Impact of economic growth on climate Change: An Environmentally Extended Social Accounting Matrix (ESAM) based approach for India

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Abstract:

This paper analyse the impact of growth in sectoral output and employment on green house gas emissions (GHG) in India. To analyse this we have used environmentally extended social accounting matrix (ESAM) based approach for India. The ESAM shows inter relationship between the economic activities as well as their impact on environment. The environmental impacts are captured through emission of GHGs, depletion of natural resources like land, coal and crude oil. India was an early leader in social accounting matrix (SAM) based analysis but this is the first ESAM for India. In this study we have constructed 35 sectors ESAM for India for the year 2006-07 with detail description of energy sectors. The pollution trade-off multiplier obtained from this ESAM helps us to analyse total (direct, and indirect-induced) impact of growth in sectoral output and employment on GHG emission in India. Here we have assumed public investment and foreign trade as exogenous variables. So the result shows that due to interdendency between the production sectors total increase in GHG emission is higher than their direct effects. Sometimes researchers rely on the direct relationship between the economic activity and GHG emissions but their indirect impact must be incorporated to see economy wide impact on GHG emission. The result of this study shows that the direct effect of paddy sector on GHG emission is substantially lower than their indirect-induced effect. The direct effect of paddy sector on GHG emission is around 6tons/Rs. lakh of output but its total effect on GHG emission is arround 32 tons /Rs. lakh of output. Also this study shows that growth in service sector in India will not be the jobless growth and its total impact on GHG emission is not significant.

Key words: SAM, India, Environment, Climate change

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1. Introduction:

Understanding the impact of climate change on the economy's performance has become an important issue for developed and developing economies. The Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report said that, the changes in atmospheric concentration of GHGs and aerosols, land cover and solar radiation alter the energy balance of the climate system and are drivers of climate change. Also the continuous increase in concentration of GHGs in the atmosphere is likely to lead to climate change resulting in large changes in ecosystems, leading to possible catastrophic disruptions of livelihoods, economic activity, living conditions, and human health (IPCC, 2007).

Historically, the industrialised countries have been the primary contributors to GHG emissions. Only 25% of the global population living in Annex I countries emit more than 70% of the total global CO_2 emissions and consume 75% to 80% of many of the other resources of the world (Parikh, et.al., 1991). But because of their high population and economic growth rates, the fossil fuel use led CO_2 emissions from developing countries are likely to soon match or exceed those from the industrialised countries (Sathaye, et.al., 2006). Therefore if the responsibility for historical emissions increase lies largely with the industrialised world, then the developing countries are likely to be the source of an increasing proportion of future increase of GHGs.

Indian economy is highly vulnerable to global warming caused by GHG emissions. The Indian Network for Climate Change Assessment report (INCCA, 2010) indicates that the average annual surface air temperature in India is increasing by 0.4^0C with not much variation in absolute rainfall. The sea level has increased at a rate of 1.06-1.25 mm/year during the last four decades across the coastal India. The same report has predicted that the temperature in India will be increased by 2-4^0C by 2050s. The climate sensitive sectors such as agriculture, forestry, coastal and water resources will be adversely affected because of climate change. A devastating impact of climate change in India will be the rise in the sea level, resulting in the inundation of coastal areas. Coupled with these, the increase in cyclones accompanied by enormous volume of sea water would bring about mass devastation of human life as well as the economy (Kumar, 2004). Estimate suggests that due to one metre increase in the sea level, 7 million people would be displaced; about 5,764 sq km land and 4,200 km stretch of roads would be lost (www.adb.org).

Indian economy has historically been an insignificant contributor to the global climate change. According to the INCCA (2010) report, India ranks fifth in aggregate GHG emissions in the world, behind USA, China, EU and Russia in 2007. But the emissions of USA and China are almost 4 times that of India in the same year. Also, India's per capita CO2 equivalent emission is 1.5 tons/capita in 2007 which is roughly one-fourth of the world average per capita emission of 4.5 tonnes per annum (INCCA, 2010). The main cause of CO2 emission in India is low energy efficiency of coal-fired power plants, scarcity of capital and the long lead time required to introduce advanced coal technologies. However, as India is now a fast-growing (2005-06 to 2008-09 average: 8 % growth in gross domestic product per annum) economy, its total emission is growing rapidly (CSO, 2009 and NCAER, 2009).

Therefore restricting rise in carbon emission can be a good strategy for India while it is on it's fast economic progress.

1.1 Literature Review

The economic impacts and effectiveness of the climate mitigation policies depend on the proper assessment of climate change impact on the economy. In the context of GHG emissions as well as climate change impact on the economy, different national and international institutes as well as environmental economists are forging together to undertake scientific studies to decide on a proper framework for impact analysis. The available literatures and their key features are described in the following Table 1.

Table 1: Some Important Literatures on Climate Change Impact Analysis

Authors	Objective of the study	Key findings
Darwin, Tsigas, Lewandrowski, Ranese(1995)	How climate change might affect water supplies and the availability of agriculturally suitable land and analyses how these impacts might affect total world production of goods and services	New temperature and precipitation patterns under climate change are likely to reduce the average productivity of the world's existing agriculture lands. Climate-induced shifts in cropland and permanent pasture are likely to raise additional social environmental issues.
Kumar and Parikh (1996)	focuses on assessment of the climate change impacts on Indian agriculture	Wheat crop is likely to be affected more than rice crop due to climate change. CO_2 fertilisation effects seem to reduce the effects of climate change dramatically.
Pohit, S (1997)	To analyse the impact of climate change on India's agriculture using a 10 sector 10 region (with one being India) global CGE model	Substantial welfare of the Indian economy in general depending on how one account for the carbon fertilisation effect.
Mckinsey and Evenson (1998)	To estimate the impact of a rise in normal temperatures and of increases in rainfall levels for different regions in India	one degree Celsius rise in temperature has negative impact on the HYV adoptions. This is most negative in Gujarat and is positive in some regions such as Andhra Pradesh, Orissa etc
Ravindranath et.al (2006)	assesses the impact of climate change on forests in India	under the climate projection for the year 2085, 77% and 68% of the forested grids in India are likely to experience shift towards wetter forest types in the north-eastern region and drier forest types in the north-western region in the absence of human influence.

Review of literature brings forth research gaps. It is observed from the above review of literatures that most of the studies in the field of climate change impact analysis are for the vulnerable sectors of the economy like agriculture sector, and forestry sector etc. On the other hand there are some other sectors which may not be vulnerable but they may have significant contribution on GHGs emissions as well as on economic growth. For example the manufacturing sector together contributes almost 27% of total GHG emission in the year 2006-07 (INCCA, 2010) and their share in gross domestic product (GDP) for that year is almost 18% (CSO, National Accounts Statistics, 2009). Therefore the growth in manufacturing sector will have significant impact on GHG emission in India. In the year 2006-07 thermal electricity sector alone contributes 37.8% of total GHG emission (INCCA, 2010) and its share in GDP is 0.8% (CSO, National Accounts Statistics, 2009). Though the share of thermal electricity sector in total GDP is not so much significant but this is the main energy source of the Indian economy. Almost 86% of energy in India comes from the thermal electricity sector (CSO, energy statistics 2009). So the growth of the Indian economy will depend on the growth of the thermal electricity sector and as a result GHGs emissions will increase in India. Again as every sector are interdependent with each other for their input requirement, the growth of a sector will have direct, indirect and induced impact on GHGs emissions.

The direct effects are the immediate effects associated with the change in the final demand for a particular industry output (Pradhan, et.al, 2006). The indirect effects are the secondary effects or production changes in backward-linked industries caused when inputs needs change due to the impact of directly affected industry. The induced effects represent the response by all industries caused by increased expenditures of new household income and inter-institutional transfers generated from the direct and indirect effects of the change in final demand for a specific industry. Hence to analyse the impact of economic growth on climate change we have to take into account all these impacts on GHGs emissions of the economy. But the above studies do not provide such kind of analysis and hence this a major research gap in the field of climate change analysis.

In the backdrop of the above research gap in the field of climate change analysis we have decided to build appropriate data base and model to assess impact of economic growth on climate change. Aim is to show empirically impact of sectoral output growth on energy demand, employment and GHG emissions.

Following this introductory section the rest of the paper is organised as follows. The section 2 describes the methodology for impact assessment. In this section we describe the methodology and estimation of sector specific greenhouse gases to construct ESAM for India. Also in this section we describe interrelationship between economic activities with GHG emission in India. In the section 3 we have analysed impact of economic growth on climate change with the help of multiplier model. Here we describe impact of growth in output and employment on GHG emission in India. Finally section 4 deals with some concluding remarks of this study.

2. Methodology for Impact Assessment

Assessments of impact of economic growth on climate change are not easy due to complex relation between environment and economic activities (Jian, 1996). The economy and environment interact with each other in complex ways. To produce goods for consumption, a production process needs to depend on the environment to provide material resources and energy. The material resources and energy provided by the environment are transformed in the production and consumption processes, and the by-products are then discharged back into the environment. The environment behaves not only as a provider of material resources and energy but also as sink of wastes generated from production and consumption. The environment's capacities to provide resources for and absorb wastes from an economy are limited. These limited capacities constrain the growth of the economy.

It is the environment's assimilative capacity by which it absorbs wastes discharged from the economy (Jian, 1996). When the amount of wastes discharged into the environment is larger than the environment's assimilative capacity, environmental degradation occurs. The degradation of environmental quality has direct negative effects on both the utility of consumers and the stock of resources. The decrease in the quantity and quality of resources also has an indirect impact on utility by reducing productivity.

As most of the environmental problems can be directly attributed to the structure of production and consumption, it seems urgent and necessary to find ways to make explicit these problems within an accounting framework. In order to do this, it is important to develop a consistent framework which will incorporate the economic and environmental indicators. This work is an attempt to respond to the need to include, explicitly and directly, the two sets of indicators (economic and environmental indicators) into a system which accounts for their relations to the economic system and provides the basis for diagnoses and eventually for policy making.

However, the conventional national accounting system has its limitations. Hence, the ensuing analysis is in turn limited and subdued. In order to overcome some of the limitations more comprehensive systems have been developed, among which the traditional and extended input output (IO) tables and their generalised form as social Accounting Matrices (SAMs) are the most prominent.

A SAM depicts the entire circular flow of income for an economy in a (square) matrix format (Pradhan et.al 2006). It shows production leading to the generation of incomes which, in turn, are allocated to institutional sectors. In addition, it shows the redistribution of income leading to disposable income of institutional sectors. These incomes are either spent on products or saved. Expenditures by institutions lead to production by domestic industries as well as supply from imports. Hence, the advantage of using a SAM to incorporate both the economic and environmental indicators is that their interrelations can become more apparent and transparent. Therefore the extension of SAM with environmental indicators can be considered as the logical step in the efforts to simultaneously account for the interrelationship between economic and environmental activity.

On the other hand the SAM has an advantage of multiplier analysis. With the help of the SAM multiplier we can analyse the direct, indirect and induced impact of exogenous factor in the economy. Therefore if we interrelate the economic indicators with the environmental indicator in a SAM framework then that evironmental social accounting matrix (ESAM) will help us to analyse the impact of economic growth on climate change.

India has been an early leader in SAM based model users. To the best of our knowledge, Sarkar and Subbarao (1981) of National Council of Applied Economic Research (NCAER) constructed the first SAM for India back in the 1980s, which provides the consistent database for their CGE model. Subsequently a number of SAMs are constructed over the years by the different researchers. In the following table 2 we have described a brief outline of these various SAMs and their salient features.

Table 2 Stylized Facts of SAMs of India

Serial No.	Name of researchers and their SAM based study	Salient Features of SAM.
1.	Sarkar, H. and Subbarao, (1981).	**Base year:** 1979-80. **Sectors (3 in all):** agriculture, industry and services. **Agents:** non-agricultural wage income class, non-agricultural non-wage income class, agricultural income class, and government.
2.	Sarkar, H. and M. Panda, (1986).	**Base year:** 1983-84.

