Notification

The report submitted by the 'Expert Committee on the Development of Database on Climate Change' under the chairmanship of Dr. K.S. Rao, Professor, Dept. of Botany, Delhi University constituted by Central Statistics Office (CSO), Ministry of Statistics & Programme Implementation is attached herewith for the comments of persons who are interested in the subject area. You are requested to kindly forward your valuable comments along with the name, contact address and the institution you are attached with, if any, to the E-mail address director.ssd3@gmail.com before 31st January, 2011.

Report of the

Expert Committee on the

Development of Database on

Climate Change

June 2010

Government of India
Ministry of Statistics and Programme Implementation
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Central Statistics Office
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Contents

Executive Summary

The Central Statistics Office (CSO) under National Statistical Organization constituted a Steering Committee on Environment Statistics in 1996 to examine the indicators identified by United Nations Statistical Division (UNSD) and recommend a set of parameters which are relevant in Indian context and applicable to the needs and requirements. The Committee recommended for the adoption of five broad categories of the framework viz., bio-diversity, atmosphere, land/soil, water and human settlements. Accordingly, CSO has been bringing out an Annual publication by name 'Compendium of Environment Statistics' since 1997.

The 16th Conference of Central and State Statistical Organizations (COCSSO) held in December, 2008 felt that India's official statistics on Climate Change is insufficient to address the challenges posed by the country and a more elaborate and a meaningful database is to be built to ascertain the impact of climate change. CSO constituted an Expert Committee on the Development of Database on Climate Change on 20th July, 2009 under the Chairmanship of Dr. K. S. Rao, Professor, Dept. of Botany, Delhi University with a mandate to (a) identify indicators/parameters for which statistical data need to be collected, (b) to suggest the data source agencies for the collection of data (c) to decide the relevant geographical unit/ climatic unit for which data may be collected and periodicity of such data collection (d) to review the data contained in the CSO's publication 'Compendium of Environment Statistics' and suggest modifications, if any, in existing tables to meet the users' requirements at national and international level.

The Committee had three meetings and discussed various aspects relating to the identification of indicators, sources and availability of data, time frame etc. The Committee agreed with continuation of the 'Compendium of Environment Statistics' in its present form and

developed a framework for Climate Change database. The Committee included all possible indicators relating to Climate Change in the framework. While data are already available in respect of some of the parameters / indicators, data need to be collected in case of certain other parameters. The Committee recommended for CSO to be the nodal agency for developing database on Climate Change and to bring out a separate publication on the same.

The Chapter - 1 is the introduction; Chapter – 2 deals with concepts and factors effecting Climate Change; Chapter – 3 describes the proposed framework of database for Climate Change developed by the Committee. Chapter - 4 deals with data availability and identification of data gaps. The recommendations of the Committee have been summarized in Chapter - 5 of the Report.

Abbreviations

CBHI	- Central Bureau of Health Intelligence
CEA	- Central Electricity Authority
CFC	- Chloro-Fluro-Carbons
CH_4	- Methane
CO	- Carbon Monoxide
CO_2	- Carbon Dioxide
COCSSO	- Conference of Central and State Statistical Organizations
CPCB	- Central Pollution Control Board
CSO	- Central Statistics Office
CWC	- Central Water Commission
DAC	- Department of Agriculture & Cooperation
DES	- Directorate of Economics & Statistics
DPSIR	- Driving forces-Pressure-State-Impact-Response framework
FDES	- Framework for the Development of Environment Statistics
FSI	- Forest Survey of India
GDP	- Gross Domestic Product
GHG	- Greenhouse Gases
GSI	- Geological Survey of India
HFC	- Hydro-fluoro-carbons
ICAR	- Indian Council for Agriculture Research
ICFRE	- Indian Council of Forest Research & Education
IMD	- India Meteorological Department
IPCC	- Inter Governmental Panel on Climate Change
MOEF	– Ministry of Environment and Forest
N_2O	- Nitrous Oxide
NAPCC	- National Action Plan on Climate Change
NATCOM	- National Communication
NDMA	- National Disaster Management Authority
NIC	- National Informatics Centre
NRIS	- Natural Resource Information System
NRSA	- National Remote Sensing Agency
ODS	- Ozone Depleting Substances
PFC	- Per-fluro-carbons
SASE	- Snow and Avalanche Studies Establishment
SF_6	- Sulpur-hexafluoride
TERI	- The Energy Resources Institute
UK	– United Kingdom
UNEP	- United Nations Environment Programme
UNFCCC	– United Nations Framework Convention on Climate Change
UNSD	- United Nations Statistics Division
USA	– United States of America
UV	- Ultra-Violet
WMO	- World Meteorological Organization

Chapter - 1

Introduction

Climate change is a phenomenon being experienced by the mankind since its origin on the earth. The Planet earth is going through this phenomenon ever since its birth. It is also a driving force of evolution that life on earth has undergone over the last million of years. As is obvious to any layman, climate change necessarily brings about changes in the weather conditions. There is reason to believe that this phenomenon could affect agricultural productivity, and cause increased health hazards and submergence of lands due to rise in the sea level to name a few. Climate change is the net result of many factors caused by continuous evolution of Planet Earth through many geological eras. However, there is growing concern about manmade developments causing, even if partially or insignificantly, the climate change outcomes. The industrialization that started from the late 17^{th} century is believed to have accelerated the process of climate change by emissions of Greenhouse Gases (GHGs) to the atmosphere. The observed levels of GHGs have perhaps nearly crossed tolerance levels in the atmosphere so that the survival for many animal and human species is at stake, while developmental needs of human race are contributing to factors like deforestation, urbanization etc., that can hasten the process of climate change.

Awareness on the impact of climate change has been increasing since 1960 when a group of people gathered together protesting against a polluting industry in Great Britain. The thinkers and social scientists have recognized the impacts of climate change since then and a movement to save the earth and the precious life on it gained momentum. The Stockholm Conference in the year 1972 was the first international recognition and manifestation of the urgency to address

climate change as it affects both the developed and developing countries, though, the degree of impact could vary. The atmosphere is a global public good and it is commonly shared by all living beings in the earth's ecosystem.

1.1. Background

The awareness on the degradation of the environment and its impact on the climate system and the natural resources have gained momentum after the efforts of the United Nations, especially after the Stockholm Conference held during June, 1972. The Stockholm conference recognized the concept of 'Sustainable Development' and the impact of development and industrialization on the environmental quality of a nation. This conference led to the formation of the United Nations Environment Programme (UNEP).

United Nations Statistics Division (UNSD) recognized the subject of Climate Change as one of its priorities in the Environment Statistics. Climate Change comes under the ambit of the UN framework Convention on Climate Change (UNFCCC) wherein different countries are required to report their GHGs emission to the UN. There is also Inter Governmental Panel on Climate Change (IPCC) which reports to UNFCCC.

With the financial assistance from UNEP, the UNSD brought out a framework for the collection of data on environment and related variables in 1984, called 'Framework for the Development of Environment Statistics' (FDES). FDES sets out the scope of environment statistics by relating the components of the environment to information categories that are based on the recognition that environmental problems are the result of human activities and natural events reflecting a sequence of action, impact, and reaction. In 1995, UNSD brought out a list of environmental indictors which evolved through the studies undertaken by them in the

participating countries and in collaboration with the Inter-Governmental Working Group on Advancement of Environment Statistics. The FDES, however, covers most of the environmental indicators which are also related with climate change. It is therefore difficult to segregate climate change as a separate subject outside the domain of environment statistics. What is important is to examine the availability of statistics for climate change indicators either under the system of environmental statistics per se or through special mechanisms addressing climate change issues. There is need to identify parameters defining necessary climate change data-needs, availability of credible data and identification of data-gaps for assessing causes and effects of climate change and provide a framework for their levels of relevance and international harmonization in the Indian context.

1.2. **Climate Change and the Economy**

A common way to assess and manage environmental problems is the so-called Driving forces-Pressure-State-Impact-Response framework (DPSIR). Driving forces are the socio-economic forces driving human activities, which increase or mitigate pressures on the environment. Pressures are the stresses that human activities generate on the environment. Impacts are the effects of environmental degradation on society, the economy and ecosystems. Responses refer to the responses of society to the environmental situation. This framework is very helpful to organize information on the state of the environment, both for researchers, policy makers and the general public. Specific indicators can be compiled for each part of the DPSIR framework. Here, climate change and its relations with the economy are described using the DPSIR model.

1.2.1. **Driving forces of climate change**

Basic economic developments are the main drivers behind human induced climate change. Increased production of goods and services, changes in the production structure, increased transportation, a higher demand for all kinds of consumer goods, etc., contribute to a higher pressure on the atmosphere thereby increasing the greenhouse gas concentration. Particularly important is, of course, the ever increasing demand for energy. At present the world's economy runs on fossil fuels. The combustion of coal, oil and natural gas and derived products provide energy to nearly all economic activities. The emission of Carbon Dioxide (CO_2) is a residual product of burning these fossil fuels. Also changes in land use pattern, deforestation and land clearings are important driving forces leading to a rise in Carbon Dioxide emissions.

1.2.2. **Pressure on the environment: Greenhouse Gas emissions**

Greenhouse Gases (GHGs) are gases in the atmosphere that absorb and emit radiation within the thermal infrared range. Earth's most abundant GHGs are water vapour, Carbon Dioxide, atmospheric Methane, Nitrous Oxide (NO), Ozone (O_3) and Chloro-Fluro-Carbons (CFCs). Greenhouse effect is a process by which radioactive energy leaving a planetary surface is absorbed by some atmospheric gases called greenhouse gases. The ability of the atmosphere to capture and recycle energy emitted/reflected by earth's surface is the defining characteristic of the greenhouse effect. Global warming is believed to be the result of the strengthening of greenhouse effect mostly due to human produced increases of greenhouse gases in the atmosphere. The pressures related to climate change being considered are the greenhouse gas emissions caused by economic activities. CO_2 is by far the most important greenhouse gas, and originates mainly from the combustion of fossil fuels and biomass. However, other greenhouse gasses like methane, Nitrous Oxide and halocarbons also contribute to climate change. Methane

is mainly produced by domesticated animals such as dairy cows, pigs etc, rice growing, gas flaring and mining activities. Nitrous Oxide mainly originates from agricultural land management, animal manure management, combustion of fossil fuels, and the production of fertilizers and nitric acid.

1.2.3. **State of the environment**

The present state of the environment with regard to climate change is reflected in the condition of the atmosphere and hydrologic system of the earth. This state can be described using the so-called Essential Climate Variables (ECV's). Within the atmospheric domain these are air temperature, air pressure, precipitation rates, surface radiation, and also the concentration of the different GHGs. In the oceanic domain these are sea surface temperatures, sea level, sea ice, ocean current etc. In the terrestrial domain these are river discharge, ground water levels, lake water levels, land cover (including vegetation type), glaciers, etc.

1.2.4. **The impact of climate change on the economy**

Climate change has the potential to create a wide range of economic impacts. In all likelihood all sectors of the economy will be affected. Some impacts will gradually affect economic processes, such as the effect of increasing temperature on energy demand, whereas others may come as extreme events, such as sudden floods or forest fires. Impacts may be either negative or positive. For example, agriculture may become more productive or tourism may flourish in areas experiencing higher or lower temperatures. However, in a global level, the negative impacts will generally outweigh the economic benefits.

Beside industry specific impacts, the economy as a whole may be at risk in certain areas due to an increase in sea level and an increase in runoff by rivers. Coastal zones usually contain

large human populations and a high concentration of economic activities. Flooding and extreme storm events may seriously disrupt economic activities and cause loss of produced capital. The same is true for areas adjacent to major river systems which may be subject to flooding when precipitation and overland flow increases.

Assessing the impact of climate change faces a fundamental challenge of complexity. The set of mechanisms through which climate may influence economic outcomes, positive or negative is extremely large and difficult to investigate. For example, a decrease in agricultural output or value added products may be induced by climate change. However, climate change is only one driver among many that will shape agriculture in future decades. Other factors, such as technological developments, socio-economic factors or other environmental issues could have a similar large impact.

1.3. Initiatives of Central Statistics Office

The Central Statistics Office (CSO) under National Statistical Organization (NSO) constituted a Steering Committee on Environment Statistics in 1996 to examine the indicators identified by UNSD and recommend a set of parameters which are relevant in Indian context and applicable to our needs and requirements. The Committee recommended for the adoption of five broad categories of the UNSD framework, 1984 viz., bio-diversity, atmosphere, land/soil, water and human settlements. Accordingly, CSO decided to bring out an Annual publication by title 'Compendium of Environment Statistics' covering all the parameters as identified by the said Committee. So far CSO has brought out ten issues and the latest one, which is a combined publication for two years (2008 & 2009), covers the data available up to 2009.

