Ministry of Earth Sciences
Mahasagar Bhawan, Block-12,
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Particulars of Organization, Functions and Duties

Introduction:

Realizing that the monsoons influence national life in critical ways and affect the lives of the people of India, recognizing that the atmosphere, the oceans and land form a complex coupled system, noting that the country has been the victim of a variety of natural disasters including droughts, floods, earthquakes, tsunamis etc., and noting that for both the common man and for agriculture, fisheries, and all industrial activity in general land and water are major resources, the Government has resolved to take a major new initiative to integrate the national effort in earth sciences. It is realized that the twenty first century is likely to be dominated by concerns regarding water, global climate change, environment, land use and ocean resources. The activities and programmes that government departments have established at various times now need to be integrated as the need for taking such an integrated view that includes atmosphere, land and ocean is being increasingly recognized across the world, and has led to the emergence of earth system science as a major inter-disciplinary scientific endeavour internationally.

In order to achieve its objectives in meteorology, ocean science and technology, seismology and related earth sciences, the Government of India in July, 2006, have established the Ministry of Earth Sciences (MoES)by putting together Department of Ocean Development, India Meteorological Department, Indian Institute of Tropical Meteorology (IITM) and National Centre for Medium Range Weather Forecast (NCMRWF).

The erstwhile Department of Ocean Development (DOD) was created in July 1981 as a part of the Cabinet Secretariat directly under the charge of the Prime Minister and came into existence as a separate Department in March 1982. The DOD functioned as a nodal Department for organizing, coordinating and promoting ocean development activities in the country. The DOD was declared fulfledged Ministry of Ocean Development in February, 2006 and later rechristened as Ministry of Earth Sciences.

Organizational Set-Up of the Ministry.

As on 1.3.2008, the sanctioned strength of the Ministry including administrative, technical and supporting staff stood at 281 in all grades, attached

offices included leaving aside agencies under its control. The Ministry has two attached offices viz. 'Centre for Marine Living Resources and Ecology (CMLRE) Kochi and Project Directorate for Integrated Coastal and Marine Area Management (ICMAM) at Chennai, and one National Centre for Medium Range Weather Forecasting (NCMRWF) at NOIDA (U.P.). It has one subordinate office namely, the India Meteorological Department (IMD) with its headquarters at New Delhi.

The Ministry has also four autonomous societies under its administrative control viz. (i) National Institute of Ocean Technology (NIOT), Chennai, (ii) National Centre for Antarctic and Ocean Research (NCAOR), Goa, (iii) Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and (iv) Indian Institute of Tropical Meteorology, Pune.

Centre for Marine Living Resources and Ecology (CMLRE), Kochi

The Sagar Sampada Cell (SSC), set up in 1989 at Kochi was renamed as Centre for Marine Living Resources and Ecology (CMLRE)taking into consideration the functional responsibilities of the office viz.; management of the Fishery Oceanographic Research Vessel (FORV) Sagar Sampada, co-ordination of the national programme on marine living resources, preparation of inventory of marine bio resources and co-ordination of the Indian activities of the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR).

Integrated Coastal and Marine Area Management (ICMAM),Chennai

A Project Directorate for Integrated Coastal and Marine Area Management (ICMAM) as initially set up as a World Bank assisted Project. On completion of the project, ICMAM was established as an attached office in 1997-98 at Chennai. The activities of the project, inter-alia, include:

- Development of GIS based information system for critical habitats in the Coastal and Marine Areas in India
- Determination of Waste Assimilation Capacity at selected estuaries along coastal areas of India
- Development of Guidelines for Environmental Impact Assessment for Marine andCoastal Developmental Activities and Process
- Preparation of Models for Integrated Coastal and Marine Area Management Plans.

