Chapter 1

INTRODUCTION

1.1 Motivation of the Study

The environmental degradation and depletion of natural resources due to the process of industrialisation have warranted ample attention of academicians in the recent decades. Traditionally, both environmental aspects were neglected in the standard accounting system of an economy, since the objective was to accomplish a higher rate of growth through optimum usage of available resources. Further, with expansion and growth of an economy, the uses of environmental and natural resources become more intensive, and their depletion posed a threat to the sustainability of the existing system of production.

Environmental resources have been considered as free goods in economics. Such an approach to environmental problems did not reflect the real cost of resources. This resulted in over-exploitation of environmental resources (especially air and water) and subsequent exhaustion of exhaustible resources in a competitive market economy, where firm maximizes profits by minimizing costs. However, in the wake of global environmental awareness, environmental repercussions resulting from the economic activities can no longer be neglected, especially in the estimations of national / regional incomes aggregates.

National income has been considered as one of the most important indicators of development. In general, on the definition of income, it is apt to quote J. R. Hicks (1946) here:
"The purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves. Following out this idea it would seem that we ought to define a man's income as the maximum value which he can consume during a week, and still expects to be as well off at the end of the week as he was at the beginning. Thus when a person saves he plans to be better off in the future; when he lives beyond his income he plans to be worse off. Remembering that the practical purpose of income is to serve as a guide for present conduct, I think it is fairly clear that this is what the central meaning must be".

In the study of national income accounting, it is essential to understand the indicators of income, such as: Gross Domestic Product (GDP), Gross National Product (GNP), Net National Product (NNP), Value Additions, Depreciation, Consumption patterns and Stock of resources etc. All data necessary for the purpose of computation of indices that measure the income of an economy are provided by the Systems of National Accounts (henceforth, SNA). National income measured in terms of Value Added is defined as a single measure of the value of goods and services produced in an economy during a particular period of time (one year), which ensures that none of the value of goods and services produced is counted more than once.

If the income is overestimated, it provides a wrong guide, and subsequently distorts the estimates of growth, development and welfare. In SNA, depreciation factor is of utmost importance as the 'Net Value Additions' is considered national income. If depreciation is underestimated, income gets inflated and vice-versa.

In SNA, consumption of fixed capital (assets) i.e., depreciation is estimated only for man-made capital while ignoring the environmental capital. Environmental economists argue that the depreciation factor in SNA is grossly underestimated, since the depletion of environmental resources (such as land, air and water) and
natural resources (such as forests and minerals) is not taken into account though they are used for all economic activities. The computations of Net Value Additions do not consider this depreciation in conventional SNA. These resources and their depreciation need to be considered as fixed capital (at par with man-made capital) in the production process, since any economic activity cannot be undertaken without having a bearing on such resources. However, a mere increase in national income cannot be considered as a true indicator of economic development particularly if it is attained at the cost of a degraded environment and depleted natural resource base. Thus, for sustainable growth, macroeconomic policies need figures of sustainable income.

In India, National income aggregates are estimated every year by the Central Statistical Organization (henceforth, CSO) of the Government of India and the State income aggregates are estimated by Directorate of Economics and Statistics (henceforth, DES) of the state governments. These are the official estimates of income in the framework of SNA. Surprisingly, the present national income figures do not adequately represent sustainable income. Thus, it is necessary to integrate environmental aspects with the SNA. This is the basic motivation of the present study.

In this context of income accounting, a number of pertinent issues can be raised as they are related to analytical, empirical and policy aspects of environmental concerns. These issues may include the following:

1. Are the depletion of natural resources and degradation of environmental resources well defined and addressed in the existing framework of SNA?

2. Does SNA account for environmental protection costs arising from pollution and degradation? If so, how? If not, why not?
3. Does the usual depreciation include, or adequately represent, depreciation of natural capital in the existing framework of SNA?

4. Is there a framework of environmental accounting that explicitly takes into account all environmental repercussions of economic activities in the SNA?

5. Are there unique methodologies that can be applied to capture sector-wise environmental costs?

6. Do the estimates of income aggregates in the existing framework of SNA represent true income for a country / region? If not, do the current estimates underestimate or overestimate the true income?

7. Can the environmental repercussions be taken into account in SNA by individual sectors in an economy? If not, should all sectors be considered as interdependent of an economy for estimation of environmentally adjusted national / regional income?

8. What are the valuation problems in estimating environmental and natural resources?

9. What are the policy implications of integrating environmental aspects in the framework of income accounting and by generating green income aggregates?

In what follows, a review of literature is undertaken with the purpose of identifying whether or not the issues above have been analysed, both at national and regional level, specifically, in the context of India in general, and Karnataka in particular. Accordingly, the researchable issues for the present study are identified.
1.2 Review of Literature

For analytical convenience, the review is divided into two classes of studies. First, studies which analyse and estimate environmental degradation and depletion, and valuation of environmental / natural resources in general. This literature review is intended to provide an analysis of professional literature on environmental concerns and its underlying framework for estimation of environmental costs. Second, studies which deal with the estimation of environmental costs and their integration with national / regional income accounting.

1.2.1 An Overview of Literature on Environmental Concerns

In his pioneering contribution, Hotelling (1931) has analysed the consequences of the depletion of exhaustible natural and mineral resources due to their excessive cheapness. As a result the resources are wastefully used in production as well as in consumption activities and thus, require conservation. He explained that the period of exhaustion depends upon the price of the commodity, given the market structures, such as free competition, monopoly and duopoly in particular. Hotelling explained that the length of the time for exhaustion of a particular commodity depends on a finite or infinite value of price of the commodity that is required to vanish the entire quantity. Thus, the rate of production becomes extremely small for higher anticipated price as compared to that of a low anticipated price. If anticipated prices are higher, more protracted will be the period of extraction of that exhaustible natural resource. Through price mechanisms, period of extraction of exhaustible resources can be prolonged.

Brookshire, et al., (1980) developed a general model for valuation of changes in natural service flow, consistent with the Hicksian concept of consumer
surplus. The model developed is a total value model that is applicable to all classes of goods; divisible as well as indivisible in production / consumption, exclusive and non-exclusive. The model focuses on total value and represents a radical departure from the partial equilibrium, benefit-cost analysis. Further, for valuation of the increments and decrements in natural resource service flows, the relationships between measures like Marshallian consumer’s surplus, Willingness to Pay (WTP) or Willingness to Accept (WTA) measures are developed. The study shows that to implement the benefit cost criterion, estimates of WTA for decrements of goods, services and amenities are required. On the other hand, the authors apply the model for the valuation of changes in the provision of wild-life-related amenities and found that the WTP formats are usually most effective of all the measures. Then in the context, where compensation is not customarily paid to those who suffer from the depletion in natural and environmental amenities, WTA approach does not appear to collect reliable data and hence, in such cases WTP approach is more reliable.