The liberalization of the Indian economy in the early 1990s and the unprecedented growth have brought our country in the centre stage of climate change discussions worldwide. The growth in the energy sector and the use of fossil fuels for the development needs have resulted increased emission of Carbon Dioxide and other GHGs in absolute terms. The findings of IPCC indicate that there was 0.4^0C change in the surface temperature in India during the last century and a recession in the Himalayan glaciers. The formation of Prime Minister's Council of National Action Plan on Climate Change (NAPCC) is an outcome of all these related events which happened in the past decade.

The 16th Conference of Central and State Statistical Organizations (COCSSO) held at Shimla during 4-5 December, 2008 felt that India's official statistics on Climate change is insufficient to address the challenges posed by the country and a more elaborate and a meaningful database to be built to ascertain the impact of climate change. Hence COCSSO recommended that

> *'for collection of statistics, to capture climate change effectively, an Expert Committee should be set up in the Ministry of Statistics and Programme Implementation with members drawn from concerned Ministries, State Departments, research Organizations and outside experts to identify the parameters that affect environment'.*

Keeping this in view, CSO organised a two days seminar on 'Climate Change – Data Availability and Requirements' at Institute of Social and Economic Change (ISEC), Bangalore during April, 2009. Researchers, academicians, technocrats and officials from Ministries who deal with environment and climate were invited and their views and research findings were gathered to prepare a status paper on the subject matter. The report of the seminar has been uploaded in the website of MOSPI.

1.4. The Committee

As an outcome of the seminar, CSO constituted an Expert Committee on the Development of Database on Climate Change on 20th July, 2009 under the Chairmanship of Dr. K. S. Rao, Professor, Dept. of Botany, Delhi University with the following terms of reference:

(i) To identify indicators/parameters for which statistical data need to be collected. Such data may be utilized to capture causes and effects of climate change and to monitor adaptability and mitigation measures

(ii) To suggest the data source agencies for the collection of above data

(iii) To decide the relevant geographical unit/ climatic unit for which data may be collected and periodicity of such data collection

(iv) To review the data contained in the CSO's publication 'Compendium of Environment Statistics' and suggest modification, if any, in existing tables to meet the users requirement at national and international level.

The Office Memoranda on the constitution of the Committee are annexed at Annexures-I & I(A).

The Committee held three meetings under the Chairmanship of Dr. K.S. Rao, after its constitution on 20th July, 2009. The first meeting held on 28th August, 2009 discussed the identification of indicators and requested the participating ministries /organizations to confirm the list of indicators which are related to their domain of activities and to share the data on such indicators with CSO. The Committee also reviewed the contents of the existing publication 'Compendium of Environment Statistics'.

In the second meeting held on 20th November, 2009, the Committee examined the feedback received from Ministry of Agriculture, Geological Survey of India, Central Water Commission, Ministry of Earth Sciences, Central Pollution Control Board (CPCB), Central

Electricity Authority (CEA), India Meteorological Department (IMD) and The Energy Resources Institute (TERI) and prepared a detailed set of indicators. After deliberations, the Committee decided that the data need to be captured in a time series manner starting from 1990. It was decided to prepare the draft report of the Committee for discussion in the next meeting.

The third and final meeting of the Committee was held on 11th March, 2010 to discuss the draft report and finalize the indicators relating to climate change to be considered. The Committee had gone through the draft report and discussed the issues at length.

The minutes of all the three meetings are placed at Annexures II, III and IV.

The next chapter, ie., chapter-2 deals with concepts and factors effecting climate change.

Chapter – 2

Concepts and Factors Effecting Climate Change

2.1. Definition of Climate Change

The Inter-Governmental Panel on Climate Change (IPCC) was established by United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear view on the current state of Climate Change and its potential environmental and socio-economic consequences. IPCC defines climate change as '*a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity'*.

The definition provided by UNFCCC is slightly different, as it emphasizes on '*a change that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods*'.

The UNSD has not, however, formulated any internationally agreed definition of climate change for statistical purposes.

2.2. Defining Environment

Understanding the causes and consequences of climate change, and design of mitigation and adaptation strategies to deal with global warming require knowledge in physical science (*Any of several branches of science, such as physics, chemistry, and astronomy, that study the nature and properties of energy and nonliving matter*), natural science (*It refers to a naturalistic approach to the study of the universe*) and social science (*Any of various disciplines that study human society and social relationships, including sociology, psychology, anthropology,*

economics, political science, and history). Different disciplines in these sciences use different approaches for collecting / generating data, analysis of data and development of indicators. Climate change and Global warming have been gaining importance at national and international level. Any substantial change in the climatic system of the earth which extends for a substantial period of time can be termed as 'Climate Change'. A substantial increase in the earth's surface temperature due to Climate Change could be termed as global warming. Carbon Dioxide, Methane and water vapour are the natural greenhouse gases which form a cover over the earth's surface and reflect back the heat emitted by earth earlier absorbed by the earth from Sun. However, before going to the subject of Climate Change, it will be important to understand the terms environment and atmosphere where the phenomenon of climate change occurs.

2.2.1. Environment: It literally means "Surroundings" and may be defined as sum total of all external conditions and influences that affect living organisms. It comprises the following (i) Atmosphere (ii) Hydrosphere (iii) Lithosphere and (iv) Biosphere. The term 'atmosphere' is explained in subsequent para. **Hydrosphere** forms that part of environment which contains water in the form of sea, oceans, rivers, lakes, ponds etc. It covers almost 75% of the earth's surface. **Lithosphere** is the solid component of the earth consisting of soil, rocks, mountains etc. The uppermost part of the earth's crust contains weathered rocks as well as organic matter and is called soil. This is also the storehouse of minerals and metallic ores. **Biosphere** is that part of the lithosphere, hydrosphere and atmosphere where living organisms interact with these parts and thus live together. A number of natural cyclic process like oxygen, water, nitrogen etc. are taking place in the environment to keep a balance of different materials present in the environment.

2.2.2. Atmosphere: To better understand the intricacies of the phenomenon of climate change and the global warming, one needs to know the structure and composition of the atmosphere

surrounded by the planet earth. Earth's atmosphere could be defined as the gaseous mass surrounded and retained by the earth through its gravitational force. Earth's atmosphere is a cover of gases that extend to a height of about 1600 km above the surface of the earth and protect the life on earth from harmful radiation of cosmic rays from the Sun. The atmosphere is divided into five layers, which are

(a) Troposphere
(b) Stratosphere or ozonosphere
(c) Mesosphere
(d) Thermosphere and
(e) Exosphere

2.2.2.1.Troposphere: It is the lowest layer on the earth's surface, which is otherwise called the boundary layer, having about 70 to 80% of the total mass present in the atmosphere. The height of the layer varies from 7 to 20 km above sea level depending on the latitude and season. The weather occurs in this layer. The air at the bottom of the layer will be warm and gets colder when the height increases. This layer contains about 79% nitrogen, 21% oxygen and only a small concentration of other gases such as argon, Carbon Dioxide etc. Dust particles and water vapour are the other major components in this layer, of which water vapor helps to form clouds. The sunlight warms the earth during day time and the heat is radiated from earth to the atmosphere. The warm air tends to rise in the atmosphere. The top portion of the layer is colder.

2.2.2.2.Stratosphere: The second layer in the atmosphere is known as the stratosphere, which starts a 20 km and extends up to 50 km from the earth's surface. There is a variation of about 8 to 16 km in the bottom of the layer due to the variation in latitude and seasons. The bottom portion of this layer is cooler and temperature increases with the increase in height. This layer plays a vital role in keeping the life on earth as the ozone is abundantly available here. Ozone absorbs the Ultra-Violet (UV) radiations from Sun. Increasing doses of UV radiations may cause skin

cancer, eye cataracts, damage to the immune system in animals and human beings and have an adverse impact on the plant growth. Ozone is scattered between 19 to 30 km in the upper layer of stratosphere. The Ozone is formed when the highly energetic solar radiation strikes the molecules of oxygen and splits it into two atoms apart and the freed atoms conjoin with the oxygen through the process of photolysis, which is a process whereby sunlight causes the chemical bonds in a molecule to break. Ozone is also naturally broken down by sunlight and by a chemical reaction with various compounds containing nitrogen, hydrogen and chlorine. In a pristine atmosphere, there is a balance between the amount of ozone generated and destroyed. The air is quite stable in the stratosphere. Air is thin and dry and no water vapour present in this region. Due to lack of vertical convection, the materials got into this region stays longer periods. The Ozone depleting substances like CFCs could stay here and react with ozone, resulting in depletion in the amount of ozone.

2.2.2.3.Mesosphere: It is the third layer in the atmosphere which starts at 50 km from the earth's surface and goes up to 85 km. The bottom portion of the mesosphere is hotter and the temperature gets colder when height increases. The upper layer of the mesosphere is the coldest with -90^0C. The air is so thin in this region that the atoms and molecules of gases hardly ever run into each other.

2.2.2.4.Thermosphere: The fourth layer in the atmosphere is thermosphere. It starts from 85 km to 500 km and extends up to 1000 km. This layer is very hot at about 500^0C when the sun is active. A good amount of sun's X-ray and UV radiations were absorbed in this area, making this region very hot. The temperature in the upper layer varies from 500^0C to 2000^0C or higher depending on the sun's activity. A most common definition says that the space begins with

thermosphere at an altitude of 100 km as the air is too thin in this region. The space shuttles and space stations are orbiting around the earth in this region only.

2.2.2.5.Exosphere: It is the fifth layer having a very thin layer of air containing atoms and molecules only. These particles escape into the space from this region only.

2.3. Some Terminologies and Definitions

2.3.1. Precipitation

Precipitation refers to the quantity of water falling to the earth at a specific period of time. The water could be in any form like rain, snow, hail, sleet or mist.

2.3.2. Natural Carbon Sinks

Natural Carbon Sinks are the reservoirs which absorb the carbon and store it for indefinite period. Forests, oceans, soils and atmosphere are better examples of carbon sinks. The plants and other organisms that use photosynthesis to remove carbon from atmosphere by incorporating it into biomass are also carbon sinks.

2.3.3. Carbon Sequestration

This term refers to describing processes that remove carbon from atmosphere.

2.3.4. Biomass

In ecology, Biomass is defined as the mass of living biological organisms in a given area or ecosystem at a given time. This is a renewable energy source and is biological material derived from living or recently living organism such as wood, waste, hydrogen (gas) and alcohol fuels.

2.3.5. Carbon Stock

The quantity of carbon contained in a reservoir or a system which has the capacity to accumulate or release carbon. The forest biomass refers to the amount of carbon stored in the forest ecosystem, mainly in living biomass and soil, but to a lesser extent in dead wood and litter.

2.3.6. Anthropogenic Emission

These are the emissions of greenhouse gases resulting from human activities.

2.4. Factors Influencing Climate Change

Climate is a vibrant phenomenon and undergoes continuous changes over centuries. There are natural forces like photosynthesis of the plants, eruption of volcanoes, emission of methane from agricultural activities, vapor emissions etc. The important factors, which are responsible for climate change and are causally contributed by human civilization on earth, are listed below:

- Greenhouse Gases
- Deforestation
- Land-use Change
- Energy Usage
- Vehicular Usage

2.4.1. Greenhouse Gases

Human civilization and industrialization have amplified the emissions of 'Greenhouse Gases', which are considered to be one of the main causal factors accelerating climate change in the post industrialization era. GHGs constitute

- Carbon Dioxide (CO_2),
- Methane (CH_4),
- Nitrous Oxide (N_2O),
- Hydrofluorocarbons (HFCs)
- Perflurocarbons (PFCs)
- Sulpurhexafluoride (SF_6)

In addition to this, water vapor, which absorbs the heat radiations from Sun and trap such radiations in the atmosphere making the earth warmer, is considered important. Emissions of GHGs beyond certain limits make earth's atmosphere hotter and induce climate change. The extent of GHGs in the atmosphere increased phenomenally from 280ppm[1] (1750) to 379ppm in 2005 (IPCC-AR4[2]). The available global data on CO_2 since 1970 indicates that the annual emissions have grown at about 80% from 21 to 38 gigatons, which represents 77% of the total anthropogenic emissions. The global increases in CO_2 concentrations are primarily due to

- Fossil Fuel Use
- Land-use and Land-use Change
- Agricultural activities
- Industrial Development
- Forestry

CO_2 is the most important anthropogenic GHG as it constitutes about 70% of the total emissions in the year 2004. CO_2 originates from burning of fossil fuel (56.6%), deforestation and decay of biomass (17.3%), agriculture etc. The largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry while deforestation, agriculture and residential/commercial buildings are only minor contributing factors.