Detailed information is available at the website of ICMAM, viz, www.icmam.gov.in)

National Centre for Medium Range Weather Forecasting (NCMRWF), NOIDA

Numerical weather forecast models of high resolution have proved to be viable tools for the production of weather forecast in the medium range (3-10

days in advance). Since inception, National Centre for Medium Range Weather Forecasting (NCMRWF) has been working on development of such models and data assimilation techniques to provide meteorological forecasts for agro-advisory purposes and other applications. The detailed information is available on the NCMRWF's website www.ncmrwf.gov.in.

India Meteorological Department (IMD)

The India Meteorological Department (IMD), established in 1876 is the national meteorological agency of the country. It is responsible for monitoring forecasting weather conditions in different scales of time. It has a network of observatories covering the landmass of the country and its surrounding sea areas from where ground-based, airborne and satellite observations are routinely taken. The services of IMD are utilized in almost all walks of national life and also provided to the international community under the charter of World Meteorological Organization. The detailed information is available on the IMD's website www.imd.gov.in.

National Institute of Ocean Technology (NIOT), Chennai

The National Institute of Ocean Technology (NIOT), Chennai is a registered society under the administrative control of the Ministry which functions as a technical arm for development of ocean related technologies. The Institute has designed and developed low temperature thermal desalination plant, technology for harnessing polymetallic nodules, technologyes for fattening lobster, etc. The detailed information is available on the NIOT's website www.niot.res.in.

National Centre for Antarctic & Ocean Research (NCAOR), Goa

In 1998-99, the Antarctic Study Centre (ASC) at Goa, an attached office, was converted into an autonomous society w.e.f. September 1998 and renamed as National Centre for Antarctic & Ocean Research (NCAOR) in May 1999. The Centre which started as logistics provider for antactic missions, has now becomes the nerve Centre for polar research guiding scientific and research activities on both the poles.The detailed information is available in the NCAOR's website www.ncaor.gov.in.

Indian National Centre for Ocean Information Services (INCOIS), Hyderabad

Indian National Centre for Ocean Information Services (INCOIS) was set up with its head quarters at Hyderabad in February 1999. The Centre is responsible for dissemination of Ocean related information to variety of users. It hass also notified as the nodal agency for running the Tsunami and Storm Surge Early Warning System started in October, 2007. The information provided by it on ocean waves, swell etc are found quite valuable by Navy, Coast Guards, Merchant Ship. Similarly, Fishing Zone Advisories are utklised by large number of fishermen on both cost. The detailed information is available on the INCOIS's website www.incois.gov.in.

Indian Institute of Tropical Meteorology (IITM), Pune.

The Indian Institute of Tropical Meteorology (IITM), was separated from the India Meteorological Department in 1962 and established as a Centre for Research. It now functions as the National Centre for basic and applied research in Tropical Meteorology and Atmospheric Sciences, in all its aspects, with special reference to the tropics and sub-tropics. The detailed information is available on the IITM's website www.tropmet.res.in.

Major Activities:

The following are the major activities undertaken by the Ministry of Earth Sciences:

(A) Ocean Science and Technology

TECHNOLOGY DEVELOPMENT

1. Polymetallic Nodules Programme

One of the important non-living resources found at the bottom of the sea is the potato shaped nodules called Polymetallic Nodules. These nodules are available at depths greater than 4000 mts. in the deep sea and contain Manganese (27-30%), Copper (1-2%), Nickel (1-2%) and Cobalt (0.2-0.3%), apart from traces of other minerals. Copper and Nickel are strategically important elements, as these are not available from terrestrial resources in the Indian sub-continent and hence it is essential that India develops technology to mine these nodules from the deep sea.

The Polymetallic Nodules (PMN) Programme is oriented towards exploration and eventual harnessing the nodules from the mine site allocated to India. India is the first country to have received the status of Pioneer Investor in 1987 and was allocated an area of 1,50,000 sq. km in Central Indian Ocean Basin (CIOB) by UN. Out of which, 50% of the area has been relinquished by

India as per the Convention. The PMN Programme consists of components like Survey & Exploration CIOB, Environmental Impact Assessment, Technology Development (Mining), Technology Development (Metallurgy) and Unmanned submersible.