Serial No.	Name of researchers and their SAM based study	Salient Features of SAM.
		Sectors (6 in all): agriculture (2), industry (2), infrastructure and services. **Agents:** non-agricultural wage income class, non-agricultural non-wage income class, agricultural income class, and government.
3.	Bhide, S. and S, Pohit. (1993).	**Base year:** 1985-86. **Sectors (6 in all):** agriculture (2), livestock & forestry, industry (2), infrastructure and services. **Agents:** government, non-agricultural wage income earners, non-agricultural profit income earners, and agricultural income earners.
4.	Pradhan, B. and A. Sahoo, (1996).	**Base year:** 1989-90. **Sectors (8 in all):** agriculture (2), mining and quarrying, industry (2), construction, electricity combined with water and gas distribution, and services (3). **Agents:** government, agricultural self-employed, agricultural labour, and non-agricultural self-employed and other labour.
5.	Pradhan, B. Sahoo, A. and M.R. Saluja, (1999).	**Base year:** 1994-95. **Sectors (60 in all):** agriculture (4), livestock products (2), forestry sector, mining (4), manufacturing (27), machinery and equipment (6), construction, electricity, transport (2), gas and water supply, other services (11). **Agents:** government, self employed in agriculture (rural & urban), self employment in non-agriculture (rural & urban), agricultural wage earners (rural & urban), other households (rural & urban), private corporate, and public non-departmental enterprises.
6.	Pradhan, B. K. M.R. Saluja and S. K. Sing (2006).	**Base year:** 1997-98. **Sectors (57 in all):** agriculture (4), livestock products (2), forestry, mining, manufacturing (27), machinery and equipment (6), construction, electricity, transport (2), gas and water supply, other services (11). **Agents:** government, self employed in agriculture (rural & urban), self employment in non-agriculture (rural & urban), agricultural wage earners (rural & urban), other households (rural & urban), private corporate, and public non-departmental enterprises.
7.	Sinha, A. Siddiqui. K.A, and Munjal. P (2007).	**Base year:** 1999-2000. **Sectors (13 in all):** agriculture (informal), formal manufacturing (9), construction (informal), other services (formal & informal), and government service. **Agents:** casual labour (rural & urban), regular wage earner (rural & urban),

Serial No.	Name of researchers and their SAM based study	Salient Features of SAM.
		own account worker (rural & urban), employer (rural & urban), and government.
8.	M.R.Saluja and Yadav.B (2006),.	**Base year:** 2003-04. **Sectors (73 in all):** agriculture (12), livestock products (4), forestry, mining (4), manufacturing (28), machinery and equipment (7), construction, energy, gas distribution, water supply, transport (2), other services (10). **Agents:** 5 rural households' expenditure classes, 5 urban households expenditure classes, private corporation, public enterprises and government.
9.	Barun deb pal, Sanjib Pohit and Joyashree Roy (2012), forthcoming publication on March 2012, Economic System research),	**Base year:** 2003-04. **Sectors (85 in all):** agriculture (18), livestock products , forestry, fishing, mining (9), manufacturing (30), machinery and equipment (2), construction, electricity (3), biomass, water supply, transport (5), other services (12). **Agents:** 5 rural households' occupation classes, 4 urban households occupation classes, private corporation, public enterprises and government.
10.	Barun deb pal, (2011), Doctoral Thesis available from Jadavpur University, August 2011	**Base year:** 2006-07. **Sectors (35 in all):** agriculture (4), livestock products, forestry, fishing, mining (3), manufacturing (12), machinery and equipment, construction, electricity (3), Biomass, water supply, transport (4), other services (2). **Agents:** 5 rural households' occupation classes, 4 urban households occupation classes, private corporation, public enterprises and government.

The above table shows that the latest SAM of India was constructed by Barun deb pal (2011) for the year 2006-07, as a part of his Ph.D thesis.[1] This is the first SAM of the year 2006-07 which is constructed on the basis of input output table of the year 2006-07. Therefore we have taken this SAM to construct ESAM for India for the year 2006-07. This SAM takes into account 35 production sectors and 9 households occupational classes of the economy.. Now as our objective in this study is to analyse interrelationship between economic activity with GHG emission, the sectoral specification of the SAM of the year 2006-07 is suitable to fulfil our purpose. Therefore we have taken into account same sectoral classification to construct

[1] Ph.d Thesis of Barun Deb Pal was submitted to Jadavpur University in the year 2011. The SAM of the year 2006-07 is available upon request to the authors.

our ESAM for the year 2006-07. The description of these production sectors and the households classes are given in Appendix 1 and Appendix 2. Below we have described detail methodology of constructing ESAM for India for the year 2006-07.

2.1 The Framework and Methodology of ESAM

Theoretically speaking, the extension of a SAM can be presented either in additional rows and columns, or in satellite tables (Keuning et.al, 1996). An example of an extension by means of satellite tables is the National Accounting Matrix including Environmental Accounts (NAMEA) for the Netherlands for the year 1992 (Keuning, S. J. 1992). In NAMEA the national accounting matrix of Netherlands is extended with three accounts on the environment. A substances account, an account for global environmental themes and an account for national environmental themes. These accounts do not express the transaction in money terms but include the information in physical unit.

In this study we have followed this NAMEA approach to construct the ESAM for India for the year 2006-07. In the following table 3 we have described the framework of ESAM for India.

Table 3 : Schematic Structure of Environmentally Extended Social Accounting Matrix

			Production	**Factors of production**	**Institutions**	**Indirect taxes**	**capital account**	**Rest of the world**	**Substances (pollutants)**	**Depletion of Natural resource**		**Env.theme**
										Renewal of Energy resource	**Renewal of land**	**Greenhouse Effect**
			1	2	3	4	5	6	7	8	9	10
Production		1	Intermediate consumption		Consumption of goods and services		Change in stocks and capital formation	Exports	Emission of pollutants from production			
Factors of production		2	Payment for factors					Net factor income from abroad		Depletion of Energy capital	Depletion in land capital	
Institutions		3		Value added income	Transfer from other institutions	Total tax receive		Net current transfers	Emission of pollutants from consumption			
Indirect taxes		4	Taxes on intermediate		Taxes on purchase		Taxes on investment					
capital account		5		Depreciation	Savings			Foreign savings				
Rest of the world		6	Imports									
Damaging Substances (pollutants)		7	Absorption of substances in production		Absorption of substances in consumption						Removal of substances	Accumulation of substances
Depletable Substances	**Renewal of Energy Resources**	8		Renewal of Energy stock								Reduction in natural stock
	Renewal of Land	9		Renewal of Land through conservation					Emission from land use change			
Environmental Themes	**Green house Effect**	10		Accumulation of Green house gases								

As table 3 shows, the first six accounts are the accounts for a SAM and details of these accounts are described in Pradhan et.al (2006). The remaining accounts of this Table 3 describe the information related to environment. The accounts that are related to environment are - the substances account (account 7, 8 and 9 in Table 3) and the account for environmental themes (account 10 in Table 3). Now the description of these accounts is given in the following paragraphs.

The 'substances account' of the ESAM provides flow data on the supply and use of a number of substances that affect in one way or the other the natural assets like air, water etc and create pollution (Keuning, 1992). The term 'substances' refers not only the matter which is of damaging in nature (e.g. emissions of chemicals, wastes, etc.) but also includes valuable matter in the form of depletable natural resources. In case of damaging substances the columns of the substances account describe only the supply of these substances from different source and the rows describe the absorption of these substances into different sectors. But in case of depletable substances the column shows the renewal of the natural capital and this comes from the new discoveries of exhaustive natural assets like coal, crude oil etc. On the other hand the row of this depletable substances account shows the use of these substances in the form of intermediate input in the production process. Finally the account for environmental themes is an inventory account which takes into account the net emission (i.e. emission minus absorption) in India. Therefore, in this way we have described all the accounts of our proposed ESAM for India. But to complete the construction of ESAM for India for the year 2006-07 we have to collect the relevant data for this ESAM and this is described in the following sections.

2.2 Estimation of Environmental Data

The substances accounts and the account for environmental themes, in this ESAM, are expressed in physical unit. So we have to estimate the environmental data in physical unit. Again our proposed ESAM of the year 2006-07 takes into account 35 production sectors and 9 household groups. So we have to estimate the environmental data from production as well as consumption activity for the year 2006-07. Now the method of estimation is given below.

2.2.1 Estimation of Generation of Damaging Substances

There are different types of damaging substances that exist in the environment which causes damage in natural resources in the form of air pollution, water pollution etc. But in this study we are concerned about the substances which are responsible for climate change. Therefore, to construct the column and row for the damaging substances for this ESAM, we are to estimate the supply and absorption of the greenhouse gases (like CO_2, CH_4 and N_2O) in India in the year 2006-07.

The GHG emissions in India are observed from the domestic production process, import, and from consumption activities (TEDDY, 2009). But in India the data on GHG emissions through import are not available. So we have taken only the production and consumption based supply of these damaging substances in India.

India has published its second communication on green house gas emission, (INCCA, 2010) which provides updated information on India's Greenhouse Gas Emission from different sectors for the year 2007 (INCCA, 2010). In this study we have taken this report as base to estimate sector specific GHG emission of India for the year 2007. But the sector described in INCCA report does not exactly match with the sectors of our SAM of the year 2006-07. So to estimate sector wise GHG emissions we have made a map of concordance between our SAM sectors and the sectors given in INCCA report which is given below.

Table 4 Mapping between ESAM sector and sector of INCCA report

Sector of ESAM	**INCCA Sectors**
Pddy rice	Agriculture, Rice Cultuvation, soils
Wheat	Agriculture, soils
Cereals	Agriculture, soils
Cash crops	Agriculture, soils
Animal husbandry	Agriculture, Enteric fermentation, Manure management
Forestry	No emission
Fishing	Agriculture
Coal	Fugitive Emission
Oil	Fugitive Emission
Gas	Fugitive Emission
Food & Beverages	Food Processing, Industrial waste water
Textiles & Leather	Textile & Leather, Industrial waste water
Wood	Non-specific industries
Minerals n.e.c	Mining & qurrying
Petroleum & Coal tar product	Other energy Industry, Industrial Waste water
Chemical, Rubber & Plastic Products	Chemicals, Industrial waste water
Paper & Paper products	Pulp & paper, Industrial waste water
Fertiliser & Pesticides	Non-specific industries, Industrial waste water
Cement	Cement
Iron & steel	Iron & steel
Aluminum	Aluminum
Other manufacturing	Ferroalloys, Lead, Zinc, Copper, Glass & cermic, soda ash, Non-specific industries
Machinery	Non-specific industries, Industrial waste water
Thermal	Electricity, Industrial waste water
Hydro	No emission
Nuclear	No emission
Biomass	No emission
Water	No emission
Construction	Non-specific industries
Land transport	Road Transport
Railway transport	Railways
air transport	Aviation
Water transport	Navigation
Health and medical	No emission
Other services	Commercial /Institutional

Source: Author's estimate

As this table shows most of sectors of our ESAM do not have one to one correspondence with the INCCA sectors. So we have to disaggregate the GHG emission for the INCCA sectors for which there is no one to one correspondence with our ESAM sectors. The method of desegregation is described below.

Desegregation of agricultural sector's GHG emission

According to INCCA report, the GHG emission from agriculture sector is due to energy use and also due to production process. The GHGs emitted from energy use in agriculture sector are CO_2, CH_4 & N_2O where as CH_4 and N_2O are emitted from production process. Almost all the agricultural sectors (except forestry) use energy for their energy requirement and so the energy based GHG emission will be observed for these sectors. Whereas only the rice cultivation sector and animal husbandry sector emit CH_4 through their production process. On the other hand N_2O emission from agricultural production process is observed due to fertilizer use into the soils and it is also observed for all agricultural sectors except forestry.

In our SAM there are 6 agricultural sectors (excluding forestry) among which rice cultivation and animal husbandry sector have separate account. So the CH4 emissions from the production process of rice cultivation and animal husbandry are directly obtained from the INCCA report. But to obtain the energy based emission from the agricultural sectors of our ESAM we have to disaggregate the energy based GHG emissions from agricultural sector into these 6 agricultural sectors of our ESAM. In this case we have estimated share of energy use of these 6 sectors from our ESAM and apply this to obtain their energy based GHG emissions for these sectors.