Table – 1
Global Carbon Dioxide Emissions and Stock

Country	Total (Mt* CO_2)		Annual Change (%)	Share of world total (%)		Per capita (t** CO_2)	
	1990	2004	1990-2004	1990	2004	1990	2004
Japan	1070.7	1257.2	1.2	4.7	4.3	8.7	9.9
USA	4818.3	6045.8	1.8	21.2	20.9	19.3	20.6
UK	579.4	586.9	0.1	2.6	2.0	10.0	9.8
Canada	415.8	639.0	3.8	1.8	2.2	15.0	20.0
Qatar	12.2	52.9	23.9	0.1	0.2	24.9	79.3

[1] ppm – Particles per Million
[2] IPCC-AR4 - Inter-Governmental Panel on Climate Change – Assessment Report 4

Russian Federation	1984.1	1524.1	-1.9	8.8	5.3	13.4	10.6
China	2398.9	5007.1	7.8	10.6	17.3	2.1	3.8
India	**681.7**	**1342.1**	**6.9**	**3.0**	**4.6**	**0.8**	**1.2**
World total	**22,702.5**	**28,982.7**	**2.0**	**100.0**	**100.0**	**4.3**	**4.5**

Source : Human Development Report 2007/2008, UNDP.
* Mt – Mega Tonne (One Million Tonne) ** t - Tonne

India's share of CO_2 in the total emissions in the world is very insignificant in per-capita terms. The per-capita emission of an Indian citizen is 1.2 tonnes of Carbon dioxide whereas his counterpart in USA contributing 20.6 tonnes. The per-capita emissions of UK and Japan are 8 and of USA 17 times higher than that of India. India's contribution to the world total is only 4.6% when compared to USA's contribution of 20.9% followed by 17.3% of China.

The energy sector is the major producer of CO_2. Our energy needs are met from coal (53%), which is abundant, locally available and cheap when compared to alternative fuels. Table–2 shows that CO_2 emissions in the power sector are continuously increasing in all parts of the country.

Table – 2
Total Absolute Emissions of Carbon Dioxide from Power Sector (Million tCO_2/year)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
North	97.87	102.74	106.81	110.00	112.21	120.10	129.55
East	58.03	61.43	66.59	75.51	83.96	92.52	96.36
South	89.02	92.18	105.24	108.12	105.60	101.76	109.25
West	135.19	141.60	148.56	144.13	157.78	153.93	157.72
NorthEast	2.21	2.16	2.29	2.46	2.47	2.53	2.65
India	**382.31**	**400.11**	**429.48**	**440.22**	**462.02**	**470.85**	**495.54**

Source : Central Electricity Authority, CO_2 Baseline Database for the Indian Power Sector, 2007.

The global atmospheric concentration of Methane has increased from pre-industrial value of about 715ppb[3] to 1774ppb in 2005 (IPCC-AR4). Methane is generated due to the following activities :

- Agriculture
- Energy Sources like biomass burning, coal mining and handling and flaring of natural gas systems
- Waste disposal
- Land-use
- Land-use Change
- Forestry
- Shifting Cultivation practice

In India, the Methane emissions in the year 1994 were 18,583 Gg[4], out of which 78% came from agriculture, 16% from energy sources and 6% from waste disposal. The rest is contributed by other activities mentioned above.

Global Nitrous Oxide concentration increased from about 270ppb (1750) to 319ppb (2005). Many halocarbons including hydro-fluro-carbons have also increased from a near-zero level to significant levels primarily due to human activities.

2.4.2. Deforestation

There is considerable reduction in the forest cover due to encroachment and land use change and economic development activities like construction of roads, canals and power stations. However, there is a slight improvement in the forest cover according to the 2007 assessment as reported by the State of Forest Report, 2009. Forests are the major source of carbon sequestration and the womb of the biodiversity, which acts as the main artery of any environment and ecosystem. National Action Plan on Climate Change (NAPCC) estimates that

[3] ppb – Particles per Billion
[4] Gg – Giga gram

77 to 68% of the forest areas in the country are likely to experience shift in forest types by the end of the 21st century, which needs our immediate attention.

2.4.3. Land-use Change

Land-use change is another major predicament to be viewed seriously. As per the data available, after the enactment of Forest Conservation Act, 1980, a huge portion of forestland is diverted for non-forest use. The reported figure for the year 1981 is 1331 ha whereas the cumulative figure till 2004 is 9,54,839 Ha. A relative growth in the land-use change is also visible in urban and rural areas due to urbanization and industrialization. Fragmentation of forests and habitats are another major reason for loss of biodiversity. The present statistical system **does not give** any indication of loss of biodiversity and loss of biomass due to this land use change.

2.4.4. Energy Usage

After the liberalization and globalization, India is on a high growth path and envisages about 7-8% GDP growth rate per annum. The energy generation has grown manifold due to the ever increasing demand for energy since 1992. Coal, Gas and Diesel being the major sources of power in India, the emissions of GHGs are also on the rise. The GHG emission level estimation, however, depends on utilization of installed capacity.

In addition to this, the unorganized sector is also engaged in power generation through low capacity diesel generator sets and coal-fired generators. Data on such activities are **not available** and extent of pollution caused by such units are still beyond our reach.

2.4.5. Vehicular Usage

The number of vehicles registered in India is on the increase over the last 5 years at a cumulative rate of 10%. It indicates the increases in the use of fossil fuel and thereby an increases in GHG emissions. It reveals from the data that there has been consistent growth in vehicular registration, however no indication on the emission load is available. The emission load depends on the types of vehicle. In India, we have standard and non-standard vehicular emissions, which also vary from place to place depending on regulatory mechanisms in use by the civic and local authorities in different areas. Some metropolitan cities have standards in consonance with the European Emission standards, but the data are **not captured** according to the types of vehicles and their average usage per annum.

2.5. Visible/Perceivable Impacts of Climate Change

The resilience of the ecosystems is likely to be disturbed in the future due to abrupt climatic change which could appear in the form of floods, drought, wildfires, ocean acidification etc., inducing further loss of biodiversity and the earth's latent capacity for mitigation and regeneration. The rise in temperature, change in precipitation patterns, sea level rise, melting of snow cover and mountain glaciers, coastal erosion and occurrence of health hazards and disaster events are perceived as the visible impacts of climate change. The following are the main dimensions/impacts of climate change and some of these are explained in brief in the sub-sections which follow.

- Temperature
- Rainfall (Precipitation)
- Mountain Glaciers
- Sea Level Rise
- Health

- Agriculture
- Coastal Erosion
- Biodiversity Loss
- Storm/Storm Events
- Soil Moisture Availability
- Sea Surface Temperature

2.5.1. Temperature

The temperature increase is wide spread across the globe and is greater at higher northern latitudes. It is estimated that there is a 100-year linear trend of 0.74^0C increase. It is observed since 1961 that the average temperature of the global ocean has been taking up over 80% of the heat being added to the climate system. Warming of the climate system induces increase in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.

In India, an increase in the linear trend of about 0.4^0C in the surface air temperature has been observed in the past century. A warming trend is visible along the west coast, central India, interior peninsula and the North-Eastern India, but some cooling trends are also visible in the North-West India and parts of South-India. (NAPCC, 2008). To analyze the comparative change in the Indian peninsula, both sea level temperature and land surface temperature are required to be recorded on long term basis at different climatic zones of the country.

India Meteorological Department (IMD) is the nodal agency to provide the data on temperature. The time series data on mean temperature of major cities in India are available with this department.

2.5.2. Rainfall (Precipitation)

Indian monsoon rains are the backbone of Indian economy as most of our agricultural activities, rivers and replenishment of ground water sources have a direct dependence on monsoon rains. Monsoon rains are a manifestation of the complex interactions between land, ocean and atmosphere. Rainfall data are collected by the India Meteorological Department (IMD) in respect of the meteorological subdivisions of the country on day-to-day basis. A significantly long series of rainfall data are therefore available to analyze patterns of change in distribution, intensity and duration of rainfall. The All-India rainfall data do not show any significant trend in monsoon rains, however, there are some regional variations. A trend of about 10 to 12% (of the normal) increase in monsoon rains were reported along the west coast, northern Andhra Pradesh and north-western India during the last century. A decreasing trend of about 6 to 8% is observed over the last 100 years over eastern Madhya Pradesh, North-Eastern India and some parts of Gujarat and Kerala (NAPCC, 2008).

2.5.3. Mountain Glaciers

The ice and snow deposits on the Himalayan ranges are lifelines of northern India in many ways. These deposits provide a perennial supply of water though many rivers, which cater to the livelihood, drinking water, and water for industrial purposes. Any recession in the snow cover in the Himalayas is going to affect the life in the Northern parts of India where half of India's population resides. The available data on snowfall in Himalayan ranges show a recession in some parts of the Himalayan ranges. The river systems of the Brahmaputra, the Ganges and the Indus draws water directly from melting of the Himalayas. National Remote Sensing Agency (NRSA) and Snow and Avalanche Studies Establishment (SASE) are responsible for collection

and supply of data on **cryosphere** (*the component of earth's system comprising frozen water like snow, permafrost and glaciers*).

2.5.4. Sea Level Rise

IPCC has estimated a sea level rise of 1 to 2 mm per year globally. In India, a study conducted by Unnikrishanan and Shankar[5] also showed a trend of 1.06 to 1.75 mm[6] rise of sea level per year. No official data are available in India to empirically check the authenticity of these estimated figures. Due to sea level rise, the fresh water sources near the coastal areas will suffer from salt intrusion and inundation of coastal areas where the density of population and their dependence on sea for livelihood activities are high.

2.5.5. Health

There is a high incidence of occurrence of vector borne diseases like Malaria, Kala-azar, Japanese Encephalitis, filaria, Chikun Gunia etc., in the immediate past. It is observed that changes in climatic patterns may alter the distribution of vector species and increase its spread in new areas. An increase in temperature and relative humidity may enlarge the transmission windows. Effluent emissions to water bodies and salination of rivers through sea level rise may increase the incidence of water borne diseases. Deaths due to heat wave are reported from several parts of the country from time to time, particularly during the summer.

Central Bureau of Health Intelligence (CBHI) under Ministry of Health and Family Welfare compiles data on incidence of diseases. However, the reasons for variations should be

[5] Unnikrishnan. A.S., Shankar, D., 2007, 'Area Sea Level Trends Along the North India Ocean Coasts with Global Estimates', Global and Planetary Change, 57, 301.
[6] mm- millimetre

traced in linkage with the climate change over time, so that the impact of climate change could be ascertained on disease patterns.

2.5.6. Agriculture

India is a predominantly agriculture-oriented economy, as 52% of the population directly depends on agriculture either as farmers or agricultural labourers, and their concentration is higher at 76% in the villages. Variation in climate will have a direct impact on the majority of the livelihood of the people. Food production in India is sensitive to climate change like variations in temperature and monsoon rainfall. Rise in temperature has a direct impact on the Rabi crop and every 1^0C rise will reduce wheat production by 4 to 5 Million Tonnes. Every small change in temperature and rainfall has significant effect on the quality and quantity of fruits, vegetables, tea, coffee, basmati rice and aromatic and medicinal plants. It is predicted that a loss of 10 to 40% in production may occur by 2100 due to climate change (NAPCC).

2.5.7. Coastal Erosion

Population in coastal regions are vulnerable to natural disasters like cyclones, floods, droughts, soil and land erosion leading to irreparable loss or damage to sown areas in arid and semi-arid zones caused by climate change. About 40 million hectares of land is flood-prone, including river-deltas on three sides of the country stretching over 6000 km of coastal belt, affecting about 30 million people on an average each year. National Disaster Management Authority (NDMA) and CSO are responsible for the collection and compilation of hazard and disaster data. State governments would also start compiling data on disasters at district levels. All these inputs are to be integrated to assess climate change impacts.

2.5.8. Biodiversity Loss

India is one of the species-rich countries in the world and about 6% of the world's biodiversity is reported from India. The existence of biodiversity helps to keep a balance between the environment and earth through its ecosystem services. A comparison of data on 'Number and status of plant species in India' published in 2001 and 2007 does not give any indication to the extent of change which happened in the last few years due to rapid economic growth, urbanization and land-use change. The existing data do not provide any insight into the loss of biodiversity in the country. The NAPCC also emphasizes on the need for 'creation of biodiversity registers (at national, district and local levels) for documenting genetic diversity and the associated traditional knowledge. Some interesting findings here are the reduction in the number of known species in India of 'Fern & Fernallics' from 1200 to 1135 during the reference period (2001-2007). It also indicates that the number of endemic species like 'Fungi' has reduced from 4000 to 3500, which is unlikely when compared to the rate and speed of deforestation and land-use changes happening in India.