Mitra (1981) pointed out that in economic analysis, natural resources are almost invariably assumed to be supplied exogenously in given amounts, which is clearly unsuitable for examining the optimal pattern of depletion of exhaustible resources. Mitra’s study considered a model in which capital, labour and an exhaustible resource produce an output that can be accumulated as capital. The production function is subject to exponential technical progress and labour grows exponentially. Assuming a changing technology as specified by a sequence of production functions, Mitra shows how to derive optimal level of exhaustible resources to be used in economic production that could be sustained in the long run.

Nadkami (1987) points out that the economists have been sharply criticised for their excessive concern with economic growth in a narrow perspective without
Economists in the past worried about the scarcity in a highly restrictive sense as if its relevance was only for the short run. He emphasises that a long-term view would bring in ecological problem in economic terms, while costing the *in situ* natural resources including air and water. The cost of using a unit of resource is a sacrifice imposed on the proximate users, distant as well as the future users of the resource. He argues that only such costing can lead to a rational use of resources.

Lutz and Serafy (1988) bring out many shortcomings of the current national income measures. Firstly, welfare aspects in the present SNA are inadequate for gauging long-term sustainable growth or income because natural resource depletion or degradation is not being considered. Second, defensive expenditures to protect the environment from degradation assume greater significance in national income accounting, especially if the degree of polluting industrialisation is high. Third, the issue of depletion and degradation of natural resources is not directly related to the level of industrialisation, it is important particularly in countries where most of the activities rely heavily on natural resources. Next, to deal with the issue of depletion and degradation of natural resources they put forward two conceptual approaches viz. (1) depreciation approach and (2) User Cost approach. With the formula provided by Serafy (1989), the "depletion factor" or the "user cost" should be set aside as a capital investment and be excluded from the national income. Finally, they point out that even though there are different approaches to environmental accounting, all of them are based on a common theme of what constitutes sustainable income and what doesn't. Thus, they strongly plead for a framework to be fully developed which would guide the optimal utilisation of natural resources without adversely affecting the future generations.

Serafy (1989) pointed out the methods to calculate the environmental cost due to the depletion of natural resources. In poor countries, natural resources are
not restored to same level as they are depleted. In such a case, national income should impute a capital consumption charge based on technically acceptable criteria against current receipts to obtain the true income from such activities. Serafy outlined two approaches to estimate environmental costs: depreciation approach and user cost approach. The weakness of depreciation approach is that in case of countries, such as Saudi Arabia where the country derives 100 per cent of receipts from, say, petroleum extraction, it would give us a GDP of 100 and a NDP of zero. In this context, Serafy proposed an alternative of conversion to a permanent income stream, where true income can be obtained. The formula is: 
\[ \frac{X}{R} = 1 - \left[ \frac{1}{(1+r)^n} \right] \], where \( X \) is true income, \( R \) is total receipts, \( 'r' \) is the rate of discount and \( 'n' \) is the number of years (periods) the resource is to be liquidated. \( R-X \) would be the user cost or depletion factor that should be set aside from GDP. Once a discount rate is fixed, true income can be obtained by using the above-mentioned formula. According to him number of years (n) can also be decided on the basis of the rate at which the owner is extracting. However, both \( n \) and \( r \) can be changed periodically, say every five years, guided by changes in the long-term market prices.

Serafy argues that user cost approach is an effective way of persuading developing countries to extract natural resources in a limited and planned way that depend on them. This way consumption of natural resources could be protracted over a long period of time. Using user cost approach, depletion factor could be estimated and adjusted in income accounting, which shall give us true income figures. However, he considers depreciation approach as the second best alternative to deduct a depletion factor from an inflated GDP to reach a corrected NDP so far as exhaustible natural resources are concerned.

Norgaard (1989) argues against the economic approach to "sustainability of development", based on accounting that relies on market valuations.
espouses "methodological pluralism" in the belief that a multiplicity of perspectives would ensure that "all values are respected" so that decision-makers have information alerting them to as many aspects of environmental and resource phenomena as possible. Norgaard, however, does not suggest how such alternative value systems can be established or used; nor does he speculate on the sort of solutions they would bring about.

Gilbert, et. al., (1990), classified the environmental assets into unconditionally renewable and conditionally renewable environmental assets. The importance is on the valuation of environmental asset stocks and changes in value of stocks over time. The net receipts from an environmental asset must be corrected for value depreciation of the asset over the accounting period to arrive at correct net income from the asset. To highlight valuation constraints and possibilities for different environmental assets, the study takes various elements into consideration such as time horizon (life expectancy of the asset), prices, quantities, costs and discount rate. In essence, the study concludes that there is no single undisputed way of valuing stock changes.

Rao (1991) has made an attempt to provide an analytical framework for understanding the causes of ecological degradation in the context of changing crop and livestock economy as well as in the context of the impact of these two on rural poverty. He espouses the view that deforestation and chemicalisation of agriculture are the major sources of environmental degradation. He has analysed the impact of extensive vs. intensive cultivation on ecological degradation and the impact of population pressure, affluence & poverty, land tenures, farm size and management patterns on environmental degradation. His analysis brings out the importance of land-augmenting and land-saving technological change in eco-preservation. He argues that the prospects of eco-development would become brighter with the advent of new bio-technology which is far more land saving than HYV technology.
Nadkami (1993), underlines the ecological issues in Indian agriculture in the context of sustainable development. Though he is critical of Indian agriculture being heavily dependent on the HYVs and Chemical farming, he agrees that in the context of modern agriculture, reverting back to traditional agriculture would not be feasible. He suggests advancing productivity through organic agriculture by methods such as those adopted by Fukuoka (1984) so that it is economically worthwhile to preserve it at least in some areas. Nadkami is critical of the drawbacks in the implementation of the "Polluter to Pay" principle, which has been accepted as a requisite for sustainable development, so that the externalities are internalised and the tendency to over-produce or over-consume a good involving negative externalities is corrected. According to him, this principle has been hard to follow. Particularly in agriculture, where huge subsidies are provided and direct costs are not even covered, water charges do not even cover the current costs of maintaining and running an irrigation project. Not to speak of environmental costs, fertiliser prices do not cover even production costs. He criticises the strategies of environmentally costly growth, followed just because most of these environmental costs are not at present precisely quantified and are not incorporated in the economic accounting.