Next we have disaggregated the N_2O emission from soils into the 6 agricultural sectors of our SAM and this is done on the basis of the share of fertilizer use of these sectors. The share of fertilizer use for these sectors is obtained from our SAM of the year 2006-07. Thus we have obtained GHG emission from all the agricultural sectors of our SAM.

Desegregation of Fugitive emissions

Only CH_4 emission from this source is observed due to extraction, production, process and transportation of fossil fuels such as coal, crude oil and natural gas (INCCA, 2010). The CH_4 emission from this source is 730 thousands tons for coal mining and 779.4 thousands tons from combined crude oil & natural gas sector. Therefore we have to estimate emission from this source separately for crude oil and natural gas sector and this is done on the basis of INCCA report. The INCCA report provides us the emission coefficients of CH_4 from this source separately for crude oil and natural gas sector. But to apply these coefficients we have taken production data of crude oil and natural gas sector from energy statistics of India (CSO, 2007). Thus we have obtained CH_4 emission from this source for coal, crude oil and natural gas sector separately for India for the year 2007.

Desegregation of Non-specific industries GHG emission

In this case we have first estimated the energy based emission for the sectors of our SAM map with non-specific industries mentioned in INCCA report. Now to estimate we have used energy use data from annual survey of industries (ASI) (CSO, 2006-07). The data obtained from ASI gives energy use in value terms and to convert into physical unit we have estimated general price level (Value of energy/quantity of energy) on the basis of energy statistics of India (CSO, 2007). Then we have applied energy specific emission coefficients given in IPCC guidelines (www.ipcc.ch) to obtain GHG emissions from these sectors. The GHGs emissions obtained in this way do not match with the GHG emission given in INCCA for this sector. So we have considered the INCCA estimate as control total and a pro-rata adjustment method has been applied to get this control total. So in this way we have disaggregated the GHG emission of the non-specific industries into the sectors of our SAM.

Desegregation of Industrial waste water

The INCCA reports CH_4 emission from Industrial waste water. Now as there is no separate account of this sector in our ESAM, we have added this emission to the CH_4 emission of the industries generated waste water. In the following table we have provided the industry wise generation of waste water.

Table 5: Waste water generation in Indian Industry

Sector	Waste water (million litter/Day
PAP (Paper and paper Products)	1881
PET (Petroleum & coal tar products)	143
FER (Fertiliser)	168
IRS (Iron & Steel)	1087
NHY (Thermal Electricity)	72219
FBV (Food & Beverages)	424
TXL (Textiles & Leather)	1930
CHM (Chemicals)	213

Source: INCCA Report, 2010

Now to estimate CH_4 emission from these sectors we have disaggregated the total emission from Industrial waste water into these sectors. To disaggregate this emission we have used share of the above industries in total industrial waste water generation.

Estimation of GHG emission from Households Activity

Households, in our SAM are categorized into nine types of household classes based on their occupation. So we have to estimate GHG emission from households activities for these nine types of households. Now to estimate the GHG emission from Household activities we have used the following estimates of INCCA and these are as follows:

1. Estimated GHG emission from Residential source
2. Estimated GHG emission from Burning of crop residue
3. Estimate GHG emission from fuel wood use
4. Estimate GHG from Municipal solid waste
5. Estimate GHG emission from Domestic waste water

The above estimates give aggregate GHG emissions for all households. So to estimate household's class wise GHG emissions we have to disaggregate all these 5 estimates according to the household's classes of our SAM and the method is given below.

Among the above 5 estimates the estimation from residential source is based on emissions from Cooking coal, LPG, and Kerosene (INCCA, 2010). In this case to disaggregate GHG emission from this source we have used share of energy consumption (excluding biomass) of each household class as obtained from our SAM. Thus we have estimated GHG emission from residential sources for each households classes of our SAM.

The GHG emissions from burning of crop residue and fuel wood use are highest for the rural households in India (INCCA, 2010). So we have to disaggregate the GHG emissions from these two sources among the rural households classes and this is done on the basis of share of biomass consumption of the rural households

On the other hand the emissions from municipal solid waste and domestic waste water is observed for urban households (INCCA, 2010). So we have to disaggregate these emissions into the urban households classes of our SAM. Now it is observed from the INCCA report that the urban households generates 0.55 kg/capita/day of municipal solid waste in India We have used this data to estimate solid waste generation for each of these households classes of urban area. Once we obtained the solid waste generation for each of the urban household classes, we can estimate the share of waste generation for each households classes of urban area. Using this share we have estimated households class wise GHG emission from municipal solid waste in India for the year 2006-07.

Next we have to estimate the GHG emission from domestic waste water for each of the urban households classes for the year 2006-07. The share of consumption expenditure on water for the urban household's classes of our SAM has been used to estimate households class wise GHG emission from this source for urban area.

Emission due to land use change

The changes in grassland resulted in the emission of 10.49 million tons of CO_2 due to decrease in grassland area by 3.4 million hector between 2006 & 2007 (INCCA, 2010).

Hence in the above mentioned way we have estimated generation of GHGs from production as well as consumption activities for India for the year 2006-07.

2.2.2 Estimation of Abatement or Absorption:

In India, the data on greenhouse gas abatement are not available for production and consumption activities. Whereas, it is observed from the INCCA report that the Land Use Land Use Change and Forestry (LULUCF) has the major role in CO_2 removals in India. The gross CO_2 removal from LULUCF is 27.53 million tons in the year 2006-07 (INCCA, 2010). In this study we have used this data to construct the row of damaging substances of our proposed ESAM for India for the year 2006-07.

2.2.3 Estimation for Depletable Natural resources

In this case we have considered crude oil, coal and land use change as the depletable natural resources. The production data in physical unit on crude oil and coal have been taken as measures of the quantities of depletion of these two types of resources and the data are available from CSO (CSO 2006). Now the data obtained in this way can be interpreted as 'free' intermediate consumption (without direct cost) used in the production process of the crude oil and natural gas sector. So to construct the row of this depletable substances account we have put the data in the row of this depletable substances account corresponding to the column of crude oil and coal sectors.

To construct the column of this depletable substances account we have obtained the data on new discoveries of crude oil and coal reserve in India in the year 2006-07. In this case we have obtained this data on new discoveries from TERI (2009). Hence in this way we have constructed the row and the column of the depletable substances account of our ESAM for India for the year 2006-07.

Now to construct the row of land use change we have used data from INCCA report. The INCCA report gives change in different types of land use data for the year 2006 and 2007. The difference between this two years data are used as land use change in the year 2007. The same report also gives the data on land conservation in India during 2006 and 2007. So we have used this data to get the column of the land use change under the item head of depletable natural resources in our proposed ESAM

Thus, we have obtained the row and column for each of the substances to construct our ESAM for India for the year 2006-07. Now apart from this substances account there is also another account i.e. account for environmental themes which is also important for our ESAM for India for the year 2006-07. Below we have described the method of estimating environmental themes for India for the year 2006-07.

2.2.4 Estimation for Environmental Themes

In this case we have to estimate the inventory of the greenhouse gases in the Indian economy for the year 2006-07 to show greenhouse effect. Now to estimate this greenhouse effect we have to estimate the net generation of greenhouse gasses in terms of CO_2 equivalent for the year 2006-07. Again to estimate generation in terms of CO_2 equivalent we have to multiply CH_4 emission by 21 and N_2O emission by 310 (INCCA, 2010). Thus we have estimated environmental themes for Indian economy for the year 2006-07.

Finally, on the basis of the method described throughout this chapter, we have obtained the complete ESAM for India for the year 2006-07. This complete ESAM is given in the Appendix 3. Now this ESAM as given in Appendix 3 is the first ESAM for India which integrates the economic as well as environmental indicators in a single accounting framework. Therefore with the help of the data given in ESAM, it would be interesting to analyse the relation between the environment and economic activities for India. Now to understand the relation between the environmental pollution with the level of output we have estimated the direct pollution coefficient directly from the ESAM data and this is given in the Table 6. The direct pollution coefficient (shown in Table 6) is nothing but the amount of pollution generated for each level of output produced by the production activity. On the other hand this direct pollution coefficient also measures the direct effect of economic activities on the environmental pollution.

Table 6: Direct Pollution Coefficient Matrix 2006-07 (Unit Tons/Lakh of output)

Sector of ESAM	CO_2	CH_4	N_2O
PAD	0.77	0.22	0.00
WHT	0.84	0.00	0.00
CER	0.55	0.00	0.00
CAS	0.28	0.00	0.00
ANH	2.31	0.48	0.00
FRS	0.00	0.00	0.00
FSH	0.00	0.00	0.00
COL	0.00	0.13	0.00
OIL	0.00	0.00	0.00
GAS	0.00	0.40	0.00
FBV	0.74	0.00	0.00
TEX	0.07	0.00	0.00
WOD	0.30	0.00	0.00
MIN	0.12	0.00	0.00
PET	1.03	0.00	0.00
CHM	0.53	0.00	0.00
PAP	1.31	0.01	0.00
FER	4.85	0.00	0.00
CEM	34.67	0.00	0.00
IRS	4.00	0.00	0.00
ALU	0.21	0.00	0.00
OMN	0.54	0.00	0.00
MCH	0.26	0.00	0.00
NHY	47.83	0.07	0.00
HYD	0.00	0.00	0.00
NUC	0.00	0.00	0.00
BIO	0.00	0.00	0.00
WAT	0.00	0.00	0.00
CON	0.00	0.00	0.00
LTR	2.37	0.00	0.00
RLY	0.70	0.00	0.00
AIR	9.61	0.00	0.00
SEA	0.83	0.00	0.00
HLM	0.00	0.00	0.00
SER	0.01	0.00	0.00

Source: Author's Estimate

Now on the basis of Table 6 the direct pollution coefficients corresponding to each type of pollutants are higher for the sectors like NHY, CEM, and IRS sector. On the basis of the above discussion these 3 sectors have the large direct impact on the environmental pollution as compared to the other production sectors of the Indian economy. Again as the data shows that the NHY sector has the highest direct pollution coefficient for each type of pollutants compared to the other sectors. Hence this NHY sector has the highest direct effect on CO_2 emission in India. For example the direct pollution coefficient of the NHY sector corresponding to CO_2 is 47.83, this implies the NHY sector generates 147.83 tons of CO_2 to produce rupees one lakh value of its output. So in this way we can understand the direct effect of the economic activities on the environmental pollution with the help of direct pollution coefficients.

On the other hand the ESAM shown in Appendix 2 the interaction between all the economic agents and their contribution in GHG emission in India. Therefore due to any exogenous reason if output of a sector increases, the output of the other sector will increase. Now, given the technological condition this increase in output will increase the GHG emission of the economy and this can be observed from the positive value of the direct emission coefficients as described in the above table 6. Again, due to any exogenous changes in the economy there is direct, indirect and induced impact on the economy as well as on GHG emission. But at what extent the GHG emission will increase and which sector is more responsible for this is a policy relevant question for the Indian economy. To answer this question we assess empirically the impact of economic growth on GHG emission for India. Below we present empirical analysis of the impact of economic growth on GHG emission in India.

3. Impact of Economic Growth on Climate Change:

In this study we have used SAM multiplier method to analyse empirically the impact of economic growth on GHG emissions in India. The SAM multiplier shows the direct, indirect and induced effect on endogenous variables due to unitary changes in exogenous variables (Pradhan, Saluja and Singh, 2006). Using SAM multiplier we can analyse the economy wide impact on endogenous variables due to any changes in the exogenous variable. For example, if we assume foreign trade account (i.e. ROW account) of our SAM as exogenous then the SAM multiplier will show the direct, indirect and induced impact on endogenous variables due to changes in the foreign trade sector, say export.

Again in the context of climate change impact analysis, the analysis on energy demand change is crucial. Therefore with the help of SAM multiplier we can also analyse the direct, indirect and induced impact on energy demand due to any exogenous changes in the economy.