Table – 7
Number and status of plant species in India - 2007

Sl. No	Type	No. of known species in the world	No. of known species in India	Percentage of occurrence in India	No. of species endemic	No. of species endangered	No. of species extinct
1	2	3	4	5	6	7	8
1	Flowering Plants						
	Gymnosperm	650	48	7.38	8	7	Not Known
	Angiosperm	250,000	17,672 (17,500)	7.00	5,725 (5775)	1,700	28
2	Non-flowering Plants						
	Fern & Fernallics	10,000	1135 (1200)	11.35 (12.00)	193	113	Not Known
	Algae	40,000	6,500	16.25	1100	120	Not Known
	Fungi	70,000	14,500	20.71	3,500 (4,000)	140	Not Known
	Lichens	13,500	2,021	14.97	417	400	Not Known
	Liverworts	7,500	852 (845)	11.26	260	100	Not Known
	Mosses	7,000	2,000 (1980)	28.6 (28.28)	608 (243)	115	Not Known

Source : Botanical Survey of India, Kolkata.
(2001 figures given in bracket for items for which changes have taken place)

Zoological Survey of India, Botanical Survey of India, Forest Survey of India and the State Forest Department are responsible for collection and supply of data related to biodiversity.

2.5.9. Storm/Storm Events

The 'Storm Event' is a rainfall event that produces more than 0.1 inch of precipitation and that, which is separated from the previous storm event by at least 72 hours of dry weather.

2.5.10. Soil Moisture Availability

'Soil moisture' is the ability of the soil to hold water. Soil moisture impacts the distribution and growth of vegetation, soil aeration, soil microbial activity, soil erosion, concentration of toxic substance, the movement of nutrients within the soil and to the roots.

2.5.11. Sea Surface Temperature

Sea surface temperature is the temperature of the water close to the surface of the sea, which is measured by drawing water from one metre below the surface of the sea.

2.6. Mitigation and Adaptation

There are two options available to address the problems which may arise out of pollutions caused to the air, water or soil. The term 'mitigation' involves actions that reduce the likelihood of the event or process. In other words, Mitigation refers to measures for reduction of emissions of GHGs that cause climate change like switching from fossil fuel based power generation to alternative sources of renewable energy like solar, wind, nuclear etc. 'Adaptation' involves actions that reduce the impact of the event or process without changing the likelihood that it will occur. The process may include relocating the communities living close to the sea level or switching to crops that can withstand higher temperature etc

Under the ambit of NAPCC, 8 Missions have been initiated to implement the programmes related to mitigation and adaptation. The missions are:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency in Industry
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a ‘Green India’
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

These eight Missions form the core of National Action Plan representing multi-pronged long term and integrated strategy for achieving the goals in the context of climate change. For institutionalizing the National Mission, nodal ministries have been identified for each of the missions.

The next chapter is Chapter – 3, which details the proposed framework of database for Climate Change.

Chapter - 3

Proposed Framework of Database for Climate Change

The Committee took up the task of finding out minimum set of indicators which are relevant and could be used for building up a database for the Climate Change in India. In its first meeting, the discussions with the representatives of the ministries and departments centered around to reviewing the existing publication 'Compendium of Environment Statistics' and identifying the indicators which were falling under the domain of the respective organizations. Accordingly, the departments/Ministries prepared a list of indicators, which formed part of the discussions of the second meeting. The Committee decided that the focus should be on a basic minimum number of indicators which have a direct bearing on climate change as it would not be possible to manage huge data if collected at micro level. The report of NAPCC formed the basis for identifying the indicators for the Climate change and the Mitigation and Adaptation activities undertaken by the Government.

3.1. Classification of Data

The availability and periodicity of data could be classified into three categories as per their source, generation and variability. These are:

(a) Data generated as a routine activity of the organization: An example of such data pertains to the temperature and rain fall data gathered by IMD. These data are captured on a day-to-day basis.

(b) Data based on estimates: the second category is based on the annual/bi-annual estimates prepared by the respective organizations. The forest data published by Forest Survey of India is an example of generation of such data.

(c) Data based on studies: The third category of data generation is based on studies conducted by the organizations at specific intervals. The estimation of GHGs is an example of

such an activity. The data on GHGs are available in the public domain for the year 1994, which formed part of the First National Communication (NATCOM-I) by the Government to the UNFCCC. The data for the year 2004 are under compilation and it will be available in the public domain as part of NATCOM-II which is expected to be communicated in the year 2011. There are 56 various organizations working for the estimation under MOEF, which is the nodal ministry for this purpose.

The Committee considered the data availability with the respective departments and its periodicity of generation at the source level. It was decided that CSO may also maintain the same periodicity and the way in which the data are generated and supplied by the respective departments. However, efforts will be made to maintain a time series data since 1990 till the latest year of the data availability. The Committee decided to include all the relevant indicators irrespective of their data availability.

With respect to the institutional mechanism, the Committee recommends that CSO should take a lead role and act as the nodal agency for collection of the data from the source agencies and compilation of the same. It should act as the single window to provide all the relevant data in respect of the indicators identified by the Committee.

The Committee also recommends that CSO should bring out a new publication on Climate Change covering only the data related to the subject.

3.2. Framework of Database

The draft framework, based on the discussions in the first two meetings and the feedback received from ministries and departments, was formulated. The members agreed with the draft framework presented with minor modifications like inclusion of other GHGs like Carbon Monoxide etc., replacing humidity (absolute) with relative humidity etc. The framework as

accepted finally by the Committee is given below. The framework describes the details of indicators of Climate Change along with data items, geographical unit for collection of data, periodicity, possible sources and meta-data linkages. The Committee also recommended that the data for those variables which are included in the framework, but not available presently need to be collected.

Indicators for Climate Change

Indicator	Variables Needed	Geographical Unit	Periodicity	Possible Sources	Meta data links
Greenhouse Gases	Emission of (1) CO_2 (2) N_2O (3) Methane (4) HFCs (5) PFCs (6) SF_6	National level State-wise depending upon the availability of data	Yearly/Monthly	(a)Central Pollution Control Board, M/o. Environment & Forests (b) NATCOM-II (c)Central Electricity Authority	www.cpcb.nic.in www.cea.nic.in
	Other Green House Gases (1)Sulpher Dioxide (2)Carbon Monoxide (3)Nitrogen Dioxide	National/State Level	Yearly	Central Pollution Control Board	www.cpcb.nic.in
Solid Waste	Municipal Solid Waste Generation	National/State level	Yearly	Central Pollution Control Board	www.cpcb.nic.in
Ozone	Ozone Depleting substance (1) CFC (2)Halogen (3) CTC	National Level	Yearly	Ozone Cell, MOEF	www.moef.nic.in
Forest Cover/Area	Extent of (1) Forest Area/Cover (2)Tree Cover (3)Mangroves	National Level/ State-wise/Region level	Biannual	Forest Survey of India, Ministry of Environment & Forests	www.fsi.org.in
Forest Produce	Different types of forest produce - Production data	National/State level	Biannual	Directorate of Education Indian Council of Forestry	www.icfre.gov.in

				Research & Education, Dehradun	
Biomass	(1)Above ground (2)Below ground (3)Litter (4)Deadwood (5)Soil organic carbon	National/State Level	Biannual	Forest Survey of India, Ministry of Environment & Forests	www.fsi.org.in
Land Use	Land Use Change	National /State Level	Annual	Ministry of Agriculture	www.moa.gov.in
Water	(1)Glacial retreat (2)Surface water (3)Ground water	National Level	Annual	(a) Geological Surevy of India (b)Central Water Commission (c)Central Ground Water Board	www.portal.gsi.gov.in www.cwc.nic.in www.cgwb.gov.in
Vehicles	No. of vehicles (1) Existing (2) Newly Registered - Both fuel usage basis	State-wise	Annual	Ministry of Road Transport & Highways	www.morth.nic.in
Energy	(1) Hydro (2) Coal (3) Diesel (4) Gas (5) Nuclear (6) Renewable	National/State level	Annual	(a)Central Electricity Authority (b) Ministry of Petroleum and Natural Gas (c) O/o. Coal Controller (d) M/o. Non-Conventional Energy Sources (e) M/o. New Renewable Energy (f) Dept. of Atomic Energy	www.cea.nic.in www.dae.gov.in
Ocean Level & Temperature	(1)Sea surface temperature (2) Sea level Rise	Region-wise	Annual	(a)National Institute of Oceanography (b) Ministry of Earth Sciences (c) Department of Science & Technology (DST)	www.nio.org www.dod.nic.in www.dst.gov.in
Temperature /Precipitation	(1) Rain Fall Max/Min./Avg (2) Snowfall (3) Temperature Max/Min/Avg	State-wise	(i) Seasonal (ii) Annual	(a)IMD, Ministry of Earth Sciences (b) NRSA(NRSC)	www.imd.nic.in www.nrsc.gov.in

	(4) Relative Humidity				
Glacier/landslides	(1) Glacier Advancement/ Retraction (2) Landslide hazards	National Level/State level	Annual	Geological Survey of India (GSI)	www.portal.gsi.gov.in
Biodiversity	(1) Total Species (2) Endangered (3) Endemic (4) Invasive	Habitat-wise	Annual	(a) Botanical Survey of India (b) Zoological Survey of India	www.bsi.gov.in www.zsi.gov.in
Health	(1) Recurring Endemic Diseases (2) Newly Reported Endemic diseases (3) Death Due to Extreme Heat/Cold	(a) Season-wise (b) State-wise	Annual	(a) Ministry of Health & FW (b) National Crime Records Bureau, Ministry of Home Affairs	www.cbhidghs.nic.in www.ndmindia.nic.in
Agriculture	Soil Degradation	National/State Level	Annual	(a) All India Soil and Land Use Survey, Ministry of Agriculture (b) NRSA	www.moa.nic.in
Extreme Events	Accidents/Disasters (Natural/Manmade)	National Level/State Level	Annual	Ministry of Home Affairs, National Disaster Management Authority	www.mha.nic.in www.ndmindia.nic.in

Indicators for Climate Change – Mitigation & Adaptation

Indicator	Variables Needed	Geographical Unit	Periodicity	Possible Source	Metadata links
Solar Energy	(1) Solar Cells (2) Solar Lanterns (3) Solar Water Heater (4) Solar Electricity Generation Plants and Capacity	National/State level	Annual	M/o. New & Renewable Energy	www.mnes.nic.in
Energy Use	(1) Use of fuel like Condensed Natural Gas(CNG), Liquid Petroleum Gas (LPG) (2) Industries adopted fuel	National/State level	Annual	(a) Ministry of. Commerce and Industry (b) Ministry of Transport	www.dipp.nic.in www.morth.nic.in

	efficient technologies (3) Use of Compact Fluorescent Light (CFL)				
Dry-land Agriculture	(1) Crop Varieties for drought prone areas (2) Varieties of pest-resistant crops	National/State level	Annual	Indian Council of Agricultural Research	www.icar.org.in
Afforestation	Forest Cover/Area	National/State level	Annual	Forest Survey of India	www.fsi.org.in

The next chapter is Chapter – 4 details the data availability and prominent data gaps for the indicators.

Chapter - 4

Data Availability and Data Gaps

In the previous chapter, a framework for the climate change data has been discussed. In India, many organizations are involved in the collection, compilation and analysis of data on various aspects of Environment and Climate Change. The data are generated as per the requirements of the respective organizations without maintaining a common framework in conformity with international datasets or for internal co-ordination and monitoring of the data. This is happening due to the absence of a coordinating agency or an established framework to conduct coordinated research on climate change. Another important point to be reckoned with climate change research is the identification of the threshold limits of the identified parameters and their levels of relevance with respect to impact on life on earth and the perceived changes which would happen when crosses the threshold limits. It is argued that the excessive presence of CO_2 in the atmosphere is better for the better growth of plants and crops, but at the same time, some argue that excessive presence of CO_2 could increase the surface temperature and have an adverse impact on crop growth. Scientific interventions are needed to assess the threshold limits and their impact at any additional increment above the threshold limits. In order to carry out a meaningful and coordinated research, identification of the sources of data, availability of data and the existing gaps need to be assessed. An attempt has been made to identify the data availability and the organizations which are responsible for collection and compilation of data along with the gaps in the data system. The details are presented in the ensuing paragraphs.