Barbier and Markandya (1993), deal with the relationship between environmental quality and sustainable economic activity. They argue that if resource base is a composite of 'exhaustibles' and 'renewables', then sustainability requires utilising renewable resources at rates less than or equal to natural or managed rates of regeneration. Also it requires generating wastes less than or equal to rates at which they can be absorbed by the assimilative capacity of environment. Sustainability also requires optimising efficiency with which exhaustible resources are used, which is determined by the rate at which renewable resources can be substituted for exhaustible resources and by technological progress. The study provides a model of environmentally sustainable
economic activity. They have taken the rate of degradation as a function of several variables; such as flow of waste in excess of amount assimilated by environment, flow of renewable resources harvested from environment in excess of biological productivity of these resources plus flow of exhaustible resources extracted from environment. On the basis of the model they developed, conditions for environmentally sustainable growth are explored. For instance, initial level of environmental quality influences choices of discount rates and thus a low initial level of environmental quality forces resource users to discount the future heavily. Thus, poor would opt for immediate economic benefits at the expense of long run sustainability for their livelihoods. They plead for sustainable resource management to be given primary developmental goal so that current benefits accrued to people would not be at the cost of future generations.

On the whole, the studies reviewed above show a wide variety of environmental concerns in the progressive literature. An important purpose of these concerns is to integrate them into SNA. The studies which have focussed on such integration are reviewed below.

1.2.2 Studies on Integration of Environmental concerns into the System of Income Accounting

Studies on integration of environmental costs into SNA are attempted in two alternative frameworks. First, by treating the sectors in SNA as independent from each other. Second, by treating the sectors in SNA as interdependent among each other. The later framework is the familiar environmental and income accounting in input-output analysis. In the following review of literature, studies which integrate environmental costs into SNA in both the frameworks, are described with special reference to India and Kamataka state.
Perrings et al., (1989), account for natural resources for Botswana and the study attempts at arriving green aggregates by modifying the existing system of income accounting. Citing inadequacy of existing national accounts that do not contain the measures of the natural resources, they tried to include a set of accounts relating to value of environmental goods and services and suggested a construction of new account. They recommended a mixed input-output system where environment is included in input-output matrix and constructed the stock accounts for Botswana. They show the advantages of environmental accounts as such accounts reveal adequacy of data on natural resource accounts. They argue that availability of physical measures of flows of environmental goods and services will enable economists to test the efficiency of current economic activities under different valuation of natural resources used and so as to test the efficiency of existing implicit valuations. They argue that this account will help government to determine the optimal level of taxes, charges or subsidies on the use of scarce natural resources and will throw light on macro-economic policies for sustainable development. They recommend that such an account on natural resources would keep Botswana at the forefront of efforts to develop appropriate economic strategies for environment management and sustainable development.

Peskin (1989,a) discussed the relationship between economic depreciation and value of services generated by environmental and natural resource assets and determinants of service values. The study outlined the determinants of value of environmental assets. He put forward an accounting structure where five sectors are included. The sectors are industrial sector, governments, households, nature and consolidated gross product account. He illustrated environment as a part of these accounts and total input is being equated with output. He demonstrates the relationship between conventional and modified accounts, where modified GNP is equal to conventional GNP minus environmental damage. Peskin gives the example of resource accounting taking Tanzanian national accounts in 1980. He
provided both conventional and modified Tanzanian accounts for the year 1980 and found that conventional accounts were grossly underestimated.

Repetto et. al, (1987) attempted to account natural resources for Indonesia. They show the weaknesses of current system of national income accounting and also pointed out the scope of natural resource accounting. They set up natural resource accounts for Indonesia in both physical accounts and monetary accounts. While undertaking Indonesian resource accounts, they accounted for forest resources, petroleum resources and soil. Repetto's study throws insight to construct accounts for natural resources in both physical accounts as well as monetary accounts to estimate depreciation of natural capital. However, the study ignores major polluting sectors of the economy of Indonesia and even the sectors, which are considered, are partially accounted for the natural resources. Though the modified aggregates obtained by the study is certainly a way forward as compared to conventional income aggregates, they could not be considered green income aggregates since environmental repercussions are not incorporated and depreciation of natural resources is partially accounted for.

Lutz (1991) integrated environment into SNA for Mexico, taking into consideration oil depletion, degradation of environmental assets and deforestation and land use pattern. He presented the current National Accounts Mexico SCNM (Sistema de Cuentas Nacionales de Mexico) and analyses the national accounts of Mexico with an analytical model which includes a supply and use identity and production functions. The study presents SCEEM (Sistema de Cuentas Ecologicas e Economics de Mexico), which is an expansion of SCNM considering the environmental assets and natural resources. In the SCEEM, Lutz introduced two new concepts of net capital accumulation; such as net accumulation of economic assets and net accumulation of environmental assets. Net accumulation of economic assets is defined as changes in the productive capacity i.e. capital used
in production, including not only produced assets, but also non-produced economic assets. Lutz defines net accumulation of environmental assets as net change in quantity and quality of environmental assets as a result of economic activities. He applied SCEEM to three environmental concerns such as: (1) Oil extraction; (2) Deforestation and land use; and (3) Degradation.

Lutz incorporates the effects of degradation which include soil erosion, solid waste materials resulting from household activities, depletion of ground water, water pollution in terms of the bio-chemical demand for oxygen (BDO) used by nature to destroy foreign substances in water; and air pollution in terms of various chemicals emitted by industrial production processes.

The study has compared between SCNM and SCEEM aggregated in monetary terms and by economic activities. His sectoral analysis focuses on three elements such as value added, balance of economic assets including produced as well as non-produced assets and the environmental protection expenses made by different sectors.

Hueting (1989) agrees with the idea of overstatement of current national income figures, as they do not reckon environmental losses, but provides three practical solutions towards correcting national income for environmental losses. First correcting national income for defensive environmental outlays. Here the correction is only partial, since greater part of environmental losses are neither restored nor compensated and mutations in both the current and corrected figures of GDP do not represent economic growth or the course of welfare over time. Second, complementing corrections for defensive outlays through surveys. In this case, information on significance of environmental functions is deficient in most cases. Also there is considerable difference between saying that one is willing to spend money on something and actually paying for it as people are interested in
the effects of their own cause. However, willingness to pay method does not present a firm basis for correcting national income for losses of scarce environmental functions. Third, corrections for defensive outlays through standards for sustainable economic development. This method consists of supplementing corrections for defensive environmental outlays with estimates of expenditure on measures required to meet physical standards for the availability and quality of environmental functions. However, the results from this approach do not represent individual valuations in a true sense and the method ignores loss of welfare suffered by people who have a strong preference for survival of plant and animal species. In addition, this method cannot account for irreversible losses apart from being quite laborious. Further, Hueting argues that national income figures should be corrected for loss of environmental functions on the basis of standards for health. A sustainable national income accounting that would provide alternative national income figures alongside existing ones and difference between these two figures will show how far a country is on the course of sustainable development.

