, wildlife habitat and medicinal values. In view of this, the forest resource can be treated as supplementary capital inputs for other capital assets in the production process of the economy.

The incorporation of the wider range of forest resource valuation would provide a more accurate estimation of resource depletion. This will have a greater implication on the national income accounts. Adopting more appropriate method like user cost and extending the benefits calculation from various forestry activities and integrating them into existing national accounts may provide a more holistic viewpoint on the forestry sector contribution.

The contribution of forestry sector GDP is less than one percent in Peninsular Malaysia. It is therefore, inappropriate to conclude that forest resource depletion adjusted aggregate national accounts of Peninsular Malaysia reflects a sustainable growth. An adjustment of resource depletion for other resource base sectoral value added (GDP and NDP) might reflect the more appropriate picture of resource depletion and adjusted income. Finally, integrated magnitude of resource depletion of all the resource base sectors of the economy will have significant implication in measuring the economic sustainability and welfare of the nation.

Potential Applications of Forest Resource Accounting

NRA can be used for monitoring and policy analysis. In practice they have been used mostly in research investigations. Policy analysis and decision-making occur at three levels that corresponded to three relatively distinct levels of decision making.

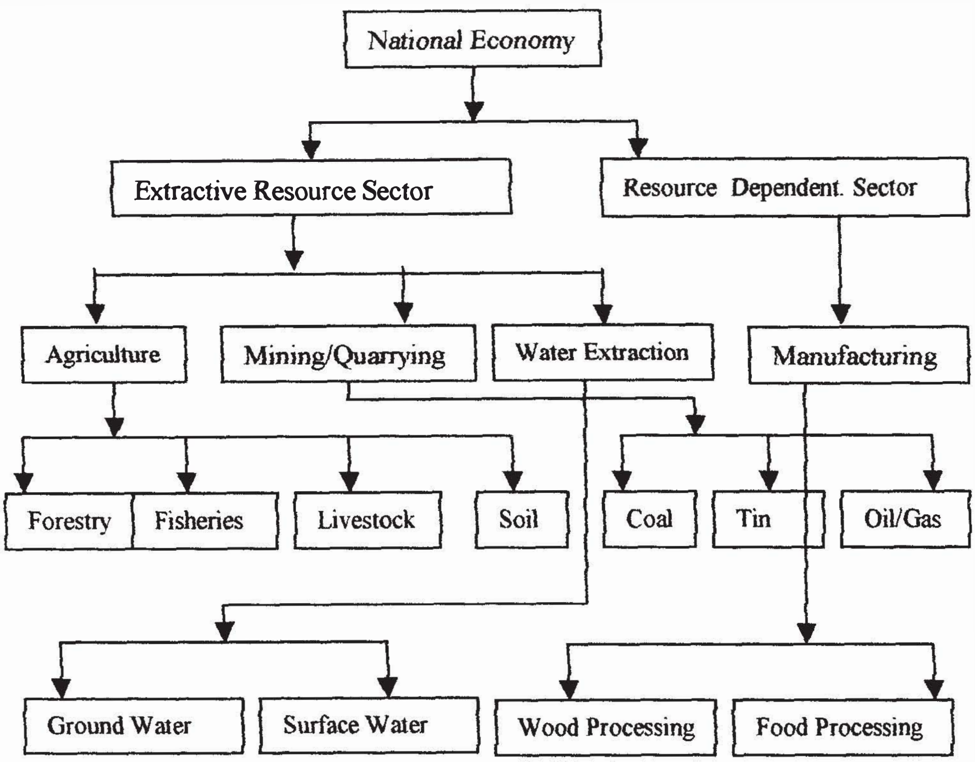
Policy making at the field level deals with practical questions pertinent to conducting a local level activity that can be best answered in the field. For instance, this involves deciding between the use of sleds versus bulldozers to construct roads for logging or the choice of technology for logging operation to reduce logging impact. While decision-makers at the sectoral level are responsible for coordinating field level activities within the sector. These decisions include allocation of quota and concessions for forests.

At the economy-wide and regional level, the policy making is multisectoral. Policy makers at this level are responsible for coordinating the activities and policies of all sectors and for weighing alternatives and trade-offs among sectors. The country's development budget is allocated at the ministerial level, where policy would be determined giving the relative importance of protecting the resources critical to economic loss and ecological threshold.

Given the role of NRA in organizing multisectoral natural resources and economic information, they are particularly well suited for economy-wide, regional and sectoral level policy analysis. Most of the policy applications of NRA have occurred at these levels.

NRA should be constructed sequentially in different resource based sector of Malaysia where the database is weak or limited. Each stage will improve the understanding of resource base and provide policy makers and practitioners with the opportunity to offer feedback about the usefulness of NRA i.e. its classifications, definitions, level of detail and physical and value of units. Preliminary NRA could be constructed based mostly on existing data. A more detailed, complete set of accounts could be constructed through defining existing data and collecting additional data. In the early stage, a simple model could be constructed.

A few alternative development strategies could be formulated for analysis with the model to demonstrate how the NRA could be used for policy analysis. Through revision over time, the more realistic scenarios and expanded modeling could be built-in, making it possible to reach a wider range of policy conclusions. Figure 30 explains how Peninsular Malaysia can carry out satellite accounts for other resource base sectors of the economy and to integrate them into national income accounts.



Figures 30: Satellite Accounts for Resource Base Sectors of Peninsular Malaysia.

Source: Adapted from C. Perrings *et al.* (1989) for Malaysian example.

Recommendations for Further Research

Resource-rich countries can sustain their consumption levels, if they accumulate stocks of reproducible capital at a rate that matches the economic depletion of natural capital.

Natural resource depletion adjusted measures provide a more complete accounting cost of economic production, but even these modifications are not comprehensive. To remain consistent with the System of National Accounts (SNA) natural resource accounting methodologies, value only market losses, of timber values. Substantial non-timber forest products, non-market forest products and environmental services thus remain outside the scope of this study. For example, the value of soil stabilization, biodiversity, and water regulation, as well as the effects of forest management on agricultural production are not captured here. The economic cost is narrowly defined as the cost of timber loss, and clearly understates the true loss in the value to society.

Thus, the study has ignored the direct consumption values of the environment. The economic growth in Peninsular Malaysia has reduced these values due to rising air and water pollution and diminishing amenity values through conversion of forestland. There is scope to develop a comprehensive forest resource account incorporating these values but a more comprehensive environmental framework would be necessary.

In the present study, the user cost is calculated based on the actual log production. In the projection of log production it is assumed to increase based on the annual rate of increase during the last 25 years anticipating more virgin forest would be logged. Further study could be carried out to estimate the forest resource depletion in terms of area and projected forest growth rates such as the logistic growth model as adopted by (Vincent, 1997). This sort of study will take into account the benefits foregone in terms of regenerating capacity of the natural capital.

The present study used gross fixed capital formation as a measure of investment and GDP as a measure of national income. There are scopes of getting a better measurement of welfare than it revealed in the present study. The one way is by collecting more information of gross investment data. The present gross investment data is incomplete as noted by Pang, 1993 (cited from Vincent, 1997). Future studies should probably use more inclusive measures of national investment and national income (GNP as opposed to GDP).

The tropical forest resource growth is very complex. The research should be carried out at the species level to include representative growth for different types and age of forests. A standardized forest growth and yield model to derive a representative forest growth rate for Malaysian forest needs to be developed.

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