Now if we link the SAM multiplier with the sector specific GHG emission coefficients, we can estimate the pollution trade-off multiplier. This pollution trade-off multiplier will show the direct, indirect and induced impact on GHG emissions due to any exogenous changes in the economy (Robert Koh, 1975).

In this study we have assumed Government Account, Account of Net Indirect taxes, and Foreign Trade accounts of our SAM as exogenous. Now keeping these accounts as exogenous we have done the following impact analysis.

1. The impact on energy use due to growth in sectoral output resulting from any exogenous changes in the economy.
2. The impact on GHG emission due to growth in sectoral output resulting from any exogenous changes in the economy.

On the other hand the exogenous changes in the economy may increase the employment opportunities within the domestic economy. Now due to difference in labour intensity pattern the employment opportunity will not increase uniformly across the sectors. So, at what extent the sector wise employment will change is an important policy relevant question. To answer this question we have also derived employment multiplier from our ESAM of the year 2006-07. The employment multiplier will show how the sector wise employment changes due to any exogenous changes into the economy. Again if we can link this employment multiplier with the GHG emission we can show the impact of employment change on GHG emissions.

Researchers across the world are presently trying to find out option for green employment creation as an outcome of global climate change mitigation action (www.ilo.org). The green employment creation implies that the employment creation in the production sector will not lead to the loss in bio-diversity, environmental ecosystem or un-sustainable energy use. Therefore, in this context the analysis on impact of employment change on GHG emission will be relevant for the Indian economy. The methodology and analysis are illustrated in the following sections.

3.1 ESAM Multiplier Model

The detailed method of estimating SAM multiplier for India is described in the book "Social Accounting Matrix for India" published by Pradhan, Saluja and Singh (2006). In this study we have used this method to estimate the SAM multiplier for the year 2006-07 and this is described below.

Let A be the domestic expenditure coefficient matrix and X be the matrix of sector-wise gross output. In addition, let Y be the matrix of exogenous variables consists of public investment, and foreign trade. Therefore, the SAM can be

written as,

X = AX + Y (1)

or

X = (I − A)−1Y (2)

If we denote the (I–A)21 matrix as M, then Equation 2 can be written as

X = MY (3)

Now to link this multiplier with environmental indicator we have estimated pollution trade-off multiplier. Here we have used method described by Robert Koh (1975). The pollution trade-off multiplier measures the direct, indirect and induced impact on pollution generation level due to exogenous change in sectoral output, households income etc. The mathematical expression of the pollution trade-off multiplier is given as follows:

$$E = P * X \qquad (4)$$

Where, E is matrix of sector wise emission,

P is the sector wise emission coefficient matrix

Replacing equation (2) into equation (4),

$$E = P * (I - A)^{-1} * Y \qquad (5)$$

$$\frac{\partial E}{\partial Y} = P * (I - A)^{-1} = T \qquad (6)$$

Therefore T is the pollution trade-off multiplier matrix which indicates impact on emission due to any exogenous changes into the economy. Now this T matrix has different blocks like pollutant-activity block, pollutant - households block etc and these can be used for different types of impact analysis. For example, if we want to analyse impact of output growth on emission we have to use pollutants - activity block of the T matrix.

Thus we have shown the method of estimating SAM multiplier as well as pollution trade-off multiplier for India for the year 2006-07. Now the results of this SAM multiplier as well as pollution trade-off multiplier in the context of our objectives of this chapter are described below.

3.2 Impact of sectoral output growth resulting from any exogenous changes in the economy on energy use

Consumption of energy input is a crucial factor for every production process. So to increase the output every production process will have to increase their energy consumption unless there is any innovation in energy efficient technology. But the innovation of energy efficient technology is not a quicker process. So in this study our objective is to analyse the sectoral growth impact on energy use under the existing technological condition. Now this SAM multiplier model is a fixed technology static model and the base year of this model is 2006-07. Therefore, the SAM multiplier model does not consider any technological improvement in the economy; rather it takes into account the direct, indirect and induced effect on energy use under constant technological condition. So with the help of our SAM multiplier model we can analyse the impact of sectoral growth on energy use under the existing technological condition of the year 2006-07.

Now to analyse the total effect (i.e. direct, indirect- induced) on energy use we have considered the energy X activity part of the SAM multiplier matrix. Again the SAM of the year 2006-07 takes into account 7 types of energy commodities but for this analysis we are concerned mainly with the commercial energy available from primary conventional sources. The commercial energy commodities available from primary conventional sources are viz. coal, crude oil, natural gas, hydro and nuclear. Now in the Table 7 given below we have shown the impact of sectoral growth on this primary energy use due to any changes in the foreign trade sector.

Table 7: Impact of sectoral growth on Primary Energy use for the Production

	Coal			Crude Oil			Natural Gas			Hydro			Nuclear		
Sectors	Total effect	Direct effect	Indirect - Induced effect	Total effect	Direct effect	Indirect - Induced effect	Total effect	Direct effect	Indirect - Induced effect	Total effect	Direct effect	Indirect - Induced effect	Total effect	Direct effect	Indirect - Induced effect
PAD	0.0597	0.0000	0.0597	0.2242	0.0000	0.2242	0.0267	0.0000	0.0267	0.0358	0.0038	0.0320	0.0054	0.0006	0.0049
WHT	0.0613	0.0000	0.0613	0.2197	0.0000	0.2197	0.0299	0.0000	0.0299	0.0386	0.0054	0.0332	0.0059	0.0008	0.0050
CER	0.0559	0.0000	0.0559	0.2014	0.0000	0.2014	0.0207	0.0000	0.0207	0.0302	0.0009	0.0293	0.0046	0.0001	0.0044
CAS	0.0556	0.0000	0.0556	0.2042	0.0000	0.2042	0.0223	0.0000	0.0223	0.0296	0.0007	0.0290	0.0045	0.0001	0.0044
ANH	0.0569	0.0000	0.0569	0.1948	0.0001	0.1946	0.0181	0.0000	0.0181	0.0296	0.0000	0.0296	0.0045	0.0000	0.0045
FRS	0.0211	0.0000	0.0211	0.0733	0.0000	0.0733	0.0065	0.0000	0.0065	0.0109	0.0000	0.0108	0.0016	0.0000	0.0016
FSH	0.0559	0.0000	0.0559	0.2109	0.0000	0.2109	0.0172	0.0000	0.0172	0.0287	0.0000	0.0287	0.0044	0.0000	0.0044
FBV	0.0531	0.0008	0.0523	0.1898	0.0000	0.1898	0.0179	0.0001	0.0179	0.0287	0.0011	0.0276	0.0044	0.0002	0.0042
TEX	0.0572	0.0010	0.0562	0.1968	0.0000	0.1968	0.0193	0.0013	0.0180	0.0337	0.0040	0.0296	0.0051	0.0006	0.0045
WOD	0.0578	0.0047	0.0531	0.1789	0.0003	0.1786	0.0167	0.0002	0.0165	0.0291	0.0021	0.0270	0.0044	0.0003	0.0041
MIN	0.0210	0.0020	0.0190	0.0619	0.0000	0.0619	0.0058	0.0001	0.0057	0.0105	0.0010	0.0095	0.0016	0.0001	0.0014
PET	0.0344	0.0077	0.0267	0.6704	0.5674	0.1030	0.0080	0.0000	0.0079	0.0156	0.0017	0.0139	0.0024	0.0003	0.0021
CHM	0.0494	0.0027	0.0467	0.1676	0.0041	0.1636	0.0226	0.0063	0.0163	0.0269	0.0028	0.0241	0.0041	0.0004	0.0037
PAP	0.0611	0.0133	0.0478	0.1589	0.0001	0.1588	0.0148	0.0005	0.0143	0.0287	0.0045	0.0242	0.0044	0.0007	0.0037
FER	0.0521	0.0050	0.0471	0.2284	0.0000	0.2284	0.0795	0.0586	0.0209	0.0266	0.0023	0.0243	0.0040	0.0003	0.0037
CEM	0.1103	0.0579	0.0523	0.1620	0.0000	0.1620	0.0242	0.0096	0.0146	0.0391	0.0123	0.0268	0.0059	0.0019	0.0041
IRS	0.1345	0.0706	0.0639	0.1589	0.0007	0.1582	0.0266	0.0109	0.0157	0.0338	0.0070	0.0268	0.0051	0.0011	0.0041
ALU	0.0610	0.0350	0.0261	0.0731	0.0001	0.0730	0.0088	0.0020	0.0068	0.0145	0.0027	0.0118	0.0022	0.0004	0.0018
OMN	0.0452	0.0075	0.0378	0.1055	0.0012	0.1043	0.0111	0.0009	0.0101	0.0188	0.0021	0.0166	0.0028	0.0003	0.0025
MCH	0.0561	0.0017	0.0544	0.1362	0.0001	0.1361	0.0146	0.0005	0.0141	0.0242	0.0017	0.0225	0.0037	0.0003	0.0034
NHY	0.2098	0.1131	0.0967	0.2539	0.0027	0.2512	0.0452	0.0218	0.0234	0.0996	0.0523	0.0473	0.0151	0.0079	0.0072
BIO	0.0571	0.0000	0.0570	0.1975	0.0000	0.1974	0.0179	0.0000	0.0179	0.0295	0.0001	0.0294	0.0045	0.0000	0.0045
WAT	0.0620	0.0001	0.0619	0.1944	0.0006	0.1939	0.0186	0.0001	0.0184	0.0355	0.0038	0.0318	0.0054	0.0006	0.0048
CON	0.0663	0.0000	0.0663	0.1961	0.0000	0.1961	0.0177	0.0000	0.0177	0.0307	0.0018	0.0288	0.0047	0.0003	0.0044
LTR	0.0502	0.0000	0.0502	0.3038	0.0000	0.3038	0.0151	0.0000	0.0151	0.0255	0.0001	0.0254	0.0039	0.0000	0.0039
RLY	0.0691	0.0005	0.0686	0.2016	0.0000	0.2016	0.0188	0.0000	0.0188	0.0494	0.0147	0.0347	0.0075	0.0022	0.0053
AIR	0.0533	0.0000	0.0533	0.2323	0.0000	0.2323	0.0168	0.0000	0.0168	0.0275	0.0004	0.0270	0.0042	0.0001	0.0041
SEA	0.0554	0.0000	0.0554	0.2016	0.0000	0.2016	0.0176	0.0000	0.0176	0.0290	0.0006	0.0285	0.0044	0.0001	0.0043
HLM	0.0556	0.0000	0.0556	0.1919	0.0000	0.1919	0.0186	0.0000	0.0186	0.0292	0.0002	0.0290	0.0044	0.0000	0.0044
SER	0.0557	0.0001	0.0556	0.1864	0.0001	0.1863	0.0171	0.0000	0.0171	0.0290	0.0005	0.0284	0.0044	0.0001	0.0043

Source: Author's Estimation

In the above Table 7 we have shown the direct and indirect-induced effect on energy use for all sectors except the above four types of primary energy sectors. In this table 7 we have also decomposed the total effect i.e. direct, indirect- induced effect into two parts viz. direct and indirect-induced effects. The direct effect on energy use is nothing but the direct energy coefficient i.e. amount of energy to be used to produce one unit of output and this can be obtained directly from our SAM of the year 2006-07. This is also called energy intensity with response to gross output of the sector. To estimate the indirect-induced effect we have subtracted this direct effect from the total effects.

Now, if we look at the impact on coal energy use for thermal electricity sector (NHY) we can see that the total effect on coal energy use is higher for the NHY sector (See table 7). The total effect of NHY sector on coal is 0.2098 out of which 0.1131 is the direct and 0.0967 is the indirect-induced effect on coal energy use. This implies that if due to any exogenous changes the output of the NHY sector increases by one unit then the total coal energy requirement of the NHY sector will be increased directly by the amount 0.1131 units and indirectly by the amount 0.0967 units.

Apart from the thermal electricity sector the total impact on coal is observed higher for the iron and steel sector and the cement sector (see Table 7) as compared to other sectors of the economy. The total impact on coal for these two sectors are 0.13 and 0.11 respectively out of which the direct impacts are 0.07 and 0.06 respectively. Therefore, if the output of the iron and steel sector increases by one unit due to any exogenous changes the economy wide demand for coal will be increased by 0.13 unit. The same logic is also valid for the cement sector.