Bartelmus (1989) agrees with the idea of incorporating environmental aspects in traditional SNA like other environmental economists. He provides the idea of having a material/energy balance (MEB) and argues to consider MEB as a physical extension of input-output tables of national accounting. He also pleads for a "resource accounting" system that can provide a coherent picture of resource use and depletion or increase, which can be integrated with national accounts. Bartelmus supports the idea of monetised environmental accounting, as physical indications and accounts cannot be aggregated into overall measures of resource depletion and environmental degradation. He distinguished three basic categories of environmental accounts such as: (1) Environmental Costs and Expenditures, (2) Natural Resource Capital; and (3) Environmental Services.
Bartelmus emphasised environmental services rather than defensive expenditures, as these services are not priced by market systems and are excluded from standard National Accounts. He pleads for introducing a natural production account into SNA that would record environmental services (such as waste disposal, cooling, and provision of oxygen and nutrients) as forms of output and environmental damage as input, with the balance representing a net environmental loss or benefit. Accordingly, he proposed the concepts of sustainable Net Product, sustainable income and expenditure to supplement traditional GDP or NDP calculations, apart from modified gross or net Product that accounts for environmental damages and services. However, Bartelmus has not focused on how to price the environmental services and damages and go for monetary accounting, which are essential for integration of environmental services with SNA.

Daly (1989) provides an approach towards measuring sustainable social net national product. In particular, he defines corrected income concept as Sustainable Social Net National Product (SSNNP) as NNP minus both defensive expenditures (DE) and depreciation of Natural Capital (DNC) that is: SSNP = NNP - DE - DNC. But the study does not provide a framework of green national income accounting as such. Also the study does not address the question of valuation problems involved in the accounting of environmental resources.

Harrison (1989) argues that from an environmental perspective, neither exhaustible resources such as mineral deposits nor permanent resources such as land and water should be treated as free gifts of nature. Since economic activities interact with nature, allowance must be made for the existence of environmental programs for maintenance of these permanent resources. He defines natural resources as natural capital instead of free gift of nature. He includes both renewable and non-renewable natural resources under the category of exploitable resources and argues for proper valuation of these resources.
In contrast to exploitable resources, Harrison refers to resources like land, water and air as *permanent* resources. He provided with three alternatives for preservation of these *permanent* resources. First, prevention expenditures may be made by industry itself; second, by government and funded by taxes levied on industry according to its pollution potential; and third by government and funded by general revenue. But in first case pollution control would be classified as intermediate expenditures and in second case as intermediate inputs and in third case as final expenditure. Under the present system of National Accounting, all alternatives lead to the conclusion that initiating a pollution prevention campaign, whichever way they are funded, increases GDP. In this context, it may be noted that, in Leontief’s model of input-output with environment, incorporation of environment leads to a higher level of production in an economy. Since, environmental degradation is a consequence of the prevailing techniques of production process, any increased level of production will necessarily be associated with an increased level of physical pollution (and therefore environmental degradation) though value additions in monetary terms for the economy will be less as compared to the original income.

Harrison provides an idea with regard to valuation of consumption of *natural capital* by estimating the cost of making its improvements. But valuation of consumption of natural capital has to be based on approximation. Thus, Harrison pleads for environmental enhancement programs and emphasises sustainability through an extended SNA and for the integration of natural, man-made, and human resources that provides the framework for defining sustainable development.

Blades (1989), argued for measuring pollution within the framework of SNA. He considers pollutants as a particular (unwanted) type of industrial output and studies generation of pollutants by an extension of conventional input-output table.
In conventional input-output framework, he includes environmental commodities and provides input-output tables isolating pollution damage costs and pollution abatement costs. He describes the benefits of pollution abatement as improvement in health, enhanced enjoyment from natural environment, and related benefits that the community at large derives from such abatement. These benefits can be valued in several ways including for instance, through estimation of demand curves to measure market valuation of abatement benefits in regard to clean air at different places. Thus, the abatement costs should be incorporated in national accounts.

Peskin (1989,b) proposed for an environmental accounts framework with three key elements. First, both positive and negative benefits which are associated with any amount of polluting activity. Second, finite availability of assets services, and hence, identification of one party as polluter and another as injured is not always appropriate. Third concern to the total availability of environmental assets services. Peskin provides an elaborate discussion on valuation concepts and investment and depreciation in the economy. He expressed gross income in terms of consumption and gross investment where gross investment is net investment plus depreciation. He also defines value depreciation as physical depreciation minus capital gains or plus capital loss. With help of all these concepts, Peskin presents an example of consolidated production account for a hypothetical economy.

In the modified accounting structure, Peskin's study includes industrial sector, government, households sector and nature. It presents consolidated national income and product account where environmental services are included in input side and environmental damages in output side to give us a modified gross national product. He provided three options for modifying GNP such as follows:
Option 1: \( GNP_1 = GNP - ED \); where ED is environmental damages.

Option 2: \( GNP_2 = GNP + ES \); where ES is environmental services.

Option 3: \( GNP_3 = GNP + NEB = GNP + ES - ED \); where NEB is net environmental benefit.

Thus, in the framework provided by Peskin, depreciation of environmental capital modifies NNP. By simply subtracting depreciation modified figures can be obtained for an economy. Though such a framework looks so simple, the task to incorporate environmental damages and services in conventional system of national income accounting empirically is a difficult one.

Bojo, et. al., (1990) justified the economic analysis of environmental resources in a general equilibrium framework for several reasons. First, a particular project may have important repercussions in the economy and in order to incorporate them in an approach based on general equilibrium theory is necessary. By taking the instance of cost of pollution control they argue that repercussions on rest of the economy also occur through changes in relative prices, since the economy has to readjust its production structure as well as its trade with other countries in such a way to minimise cost of pollution control. Second, national and regional policies that are not directly aimed at environmental issues will have a substantial impact on environment through repercussions in the economy. Finally, economic analysis of a set of environmental problems is directed toward optimisation and since general equilibrium models give one set of tools that can be used to implement such optimisation, it is quite relevant to deal with environmental issues in a general equilibrium framework. In addition, a hypothetical SAM model developed where eight different accounts are presented. The study modifies accounting system with environmental measures and develops a green accounting
system; where a new account is added to original SAM, that is environmental account. The study highlights sustainable development that fits very well in the new green accounting framework.