1.1 Technology for deep sea mining: National Institute of Ocean Technology (NIOT), Chennai, the technical arm of the Ministry of Earth Sciences is engaged in development technologies for harnessing ocean resources. Considering that the technology to mine nodules at depths greater than 5000m is highly challenging, this work has been taken up in phases. The first phase of development was through collaboration with University of Siegen in Germany, to validate the concept of flexible riser for slurry transport at a water depth of 400 to 500 m. As part of this programme, an underwater crawler was developed with a manipulator, cutter, slurry pump, instrumentation and control system. The crawler based system was tested initially in the year 2001.

In the second phase, the system was tested successfully at a depth of 451m (where ambient pressure is 45 bar) along with the slurry pumping operation, off Goa at an identified site in Feb./March'06 fighting against all odd challenges. This part of the programme was completely done by Indian scientists independently with technology and knowledge gained during earlier trials.

1.2 In-situ soil property measurement system: As part of this programme, the next phase is to design a crawler for 6000 m operation. The major challenges at 6000 m are high pressure of 600 bar, extremely soft sea bed and the varied topography of the ocean floor. In order to design a crawler capable of locomotion in the soft sea bed, it is essential that the sea bed property is measured in-situ which will provide undisturbed ground truth measurement. An instrument has been developed jointly with Sevmorgeo, Russia to measure the soil property in-situ, at a depth of 6000 m. In this system, the sensor developed by Sevmorgeo, Russia was integrated with mechanical hardware, electronics and control software for measuring soil properties at 6000m on line. The system has been indigenously designed considering the weight and contact area in soft sea bed, to measure the soil property without disturbing the virginity of sea bed.

The instrument was launched using a special underwater cable which carries the weight of the instrument, transmits power and data. It was initially tested at a depth of 1280 m off Mangalore and later tested successfully at a depth of 5200m in the Central Indian Ocean Basin (Latitude 10^{o}05.85' S, Longitude 75^{o}15.59' E) during the month of November 2006. It is worth mentioning that this is the first time an instrument for in-situ soil property measurement has been developed and tested at a depth of 5200m successfully by Indian Scientists.

1.3 Remotely Operable Vehicle (ROV): In order to assist the mining system during its operation and also for other deep sea related work, the Ministry also has taken up a project for development of a ROV jointly with Experimental

Design Bureau of Oceanological Engineering (EDBOE), of the Russian Academy of Sciences, Russia. The scope of this project is to develop a world class ROV for operation at a depth of 6000 m. The system comprises of a ROV and Tether Management System (TMS) which is launched using a dedicated Launching and Recovery System (LARS). The complete hardware and software for the instrumentation and control system was developed by Indian Scientists. This is the first prototype developed and tested successfully for its functionality at a depth of 205m off Mangalore during October 2006. Further tests to qualify the system at greater depths are in progress. The new ROV will be the flagship for the next phase of deep-sea exploration, and many exciting discoveries are anticipated in the coming decades.

The technology being niche, support from other countries is very minimal. The above successes have put India in the list of other top developed countries in the area of deep sea technology. With this technology and know how already developed and proved by Indian scientists, it is expected that India can explore greater depths in the deep ocean in the future.

1.4 Survey & Exploration: An area of 17,500 km has been outlined within the Retained Area where nodules of high grade are available in abundance for the possible location of the Ist generation mine site. Approximately, 70 % of the delineated area has been mapped using a multibeam sonar system. Nodules from all the stations covered were analysed for the five critical elements viz. Ni, Co, Cu, Mn and Fe. Work is continuing for identification of the mine site.

1.5 **Extractive Metallurgy**: Towards this, a demonstration pilot plant with a capacity to process 500 kg nodules per day was commissioned successfully in 2003 for extracting copper, nickel and cobalt at Hindustan Zinc Limited, Udaipur for the first time. Three primary process routes were tested on the semi-continuous demonstration pilot plant set up at Hindustan Zinc Limited with successful extraction of Copper, Nickel and Cobalt from Polymetallic Nodules. The data generated during the demonstration campaigns is being used for evaluation and validation of process packages. Another pilot plant with 500 kg/day capacity has also been commissioned successfully at NML, Jamshedpur for production of ferro-sillico-mangamnese ore from the residue obtained from the HZL plant.