On the other hand the table 7 shows that the direct and indirect-induced impact on coal is significantly low for agriculture and other services sector. The direct uses of coal in these sectors are negligible. Therefore, whatever increase in coal demand is observed for these sectors is due to indirect-induced effect.

In case of crude oil we can observe from the Table 7 that only the petroleum sector has significant direct impact on crude oil. This direct effect is negligible for some sectors and for most of the sector this is almost zeor. But when we take into account indirect-induced effect the total impact on crude oil demand in the economy will increase significantly. For the thermal electricity sector and for most of the manufacturing sector we have observed significant impact on crude oil demand (see Table 7). We can say that though there are negligible direct impact in some sectors but due to indirect-induced effect their output growth will increase the economy wide demand for energy.

If we compare the direct and indirect-induced impact on different energy types we can see this impact is higher for crude oil as compared to other commercial enrgy type available from primay conventional sources (see Table 7). This impact is much lower in case of enrgy type like hydro, natural gas and nuclear. We can say that crude oil is the key source of primary energy in India.

The direct and indirect-induced impact on energy use and GHG emissions are observed due to the backward and forward linkage of the production sectors of the economy. The growth in a sector with high backward linkage provides stimulus to other sectors by requiring more inputs, whereas growth in a sector with high forward linkage stimulates higher outputs in other sectors by providing more inputs to them (Pradhan et.al 2006). Now let us analyse the forward and backward linkage effect with an example of thermal electricity sector. In case of Indian economy the thermal electricity sector is a key source of the electric supply. The share of thermal electricity sector in total electric supply is about 86% in the year 2006-07 (Estimated from SAM of the year 2006-07). So, the other production sectors of the economy are strongly dependent on the thermal electricity sector for their electricity requirement and hence the thermal electricity sector has a high forward linkage. As there is high forward linkage, so the expansion of thermal electricity sector will lead to expansion of the output of other sectors in the economy. Thermal electricity sector requires both energy and non-energy inputs for its production process and these are supplied by the other production sectors of the economy. Now if we look at the column of the thermal electricity sector from our ESAM, we can see that the most of the non-energy inputs of this sector are supplied from the energy intensive sectors. Total energy use in the energy intensive sectors will be increased due to expansion of thermal electricity sector.

Thus we have seen how the energy use will be increased if there is growth in sectoral output. Again, this energy use causes GHG emissions in the atmosphere. According to INCCA report the enrgy based GHG emission is most in India. Almost 58% of total CO_2 equivalent emission is due to energy use (INCCA, 2010). So our next objective is to analyse the impact on GHG emission if the sectoral output grows due to any exogenous injection and this is described in the following section.

3.3 Impact on GHG emission due to sectoral growth resulting from any exogenous changes in the economy

In this case we have used the pollutant X activity block of pollution trade-off multiplier to analyse the impact of sectoral growth on the pollution emission and this is given in Table 8. Each cell entry of this Table 8 shows the direct, and indirect- induced effect on generation of the pollutants due to change in output of the production sectors. Higher the value of multiplier in this Table 8 implies larger is the impact on pollution generation. Therefore the analysis would help us to find out the leading sectors of the economy which have highest impact on the environment.

Table 8: Impact of Output growth on GHG emission (Tons/lakhs of Rs. of Output)

	CO_2 Emission			CH_4 Emission			N_2O Emission			CO_2 Equivalent Emission		
Sectors	Total Effect	Direct effect	Indirect-Induced Effect	Total Effect	Direct effect	Indirect-Induced Effect	Total Effect	Direct effect	Indirect-Induced Effect	Total Effect	Direct effect	Indirect-Induced Effect
PAD	18.677	0.775	17.902	0.515	0.222	0.293	0.006	0.003	0.003	31.270	6.285	24.984
WHT	19.608	0.839	18.769	0.205	0.000	0.205	0.007	0.003	0.003	26.071	1.923	24.148
CER	16.318	0.548	15.770	0.219	0.000	0.219	0.004	0.001	0.002	22.005	0.922	21.083
CAS	16.047	0.277	15.770	0.226	0.000	0.226	0.004	0.002	0.002	22.085	0.866	21.220
ANH	17.837	2.314	15.522	0.682	0.478	0.203	0.002	0.000	0.002	32.889	12.375	20.515
FRS	5.672	0.000	5.672	0.073	0.000	0.073	0.001	0.000	0.001	7.450	0.000	7.450
FSH	14.964	0.000	14.964	0.193	0.000	0.193	0.002	0.000	0.002	19.654	0.000	19.654
COL	13.355	0.000	13.355	0.281	0.128	0.153	0.002	0.000	0.002	19.780	2.691	17.088
OIL	3.480	0.000	3.480	0.046	0.004	0.042	0.000	0.000	0.000	4.581	0.078	4.503
GAS	9.323	0.000	9.323	0.510	0.397	0.113	0.001	0.000	0.001	20.409	8.337	12.072
FBV	15.677	0.743	14.934	0.210	0.000	0.210	0.003	0.000	0.003	20.885	0.749	20.136
TEX	15.989	0.066	15.923	0.187	0.001	0.187	0.002	0.000	0.002	20.585	0.085	20.500
WOD	14.778	0.296	14.482	0.175	0.000	0.175	0.002	0.000	0.002	19.044	0.298	18.747
MIN	5.225	0.124	5.101	0.061	0.000	0.061	0.001	0.000	0.001	6.699	0.124	6.575
PET	8.375	1.027	7.348	0.086	0.000	0.086	0.001	0.000	0.001	10.455	1.030	9.426
CHM	13.411	0.533	12.878	0.147	0.000	0.147	0.002	0.000	0.002	17.136	0.642	16.495
PAP	14.496	1.306	13.190	0.147	0.006	0.141	0.002	0.000	0.002	18.073	1.446	16.628
FER	18.142	4.846	13.296	0.169	0.000	0.169	0.002	0.000	0.002	22.240	4.885	17.355
CEM	50.249	34.669	15.579	0.151	0.000	0.151	0.002	0.000	0.002	53.887	34.669	19.218
IRS	18.800	3.995	14.805	0.156	0.001	0.156	0.002	0.000	0.002	22.564	4.018	18.546
ALU	6.596	0.209	6.387	0.071	0.000	0.071	0.001	0.000	0.001	8.299	0.209	8.090
OMN	9.525	0.545	8.980	0.097	0.000	0.097	0.001	0.000	0.001	11.893	0.548	11.344
MCH	12.181	0.263	11.918	0.128	0.000	0.128	0.001	0.000	0.001	15.309	0.264	15.044
NHY	80.212	47.827	32.385	0.278	0.065	0.213	0.003	0.001	0.002	86.883	49.422	37.461
HYD	15.383	0.000	15.383	0.198	0.000	0.198	0.002	0.000	0.002	20.198	0.000	20.198
NUC	24.600	0.000	24.600	0.200	0.000	0.200	0.002	0.000	0.002	29.446	0.000	29.446
BIO	15.452	0.000	15.452	0.201	0.000	0.201	0.002	0.000	0.002	20.355	0.000	20.355
WAT	17.019	0.000	17.019	0.197	0.000	0.197	0.002	0.000	0.002	21.816	0.000	21.816
CON	16.794	0.001	16.793	0.173	0.000	0.173	0.002	0.000	0.002	21.006	0.001	21.005
LTR	15.703	2.366	13.337	0.162	0.000	0.161	0.002	0.000	0.002	19.689	2.412	17.277
RLY	20.731	0.698	20.033	0.185	0.000	0.185	0.002	0.000	0.002	25.324	0.782	24.541
AIR	23.815	9.609	14.207	0.171	0.000	0.171	0.002	0.000	0.002	28.091	9.693	18.398
SEA	15.745	0.830	14.916	0.184	0.000	0.184	0.002	0.000	0.002	20.257	0.839	19.418
HLM	15.045	0.000	15.045	0.189	0.000	0.189	0.002	0.000	0.002	19.677	0.000	19.677
SER	14.972	0.007	14.964	0.193	0.000	0.193	0.002	0.000	0.002	19.670	0.007	19.663

Source: Author' Estimate

As the Table 8 shows the direct, indirect-induced impact on CO_2 equivalent emission is the highest i.e. 86.88 for thermal electricity sector. Out of this total impact the direct impact of thermal electricity sector is about 49.22 (see Table 8). Therefore if the output of the thermal electricity sector is increased by one unit the total CO_2 equivalent generation in India will be increased by 86.88 tons. Therefore thermal electricity sector of India is the leading sector in terms of GHG emissions and the same thing is also evident from the INCCA report (INCCA, 2010). The INCCA report also says that the CO_2 equivalent emission from thermal electricity sector is high due to coal use in its production process. The coal constitutes about 90% of the total fuel mix used in the thermal electricity sector. Therefore the increase in output in thermal electrcity sector will have significant direct effect on total CO_2 equivalent emission in India. In the above section we have discussed about the backward and forward linkage of thermal electricity sector. Due to this backward and forward linkage effect the total impact on GHG emission will increase for thermal electricity sector.

Next to thermal electricity sector the total impact on CO_2 equivalent emission is observed higher for cement sector. It is observed from the Table 8 that if the output of cement sector increases by Rs. 1 lakh the total CO_2 equivalent emission in India will increase by 53.88 tons. The CO_2 equivalent emission from cement sector is observed due to energy use and due to production process. The energy based emission from cement sector is almost 44% whereas production process based CO_2 equivalent emission is 56% (INCCA, 2010). Therefore increase in output of the cement sector will increase directly due to both energy use and production process. On the other hand due to backward and forward linkage effect we have observed significant impact on coal use (see table 7). Therefore for cement sector we have observed significant direct and indirect-induced impact on CO_2 equivalent emission.

On the other hand the values of the direct pollution coefficients are very small for the agricultural sectors and other services sectors of the Indian economy (Table 8). If we look at the direct effect of paddy sector we find that the CO_2 equivalent emission per unit of paddy output is arrround 6.29 tons per Rs lakh of output. But it is observed from Table 8 that the total effect on CO_2 equivalent emission generation is significant (i.e.32.17) in paddy sector. In case of service sector it is observed from Table 8 that the direct effect is negligible. But due to indirect-induced effect the CO_2 equivalent emission in India will increase by 19.67 tons resulting from increase in service sector output by 1 lakh rupees. Therefore, it can be said that the sectors have small direct impact may have significant indirect and induced effect on the GHG emission.

From the above discussion we have seen that the energy intensive sector has the significant impact on energy use and GHG emission. But it will be wrong to say that the growth in non energy intensive sector will not have significant impact on energy use as well as on GHG emission. Because there are backward and forward linkage effects between the sector and due to this there may have significant impact on energy use and GHG emission.

So far this study describes the impact of output growth in GHG emission in India. But this growth in output will increase the sector wise employment in the economy. Now in the context of economic growth analysis in India the analysis of employment change is essential. On the other hand it will be interesting to see whether this increase in employment have adverse impact on GHG emission in India or not. This issue is addressed in the following section.

3.4 Impact of change in Employment on GHG emission

To analyse the impact of sector specific employment change on GHG emission we have used method of employment multiplier. Before we estimate this employment multiplier let us see the pattern of sector wise employment for the year 2006-07 and this is given in following Table 9.

Table 9: Sector wise Share of Employment and labour intensity (2006-07)

Activity sector	Share of employment	Labour Intensity (number of persons per lakh of rupees of Output)
Agriculture	0.685	2.623
Energy	0.018	0.088
Manufacturing	0.114	0.105
Transport	0.039	0.243
Other Services	0.145	0.245
Total	1.000	

Source: www.indiastat.com

As this Table 9 shows that the share in total employment and labour intensity is the highest in the agriculture sector and other services sector. It is more interesting to see that the share of employment as well as labour intensity is higher in other services sector as compared to the manufacturing sector. Therefore, if sectoral output changes due to unitary changes in the exogenous account of SAM, the employment opportunity will increase more in agriculture and other services sector as compared to the manufacturing and other sectors of the economy. Now if we can link GHG emission with this employment growth we can find the sector for which the impact of increase in GHG emission is less as compared to other sector. To do this we have first estimated sector wise employment multipier and then we relate that with the GHG emission. The methodology and analysis is described below.