Lutz and Munasinghe (1991) highlight the deficiencies of present SNA and suggest that an improved way of preparing national accounts could help to achieve sustainable development. The deficiencies of present SNA represent limited indicators of national well-being. Though clean up costs are often included in national income, environmental damages are not considered. They show that for private firms, defensive expenditures are netted out of final value added. But in contrast, such clean up costs are considered as productive contributors to national output if public sector or households incur them. They show two major distinctions in calculation of national income. First, undesirable outputs like pollution are overlooked and second, beneficial environmental related inputs related to environmental needs are often implicitly valued at zero. They suggested computation of measures like "Environmentally Adjusted Net Domestic Product (EDP) and Environmentally Adjusted Net Income (ENI). For instances, the procedures to arrive at ENI are as follows: (1) subtract environmental protection expenditures of government and households, which are treated as final expenditure in SNA; (2) subtraction of environmental effects on health and other aspects of human life; (3) subtract environmental costs of household and government consumption activities; and (4) subtract negative environmental effects in the country caused by production activities. Once ENI is estimated, it serves as a better indicator of status of the economy where emphasis has been on sustainable development.

Friend and Rapport (1991) analysed the changing perception of environmental problem that has shifted the issue of environment information from an almost exclusive focus on pollution towards changes in natural productivity and
resource depletion. This has re-oriented environmental data needs towards macro
perspective of national income accounting as reflected in natural resource stocks
and flows, indicators of the state of environment and sustainable development.
They proposed a framework which tracks stocks and flows of natural resources,
incorporates a critical set of indicators of ecological integrity and integrate certain
parameters in SNA with those found in Natural Resource Accounting (henceforth,
NRA).

In particular, the authors point out three major components of NRA. They
are: (a) biological/ecological accounts (b) geological accounts, and (c) cycling
systems accounts (which describe the change of stocks and flows in specific
components of the atmosphere, hydrosphere, and lithosphere that are critically
linked to human concerns). Focusing on Canadian experience in macro-
environmental information systems, they developed a framework of Stress-
Response Environmental Statistical System (STRESS), which forms the conceptual
basis for state of environmental reporting. Describing environmental problems as
regional, national, international and global in scale, they argue that shift from local
to global has made it imperative to integrate macro-level environmental indicator
with indicators of economy.

Thampapillai (1995) attempted to introduce environment into policy
frameworks in macroeconomics. First, he developed an environmental cost
function and examined the policies that emerge when the cost function is
considered in frameworks of Harrod-Domar model of economic growth. He defines
total environmental costs that are incurred during an accounting period as
environmental restoration cost and environmental maintenance cost. He espouses
the view of other environmentalists that the performance of an economy is better
measured by "NNP-CE" than NNP alone. He finds that when environmental cost
function can be developed from the statement of environmental accounts, output
targets can be nominated and the level of investments that comply with these output targets can be determined. Second, he incorporated environmental cost function in IS-LM analysis and found that the interest rate should be allowed to emerge from a set of policies that clearly recognise the limits imposed by environment. He pleads that the choice of policies for a sustainable development can be better served by constraining the process of output formation by an environmental cost function. Third, he incorporated the cost function in aggregate supply analysis and in a Keynesian expenditure model. He concludes that in Aggregate analysis and Keynesian model, the full employment and general equilibrium should be achieved by investing in environmental technologies or choosing a lower real wage policy.

Hannon (1995) describes the usefulness of the input-output model of an economy where energy scarcity and related natural resources can be accounted in such a framework. The model helps to estimate ecological prices and discount rates. Hannon describes that the static input-output view of an ecosystem is similar to the static description of the eco-system, except that there is no counterpart to personal consumption in the ecosystem and the existence of species and tropic levels makes it difficult to conceive of the division of labor in nature as being comparable with that in an economy. Hannon’s argument is that in Leontief’s dynamic input-output model, applied to the equation to ecosystems combined with control theory can handle the inherent instability when run forward in time by use of a variety of controls. Using the resulting equation, dynamic production paths could be demonstrated that would lead the ecosystem most efficiently to a desired future level of net output. Hannon is of opinion that with Leontief’s ideas, one could consider non-linear dynamics and simulation, a system approach that is theory-rich but data poor. However, the study does not cover any empirical analysis of ecology incorporated into the framework of input-output analysis.
Ritu Kumar and Carlos Young (1996) incorporated water resources in the SAM of Thailand and illustrated possible supply and demand functions of water. The framework is based upon an integrated approach to demand and supply management of water resources and its implications for water pricing policies. The discussion mostly revolves around modifications and extensions of SAM and demand and supply equations for water that reflect true scarcity of water for different users and from different sources. Also they attempted to introduce user cost of water in accounting matrix, at the conceptual level, thereby enabling a link between Computable General Equilibrium Models (CGE) and user costs. They discussed different sources of irrigation water for agricultural purposes and analysed transmission of irrigation water by showing inter-sectoral linkages in SAM framework. In an extended version of SAM for Thailand, they included surface pipe water, ground water and recycled wastewater and studied their inter-sectoral linkages. The study presents an Economic and Environmental Accounting Matrix where water is incorporated both as an item of intermediate consumption and as a natural resource or primary factor of production. In short, the study presents a detailed account of how SAM can be modified to include different types of water, incorporating changes in inter-sectoral flows. It highlights seriousness of over-exploitation of aquifers, land subsidence and wasteful utilisation of water resources by agriculture and industry in Thailand.

Atkinson et. al., (1997) provide a framework of resource and environmental accounting and argue for development of ecological indicators for sustainable development. The formal approach to income accounting based on models of welfare maximization over the long term provides consistent guidance of green national accounting aggregates. The NNP need to be adjusted to value both resource depletion and in case of living resources, resource growth (for example, forestry). They argue that by including the effects of pollution emissions, the green
aggregate is necessarily a welfare measure rather than a national income measure; although NNP is the starting point. It is necessary to value pollution emissions, pollution dissipation and the level of environmental services when adjusting for pollution. They opine that where resource use leads itself to pollution emissions, resource rents should be reduced by the amount of an optimal tax on resource use. They espouse the view of others that household defensive expenditures should not be deducted from green welfare measure.