4.1. Greenhouse Gases

India is a Party to the UNFCCC. The Convention enjoins Parties to communicate information about the implementation of the Convention, taking into account their common but

differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances. Each Party is required to communicate national inventory of anthropogenic emissions by sources and removals by sinks of all GHGs using comparable methodologies to be promoted and agreed upon by the Conference of the Parties (CoP). Towards fulfillment of obligations under the Convention, India furnished its Initial National Communication (NATCOM-I) on June 22, 2004 within the stipulated time. The NATCOM-I provided information on emission of GHGs of anthropogenic origin by sources and removals by sinks at 1994 level. The NATCOM-II devised the work programme by involving 56 institutions for the preparation of national level assessment of sectors such as Water, Agriculture, National Eco-System and Forestry, Coastal Zones, Health etc and also to undertake assessment of impact, vulnerability and adaptation framework in relevant thematic areas. The NATCOM-II in its report to UNFCCC gave a summary of gas emissions of anthropogenic origin by sources and removals by sinks for the base year 1994. It covered CO_2, CH_4, N_2O emissions at national level. The data on CH_4 and CO_2 are available only at aggregate level using some modeling technique. The sectors covered are energy, industrial process, agriculture, land-use, land use change and forestry, waste management practices and CO_2 removals. The IPCC AR-4 also estimated the emission of CO_2 for the year 2004. As per the NAPCC, India is determined that its per capita GHG emissions will at no point exceed that of the developed countries even as the country pursues various developmental goals. The National Action Plan identifies measures that promote development objectives yielding co-benefits for addressing climate change effectively

The UNFCCC/NAPCC in their reports considered six GHGs that affect climate change. These are CO_2, CH_4, N_2O, HFCs, PFCs, SF_6. Data availability in respect of emission of these gases is a problem. The CEA is estimating the CO_2 emissions from the power sector and makes

the same available in the public domain. These data are compiled at source level. The CPCB informed that the data on CO_2 emissions from other sectors and CH_4 are not available with them, even though it is a major contributor to the GHG. These data are, however, available with NATCOM-II. These estimates were based on one time study. The source-wise data available in the public domain given by NATCOM dated back to 1994. A renewed estimate for GHGs for the year 2004 is being worked out by NATCOM, but the same could be made available for the year 2004 to public by the year 2011 at the national level. The periodicity of data on GHG depends on availability of data while the data will be available at national level by source of emissions and sink.

The Committee also considered for inclusion of other Gases like Carbon Monoxide, Sulphur Dioxide and Nitrogen dioxide for which data will be supplied by the CPCB at national/state Level. The CPCB will be compiling the data year-wise. The other indicators like Ozone Depleting Substance (ODS) available with MOEF may also be included in the database. Similarly, the data on Solid Waste Generation for estimation of methane gas may also be included in the framework.

4.2. Forest Area/Forest Cover and Bio-Mass

The Forest survey of India, MOEF is bringing out a publication 'State of Forest Report' bi-annually, which includes estimates on Forest Area/Cover, its type, Biomass like growing stock etc. These data are available at national/state level. The data are also available at disaggregated level (Districts). The data are being estimated using remote sensing technology. The data on volume of growing stock is not regularly available in their report. The Committee recommended to include data on carbon sequestration annexing its methodology to the report, if

it could be procured from FSI. The methodology has been obtained from FSI and the same is at Annexure-V.

4.3. Forest Produce

The Directorate of Education, Indian Council of Forest Research & Education (ICFRE), MOEF is bringing out a publication 'Forestry Statistics in India' estimating the data on forest produce bi-annually. The data on forest produce are available state-wise with a gap of two years.

4.4. Land Use Statistics

Presently, the Directorate of Economics & Statistics (DES), M/o. Agriculture has a database, which provides information on Agricultural Statistics covering all aspects relating to Land Use, Area, Production & Yield, and this database is accessible from both the websites of the Department of Agriculture & Cooperation (DAC) (http://www.agricoop.nic.in) and the Directorate of Economics & Statistics (http://www.dacnet.nic.in/eands). This database has been created in collaboration with National Informatics Centre (NIC). The comprehensive information pertaining to various parameters of Land Use Pattern and Area under Cultivation are captured systematically in different analytical reports, after validating all the data received from the States/ UTs. All the concerned Departments in Government of India and State Governments, planners, policy makers, researchers and others are using these data extensively.

Currently, DES is hosting data pertaining to nine-fold classification of land use both State-wise and District-wise as follows:

(i) Forest area
(ii) Area under Non Agriculture Use
(iii) Barren and Unculturable Land

(iv) Permanent Pastures Other than Grazing Land

(v) Land Under Misc. Tree Crops

(vi) Culturable Waste Land

(vii) Current Fallows

(viii) Fallow land Other than Current Fallows

(ix) Net Area Sown

Besides the data on items mentioned above, the Committee recommended to include data on Gross and Net Irrigated Areas.

The present status of soil survey and mapping carried out by the various Central Government Organizations is given below:

Name of the Organization	Kind of Survey and Mapping with scale	Area so far covered (in Million ha)
A. Soil and Land Use Survey of India (Formerly AISLUS), DAC	Rapid Reconnaissance Survey for Watershed Prioritization (1: 50000)	200.00
	Land Degradation Mapping (1: 50000)	65 Districts
	Detailed Soil Survey (1: 4000/15000)	13.50
	Soil Resource Mapping (1: 50000 under NRIS (DOS) Project)	89 Districts
B. National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), ICAR	Small Scale Soil Mapping (1: 250000)	300.50
	Soil Resource Mapping (1: 50000)	198.40
	Detailed Soil Survey (1: 4000/ 12500)	8.48
C. NRSA, Department of Space (DOS)	Wasteland Mapping (1: 50000)	Whole country

Source: Department of Agriculture and Cooperation, Ministry of Agriculture, 2008

The DAC has already taken steps to digitize “the survey data as well as the relevant maps” carried out by Soil & Land Use Survey of India (SLUSI), in collaboration with NIC. All India Land Use Survey Division in the Ministry of Agriculture may be approached for data on land degradation.

4.5. Water Availability

The Committee agreed to include indicator on water availability in the database which is being compiled by the Central Water Commission. The data includes the surface water and water availability from rivers, lakes etc. The data on ground water is available with the Central Ground Water Board. They have published the data for the year 2000 and the results of the study undertaken for the year 2010 are expected shortly.

4.6. Vehicular Statistics

The Ministry of Transport, Roads and Highways is compiling data on registered vehicles. The data are available at national/state level annually. Even though the data published by the Ministry gives the absolute figures of the types of vehicles registered for the year, the methodology to work out the extent of pollution caused by the vehicular use is absent due to the absence of data on emission load, fuel usage by types of vehicles etc.

4.7. Energy Uses

The data on energy uses by fuel type like coal, fuel oil, natural gas, nuclear and non renewable energy are being compiled by the Office of Coal Controller of India, Ministry of Petroleum and Natural Gas and Ministry of New Renewable Energy and are available on annual basis. The Central Electricity Authority brings out the annual figures on installed capacity, power generated, type of fuel used and CO_2 emissions from the power plants under their jurisdiction. The activities of the unorganized sector, which depend on fuels like coal, diesel etc for generation of power are not captured and such data are not available.

4.8. Ocean Level & Temperature

The data on change in sea level and sea surface temperature are being compiled by the Ministry of Earth Sciences and the Department of Science and Technology. At present the data are not available in the public domain.

4.9. Temperature /Precipitation

IMD advocated for the deletion of 'Humidity' as an indicator as it would not make any sense in arriving at any conclusions about climate change, without a set of supporting parameters. However, 'Specific Humidity' could be considered as an indicator for future use, as the data are not readily available at present. The pH value of the rainfall is a good indicator which may be included in the data base. It was suggested to approach Snow and Avalanche Study Establishment (SASE) for the snowfall data. The IMD Agreed to provide the temperature and rainfall data.

4. 10. Glaciers/landslides

The Data on Glaciers and Land slides are being maintained by the Geological Survey of India. The Committee considered including the time series data on major glaciers which are available. The data on landslides will be made available by the GSI.

4.11. Bio-Diversity

The data on Total Species, Endangered, Endemic and Invasive are compiled by the Botanical and Zoological Survey of India. The data are not compiled regularly and the estimates are based on studies/surveys undertaken in certain time intervals.

4.12. Health

The data on health indicators may be obtained from National Institute of Occupational Health. Data regarding deaths due to extreme heat or cold, floods, etc. are already available and being published in 'Statistical Abstract' of CSO. For such data, the publication 'Statistical Abstract' as well as publications of National Crime Record Bureau, Ministry of Home Affairs may be consulted.

4.13. Extreme events

The data on extreme events, natural or manmade disasters may be obtained from Natural Disaster Division of Ministry of Home Affairs.

4.14. Mitigation and Adaptation

As discussed in para 2.4., under the ambit of NAPCC, 8 Missions have been initiated to implement the Mitigation and Adaptation strategies of the Government of India. For institutionalizing the National Mission, nodal ministries have been identified for each of the missions and various programmes are under implementation. The data on Adaptation and Mitigation may be obtained from the nodal ministries which are responsible for the eight missions identified by NAPCC for mitigation and adaptation strategies. The data on the success of the programmes are not available in the public domain and efforts are to be made to bring out the data from the respective organizations to ascertain the reach and success of the programmes.

In Chapter 5, recommendations and conclusions have been summarized.

Chapter - 5

Recommendations and Conclusions

The awareness on the impact of climate change is growing the world over and the researchers and policy makers alike are burning the midnight oil to bring out solutions to the most perceivable impacts of climate change. The industrialization and the rapid growth of the economies in the 19th and 20th centuries have witnessed the growth in the emissions of the GHGs, generation of solid waste, atmospheric and water pollutants and increased urbanization. The United Nations' effort to bring the subject of Climate Change in the centre stage and the institution of bodies like UNEP, UNFCCC etc have given a different perspective into the affairs of climate change and related issues. The Brundtland Commission report on sustainable development clearly states that "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs". This necessitates the world to look into the development and growth of the economies in a different perspective and makes them responsible to safe keep the nature's gifts for the use of the future generations to meet their needs and deeds.

The Expert Committee on the Development of Database on Climate Change constituted by CSO has the task of examining the contents of the annual publication on Environment Statistics, identifying the indicators responsible for climate change in India and recommending the framework for climate change statistics. The parameters responsible for climate change in India and the knowledge about its inter-relations and interactions could be ascertained if only if proper dataset with reasonably fair in terms of its international comparability and with a historical base is available. So, the task is to identify a set of indicators and collect and compile

time series data to help the policy makers and researchers to arrive at conclusions on the impact of climate change for bringing out necessary policy prescriptions.

The recommendations of the Committee are as under:

(1) The Annual publication entitled ‘Compendium of Environment Statistics’ should be continued in the present form without any modification in terms of its contents, parameters or its time-period as it is in conformity with the FDES.

(2) The data source agencies identified in the report will supply the necessary data in the specified format to the CSO as per periodicity indicated.

(3) Climate change is an ongoing phenomenon and needs historical information to identify changes if any, in the long run. So, time series data need to be compiled starting from 1990 or depending upon the availability of data.

(4) Various ministries and departments are collecting data as per their requirements and maintaining with them in aggregate and disaggregate levels. CSO may publish the data in the aggregate form with state as the basic unit.

(5) The periodicity of the data as indicated in the report may be followed.

(6) The data on Mitigation and Adaptation activities may be obtained from the nodal ministries so that the same could be used for analyzing the extent and reach of the activities undertaken by them. The analysis would help to identify the strengths and weaknesses of the missions.

(7) CSO should initiate concerted efforts to capture data for some of the indicators which are not available at present, by approaching the concerned organizations.

(8) CSO should be the nodal agency to coordinate with the data source agencies.

(9) CSO should bring out a new publication on Climate Change Statistics covering only the data related to the subject.

It is felt that the Climate Change is a growing area of research and the nuances of the subject are yet to be revealed. Concerned efforts and coordinated research are needed for further expansion of the hidden facts on climate change and the environmental system surrounded by the earth and the life on it. The historical data play a vital role in identifying the visible changes happening in our environment. So, the Committee felt that there is enough scope to include more indicators and when necessity arises another Committee may look into the future requirements of indicators and data.

Annexure – I

M-12012/1/2008-Envs
Government of India
Ministry of Statistics & Programme Implementation
(Social Statistics Division)

West Block-8, Wing-6 (Ground Floor),
R.K. Puram, New Delhi-110066.

Dated 20th July, 2009

OFFICE MEMORANDUM

SUBJECT: An Expert Committee for Development of Database on Climate Change

*****

In accordance with one of the recommendations of the 16th Conference of Central and State Statistical Organisation (COCSSO) held in Shimla on 4-5 December, 2008, an Expert Committee is hereby constituted to advise on creation of sound database in the CSO on Climate Change Statistics.