Employment Multiplier

Employment multiplier shows the direct and indirect changes in employment if the output of a sector changes due to any exogenous changes in the economy (Pradhan et al. 2006). The method of estimating employment multiplier is described in the book 'Social Accounting Matrix for India' by Pradhan, Saluja and Singh (2006). But in this book authors have estimated employment multiplier by multiplying the employment coefficients (number of labour per unit of output) with the IO multiplier. Therefore this employment multiplier shows direct and indirect impact on employment due to exogenous changes in the economy. In this study we have estimate the employment multiplier to show the direct and indirect-induced impact on employment due to any exogenous changes in the economy. Therefore, we have used SAM multiplier matrix to derive the employment multiplier for India for the year 2006-07 and the method is described below.

Let us suppose Li is the employment in sector i and Ei is fixed employment coefficient.

Therefore,

$$Ei = Li/Yi \qquad (6)$$

Now, re-organising this equation with Equation (6) by substituting MX for Y, we may rewrite it as

$L = e\ M\ X$ (7)

Where e is the diagonalised matrix formed with elements Ei and the element of 'e' corresponding to non-production account are zero.

Differentiating the above equation we get,

$\partial L/\partial X = e\ M = R$ (8)

Therefore the Ri gives us the employment multiplier for sector I which indicate the direct, indirect and induced employment created in the whole economy when the exogenous variable changes by one unit.

Impact of Employment Creation on GHG emission

Now to see the impact of employment creation on GHG emission we have to link this employment multiplier with the GHG emissions. To link GHG emission with employment multiplier we have followed the same method as we have applied for pollution-trade off multiplier. Here we have estimated sector wise emission employment ratio by dividing sector wise total emission from their corresponding level of employment (i.e. number of labour engaged in that particular sector). Pre multiplying this with the employment multiplier we have obtained the employment-emission multiplier and this is shown in the following equation.

$E_P = e_p * R$ (9)

Where e_p is the employment emission ratio.

Thus we have estimated the impact on sectoral GHG emission due to increase in sectoral employment resulting from unitary changes in the exogenous account in our SAM. The result obtained in this way is given in the Table 10.

Table 10: Impact of employment change on GHG emission

Production Sector	Employment Multiplier	CO_2 (tons)	CH_4 (tons)	N_2O ('tons)	CO_2Eq (tons)
PAD	3.718	1.466	0.421	0.005	11.897
WHT	4.225	2.002	0.000	0.008	4.587
CER	5.601	1.024	0.000	0.002	1.723
CAS	4.637	0.435	0.000	0.003	1.361
ANH	4.031	3.669	0.758	0.000	19.618
FRS	2.745	0.000	0.000	0.000	0.000
FSH	4.222	0.000	0.000	0.000	0.000
COL	0.912	0.000	0.331	0.000	6.948
OIL	1.824	0.000	0.071	0.000	1.497
GAS	1.179	0.000	0.944	0.000	19.822
FBV	0.603	2.150	0.001	0.000	2.167
TEX	0.694	0.222	0.003	0.000	0.287
WOD	0.723	0.467	0.000	0.000	0.470
MIN	1.125	0.964	0.000	0.000	0.967
PET	1.803	328.319	0.035	0.001	329.273
CHM	2.032	16.023	0.008	0.010	19.278
PAP	0.288	6.343	0.031	0.000	7.020
FER	1.821	40.496	0.004	0.001	40.819
CEM	0.138	105.931	0.000	0.000	105.931
IRS	0.439	64.020	0.008	0.001	64.382
ALU	0.257	10.158	0.000	0.000	10.159
OMN	1.144	15.463	0.000	0.000	15.563
MCH	0.856	4.440	0.000	0.000	4.469
NHY	0.281	965.130	1.321	0.014	997.319
HYD	1.291	0.000	0.000	0.000	0.000
NUC	0.178	0.000	0.000	0.000	0.000
BIO	4.184	0.000	0.000	0.000	0.000
WAT	0.661	0.000	0.000	0.000	0.000
CON	1.039	0.006	0.000	0.000	0.006
LTR	1.700	16.978	0.003	0.001	17.306
RLY	0.712	2.020	0.000	0.001	2.263
AIR	0.524	9.679	0.000	0.000	9.764
SEA	0.414	1.330	0.000	0.000	1.344
HLM	0.437	0.000	0.000	0.000	0.000
SER	4.523	0.132	0.000	0.000	0.133

Source: Author Estimate

From the above table we can see that the value of employment multiplier is significant for agriculture and service sector as compared to other sectors of the economy. This is due to their labour intensity as shown in the Table 10. But if we look at the impact on GHG emission we find that the increase in GHG emission is not significant for service sector as compared to the manufacturing and other sectors of the economy. In case of manufacturing sector, though its value of employment multiplier is less but it has significant impact on GHG emission.

Thus, we have seen that the sector wise employment will change at a different rate due to unitary changes in exogenous variable for all sectors. Also, we have seen that the impacts of employment change on GHG emissions are different for different sectors. Now, this difference in impact is due to the sector wise difference in energy consumption. In this case it will be interesting to see the difference in energy consumption per unit of labour in the production sector. Here it is assumed that the energy consumption per unit labour for the group of sectors will be followed by their counterpart. So in the following table 11 we have estimated energy consumption per unit of labour for broad group of sector in India for the year 2006-07.

Table 11: Energy cost per unit of labour employed (energy in rupee value/Labour)

Production Sector	Rupees of primary energy use/Labour	Rupees of petroleum energy use/Labour	Rupees of Thermal electricity use/Labour
Agriculture	1.36	544.01	298.17
Energy	306828.51	41186.32	68904.85
Manufacturing	11922.10	19506.07	13074.87
Transport	27.33	82546.33	4787.66
Services	71.87	1796.37	1164.83

Source: Author Estimate with the help of SAM of the year 2006-07

It is clear from the Table 11 that the payment for energy use per unit of labour is the highest for energy production sector itself. In case of manufacturing sector the payment for electricity use per unit of labour is almost 13 times higher than the other services sector. The payment for thermal electricity consumption is almost negligible for agriculture sector. Again in case of other forms of energy the payment for energy use per unit of labour is significantly less than the manufacturing sector. As a result, despite the low employment multiplier the impact on GHG emission is high for manufacturing sector as compared to the other services sector in India.

Again it is observed from the following Table 11 and figure 1 that the share of other services sector in gross domestic product is the highest in India. In the year 2006-07 the share of of service sector is arround 43% where as the same for agriculture sector is 18% and for manufacturing sector it is 15.59%. On the other hand the share of service sector is gradually increasing over the years, whereas this is declining for agricultural sector. In case of manufacturing the share in GDP is almost constant over the years between 1999-00 to 2006-07. Therefore it is evident from the Table 12 that the indian economy is structurally biased towards service sector. Hence we can say that if the Indian economy follows this structure in future, its economic growth will increase with less impact on GHG emission.

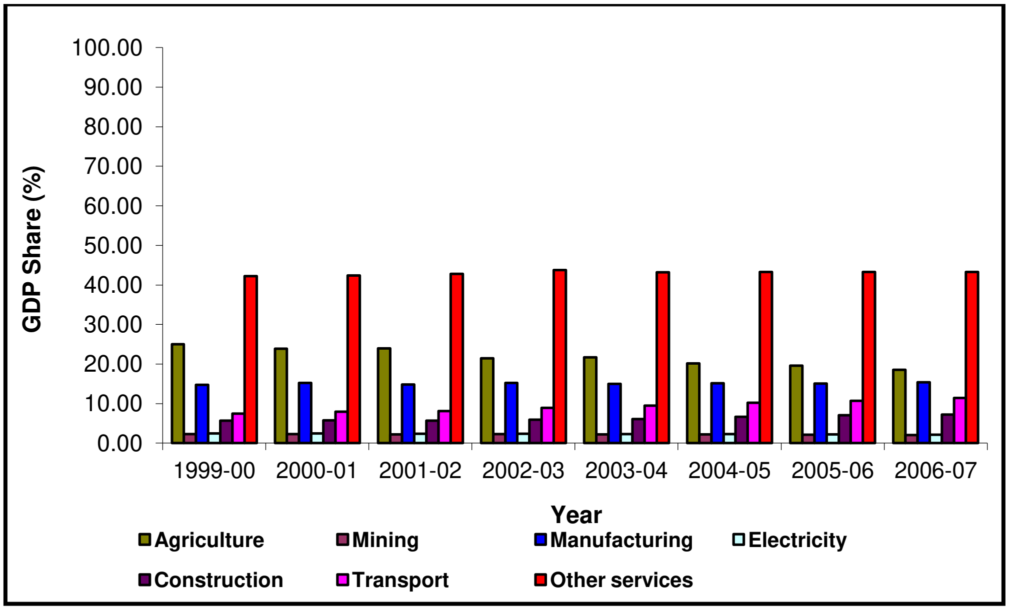
Table 4.7 Sector specific share in gross domestic product at factor cost

Year	Agriculture	Mining	Manufacturing	Electricity	Construction	Transport	Other service
1999-00	24.99	2.33	14.78	2.49	5.71	7.47	42.23
2000-01	23.89	2.28	15.26	2.44	5.81	7.96	42.35
2001-02	23.99	2.20	14.79	2.34	5.71	8.15	42.81
2002-03	21.43	2.30	15.22	2.36	5.94	8.96	43.79
2003-04	21.72	2.19	14.95	2.28	6.13	9.52	43.21
2004-05	20.20	2.20	15.12	2.29	6.62	10.25	43.32
2005-06	19.56	2.11	15.06	2.19	7.05	10.74	43.29
2006-07	18.51	2.04	15.39	2.12	7.20	11.42	43.32

Source: Author;s estimate with the help of national account statistics,2009

Therefore, in this chapter we have seen that if there is growth in sector specific output the GHG emission will increase.

Figure 4.1 Sector specific share in Gross Domestic product



Source: CSO (2009), National Accounts Statistics

4. Conclusion

The contribution of this study is construction of ESAM of India for the year 2006-07. In the process of constructing the ESAM this chapter shows the direct relationship between the economic activities with the environmental indicators like GHG emission, and change in natural resource. This study also shows that the impact on GHG emission of the economy is not only dependent on the sector specific energy intensity but also due to the backward and forward linkages between the activites. Due to this linkage effect the growth in output of low energy intensive or low emission intensive sectors may have significant indirect-induced impact on total GHG emission. If this backward and forward linkages between the sectors changes, the indirect-induced impact may change and hence we may observe different impact on GHG emission. On the other hand if any technological changes can change the emission intensity then direct impact on the GHG emission may change. Now this change in backward and forward linkage between the sectors will change if there in change in input-output coefficients. But the SAM multiplier model in this chapter is based on fixed input output coefficient of the production process. With the help of fixed input output coefficient it is not possible to do such kind of analysis. This needs further analysis which will be taken care of in future.