Sadoff (1996) used both user cost and depreciation approaches to assess the effects of Thailand's forest management. He found both methodologies suggest that the standard GDP calculations overstated Thailand's national income by failing to account for forest depletion. While user cost methodology suggested that real GDP was overstated by an average of 1.5 per cent annually, depreciation adjustments found GDP inflated at an average of 2.2 per cent. The user cost analysis found logging ban to be both ecologically and economically beneficial, while depreciation adjustments suggest that forest protection was not sufficient to reap net economic gains. He points out that this divergence between methodologies is due to choice of data in their application. However, theoretically, user cost approach appears to be more defensible. The modification of national income accounts following a user cost approach would bring the system more closely in line with proper economic definitions of income and capital consumption. It would separate cost of environmental disinvestment from value added and income, where depreciation methodology would not serve these purposes. He points out that resource-related incomes in national accounts are relatively inflated and unsustainable. The study recommends that a natural resource accounting with a standardised valuation methodology would provide a consistent analytical framework for the economic evaluation of resource management.
Leontief (1970) introduced environment in an input-output framework. In his study, the undesirable by-products and (unpaid for) natural resources are linked directly to the network of physical relationships in the economic system. The study incorporates pollution as an additional sector into a hypothetical two-sector (agriculture and manufacturing) input-output model and observes that, incorporation of pollutant sector results in higher levels of gross output for both the producing sectors of the economy. The study shows that, if the sectors take up eliminating part of the pollution, the costs of such abatement might be passed onto the Household. The price mechanism could ensure that the purchaser pays for the elimination of some of the pollution generated in the process of production. However, in real terms, the NVA from sectors would be less (as compared to the initial NVA without the pollution sector), if pollution were taken into the system. This is because part of the increased output is required for the elimination of pollution generated in the production process. The study provides a theoretical framework of incorporating environmental concerns in an accounting system (input-output analysis) that can be analysed in a general equilibrium framework.

Leontief and Ford (1972) extended the structural coefficient matrix of US economy to the generation and elimination of pollutants along with the production and consumption of other goods. In this study, only increment to the value added coefficients of regular activities for elimination of four air pollutants (particulates, sulphur oxides, hydrocarbons and carbon monoxide) are taken together for which data were available. The study has aggregated the original 270 sector table available for US economy into 90 sector table. From this 90 sectors, 30 sectors were considered from which most of the atmospheric pollution comes are described in a relatively detailed breakdown. The pollution coefficients describe the thousand tones of particular pollutants emitted by each industry per million dollars' worth of its total output. The study cover observed past and anticipated
future changes in the structure of American economy from the year 1958 over the years 1963, 1967 and the future period of 1980. They find that as time goes on, the total amount of pollution emitted is affected by: (a) the increase in the aggregate level of final demand, (b) changes in the distribution of this aggregate demand among different goods; and (c) changes in industrial technology as reflected in a changing $A$ matrix.

They have endogenized the industrial pollution abatement costs, which are included in the price computations of all industrial sectors that emit pollutants. They observe that such an exercise does not take into account the fact that processes used to control one kind of pollutant often generate other kinds of pollutants. Since the information on values of coefficients were not available, the coefficients were assumed in the price computations equal to zero and the authors feel that this results in a general underestimation of the repercussions on the industrial price structure of the pollution abatement measures. The study concludes that other pollution such as water can be incorporated in such a model with the availability of data within the framework of regional and multi-regional input-output systems that have already been implemented.

Flick W. A. (1974) points out an inconsistency in the Leontief model of input-output where pollution sector is taken into account. Flick points out that, when the generation of pollution is below tolerable limit, there need not be any adjustments made to the final demands of the sectors. Although the price equations do not account for the dependence between the producing sectors and the anti-pollution sector, the quantity systems of equations accounts for the structural dependence. Therefore, the computed prices are lower than they should be. Further, Flick points out that, the set of equations in the Leontief’s study are inconsistent in the sense that in the price systems equations pollution is natural while these equations are derived from the quantity equations where
pollution is non-existent. However, Flick’s study has not covered any empirical study of an extended input-output model with environment.

Steenge (1978) points out that Leontief’s extension to include pollution was made at the cost of a very attractive feature of the open input-output model. He opines that the existence of a nonnegative vector of gross output levels (where tolerated pollution level is included) for any final demand is not guaranteed that is shown by Flick’s counter example of requiring a negative level of anti-pollution sector. The study points out that Flick’s argument is not appropriate because a certain dependency between the model’s equations has not been accounted for; the dependency being that tolerated pollution can not exceed total generated pollution in Leontief’s formulation.

Steenge (1978) points out that a substitution is possible in Leontief’s environmental repercussions model that generates an adjusted system; i.e. the adjustment corresponding to the extent to which industries have to participate in an antipollution measures. Adjusted value added coefficients can be found by the same substitution next to the adjusted technical coefficients. The price systems can be determined as a function of the degree to which the polluter pays principle is applied to the economy. By using the same numerical example of Leontief (1970) and the model of Leontief and Ford (1972), Steenge has shown that the substitution allows to confine to the original $m \times m$ system instead of working with Leontief’s extended system. Steenge has shown that with the introduction of the substitution factor, the corrected gross outputs of the sectors and required labor supply is higher than the original amounts before adjustment. He argues that the anti-pollution facilities become gradually integrated in normal production processes because abatement at the sources becomes more and more imperative. Also the systems of equations provide solutions for the polluter pays principle for the environmental policy decisions. With the help of Leontief’s
numerical example, Steenge shows that prices can be determined on the basis of the policy decision whether to charge the polluting industries fully or partially for the generated pollution.

Rhee and Miranowski (1984) present a multiplier approach to solve an extended version of the Leontief pollution model with income incorporated as an endogenous variable. This approach provides solution for each variable of the model, which can be expressed in terms of the non-augmented Leontief inverse, exogenous variables, and two important multipliers, “the pollution control multiplier” and “a modified Keynesian multiplier” modified by pollution control. The study shows that the induced effect and the effect of pollution control on a given economy can be separated from the model. Further, it is shown that the multiplier approach solves the Leontief’s pollution model in a more directly interpretable and computationally efficient manner than the conventional method of directly using the Leontief inverse matrix. They argue that the computational burden in multiplier approach is far from comparable with that of the Leontief inverse. Though the multiplier approach they have demonstrated deals with industrial pollution only, they conclude that such a model can be extended to handle the pollution arising from the final demand sector also.

Parikh et. al, (1992) put forward a framework of natural resource accounting for India. They attempted to extend SNA to NRA and to value natural resources. Apart from that, they accounted for soil, air and water resources in NRA and emphasised that forests and Bio diversity also need to be taken into account. They extended the traditional input-output framework of national income accounting and incorporated natural assets such as land, air, water and forests. The study assumes importance as it provides a basic framework for natural resource accounting in the context of India.
The study considered various emissions and effluent associated with various economic activities of production and consumption. The study focused on most important natural assets particularly land, forests, virgin forests, water, air, biodiversity and various exhaustible resources such as oil, coal, gas, other minerals and ores. They emphasised the importance of non-market sector in developing countries and argue that it should be captured in the standard framework of SNA. Focusing on resource flows in NRA, they listed few resources and argue to treat them separately in SNA input-output table. The study highlights the benefits of improved air quality and argues to integrate NRA into SNA so as to have better indicators of national income aggregates. However, the study does not empirically integrate environment in SNA.