2. The terms of reference and constitution of the Expert Committee are as follows:-

(a) Terms of Reference

(i) To identify indicators/parameters for which statistical data need to be collected. Such data may be utilised to capture causes and effects of climate change and to monitor adaptability and mitigation measures
(ii) To suggest the data source agencies for the collection of above data
(iii) To decide the relevant geographical unit/ climatic unit for which data may be collected and periodicity of such data collection
(iv) To review the data contained in the CSO's publication 'Compendium of Environment Statistics' and suggest modification, if any, in existing tables to meet the users requirement at national and international level

(b) Constitution of the Expert Committee:

(i)	Prof. K.S Rao, Department of Botany, Delhi University	Chairman
(ii)	Additional Director General, CSO, SSD	Member
(iii)	Statistical Adviser, Ministry of Environment & Forests	Member
(iv)	Statistical Adviser, Ministry of Agriculture	Member
(v)	Representative from Ministry of New & Renewable Energy	Member

(vi) Representative from Ministry of Earth Sciences	Member
(vii) Representative from Central Pollution Control Board	Member
(viii) Representative from India Meteorological Department	Member
(ix) Statistical Adviser, Central Water Commission	Member
(x) Representative from Central Electricity Authority	Member
(xi) Representative from Geological Survey of India	Member
(xii) Director, DES, Government of Himachal Pradesh	Member
(xiii) Director, DES, Government of Madhya Pradesh	Member
(xiv) Director, DES, Government of Meghalaya	Member
(xv) Director, DES, Government of Tamil Nadu	Member
(xvi) Representative from TERI	Member
(xvii)Dr.Sunil Nautiyal, Associate Professor, ISEC, Bangalore	Member
(xviii) Deputy Director General, SSD, CSO	Member Secretary

3. The Expert Committee may co-opt any other person deemed fit as a Member of the Committee.

4. The Committee shall submit its report in six months time from the date of its constitution.

5. The official members will be entitled to draw TA/DA from their respective organizations for attending the meetings of the Committee. The Non-official members will, however, be reimbursed TA/DA as per SR 190(a) by the Ministry, from the funds available under object Head 'Domestic Travel Expenses' under the plan Scheme "Capacity Development (Capacity Development of CSO and Institutional Development & Capacity Building)".

This issues with the concurrence of AS&FA vide Director Finance Dy. No. -1271/Dir(F) dated 3rd July, 2009.

(M.R.Meena)
Deputy Director General

Copy forwarded for information/ necessary action to:
1. All Members of the Technical Committee
2. Sr. PPS to Secretary, MOS&PI for information
3. Director (IFD), MOS&PI
4. Cash & Accounts Section
5. Budget & Finance Section, CSO, S.P. Bhawan, New Delhi.
6. Concerned file

Annexure – I (A)

M-12012/1/2008-Envs
Government of India
Ministry of Statistics & Programme Implementation
(Social Statistics Division)

West Block-8, Wing-6 (Ground Floor),
R.K. Puram, New Delhi-110066.

Dated 10th February 2010

OFFICE MEMORANDUM

SUBJECT: Extension of the tenure of an Expert Committee for Development of Database on Climate Change

*****

On the recommendations of the 16th Conference of Central and State Statistical Organisation (COCSSO), the CSO constituted an Expert Committee on Climate Change under the chairpersonship of Prof. K.S.Rao, Department of Botany, Delhi University, New Delhi on 20th July, 2009 to advise on creation of sound database in the CSO on Climate Change Statistics.

2. The tenure of the Committee was fixed for six months and is expiring on 20th January, 2010. It has been decided with the approval of the Competent Authority to extend the tenure of the Committee for another two months i.e. upto 20th March, 2010 with the same terms of reference and same composition as contained in OM dated 20th July, 2009.

3. The Committee is required to submit its report by 20th March, 2010.

4. The official members will be entitled to draw TA/DA from their respective organizations for attending the meetings of the Committee. The Non-official members will, however, be reimbursed TA/DA as per SR 190(a) by the Ministry, from the funds available under object Head 'Domestic Travel Expenses' under the plan Scheme "Capacity Development (Capacity Development of CSO and Institutional Development & Capacity Building)".

5. This issues with the concurrence of AS&FA vide Director Finance Dy. No. 2464/Dir(Fin) dated 28th January, 2010 .

(R.C.Aggarwal)
Director

Copy forwarded for information/ necessary action to:
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3. Director (IFD), MOS&PI
4. Cash & Accounts Section
5. Budget & Finance Section, CSO, S.P. Bhawan, New Delhi.

6. Concerned file

CHAIRMAN

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11. Ms. Shobha Marwah, Statistical Adviser, Directorate of Economics & Statistics, Ministry of Agriculture, Krishi Bhawan, New Delhi-110002
12. Shri Pradeep Chauhan, Economic Adviser, Directorate of Economics & Statistics, Govt.of Himachal Pradesh, Block No. 38, SDA Complex, Kasumpti, Shimla-171009
13. Shri D.P. Ahirwar, Director, Directorate of Economics & Statistics, Govt. of Madhya Pradesh, Vindhyachal Bhavan, Ground Floor,Bhopal-462004
14. Shri A. Marbaniang, Director, Directorate of Economics & Statistics, Govt. of Meghalaya, Lower Lachumiere, Shillong-793001
15. Smt. M. Sheela Priya, IAS, Special Commissioner and Director of Economics & Statistics, Govt. of Tamil Nadu, Block II, Administrative Office Building, 259, Annasalai, Teynampet, Chennai-600006.

16. Dr. Sunil Nautiyal, Associate Professor, Institute for Social and Economic Change, Nagarabhavi, Bangalore-560072

Annexure – II

Minutes of the first Meeting of the Expert Committee on development of database on Climate Change Statistics held on 28th August, 2009

The first meeting of Expert Committee on development of database on Climate Change Statistics was held under the Chairmanship of Professor. K.S Rao, on 28th August, 2008 in the Committee Room No. 223, Sardar Patel Bhawan, New Delhi to discuss various issues with regard to development of database on Climate Change Statistics including making assessment on data availability with concerned organizations on various indicators/parameters for which statistical data can be collected and compiled. A list of participants is annexed.

2. Shri S.K.Das, Director General, in his initial remarks said this is a very good subject and highlighted the need for the development of database on Climate Change Statistics in the current scenario where a lot of discussions are held at national and international level. He also mentioned that a Seminar on this subject was organized by the CSO at ISEC Bangalore in April, 2009 to discuss data availability and requirements on various aspects of climate change. He hoped that this Committee will do a commendable job in finalizing the indicators along with datasets.

3. Shri J.Dash, Additional Director General, CSO referred to the CSO's publication 'Compendium of Environment Statistics' which contains data on various parameters of Environment that are compiled on the basis of information made available by specific data source agencies dealing with the subject. The publication also contains some data on environmental parameters pertaining to climate change. Shri Suresh Kumar, Deputy Director made a power point presentation on the data availability with the CSO on climate change. The participants were requested to supply data on climate change which are not covered in the publication so far but are available with the organizations.

4. Prof. K.S.Rao, the Chairman, briefed the participants about the background of formation of the Expert Committee on Climate Change and an agenda of the meeting. He asked the participants to briefly mention about the indicators, data availability, meta-data links, and sharing of data with CSO which are available with their respective organizations. He asked the participants to give in writing the details of indicators, data availability, meta-data links, and sharing of data with CSO subsequently.

5. The representative of Central Pollution Control Board mentioned that they have data on CO2 emissions, Methane, Nitrogen Oxide, Air Pollution, and Waste Generation. The major generators of CO2 emission are from power sector and vehicular while methane emissions are from agriculture, bio-mass burning, industry, solid waste dump site etc. The data on Methane and CO2 are available only at aggregated level using some modeling techniques.

6. The representative of Ministry of Earth and Sciences said that they have ocean temperature data which is taken from International Organisation of Oceans. The data is available with India National Centre for Ocean Information Service (INCOIS), Hyderabad (www.incois.gov.in). Presently they are assessing the impact of climate change and are working on plan programme to minimise the impact of climate change and disasters. He stressed the need to develop a web based visual-interface so that the respective organizations could do the updation of data online with proper linkages.

7. The representative of the Geological Survey of India mentioned that they are the nodal agency for monitoring the effect of Climate Change on glaciers and land slides disasters for the last three years. They have the data on Glaciers which earlier was the component of water reservoir. It is being re-oriented to cater the need of Climate Change. The occurrence of landslides is monitored with rainfall for which they have maps of various zones with other geological parameters. The pertinent issue is what to do with existing data and how do we relate one set of data with other for analyzing using modern technology.

8. Ministry of Agriculture's representative said that they were a part of PM's National Action Plan for Climate Change wherein two databases were prepared namely (i) area under cultivation, production and cost of cultivation (ii) soil profile by All India land Use Survey. The area and production data for the year 1995-96 up to district level has been digitized. The data on land use statistics including as per nine fold classification for State and Districts are available up to the year 2006-07. A weekly weather watch group meeting is held in the Ministry to asses the rainfall situation and water availability in the reservoirs.

9. The representative of IMD said that the data on temperature and rainfall are available with them meteorological sub division-wise. A power point presentation was made by IMD

focusing on trend of temperature rise in the last 100 years, change in minimum temperature after 1990, classification of drought years from 1901-2004, extreme rain fall in one day.

10. The representative of Central Electricity Authority indicated that the data base on CO2 emissions from all types of power stations, station-wise are available for the year 2007. The data for the year 2008 are under preparation.

11. The Central Water Commission's representative said that they have classified and non-classified information available with them. He was very specific to know that what type of indicators are required for which the data are to be made available. He was requested to examine the availability of data on Hydrology and Water Quality and suggest what type of data is relevant and can be made available to CSO in connection with climate change.

12. Director, DES, Government of Himachal Pradesh stressed the need for bringing out State level data on climate change.

13. The representative from TERI said they have a lot of data on climate change but these are project based data. The problem is that these data do not match with the scale of resolution. He suggested that the data can be given link through web. TERI was requested to examine what data are useful and can be shared with CSO.

14. Director, DES, Government of Meghalaya spoke about the problems of mining and depletion of water table in their state.

15. Dr. Sunil Nautiyal, from ISEC mentioned that there are 127 ecological zones in India. A structure of the database to be made keeping in view (i) impact of climate change on social groups (ii) Researcher's agenda and the CSO data (iii) influence of locals to change the land-use patterns (iv) role of local institutions in collecting the data.

16. Shri J.Dash, Additional Director General said that besides the development of data base on climate change, one of the terms of references of the Committee is to review the data currently available in the CSO's publication 'Compendium of Environment Statistics'. The participants may give their views about new or latest data which are not covered in the publication so far but are available with the organizations. There was a debate over whether climate change should be a part of the existing publication as a separate chapter or as a separate

publication. The general opinion was that there should be a separate publication on Climate Change. There was also a talk on the geographical unit for which the data can be collected, be it NSS region or agro-climatic zone or any other unit for which the data are readily available. It was suggested that it would be better to take NSS region as a geographical unit but will be examined in the next meeting depending on the feasibility and availability of data.. There is need to expand the indicators, confirm the data sources and bring concrete suggestions in the next meeting.

17. Based on the detailed deliberations, the following decisions were taken in the meeting:

(i) All the organizations will confirm in writing to CSO the followings with in a fortnight for discussion in the next meeting:

(a) the indicators to be included in the database along with data availability with them

(b) the details of metadata and linkages

(c) what data can be sharable/non-shareable with CSO

(d) Generation of more data, if required

(e) approach for using the data that will help in making the structure of the report

(ii) The next meeting tentatively may be convened in 30 to 45 days.

(iii) The first draft of the report should be ready in about three month's time or after third meeting.

(iv) A list of NSS regions may be kept ready for deciding the geographical unit for compilation of data.

List of Participants

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20. Shri R.K.Panwar,
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Annexure – III

Minutes of the second Meeting of the Expert Committee on development of database on Climate Change Statistics held on 20th November, 2009

The second meeting of Expert Committee on development of database on Climate Change Statistics was held under the Chairpersonship of Prof. K.S Rao on 20th November, 2009 at 11.00 A.M. in the Conference Hall. 223, Sardar Patel Bhawan, New Delhi, to discuss various issues with regard to finalization of indicators for the development of database on Climate Change Statistics including making assessment on data availability with concerned organizations. A list of participants is annexed.

2. The Chairman, welcoming the participants, stated that at the first meeting, all organizations were asked to suggest the indicators relevant to climate change statistics, data characteristics such as meta data and linkages and data availability with concerned organizations. The feed back had been received from the Ministry of Agriculture, Geological Survey of India, Central Water Commission, Ministry of Earth Sciences, Central Pollution Control Board, Central Electricity Authority, India Meteorological Division, and TERI. Ministry of Environment and Forests gave their written communication on indicators of climate change on the day of the meeting, which was circulated to all members. The feedback received from organizations has been summarized as agenda note for facilitating further discussions.

3. The Chairman invited the members to present their views and the extent to which the data can be shared with CSO. The members presented data sets available with their organizations which could be captured at aggregated and disaggregated levels. There was a long debate over what type of data can be captured for climate change statistics whether at micro level like "soil characteristics experimental data available with IASRI at village / panchayat level", intensity of rainfall etc. Further discussions were held on the type of data to be included in the publication or providing for links. After deliberations, it was decided that the focus should be on the basic minimum number of indicators which have a direct bearing on climate change.

4. ADG(SSD) informed the Chairman and Committee members the suggestions of National Statistical Commission to invite representatives from National Remote Sensing Centre,

Hyderabad and Indian Institute of Remote Sensing, Dehradun, in its subsequent meeting(s), if possible.