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Appendix 1: Description of 35 sectors of 2006-07 SAM and its mapping with IO Table

Serial No.	Sector Code	Sectors for SAM	Sectors of IO table 2006-07
1	PAD	Paddy Rice	1
2	WHT	Wheat	2
3	CER	Cereal, Grains etc, other crops	Part of (3-7,18,19, 20)
4	CAS	Cash crops	8,9,10-17
5	ANH	Animal husbandry & prod.	Part of (21, 22, 23, 24)
6	FOR	Forestry	Part of 25
7	FSH	Fishing	26
8	COL	Coal	27
9	OIL	Oil	29
10	GAS	Gas	28
11	MIN	Minerals n.e.c.	30-37
12	FBV	Food & beverage	Part of (38-45)
13	TEX	Textile & Leather	46-54, 59, 60
14	WOD	Wood	56
15	PET	Petroleum & Coal Prod.	63,64
16	CHM	Chemical, Rubber & Plastic prod.	58,61,62,65,66, 69-73
17	PAP	Paper & Paper prod.	Part of 57
18	FER	Fertilizers & Pesticides	67,68
19	CEM	Cement	75
20	IRS	Iron & Steel	77,78, 79
21	ALU	Aluminum	80
22	OMN	Other manufacturing	55, 74, 76, 81, 82, 95-105
23	MCH	Machinery	83-94
24	HYD	Hydro	107
25	NHY	Thermal	107
26	NUC	Nuclear	107
27	BIO	Biomass	Part of (3-7,18,19, 20), Part of (21, 22, 23, 24), Part of 25, Part of (38-45), Part of 57
28	WAT	Water	108
29	CON	Construction	106
30	LTR	Land transport	110, 113
31	RLY	Rail Transport	109, 113
32	AIR	Air Transport	112, 113
33	SEA	Sea Transport	111, 113
34	HLM	Health & medical	122
35	SER	All other services	114-121, 123, 124-126, 127-130

Appendix 2: Description of Economic Agents of 2006-07 SAM

Agent code	**Description**
RNASE	Rural non-agricultural self employed
RAL	Rural agricultural labour
ROL	Rural other labour
RASE	Rural agricultural self employed
ROH	Rural other households
USE	Urban self employed
USC	Urban salaried class
UCL	Urban casual labour
UOH	Urban other households
PVT	Private corporate
PUB	Public non-departmental enterprises
GOV	Government

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	PAD	WHT	CER	CAS	ANH	FRS	FSH	COL	OIL
PAD	3604537	56673	297765	333	45486	6	513	0	0
WHT	63062	2703447	377231	4	13612	0	6	0	0
CER	53742	128243	1813875	9	2555577	18	7	0	0
CAS	4048	14766	47603	798319	1295	0	0	0	0
ANH	586772	81354	954233	657037	26038	1	83	0	1
FRS	132	24	60	0	40	230	0	0	0
FSH	223	571	1182	0	0	0	246158	0	0
COL	47	35	74	15	202	0	0	11356	2
OIL	0	0	1	0	2590	0	0	0	54713
GAS	0	0	0	19	257	0	0	0	0
FBV	45025	6549	18793	14	272968	0	11467	0	0
TEX	21267	21413	15603	3338	2474	393	140281	88	3
WOD	81	209	433	43	236	11	6893	29899	3
MIN	1	3	9	1	503	0	0	0	16
PET	440637	197486	428076	200894	1292	3538	159517	42221	96751
CHM	3040	3257	5886	2217	19365	1043	9975	305214	68299
PAP	846	1023	1691	419	644	164	0	4436	3
FER	1551704	1351880	1533062	951908	194	44	219	0	0
CEM	0	0	0	0	33	1	0	0	857
IRS	0	1	7	1	1314	1	6856	2	1302
ALU	1	3	8	1	662	19	362	0	23
OMN	13173	8489	8675	4004	2950	3088	105725	109983	157816
MCH	63300	74441	81915	13137	6681	633	9	208316	193424
NHY	303163	292496	154790	47095	919	63	43	105965	28621
HYD	56174	54198	28682	8726	170	12	8	19635	5303
NUC	8532	8232	4356	1325	26	2	1	2982	806
BIO	62499	9197	108434	69230	13710	776	9	0	1
WAT	62	53	71	33	16	28	0	1859	0
CON	299358	186107	241647	95450	4927	3305	42	30402	299685
LTR	465228	308397	416869	214952	470359	10505	62115	145944	54946
RLY	218678	54027	77352	32208	28198	744	2773	8572	3718
AIR	33234	21421	15620	7991	2153	46	2312	697	1147
SEA	1017	1500	3189	362	32522	25	57	869	543
HLM	0	0	0	0	0	0	0	0	0
SER	848437	522990	860076	350991	2020029	9655	56472	179594	192200
Lab	3689555	2645224	13081859	4985874	7939400	155015	1870083	950571	880277
Cap	1115629	799304	3842846	1408910	7823192	166197	1535925	2387623	2272012
Land	2546449	1825601	9153113	3501862					
RNASE									
RAL									
ROL									
RASE									
ROH									
USE									
USC									
UCL									
UOH									
PVT									
PUB									
GOV									
ITX	-1139709	-1310720	-1108597	-581101	31009	11379	-202612	90587	81514
CAC									
ROW	53	31699	831853	283794	34943	626973	15046	1059286	14830033
TOT	14960001	10099591	33298342	13059415	21355984	993915	4030348	5696101	19224020

Contd………..

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	PAD	WHT	CER	CAS	ANH	FRS	FSH	COL	OIL
CO_2 (000'tons)									
CH_4 (000'tons)									
N_2O (000'tons)									
Oil (mt)									34
coal (mt)								361	
Forest Land (Mha)									
Crop land (Mha)									
Grass land(Mha)									
Greenhouse Effect (000' tons)									

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	GAS	FBV	TEX	WOD	MIN	PET	CHM	PAP	FER
PAD	0	480042	41	8	3	0	20196	1773	340
WHT	0	915729	74	20	1	0	36804	137	735
CER	1	3051005	7501	503	81	880	308401	19754	4427
CAS	2	5426983	2056049	341	201	1637	728827	4493	8404
ANH	3	1601763	372582	325	153	308	157594	882	2331
FRS	4	19532	290	55073	37	217	16076	50715	69
FSH	0	458661	40	2	1	0	19972	172	356
COL	957	29140	27400	5525	23948	252434	139313	53150	32516
OIL	1376	194	12	300	58	18673034	211974	556	1
GAS	5	3010	36448	183	1484	886	327777	2027	381218
FBV	2	4300382	16609	498	218	1015	479422	11745	10967
TEX	19	106573	5501608	1518	3789	4247	368217	11427	9356
WOD	2114	170905	78689	14647	2562	9784	268310	67587	24950
MIN	70	4328	6850	1884	26313	2631	193568	4602	162315
PET	11260	406413	407654	7406	63514	1020947	1182041	84364	791718
CHM	28662	1241295	2158888	38087	121069	546658	15269445	421793	1275236
PAP	325	442279	160128	19331	1797	14496	962974	617782	8541
FER	3	61026	1978	6754	80	3612	225431	525	577350
CEM	53	76	370	140	218	3105	7641	70	55
IRS	329	1671	17261	8151	12877	4515	215983	13309	3104
ALU	116	3941	11634	3771	49536	10981	225889	7481	5077
OMN	19255	49225	196681	18950	64147	20287	564638	12863	9520
MCH	25725	275599	558968	7848	33712	41103	484615	15348	23692
NHY	15172	218487	616474	13510	61600	294141	789216	97953	79410
HYD	2811	40484	114228	2503	11414	54502	146236	18150	14714
NUC	427	6149	17350	380	1734	8278	22212	2757	2235
BIO	13	94233	1534	185645	130	781	59890	172836	313
WAT	133	6695	3641	46	404	209	11973	115	1729
CON	18053	333190	411837	2372	58265	192032	328759	9861	49682
LTR	17441	1665994	2120591	44524	45926	120362	1709841	195932	258956
RLY	1848	93918	29913	4081	14546	548377	166346	24430	40166
AIR	153	106956	7532	3512	1299	15347	31377	5648	13136
SEA	114	19230	37301	242	278	3792	52835	5044	1304
HLM	0	0	0	0	0	0	0	0	0
SER	27914	5985966	4626498	126727	171480	986547	4137078	325955	592151
Lab	422077	2468376	3448211	295948	832851	306368	3575263	259182	334750
Cap	423125	3621031	3414704	215792	2092439	4606321	7319453	423864	931988
Land									
RNASE									
RAL									
ROL									
RASE									
ROH									
USE									
USC									
UCL									
UOH									
PVT									
PUB									
GOV									
ITX	13229	768166	483529	20759	61959	1554145	2787084	233237	301979
CAC									
ROW	751027	2686079	1315523	78402	8023533	3604127	8735582	820494	548325
TOT	1783816	37164725	28266621	1185711	11783655	32908109	52288252	3998014	6503117

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	GAS	FBV	TEX	WOD	MIN	PET	CHM	PAP	FER
CO2 (000'tons)									
CH4 (000'tons)									
N2O (000'tons)									
Oil (mt)									
coal (mt)									
Forest Land (Mha)									
Crop land (Mha)									
Grass land(Mha)									
Greenhouse Effect (000' tons)									

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	CEM	IRS	ALU	OMN	MCH	NHY	HYD	NUC	BIO
PAD	0	19	1	1578	281	1309	0	0	5115
WHT	0	30	1	3020	546	2266	0	0	3042
CER	44	378	183	16627	3852	10779	0	0	213747
CAS	111	924	729	34391	9627	16922	0	0	2881
ANH	59	1459	1161	45847	12678	4697	0	0	6689
FRS	19	643	154	35230	2603	704	0	0	1832
FSH	0	17	1	1639	343	1226	0	0	223
COL	217084	2065513	457147	574505	114056	1692816	0	0	164
OIL	2	20936	1085	91313	4544	40917	0	0	209
GAS	35930	317837	26419	70721	35564	325683	0	0	27
FBV	166	2712	2049	22239	6140	12255	0	0	24024
TEX	9504	11516	4827	180233	196041	7383	0	0	3233
WOD	28946	16799	5632	171272	227330	2250	0	0	350
MIN	368646	651084	477031	1175277	213464	0	0	6146	54
PET	126628	734155	145332	863213	521420	1654974	0	0	28271
CHM	137084	308761	232203	2018159	2645906	117745	0	1711	10884
PAP	37859	20696	9488	186071	248553	27143	7055	497	3004
FER	17	5835	198	6348	6177	3234	0	0	6528
CEM	1419	4361	1758	72661	7136	31	24	0	9
IRS	3193	3560402	176752	3869196	6330835	18877	2020	0	147
ALU	1372	3380076	935163	2161226	4271787	18924	2551	0	212
OMN	171932	1036459	217809	7001479	4244945	361252	12119	5426	23057
MCH	7106	342501	157092	2824181	12649358	797475	40206	12174	5690
NHY	248364	1113522	190742	874539	603835	4222060	832	61371	1508
HYD	46020	206328	35343	162046	111887	782319	154	11372	280
NUC	6990	31339	5368	24613	16994	118826	23	1727	42
BIO	176	2237	555	119407	8788	2418	0	0	7717
WAT	23	633	187	20829	1912	21709	0	315	211
CON	9669	103161	68902	858778	1039096	353407	21809	5453	25876
LTR	127948	611392	161034	1316451	1293680	389306	11580	5827	118111
RLY	147032	955566	161873	524171	211815	531289	12148	7897	8184
AIR	13577	51495	11825	41876	12219	53022	406	776	635
SEA	655	3886	1032	32578	33574	4699	853	81	2670
HLM	0	0	0	0	0	0	0	0	0
SER	383060	3200680	651886	5679499	7705456	2107244	139633	32654	240078
Lab	251382	2243925	786206	5060576	3681199	320002	1087917	25610	1877973
Cap	624803	3903004	350669	7187010	4935561	2711260	1466763	241362	1859180
Land									
RNASE									
RAL									
ROL									
RASE									
ROH									
USE									
USC									
UCL									
UOH									
PVT									
PUB									
GOV									
ITX	111024	1029909	356922	2600023	4055593	-1769435	-32813	834	0
CAC									
ROW	629557	3333828	7439439	30835793	11813863	0	0	0	0
TOT	3747403	29274019	13074201	76764616	67278659	14966987	2773280	421233	4481857

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	CEM	IRS	ALU	OMN	MCH	NHY	HYD	NUC	BIO
CO_2 (000'tons)									
CH_4 (000'tons)									
N_2O (000'tons)									
Oil (mt)									
coal (mt)									
Forest Land (Mha)									
Crop land (Mha)									
Grass land(Mha)									
Greenhouse Effect (000' tons)									