1.6 **EIA Study**: Mining of the deep-sea minerals is expected to alter the environmental conditions of the marine ecosystem. Environmental studies for mining of deep-sea polymetallic nodules are undertaken to evaluate the possible impacts of mining on deep-sea environment and develop protocols for environmental studies, to fulfill one of the obligations of the country as a Pioneer Investor under the UN Law of the Sea.

In order to study effects of sediment re-suspension and resettlement, monitoring of the environmental parameters are being carried out by collection of

samples at the test and reference areas for the benthic disturbance experiment periodically. Results of the monitoring cruises have indicated that some of the sediment characteristics appear to have regained the conditions similar to that of pre-disturbance stage, the numbers and diversity of benthic organisms showed only marginal restoration. The parameters indicate that the benthic conditions are steadily moving towards restoration and the effect of disturbance is waning off.

(2) Low Temperature Thermal Desalination(LTTD):

Towards alleviation of acute shortage of fresh water in the coastal areas and island territories of India, National Institute of Ocean Technology (NIOT), Chennai, an autonomous body under this Ministry, has undertaken to establish low temperature thermal desalination plants to generate fresh water from sea water (28 – 30 °C) and cold deep sea water (11 – 15 °C). The LTTD is a process by which the warm sea water is flash evaporated under low pressure and condensing the water vapour with the cold sea water, to produce potable water. After conducting several experiments in the Laboratory (500 Liter per day capacity & 5000 Liter per day capacity), a LTTD plant with a capacity of 1 lakh liter per day production of fresh water was developed and installed in May 2005, at Kavaratti, Lakshadweep Island. This plant was handed over to Lakshadweep Administration in April 2006 for operation and maintenance. The plant has been effectively working since then and catering significantly to the needs of the population of Kavaratti. This LTTD plant has produced over 6 crore litre of water so far. The Lakshadweep Islands have the advantage of ocean depth (~500 m) available within few hundred meters from the coast and hence, land based plants are possible.

As the Indian mainland doesn't have the required depths near the coast, a barge mounted 10-lakh liter per day capacity plant was developed and demonstrated about 40 kms off Chennai in April 2007. The barge based demonstration plant was successfully run continuously for over a period of several weeks. However, the barge based technology needs further improvement for long term service under dynamic ocean conditions. Currently, the Ministry in the process of formulating a project for development of 1 crore liter per day capacity barge based plant. After the demonstration of these higher capacity plants, the number of plants could be replicated. Eight more such units are being set up in other islands of Lakshadweep. So far close to 5 crore litre of water has been produced for distribution to the public from Kavarati plant. Hundreds of such plants in coming few years would alleviate the drinking water problem in coastal regions. The technology demonstration plants also include water transportation from barge based desalination systems.

(3) **Technology for Marine Instrumentation System**:

A state-of-the-art Acoustic Test Facility (ATF) has been set up with a completely automated Acoustic Control System at NIOT. Under this programme

various instrumentation technologies are being developed indigenously. Acoustic Tide Gauge**,** Databouy have been developed indigenously resulting in significant reduction in cost. Various systems are under different stages of development. This facility is being used by a number of institutes for testing the equipment viz., BHEL etc.,

(4) Gas Hydrate Programme:

Gas hydrate is a crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules. Gas hydrates, which look like water ice, occur abundantly in nature, both in Arctic regions and in marine sediments. Since Hydrates store immense amount of methane, extraction of methane from hydrates could provide an enormous energy and petroleum feedstock resource. Thus its economic extraction has major implications for energy resources for the country. Methane hydrate is stable in ocean floor sediments at water depths greater than 300 meters, and where it occurs, it is known to cement loose sediments in a surface layer several hundred meters thick. The worldwide amounts of carbon bound in gas hydrates is conservatively estimated to total twice the amount of carbon to be found in all known fossil fuels on Earth. Additionally, conventional gas resources appear to be trapped beneath methane hydrate layers in ocean sediments.