Mishra et. al. (2001) analyze the role of technology on the generation of industrial water pollution in Indian economy over the period 1983-84 to 1993-94. The analysis has been done for two sub-periods, 1983-84 to 1989-90 and 1989-90 to 1993-94 at 56-sector aggregation for 38 different organic, inorganic and toxic water pollutants. The study has used Leontief's input-output model extended to pollution sector. The data on water pollutants by the industrial sectors are collected from the Central Pollution Control Board (CPCB). The input-output transaction tables prepared by CSO, planning commission, have been used and extended to include water pollutants. The study finds that over the years input technology has generated more pollutants. During the first period technology deterioration in terms of environmental pollution is more evident than the second period. In the second period a slight fall in pollution growth is observed for the highly polluting industries. The study also finds that 70-80 per cent pollution in the economy is generated by the highly polluting industries and around 80 per cent pollution is abated for most of the pollutants.
Kuik et. al., (1997) provide a comparative assessment of environmental policy approaches in India and Netherlands. The study compares major policy changes by governments of these two countries with regard to handling of environmental issues and pollution control. The study highlights the instruments of environmental policy with regard to pollution control, in theory and practice, in both countries and highlights recent developments in pollution control measures adopted by these governments. The study chose Karnataka state as a representative of India and analysed policy instruments, economic incentives and other measures adopted to prevent pollution in Karnataka with a historical background and highlights major developments in 1990's. The study provides an analytical framework and throws insights into constraints and strengths of pollution control instruments prevalent in both countries and recommends improvements in the efficiency and effectiveness of such measures. The study analyses highly polluting industries such as Textiles, Cement and Fertiliser in both the countries and makes a comparison with regard to environmental pollution these industries generate with that of total emissions. The study highlights similarities and differences in environmental policies and pollution control in both countries and underline the opportunities for improvement in pollution control policies.

On the whole, the above-mentioned studies mostly dealt with the problems in conventional system of national income accounting and estimation of environmental costs and benefits. The studies highlight deficiencies in the existing system of national accounting and need to introduce environment so that green income aggregates provide a better indicator as compared to income aggregates obtained through conventional SNA. While most studies argue that natural resources need to be treated at par with man-made capital and hence its depreciation should get into the accounting system, others suggest that green income aggregates could be derived by extending input-output transaction tables to environmental repercussions. However, only a few studies have empirically dealt
with natural resource accounting and have provided frameworks to extend environmental and natural resources in existing system of income accounting.

An important implication of the review of literature above is that the issues of environmental concerns, which were raised at the end of sub-section 1.1 in this chapter, are only partially answered, if not totally neglected. These neglected aspects of the environmental concerns provide researchable issues and justification for further study in the subject, such as, the present study. Thus, the present study is an attempt at estimation and integration of environmental costs into SNA as they are related to Karnataka state in India.

1.3 Objectives of the Study

The objectives of this study are as follows:

1. To provide a general methodological framework of regional income accounting that explicitly accounts for the environmental costs which is not taken care in the conventional SNA;

2. To correct for the state income figures adjusted for environmental costs and estimate the true income of Karnataka state which would be helpful to formulate policies for sustainable development;

3. To derive a functional relationship between the income aggregates and environmental aspects and provide a model for sustainable economic growth for Karnataka State in particular, and other states in India in general;
4. Examine likely changes in the State income aggregates if the Karnataka State adopts environmentally sustainable economic activities.

1.4 The Period of the Study and Study Area

The estimation of environmental costs and its integration with conventional SNA is undertaken in this study for the state of Karnataka in India. The year 1994-95 is chosen to be the period for the analysis of environmental costs and estimation of green income aggregates in this study. The year 1994-95 was the most recent year for which all data related to this study were available for Karnataka when the study was initiated.

All the sectors of national income accounting in India viz. primary, secondary and tertiary are well represented in the State income aggregates of Karnataka. Furthermore, the official databases in Karnataka are considered as one of the best among Indian states. Karnataka is also one of the first states in India to implement environmental policies effectively as prescribed by the Ministry of Environment and Forests. For these reasons, Karnataka state is chosen as the study area for the present study. The profile of the Karnataka state, which is chosen as study area is presented below.

The southern state of Karnataka is in many ways the archetypal Indian state. The location of Karnataka is close to the nation's heartland. In terms of development, the state is at the median level in major sectors. This makes the profile of Karnataka more or less reflect where the country as a whole stands.

Karnataka is the eighth largest state of India in terms of both area and population. The total area of Karnataka spans across 191,791 sq. kms. The estimated total population in the year 1994-95 was 4.75 crores (5.83% of the...
population of India). The density of population is 240 per sq. km. as compared to 257 of India. The male to female sex ratio is 52:48. The literacy rate is 56% as against the Indian literacy rate of 52.2%. The principal crops in Karnataka are Rice, Ragi, Coconut, Mulberry etc. Furthermore, the state capital Bangalore is known internationally as the hub of information technology and electronics in India.

The Net National Product (henceforth NNP) at current prices of India in the year 1994-95 is Rs. 744,663 crore at current prices, and Rs. 217,041 crore at constant prices (i.e. 1980-81 prices). On the other hand, Karnataka’s Net Domestic Product (henceforth, NDP) at current prices is Rs. 38,421 crore and Rs. 11,892 crore at constant prices. The per capita income of India for the year 1994-95 is Rs. 8,237 at current prices and Rs. 2,401 at constant prices. For Karnataka the per capita income for the same year is Rs. 8,082 at current prices and Rs. 2,501 at constant prices. The share of Karnataka’s income in national income for the year 1994-95 is 5.15% and 5.47% at current and constant prices respectively. A comparison of the income figures in per capita terms at constant prices reveals that, Karnataka represents India to a large extent in terms of income aggregates.

The share of primary sector to Karnataka’s NDP is 39.7% per cent at current price and 36.1% at constant prices for the year 1994-95. For the secondary sector, the share is 21.7% and 23% at current and constant prices respectively. As far as the tertiary sector is concerned, the contribution to Karnataka’s NDP is 38.6% at current prices and 40.9% at constant prices. At all India level, the share of primary sector in national income is 32.2 per cent in the year 1994-95. The secondary sector’s share of contribution to national income is 26.5 per cent. The contribution of tertiary sector to national income accounts for 41.3 per cent in the year 1994-95. A comparison of sectoral income composition at the state level and national level shows that Karnataka fairly represents India especially in terms of income aggregates. With this backdrop of Karnataka, the rest of this study focuses on
providing a methodological framework of green accounting and estimating sectoral incomes adjusted for environmental costs for the state.