5. After a detailed examination of the points raised by the members, the committee decided to focus on the following dimensions which are directly related to Climate Change.

(a) Rainfall
- Maximum/Minimum Rainfall
- Precipitation
Temperature – Max/Min/Average
Relative Humidity
Geographical Unit: State level
(Source – IMD and any other source like Indian Institute of Tropical Meteorology (IITM))

(b) Land Use and Land Use Change
(Source – Ministry of Agriculture)

(c) Forest Area and Forest Cover
(Forest Survey of India (FSI))

(d) Sea Level Rise and Sea Temperature
(Source –National Institute of Oceanography, under Ministry of Earth Sciences and Department of Science and Technology)

(e) Soil Degradation – State level data
(Source – FSI, National Remote Sensing Centre, Ministry of Agriculture)

(f) Emission of Greenhouse Gases
Power Sector – all data relating to total generation, fuels used, CO2 emissions etc.
(Source – Central Electricity Authority)

CO2 Emissions other than Power Sector are available in second National Communication to United Nations Framework Conventions on Climate Change (UNFCCC)

Data on other Greenhouse gases like Nitrous Oxide (N2O), Methane, Hydrofluorocarbons (HFCs), Perflurocarbons(PFCs), Sulpurhexafluride (SF6) are not available, and the possibility of getting the same from CPCB to be explored

(g) Ozone data: (Ozone Cell under MOEF)

(h) Glaciological data and land Slide hazards)
(Source – Geological Survey of India, Calcutta)

(i) Vulnerable Species living in aquatic, terrestrial areas and Vulnerability maps

(j) Impact of Extreme Events such as Accidents/Disasters (Natural/Manmade)

(Ministry of Home Affairs, National Disasters Management Authority)

(k) Vehicular Pollution
- No. of vehicles registered etc.
(Ministry of Transport)

(l) Derived data Sets
- Forest Produce, Major, Minor
- Vector Borne Diseases

(m) Total amount of carbon stock, Potential Carbon Sinks and Potential Sequestration Capacity

6. After deliberations on all the points as mentioned above, the Committee also took the following decisions:

(a) The task of the Committee is to identify the indicators of Climate Change and should be focused to identify the datasets for the identified dimensions in para 5.

(b) The concerned agencies may be contacted to asses the availability of data and the extent to which it could be shared with CSO.

(c) Explore the possibilities of obtaining the data through surveys or any other methods, if the desired data is not readily available with the concerned agencies.

(d) The data should be made available from 1990 in a time series manner.

(e) The status paper prepared by the CSO was circulated to all the members to give their comments as it forms the basis of the draft report of the Committee.

(f) The first draft report of the Committee may be prepared for consideration in the next meeting of the Committee which may be convened in the first week of January.

The meeting ended with a vote of thanks to the chair.

List of Participants

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Annexure – IV

Minutes of the third Meeting of the Expert Committee on the Development of Database on Climate Change Statistics held on 11th March, 2010.

The third meeting of the Expert Committee on the development of a database on climate change statistics was held under the chairmanship of Prof. K. S. Rao on 11th March, 2010 at 11 AM in the conference Hall, 223, Sardar Patel Bhavan, New Delhi to discuss the draft report of the Committee and finalize the indicators to be considered for the publication of data on Climate Change Statistics. The agenda and the list of participants are given at annexure-I and annexure-II.

2. Shri. S.K. Das, Director General, Central Statistical Organisation (CSO) welcomed the participants and said it would be the final meeting of the Committee as the extension of tenure of the Committee is expiring on 20th March, 2010. He stressed the need for discussing all issues relating to identification of indicators, availability of data on such indicators, etc. and finalise the same in this meeting.

3. The Chairman reiterated in his address, the need to bring out a publication on database on Climate Change, to help the policy makers and the research community. He appreciated the steps initiated by Central Statistical Organization for taking up a challenging assignment like this.

4. Shri. R.C. Aggarwal, Director (SSD), made a power point presentation highlighting the background of the formation of the Committee and the contribution of the members in developing a framework on climate change statistics. In his presentation, he enlisted a framework of indicators (Annexure-III) which evolved out of the previous two meetings with respect to the identification of the indicators, their levels of relevance, coverage, periodicity, data source agency, data availability and meta-data links.

5. After the presentation, the Chairman said that before having detailed discussions on each item of framework/indicators, he would like to have the opinion of the members whether they are satisfied with the broad framework with respect to selection of indicators and other information required for bringing out the publication.

6. As all the members agreed with the framework in the draft report, the Chairperson initiated detailed discussions on the indicators and data base.

7. The Chairman raised a major point whether the framework should include only those indicators on which data are available or even other indicators which are relevant to climate change but data not available presently. Smt. S. Jeyalakshmi, Additional Director General (SSD) opined that the report must include all indicators which are relevant to climate change irrespective of the status of data availability. Shri V. Parameswaran, DDG, said that the CSO is already bringing out an annual publication 'Compendium of Environment Statistics' since 1997, covering the broad indicators on Environment as per the United Nations Statistics Division (UNSD) framework. As all members of the Committee agreed with the suggestions of ADG(SSD), it was decided that the framework should cover all major variables of climate change irrespective of data availability or otherwise for these variables. In case of non-availability of data for some of the variables, the Committee can give its recommendation that the data on these variables can be collected in future.

8. The Chairman initiated detailed discussions and invited comments on the framework already presented before the Committee. The Additional Director General (SSD) explored the possibility of including data on other Greenhouses Gases like, Sulphur Dioxide, Carbon Monoxide (CO) etc. which also have a bearing on climate change. The Central Pollution Control Board (CPCB) was requested to provide a list of such gases, which could be included in the data base. The other indicators like Ozone Depleting Substance (ODS), as discussed in the last meeting, available with MOEF may also be included in the database. Similarly, the data on Solid Waste Generation for estimation of methane gas may also be included in the framework.

9. With respect to the data on Greenhouse Gases (GHG), the following points emerged in the discussion:

(i) The Chairman indicated that the sources of emissions and sinks and data availability are to be reported for each of the GHGs separately (ii) Shri. Praveen Gupta, Director, CEA informed that the Carbon Dioxide (CO_2) emissions from the power sector are estimated by CEA and available in the public domain. These data are calculated at source level. (iii) Dr. Nigam, Director, CPCB informed that the data on CO_2 emissions from other sectors like industries, transport, household,

etc. and Methane (CH_4) are not available with them, even though it is a major contributor to the GHG. These data are, however, available with India's second National Communication to United Nations Framework Convention of Climate Change (UNFCCC) (NATCOM-2). DDG (SSD) raised a point that estimates of CO_2 emissions pertained to the year 1994 and if these estimates are based on some methodology, then why could not CPCB update the estimates using the data they are collecting annually. It was clarified by Dr. Nigam that these estimates were based on one time study. He further added that the source-wise data available in the public domain given by NATCOM dated back to 1994. A renewed estimate for GHGs for the year 2004 is being worked out by NATCOM, but the same could be made available to public by the year 2011.

10. Shri. N.K. Ghosh, Advisor, MOEF, said that the data available with ENVIS Centres on forest area, forest produce, biodiversity etc. at aggregated level may be utilized by the CSO for the publication. The MOEF can help in making the data available to the CSO.

11. Dr. S.P. Sharma, Director, DES, Madhya Pradesh, indicated the need for building up an infrastructure for the flow of climate change data by ensuring the quality and coverage at state level, but expressed his concerns with regard to the limitations of the state in capturing the data and reporting the same in a timely manner.

12. Shri D.P. Mondal, DDG, CWC indicated that there is need to include indicator on water availability in the database which was also agreed to by the Chairperson. In case of biomass, it was suggested to include carbon sequestration data and annexing its methodology to the report, if available.

13. Smt Shobha Morwah, Statistical Adviser, M/o. Agriculture said that nine fold classification for the land-use data alongwith gross and net irrigated areas could be used. The data are available with Directorate of Economics and Statistics, Ministry of Agriculture at National and State level. All India Land Use Survey Division in the Ministry of Agriculture may be approached for data on land degradation.

14. Sri. A.K.Srivastava, Director, IMD advocated for the deletion of 'Humidity' as an indicator as it would not make any sense in arriving at any conclusions about climate change, without a set of supporting parameters. However, 'Specific Humidity' could be considered as an indicator for future use, as the data are not readily available at present. The pH (acidity of water)

value of the rainfall is a good indicator which may be included in the data base. It was suggested to approach Snow and Avalanche Study Establishment (SASE) for the snowfall data.

15. Dr. Wadawan, Director, GSI, brought a dataset on major glaciers for the use of CSO and broadly agreed with the indicators identified and presented in the meeting. He also agreed to give some more data relating to glaciers/landslides. He further suggested a change in para 4.1.11 of the agenda. The sentence " the river systems of the Brahmaputra, the Ganges and the Indus draws water directly from melting of the Himalaya" may be read as " the river systems of the Brahmaputra, the Ganges and the Indus draws water directly from melting of the Himalayan glaciers and seasonal rainfall". The modification suggested was accepted by the Chairman.

16. Indicators related to Vehicles, Energy Production and fuel use are to be included in the dataset and the indicators identified for the same are sufficient. It was decided to include fuel oil in place of diesel.

17. The data on health indicators may be obtained from National Institute of Occupational Health. DDG (SSD) said that data regarding deaths due to extreme heat or cold, floods, etc. are already available and being published in 'Statistical Abstract' of CSO. For such data, the publication 'Statistical Abstract' as well as publications of National Crime Record Bureau, Ministry of Home Affairs will be consulted. As regards the data on drought, the same are available with Ministry of Agriculture.

18. The Chairman suggested that the data on Adaptation and Mitigation may be obtained from the nodal ministries which are responsible for the eight missions identified by the National Action Plan on Climate Change (NAPCC) for mitigation and adaptation strategies.

19. The Chairman suggested that the draft report of the committee may be circulated among the members for their comments before its finalization. The report would also be sent to Ministry of Environment & Forests for their comments/suggestions. Thereafter, the draft report could be posted in the website of the Ministry for a period of one month for obtaining comments from public. Good suggestions from the public may also be included in the final report.

20. Shri. S.K. Das, Director General, CSO, in his concluding remarks, thanked Prof. K.S. Rao, Chairman of the Committee for his valuable time and guidance. He also thanked all the

members of the committee for their inputs and valuable suggestions. The DG, CSO summed up the decisions of the Committee as under:-

(i) The draft report may be revised as per discussions held in this meeting

(ii) There should be enough scope to include data on the future requirements

(iii) The data should be presented in the aggregated level. The level of aggregation may depend on the availability of data.

(iv) Another Committee may look into further requirements of data in the future as well as other related aspects, whenever required.

(iv) The members were requested to give their comments on draft report by the end of the March, 2010.

(v) The report of the Committee may be finalized by the end of April, 2010.

The meeting ended with a vote of thanks to the chair.

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Annexure - V

Methodology for Estimation of Carbon Stocks of India's forests

Forest Survey of India, Dehradun

1. Introduction

In forest ecosystem the biomass which is the live portion of the above and below ground plant matter, is a significant store of carbon. As a result, changes that affect biomass also affect greenhouse gas (GHG) concentrations. The forest carbon pool estimates reported by several countries are primarily based on extrapolation of growing stock (volume) data as the primary observational value because the existing forest inventories were not designed for carbon stock assessment. As per IPCC guidelines carbon stock in the forest ecosystem are distributed in five pools; aboveground biomass, belowground biomass, litter, deadwood and soil organic carbon. Carbon stock estimates for each pool require separate data collection and its analysis.

2. Brief Review of studies on Indian forest carbon stock

In India, the Forest Survey of India (FSI) has been mandated to monitor the forest resource of the country. FSI made the first tentative estimate of woody growing stock of the country's forests in 1995 using its forest inventory data collected during 1965 to 1990 (SFR, 1995). Further, using this growing stock data of different forest types the annual increment was also estimated based on certain thumb rules and assumptions. These data have been the main source for estimating forest carbon stock by different institutes and scientists in the country. The growing stock volume data is first converted into biomass by using specific gravity of the wood which is different for different species. Thereafter, biomass expansion factors are used to convert woody biomass to total biomass which includes all other factors like small wood and foliage of trees, shrub, herbs, roots etc. The total biomass so obtained is then converted into carbon by multiplying by conversion factor; mainly default values from IPCC good practice guidance have been used. This is known as 'tier 1 approach', sometimes referred to as simple first order approach which uses several approximations and assumptions.

During 2001- 03 of NATCOM I process, the FSI estimated forest carbon of only woody growing stock (which excluded small wood, belowground biomass, soil organic carbon and carbon in other pools) using the old data. The estimated growing stock of 4,326 million m^3 was converted into biomass of 2,398 million tones by multiplying with specific gravities of different species

and subsequently into 1,085 million tones of carbon using conversion factors. The carbon stock in forest ecosystem was highly under estimated.