The preliminary assessment of geological condition and limited available seismic data suggests high possibility of occurrence of large quantity of gas hydrates within the EEZ of India. Gas hydrate exploration is a nascent science and a mission mode programme has been taken up to develop science and technology in India in respect of exploration of gas hydrate and to recommend suitable sites for drilling for ground truth validation and subsequent technology development for harvesting. This consists of science component as well as technology development component. The Ministry, in association with CSIR and other laboratories, is focusing on scientific research with special emphasis on resource extent evaluation and environmental impacts and development of technology for detection and qualification of gas hydrates in sediments. Under science component, available data has been examined and analysed and two sites for detailed survey have been identified in K.G.basin. Synthetic Gas Hydrates were prepared in laboratory to take up detailed analysis. Further, two Indo-Russian scientific expeditions were carried out in Lake Baikal. Under technology component, ROSUB-2500 was designed and developed and currently being tested at various depths.

(5) Indian Ocean Modelling and Dynamics (INDOMOD) Project

The significant initiatives towards realising the national capability in ocean atmospheric modelling during IXth Plan resulted in to a new phase of modelling efforts under INDOMOD project during the Xth Plan, focusing towards the goal of achieving ocean predictability and enabling climate predictability in a mission-

mode with concomitant efforts in Modelling, Data Assimilation and Validation. The main objectives of the project are:

- To develop and calibrate a wide range ocean-atmospheric models by a network of reputed national agencies for operational use at INCOIS
- To generate regional algorithms for retrieval of remote sensing parameters from the satellite sensors
- To generate insitu data using Drifters, Current meter arrays, XBT etc., required for validation of models and algorithms .

Achievement & Future plans:

The project envisages focused research in 5 modules with active participation of several institutions, with a mission to enhance the basic understanding and knowledge base on oceanic and atmospheric processes and catastrophic weather events and improve operation prediction by the respective agencies.

Module-1: Ocean and Climate (IISc, IITM, NIO, C-MMACS)

- Ocean general circulation models viz. MOM, POM, GCM and atmospheric general circulation models such as CCM-3, COLA, UK-Met and Hydra for hydrological model were used for understanding the dynamics and thermodynamics of Upper Ocean.
- 28 papers published and 2 Ph.Ds were awarded under this module.

Module-2: Coastal Ocean (IIT-D)

- WAM, SWAN and POM model were used for generating wave near the coast. WAM was successfully nested with coastal wave model (SWAN).
- Sediment transport model developed under this module will be used on operational basis at INCOIS after validation.
- 4 papers were published & 2 Ph.d were awarded.

Module-3: Hazardous Events (IIT-D, NRSA)

- NCAR's MM5 , NRL's COAMPS and 1-d price model were used for hindcasting the track and intensity of the storm.
- The track and intensity of the storm were better simulated using satellite observed SST for initial conditions instead of weekly SST. Incorporation of mixed layer depth and upper ocean heat content is under progress.

Module-4: Ocean Data Assimilation (IISc, C-MMACS, NCMRWF, IITM)

- High resolution Indian Ocean Model based on MOM4 and POM has been configured for ocean data assimilation. Assimilated altimeter data and compared the model temperature with Argo temp. Assimilation of Argo profiles is under progress.

Module-5: Validation with Observations (NIO)

- 10 Drifter buoys were deployed
- XBT observations were carried out along the Kochi-Lakshdweep Islands
- The Equatorial Current Meter Mooring Arrays were retrieved and redeployed
- The data from all these observing systems were made available through INCOIS and NIO website

Key Institutions: CAOS/IISc, CAS/IIT-D, Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Indian Institute of Tropical Meteorology (IITM), IMD, NIO, NCMRWF, Naval Physical Oceanographic Laboratory (NPOL), NRSA, SAC and SOI played a key role in realizing this mission.