The comparisons of macro indicators between Karnataka state (regional level) and India (national level) are summarized in table 1.1 below.

### Table 1.1
Comparison of macro indicators between Karnataka and India

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Karnataka State</th>
<th>All India level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Population</td>
<td>4.75 crores</td>
<td>81.47 crores</td>
</tr>
<tr>
<td>2. Population as % to Total</td>
<td>5.83 %</td>
<td>100%</td>
</tr>
<tr>
<td>3. Density of Population</td>
<td>240 per Sq. Km.</td>
<td>257 per Sq. Km.</td>
</tr>
<tr>
<td>4. Sex Ratio (Male: Female)</td>
<td>52.48</td>
<td>53:47</td>
</tr>
<tr>
<td>5. NNP at current prices</td>
<td>Rs. 38, 421 crore</td>
<td>Rs. 744, 633 crore</td>
</tr>
<tr>
<td>6. NNP at constant prices</td>
<td>Rs. 11, 892 crore</td>
<td>Rs. 217, 041 crore</td>
</tr>
<tr>
<td>7. Share of Karnataka's income to India at current prices</td>
<td>5.15 %</td>
<td>100%</td>
</tr>
<tr>
<td>8. Share of Karnataka's income to India at constant prices</td>
<td>5.47%</td>
<td>100%</td>
</tr>
<tr>
<td>9. Per Capita Income at current prices</td>
<td>Rs. 8, 082</td>
<td>Rs. 8, 237</td>
</tr>
<tr>
<td>10. Per capita Income at constant prices</td>
<td>Rs. 2, 501</td>
<td>Rs. 2, 401</td>
</tr>
<tr>
<td>11. Share of Primary Sector at constant Prices</td>
<td>36.1%</td>
<td>32.2%</td>
</tr>
<tr>
<td>12. Share of Secondary Sector at constant Prices</td>
<td>23%</td>
<td>26.5%</td>
</tr>
<tr>
<td>13. Share of Tertiary Sector at constant Prices</td>
<td>40.9%</td>
<td>41.3%</td>
</tr>
</tbody>
</table>

Source: Planning Department (1999), Human Development in Karnataka : 1999,
Government of Karnataka
EPW Research Foundation (1997): National Accounts Statistics of India
1.5 Methodological Issues and Databases for the Study

The DES of Karnataka officially provides the estimates of income aggregates. But the income estimates of DES are based on conventional SNA that does not take into account environmental concerns. In this context, three methodological issues can be raised as follows:

1. Estimation of sector-wise environmental costs.
2. Integration of environmental costs into state income estimates obtained through conventional system of income accounting.
3. Capturing the interdependence of sectors in the context of integrating environmental costs with income accounting.

The income aggregates adjusted for environmental costs can be obtained by two ways: (1) Estimating environmental costs sector wise at source and integrating them into sectoral income (2) Estimating environmental costs by taking into consideration the sectoral interdependence of an economy. In the first method, the true income aggregates are obtained but the sectoral interdependence of environmental repercussions are not captured. Whereas in the second method, sectoral interdependence of environmental repercussions are captured. However, to capture the interdependence of sectoral income as well as environmental repercussions, it is essential to estimate sector wise environmental costs. For this reason, both the methods (1) and (2) considered in this study.

As far as method (1) is concerned, environmental costs can be estimated in two ways: (a) Estimating the environmental costs for the entire economy by taking into account total degradation in environment / depletion of natural resources (b) Estimation of environmental costs at source of degradation. In the first case, one can estimate total expenditure needed to restore the environment into original level.
before the accounting period and estimate the cost of depreciation of natural resources. However, it is difficult to estimate the extent of environmental degradation for an economy due to following reasons. First, pollutions are of different forms and leads to aggregation problems. Secondly, pollutions apart, depletion of exhaustible natural resources cannot be aggregated for the entire economy. Even if one is able to estimate the extent of degradation, it is impossible to segregate the damage caused to the environment / natural resources in the particular year under consideration. Hence, keeping in mind the methodological limitations, method (b) is considered more relevant and practical as far as estimation of environmental costs is concerned.

In the context of income accounting, the natural resources are divided into two parts i.e., exhaustible resources and renewable resources. For exhaustible natural resources the user cost approach is used. And for renewable natural resources the depreciation approach is considered. In the case of pollution and degradation of environmental resources the defensive expenditures approach is used.

To capture interdependence of sectoral incomes and environmental repercussions, the framework of static, linear and open input-output model of Leontief is adopted.

All data on sectoral income aggregates are taken from the DES, Government of Karnataka. The detailed disaggregated data on various sectors are taken from documents published by official sources in the state and by Government of India. The state income figures are adjusted for environmental costs only at constant prices (i.e. at 1980-81prices). Due to non-availability of basic input-output transaction table for Karnataka state since 1966, the latest
input-output transaction tables at all-India level for the year 1993-94, published by CSO (2000), is suitably adopted.

### 1.6 Organisation of the Study

The rest of the study is organised into six chapters. The issues related to valuation of environmental / natural resources and estimation of environmental costs and sectoral income aggregates are discussed in chapter 2. The empirical estimation of environmental costs and green income figures (sector-wise) for Karnataka are presented and compared with the figures obtained through traditional SNA for (a) Primary sector in chapter 3; (b) Secondary sector in chapter 4; and (c) Tertiary sector in chapter 5. In chapter 6, an attempt is made to incorporate environment in an input-output framework for the Karnataka economy. The results obtained through environmental accounting in an input-output framework are compared with the results of green income estimated by sectors in the previous chapters. Chapter 7 presents the summary, main conclusions and policy implications of the study.

Throughout the study, all tables are presented as part of the running text. All notes are given as endnotes at the end of each chapter. The consolidated list of references of the study is given after chapter 7.
End Notes:

1 Daly (1989) quotes J.R. Hicks' (1946) definition of income in his paper.

2 The details of GDP and other indicators of national income can be found in any standard textbook of macroeconomics; such as, Dornbusch et. al (1998).

3 All data presented below are taken from Human Development in Karnataka, 1999, Government of Karnataka.

4 1 crore is equal to 100 lakhs; 1 lakh equals to 100 thousand; One million equals to 10 lakhs.

5 NNP refers to national level income whereas NDP refers to state income. This is usually termed NSDP in the official documents.