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	WAT	CON	LTR	RLY	AIR	SEA	HLM	SER	Lab
PAD	49	113	18	0	0	111	3612	718905	
WHT	93	80	1300	0	0	117	4530	397700	
CER	388	1061416	953328	0	0	712	13580	2341984	
CAS	611	800	0	0	2	0	0	146536	
ANH	178	601652	0	0	0	0	10338	1285048	
FRS	41	83419	0	9	0	0	0	2992	
FSH	50	43	0	0	0	0	0	17098	
COL	101	1970	0	4164	0	0	0	20790	
OIL	619	23	0	0	11	0	0	13295	
GAS	163	325	0	0	0	0	0	6777	
FBV	543	424	18874	0	0	837	0	2467947	
TEX	112	93123	79766	910	50	941	17421	152856	
WOD	99	919489	1068	97	0	0	0	23867	
MIN	10	3729164	0	0	0	0	0	27148	
PET	2190	3355210	12200344	268248	97767	43643	70748	950541	
CHM	6332	1141838	2324087	8258	135793	183592	2391228	1138535	
PAP	1524	36405	153476	4697	951	460	14464	287397	
FER	1241	11379	230	6	0	0	0	14203	
CEM	0	3969131	0	0	0	0	0	1738	
IRS	2159	10273278	891	409	0	0	0	207244	
ALU	57	3853	326	0	0	0	0	122373	
OMN	4979	8386495	2113947	1250215	91698	103333	133745	2538691	
MCH	4336	2366624	933154	41763	5363	12665	104722	2176907	
NHY	22460	895618	28247	695572	2400	5157	15150	647088	
HYD	4162	165952	5234	128885	445	956	2807	119901	
NUC	632	25206	795	19576	68	145	426	18212	
BIO	140	285604	4041	29	0	3	58	20010	
WAT	141549	177244	15485	320	985	18334	900	109167	
CON	116775	3790532	642021	866250	36259	36649	222340	3491684	
LTR	6722	4110131	2382395	91440	60647	77416	227590	3952304	
RLY	656	981304	532260	568506	1416	1228	1859	114131	
AIR	47	92231	142044	3437	1177	512	1043	57923	
SEA	183	25850	41715	1673	375	201	43820	103162	
HLM	0	0	0	100676	0	0	0	173246	
SER	89571	9607585	8210058	232405	112249	176900	761775	19477882	
Lab	326430	22499481	9807816	2462740	263300	578908	4692207	71922015	
Cap	363570	9461837	7531709	1774196	197957	415166	2693040	95799645	
Land									
RNASE									13686272
RAL									30655386
ROL									9597032
RASE									23604200
ROH									6014659
USE									17416862
USC									63190125
UCL									9330416
UOH									2282323
PVT									
PUB									
GOV									
ITX	8260	2468171	2627536	224044	44498	48704	414210	790126	
CAC									
ROW	0	0	478851	0	0	0	0	7888498	
TOT	1107034	90622999	51231016	8748525	1053410	1706690	11841614	########	175777274

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	WAT	CON	LTR	RLY	AIR	SEA	HLM	SER	LAB
CO_2 (000'tons)									
CH_4 (000'tons)									
N_2O (000'tons)									
Oil (mt)									
coal (mt)									
Forest Land (Mha)									
Crop land (Mha)									
Grass land(Mha)									
Greenhouse Effect (000' tons)									

Contd………..

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	Cap	Land	RNASE	RAL	ROL	RASE	ROH	USE	USC
PAD			921172	1929082	465192	2615038	686698	882091	971107
WHT			527070	1103765	266169	1496249	392909	504706	555640
CER			1827586	3590841	947921	4944834	1532174	2474139	2817419
CAS			299626	627464	151311	850582	223359	286913	315868
ANH			1203885	1541555	566288	4038074	1205631	2093656	2433331
FRS			56650	106912	28156	168129	46044	38522	42409
FSH			270564	566605	136635	768082	201695	259085	285231
COL			2587	4806	1392	7050	2297	3982	4539
OIL			0	0	0	0	0	0	0
GAS			8530	15845	4591	23244	7574	13128	14966
FBV			2337903	4286378	1252981	6672925	2092675	3174404	3775280
TEX			1086663	1857987	535414	3279454	1057461	1576595	1917142
WOD			5587	5428	2970	18109	5942	11599	15773
MIN			0	0	0	0	0	0	0
PET			345403	571748	238310	1112680	650630	723282	1928089
CHM			419787	578193	220158	1431805	465963	850403	1564865
PAP			27994	36969	13736	96565	26651	56321	93756
FER			0	0	0	0	0	0	0
CEM			0	0	0	0	0	0	0
IRS			0	0	0	0	0	0	0
ALU			0	0	0	0	0	0	0
OMN			330690	364709	172486	1016206	356694	699474	968900
MCH			386716	426498	201709	1188372	417126	817979	1133052
NHY			149390	277486	80407	407068	132646	229909	262088
HYD			27681	51416	14899	75427	24578	42600	48563
NUC			4204	7810	2263	11457	3733	6471	7376
BIO			363625	686243	180725	1079176	295545	247261	272214
WAT			9931	18447	5345	27062	8818	15284	17423
CON			170198	280178	90104	537936	181655	295588	465387
LTR			1616071	2134167	792934	5560509	1538523	3251313	5412380
RLY			77718	102633	38133	288570	73988	156357	260284
AIR			18739	24745	9194	-48923	17839	37698	62755
SEA			58125	76759	28519	307632	55336	116939	194666
HLM			534718	1300190	354222	2104424	1185892	930716	1834783
SER			4613267	6644682	2597189	15922245	6145036	10965155	21129082
Lab									
Cap									
Land									
RNASE	11301847								
RAL	99289								
ROL	591941								
RASE	28570049	17027026							
ROH	17120543								
USE	19042479								
USC	4147757								
UCL	1346862								
UOH	6309825								
PVT	32937007								
PUB	9545700								
GOV	7439300		355411	0	0	4142314	1419397	0	2379634
ITX			802814	1317718	426876	2548941	867247	1406262	2238702
CAC	44737987		10554871	5666113	2167887	18770185	5912228	10750880	25845192
ROW									
TOT	183190587	17027026	29415175	36203372	11994117	81461420	27233983	42918713	79267896

Contd………..

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	CAP	LAND	RNASE	RAL	ROL	RASE	ROH	USE	USC
CO2 (000'tons)									
CH4 (000'tons)									
N2O (000'tons)									
Oil (mt)									
coal (mt)									
Forest Land (Mha)		0.16							
Crop land (Mha)		0.45							
Grass land(Mha)		0.01							
Greenhouse Effect (000' tons)	1769746								

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	UCL	UOH	PVT	PUB	GOV	ITX	CAC	ROW	TOT
PAD	295510	156272			102487		101482	595043	14960001
WHT	169082	89414			53035		-115959	533924	10099591
CER	662037	460271			185878		551811	742389	33298342
CAS	96119	50830			0		709321	141521	13059415
ANH	405042	396006			340150		438181	282915	21355984
FRS	12905	6825			61		4938	212218	993915
FSH	86796	45899			0		4929	656848	4030348
COL	1797	815			6326		-80482	16566	5696101
OIL	0	0			0		-6482	112740	19224020
GAS	5924	2688			27381		11623	75561	1783816
FBV	892075	647357			398033		1400206	2500625	37164725
TEX	342432	326420			328519		594522	8394477	28266621
WOD	1513	2298			107		-1003963	45794	1185711
MIN	0	0			0		-130444	4862982	11783655
PET	211808	209213			421402		-2900636	2787765	32908109
CHM	188901	230639			908608		4992972	6114416	52288252
PAP	11664	15059			80533		94443	167706	3998014
FER	0	0			213		-58531	240268	6503117
CEM	0	0			0		-330620	7135	3747403
IRS	0	0			0		1842627	2699301	29274019
ALU	0	0			0		543543	1313233	13074201
OMN	100834	150272			539350		21869319	21128635	76764616
MCH	117917	175731			580572		30745595	6497608	67278659
NHY	103738	47068			529604		0	0	14966987
HYD	19222	8721			98132		0	0	2773280
NUC	2920	1325			14905		0	0	421233
BIO	82835	43821			0		0	0	4481857
WAT	6896	3129			457828		0	0	1107034
CON	69489	84079			738347		73456402	0	90622999
LTR	673354	869322			844476		1440554	3824555	51231016
RLY	32382	41806			151856		455432	958135	8748525
AIR	7807	10080			20100		33413	106138	1053410
SEA	24218	31267			45962		197583	112451	1706690
HLM	322525	810765			2189457		0	0	11841614
SER	2307761	3926428			33042548		4512415	27110384	219745567
Lab								-251300	175777274
Cap								-2726500	183190587
Land									17027026
RNASE					3307145			1119912	29415175
RAL					4070341			1378356	36203372
ROL					1348497			456647	11994117
RASE					9158699			3101446	81461420
ROH					3061914			1036868	27233983
USE					4825346			1634026	42918713
USC					8912081			3017933	79267896
UCL					1413124			478532	12568935
UOH					1137160			385081	10114388
PVT					2163093				35100100
PUB									9545700
GOV	3975924	634321	14434600			35574693		4669800	75025393
ITX	330440.287	408564			594826		8762980	795880	35574693
CAC	1007065	227683	20665500	9545700	-7072703			-641415	148137174
ROW									106696599
TOT	12568935	10114388	35100100	9545700	75025393	35574693	148137174	106696599	

Contd………..

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	UCL	UOH	PVT	PUB	GOV	ITX	CAC	ROW	TOT
CO2 (000'tons)									
CH4 (000'tons)									
N2O (000'tons)									
Oil (mt)									
coal (mt)									
Forest Land (Mha)									
Crop land (Mha)									
Grass land(Mha)									
Greenhouse Effect (000' tons)									

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	CO2 (000'tons)	CH4 (000'tons)	N2O (000'tons)	Oil (mt)	coal (mt)	Forest Land (Mha)	Crop land (Mha)	Grass land(Mha)	Greenhouse Effect (000' tons)
PAD	11589	3327	41						94028
WHT	8477	0	35						19420
CER	18240	0	40						30705
CAS	3615	0	25						11305
ANH	49426	10216	1						264278
FRS	0	0	0						0
FSH	1	0	0						1
COL		730			8410				15330
OIL		71		20					1495
GAS		708							14872
FBV	27626	7	0						27837
TEX	1861	26	0						2413
WOD	351	0	0						353
MIN	1460	0	0						1465
PET	33788	4	0						33886
CHM	27889	14	17						33555
PAP	5223	25	0						5780
FER	31514	3	1						31765
CEM	129920								129920
IRS	116958	15	1						117621
ALU	2729	0	0						2729
OMN	41822	1	1						42092
MCH	17662	0	0						17776
NHY	715830	980	11						739704
HYD									0
NUC									0
BIO									0
WAT									0
CON	89	0	0						90
LTR	121211	23	6						123554
RLY	6109	0	2						6845
AIR	10122	0	0						10211
SEA	1416	0	0						1431
HLM									0
SER	1568	0	0						1583
Lab									0
Cap									0
Land						0.09	1.34	0.20	0
RNASE	16306	190.189	3	21215.69					21216
RAL	29861	323	5	38226.28					38226
ROL	8866	124	2	12056.42					12056
RASE	49358	602	9	64877.3					64877
ROH	17461	320	5	25597.61					25598
USE	8403	919	4	29074.43					29074
USC	22105	1454	12	56212.31					56212
UCL	2492	284	1	8858.502					8858
UOH	2414	197	1	6943.122					6943
PVT									
PUB									
GOV									
ITX									
CAC									
ROW									
TOT									

Contd……….

Appendix 3: Environmental Social Accounting matrix of India 2006-07 (Rs. Lakhs for monetary transaction & others in physical units)

	CO_2 (000'tons)	CH_4 (000'tons)	N_2O (000'tons)	Oil (mt)	coal (mt)	Forest Land (Mha)	Crop land (Mha)	Grass land(Mha)	Greenhouse Effect (000' tons)
CO_2 (000'tons)						67800	207520	38	-275358
CH_4 (000'tons)									
N_2O (000'tons)									
Oil (mt)									
Coal (mt)									
Forest Land (Mha)									
Crop land (Mha)									
Grass land(Mha)	10490								
Greenhouse Effect (000' tons)									