(6) Oil spill modelling:

An oil spill modelling capability has also been developed by ICMAM (Integrated Coastal and Marine Area Management Project Directorate) Chennai, an attached body of the ministry. The model predicts movement of oil spill which is highly useful for agencies engaged in disaster recovery like Coast Guard, State Government agencies etc. This has become operational and coexists with the Tsunami Warning System at INCOIS Hyderabad.

(7) Development of Potential Drugs from the Ocean

The Ministry has been implementing a national coordinated research programme on “Development of potential drugs from the Ocean” since 1990, with a view to harness the bioactive substances extracted from the potential marine organisms for human therapeutic purposes. The activities of product development are in advance stages. The single dose clinical trials of Phase –I of anti-diabetic preparation CDR-134 D-123 were completed successfully on 31 volunteers without any undesirable effects. The dose was well tolerated and the clinical bio-chemistry values were found in normal range except the dose produced a slight lowering of glucose in the volunteers as expected. The regulatory and pharmacokinetic data on CDR-134-123 were generated and submitted to Drugs Controller General of India (DCGI) for getting permission for multiple dose trials in humans.

The anti-hyperlipidaemic product of puffer fish oil possessing potent lipid lowering activity was found safe in chronic monkey toxicity studies. The dossier is being prepared and is in the final stage to be submitted to DCGI soon. Private

industry is showing interest for commercialization of two marine products. The new leads, which has confirmed bioactivities, will be taken up for further optimization of bio-activities and simultaneously, efforts will be made to isolate single molecule for developing novel drugs form marine biota.

SURVEY & SERVICE ORIENTED WORK

(8) Comprehensive Swath Bathymetric Survey of entire Indian EEZ

The area of our Exclusive Economic Zone is over 2 million sq. km. abound with various living and non-living resources. This new programme entails scientific mapping of this area to have an inventory of potential resources and to identify the causes of hazards. Surveys in shallow water using the coastal vessels at NIOT, NIO are being carried out. Processing and interpretation of the data collected is under progress. Four successful cruises were carried out off-Goa covering 1654 line km (397 sq km area). An area of little more than 25,000 sq km around Andaman subduction trench and near about 2000 sq km around Great Nicobar Island were surveyed to obtain necessary data to produce swath bathymetry map of this area. The Andaman subduction trench, where the heavier oceanic Indian plate is shoving below the lighter continental Southeast Asian plate, has been mapped successfully, along with several structural and geomorphic features. In addition, columns of sediment have been recovered from eight locations, obtained through spade corer from five spots and gravity corer from three spots.

(9) Geophysical Study of Laxmi Basin

The main aim of the study is to establish the nature of basement in the Laxmi Basin and acquisition and processing of geophysical data. The analysis and processing of marine geophysical data including seismic reflection and seismic refraction, gravity and magnetic data has been done followed by processing and interpretation of marine geophysical data gathered to arrive at a logical conclusion on the type and nature of the crust flooring the Laxmi Basin and Ridge and to facilitate an understanding of the Arabian Sea basin. The draft report on geophysical studies of Laxmi Basin is ready.

(10) Survey for Delineation of Continental Shelf:

India ratified the United Nations Convention on the Law of the Sea (UNCLOS) in June 1995, which requires any country to lodge its claims for an extended continental shelf latest by May 2009. For putting forth our claim, a scheme to take up a comprehensive marine geophysical work comprising deep-penetration multi-channel seismic reflection, refraction, magnetic and gravity surveys covering over 33 000 line km from the Bay of Bengal and the Arabian Sea in and off the EEZ of India, was given final shape in 2001. This programme has moved fast in the last one and half years. All the data in the Bay of Bengal

and Arabian has been completed. All the exercise of geophysical interpretation and documentation for submitting to the international agency has been completed. Briefings have been organized to national agencies including the Ministry of External Affairs Legal Cell. The draft Cabinet Note has been prepared and circulated to all concerned Ministries/Departments and Planning Commission. It will be put up to Cabinet for approval in the month of May 2007. Also, additional work on Lakshmi Ridge to extend the Indian claim on continental shelf has been completed. Our claim will have far reaching consequences for the country in future.