3. Methodology of current estimation of forest carbon stock by FSI

The current methodology aims to completeness of the data and improvement of the accuracy level to follow Tier 2 approach of IPCC good practice guidance for LULUCF using country specific data. For this purpose, in addition to regular activities of 'forest cover mapping' and 'national forest inventory', FSI under took a special nation wide study since August 2008 on missing components of forest biomass for generating country specific information.

The input used in the methodology are;

i) Latest forest cover (of years 2005) and forest type area data analyzed by remote sensing
ii) Recent growing stock data obtained from National Forest Inventory done during 2002-2008
iii) Soil organic carbon data obtained from NFI
iv) Biomass data of missing components (smallwood, branchwood, deadwood, litter, shrub, herb and foliage) analyzed from 2008-09 study.
v) IPCC default values for below ground biomass

Most of the input used for estimating the forest carbon stock has been generated at the FSI. The specific gravity for determining the biomass and factors for converting biomass into carbon has however, been taken from published papers from FRI and other research institutes in addition to IPCC default values.

3.1 Forest Cover mapping and Forest Type mapping:

FSI has been assessing the forest cover of the country on a two year cycle using remote sensing technology since 1987. Over the years there has been improvement in the technology and methodology of interpretation. Since 2001 the satellite imagery of 23.5 m resolution is digitally interpreted on 1:50,000 scale, allowing for a more objective and accurate assessment of

the forest area and the changes. In the assessment three classes are made based on the canopy densities; very dense forests (more than 70% density), moderately dense forests (density between 40 to 70%) and open forests (density between 10 to 40%). The change analysis is carried out using the results of the preceding cycle which provides shift of area from one to other class within forest as well as between forest and non-forest. In this exercise the area of 67.71 million ha the published forest cover data of the country as in 2005 has been used. By overlying the layer of forest types the forest cover of the country gets divided into 33 homogeneous strata (each stratum of a type and a density).

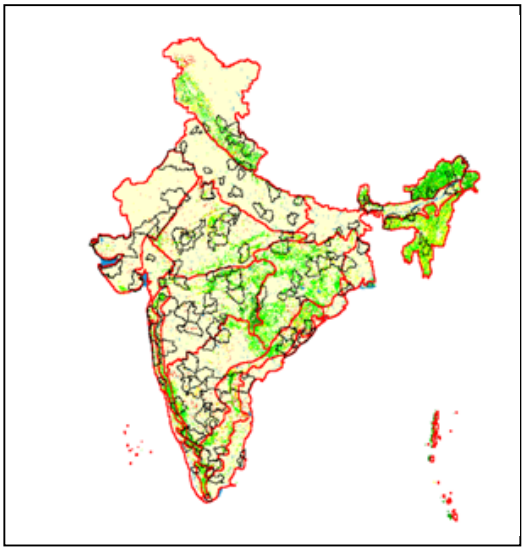
3.2 National Forest Inventory:

3.2.1 Introduction: Forest growing stock has traditionally been a key indicator of forest capacity for wood production and its estimation has formed a major activity of forest resource assessment/inventory. The forest inventory on a relatively large area using a statistically robust approach and aerial photographs began in 1965 when the Pre-Investment Survey of Forest Resources (PISFR) was launched in the country with FAO/UNDP assistance. Even after the creation of the FSI the inventory remained the primary activity.

3.2.2 Sampling Design: A new National Forest Inventory (NFI) has been designed and adopted by FSI since 2002. The country has been stratified into following 14 physiographic zones.

1. Western Himalayas (WH)
2. Eastern Himalayas (EH)
3. North East (NE)
4. Northern Plains (NP)
5. Eastern Plains (EP)
6. Western Plains (WP)
7. Central Highlands (CH)
8. North Deccan (ND)
9. East Deccan (ED)
10. South Deccan (SD)
11. Western Ghats (WG)
12. Eastern Ghats (EG)
13. West Coast (WC)
14. East Coast (EC)

Physiographic Zones with selected districts



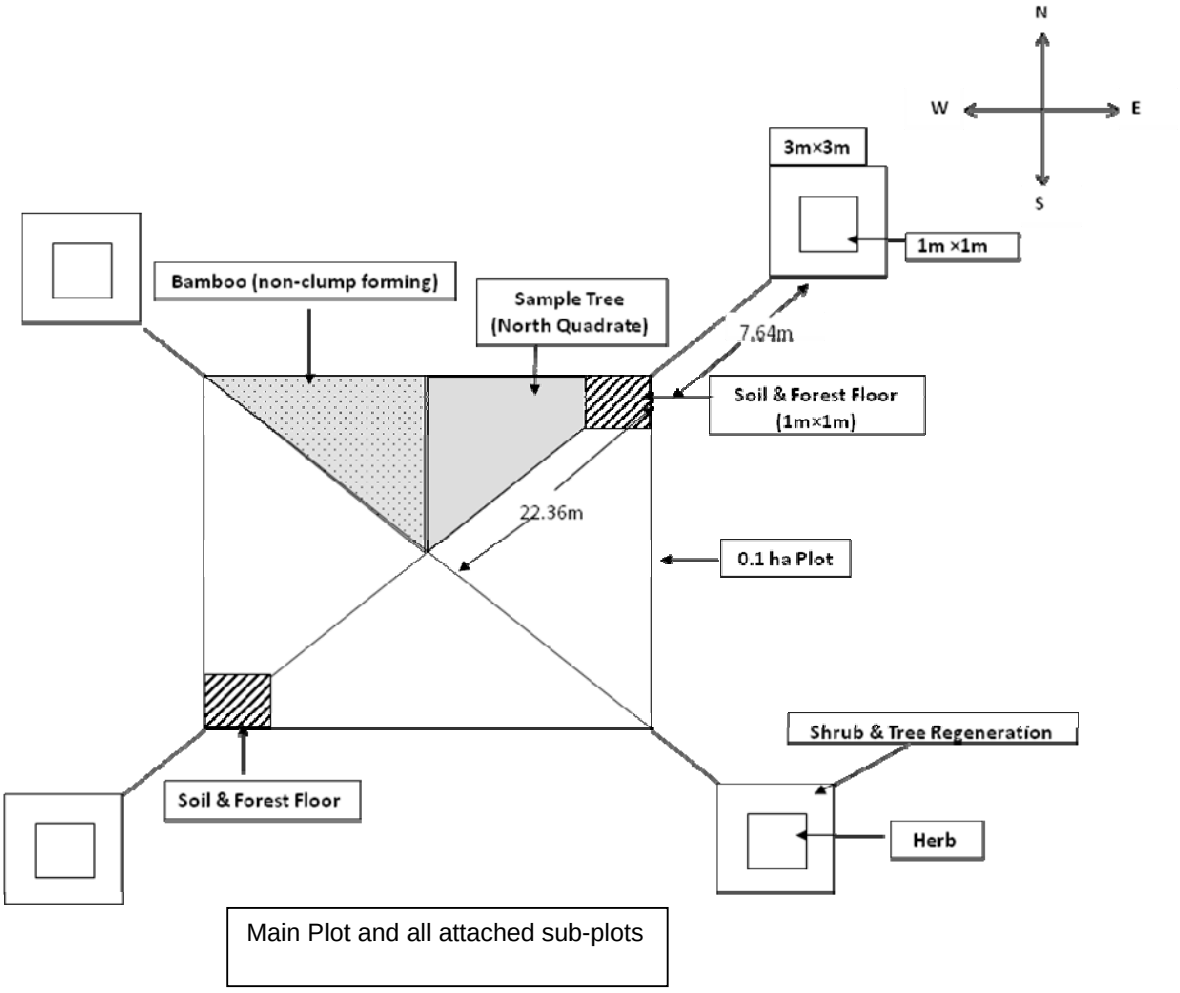
A sample of 10 percent districts (or 60 districts in the country) randomly selected and distributed over all the physiographic zones, is taken for detailed inventory of forests to estimate the growing stock at zonal and national level during a cycle of two years. These estimates are to be further improved in the second and subsequent cycles as the data of first cycle will be combined with second and subsequent cycles. The random selection is without replacement; hence each time new districts are selected.

In the selected districts all those areas indicated on topographic sheets by double dotted line, printed as RF, PF, thick jungle, thick forest etc., shown as green-wash and any other area reported to be a forest area by the local Divisional Forest Officers, are treated as forest area for the inventory.

For each selected district, Survey of India (SOI) topographic sheets of 1:50,000 (size 15′ × 15′) scale was divided into 36 grids of 2½′ × 2½′. Further, each grid is divided into 4 sub-grids of 1¼′ × 1¼′ forming the basic sampling frame. Two of these sub-grids are then randomly selected to lay the sample plots. The intersections of diagonals of such sub-grids are marked as the centre of the plot at which a square sample plots of 0.1 ha area is laid out to conduct field inventory.

3.2.3 Data Collection: Within this 0.1 ha plot, sub plots of 1m x 1m are laid out at NE & SW corner for collecting data on soil (from pit of 30x30x30 cm^3), forest floor (humus and litter carbon). The data regarding herbs and shrubs (including regeneration) is collected from four square plots of 1m x 1m and 3m x 3m respectively. These plots are laid out 30 meters from the centre of 0.1 ha plot in all four directions along diagonals in non-hilly area and along trails in hilly areas. In case of hilly areas the plot are taken randomly 2-10 meters away either side of the trail.

After demarcating the plot and after satisfying that it is correctly oriented the Crew Leader collects the data. He shall be personally responsible for data to be collected. Besides measurement on tree parameters like species name, dbh, height of selected trees, etc., data on legal status, land use, topography, crop composition, bamboo, regeneration, biotic pressure, etc are also recorded.



3.3 Study for Missing component of Forest Biomass:

3.3.1 Introduction: The Forest Survey of India has been entrusted with the responsibility of estimation of the carbon in forest ecosystem of India. FSI is already having information on above ground woody biomass of all trees with dbh 10 cm and more as discussed above. In addition, the information on carbon in forest soil (up to 30cm depth), humus and litter (other than woody branches) is also available under NFI. However, the information on biomass of branches, foliage, flowers, fruits, twigs, barks and roots of NFI trees, all trees below 10 cm dbh, shrubs, herbs, climbers etc, dead wood, litter (branches only) are not available under NFI. Therefore FSI has initiated a special study to estimate the missing components of forest biomass. For this purpose, following information is being collected from 15 selected districts from all physiographic zones representing almost all forest types of the country.

3.3.2 Biomass of shrubs, herbs, climbers, dead wood and litter: For this purpose, the data of forest inventory conducted during 2002-06 was analysed for each physiographic zone to ascertain the important crop compositions and optimum number of plots required for each combination of crop composition and forest density. It reveals that about 15 plots for each

combination will suffice if 30% permissible error is considered. This will be part of regular inventory and the estimates will be improved continuously.

For the selected district, the latitude and longitude of the optimum number of plots are supplied to field parties from headquarters. Taking lat & long as centre of sample point, three concentric plots of size 5mx5m, 3mx3m and 1mx1m are laid out at a distance of 30m away from the centre of sample point in North and South direction. In 5mx5m plot, all dead wood above 5 cm diameter is collected, weighed and recorded. In 3mx3m plot, all woody litter i.e. all branches below 5 cm diameter are collected, weighed and recorded. All shrubs & climbers in 3mx3m plots are uprooted, weighed and recorded in the prescribed format. In 1m x 1m plot, all herbs are uprooted, weighed and recorded. In all the three plots, the name of the dominant species is also recorded.

3.3.3 Biomass of trees below 10 cm diameter: In each physiographic zone, 20 important tree species have been identified using the forest inventory conducted by FSI during 2002-06. For each of such species, 3 trees of diameters 1- 9 cm (at 1 .37 m. height) are felled. From the felled trees, separate biomass is calculated and recorded for wood, twigs and leaves in the prescribed format. For this purpose no plot is laid out and work is carried out while approaching the plot or around the plots.

3.3.4 Biomass of branches, foliage etc. of tress above 10 cm diameter: As above, 20 important tree species in each physiographic zone have been identified. For each such species other than palm like trees, in each of the diameter class, three normal trees are selected. Its diameter, height, crown length, crown width in two direction and shape of the crown is recorded. For the purpose of biomass calculation one normal tree of each diameter class of each species is selected. In the selected tree one square meter window in all the four directions is opened in the crown until woody branches of 5 cm. dia is reached. All such material from window is felled i.e. woody branches up to 5 cm dia, twigs, leaves, fruits and flowers. Biomass of all these parameters is separately recorded in the prescribed formats. This is also independent of plot and work is carried out while approaching the plot or around the plot. For palm like species two leaves are felled from each tree in each diameter class and their weight and total number of leaves in those trees is counted and recorded for biomass calculation.

The estimate of forest biomass and carbon stock is being generated using the above methodology.