(11) Advisories for Potential Fishing Zone:

With concerted efforts of scientists from Earth Sciences, Space and Fishery Science, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, an autonomous body under MoES, is providing a unique service in the form of reliable and timely potential fishing zone advisories to the Indian fishing community through a wide range of media (such as telephone, fax, electronic boards, satellite radio and internet) in local languages. The advisory not only reduces time taken to locate fish shoals but also reduces cost of fuel which would be of the order of lakhs of fishermen. This is an excellent example of reaching the benefits of ocean science to the society. The methodology is further being upgraded by incorporating additional information of ocean currents for further improving accuracy and providing this service through mobile.

(12) Recovery operations of GSLV

The recovery operations off Sriharikota for the illfated GSLV subsystems were completed successfully on 21 October, 2006 with recovery of all the 4 strap on engines viz. S1, S2, S3 and S4. GSLV debris recovery from sea is perhaps the only second such attempt in the world. Four ships of Ministry of Earth Sciences, i.e., ORV Sagar Kanya, CRV Sagar Purvi, CRV Sagar Paschimi and a chartered vessel, Akademik Boris Petrov were pressed into operation for sonar surveys and diving. About 550 diving operations were carried out during the campaign that lasted for nearly 100 days. Remotely Operated Vehicle (ROV) was also used in a limited area during the nights due to depth and visibility limitations.

(13) Societal Programmes

NIOT has been successful in creating the requisite infrastructure for carrying out technology development activity in the island for the benefit of island community, monitoring the health of seas, analysis of data on ocean parameters, enhancement of Marine Living Resources through mariculture, biofouling control, etc. Utilizing those infrastructures and expertise already developed by NIOT, the programmes such as mud crab farming and open sea cage culture of lobsters, fish aggregation devices around Lakshadweep islands, biofouling study of marine structures, completion of life cycle of two species of lobsters and experiments

study on Deep Ocean water were successfully implemented during the X Five Year Plan period, for overall economic development of island and coastal community. Other activities carried out are as under:

- Pilot scale demonstration of fattening of lobster and crabs in A&N Islands and the main land, using different feeds was completed.
- Technology in breeding and rearing of lobsters from egg to juvenile stage was developed.
- Sea ranching of early developmental stages of spiny lobsters in A&N Islands was taken up. Marine ornamental fish culture activities in A&N Islands have been initiated.

WORK RELATING TO ANTARCTICA AND POLAR RESEARCH

(14) Setting up of third Station at Antarctica:

According to the Protocol on Environmental Protection to the Antarctic Treaty, continuous environmental monitoring of existing scientific and logistic activity and Environmental Impact Assessment for any new activity is mandatory. Keeping in view of the requirement, the process of setting up the third station at Larseman Hills in Antarctica has been initiated and assessment on environment impact has been submitted to international body. The Antarctic Programme is being given science based thrust and institutionalized scientific programme with goal oriented long term studies. The Southern Ocean Programme and Arctic Ocean Research Programme are being organized. A wind mill and a satellite data reception with INSAT connectivity will also be established at Maitri, the second station at Antarctica.

(15) Antarctic Ice Core Research:

An Antarctic Ice Core Research Laboratory has been set up by National Centre for Antarctic & Ocean Research, Goa, for studying accumulation rate and for chronology, etc. which will provide benchmarks for testing and validation of the cores and will also open up challenging opportunities in the study of past climate and the environment. This is a major scientific initiative on paleoclimatology.

(16) Antarctic Treaty Consultative Meeting:

India hosted the XXX Antarctic Treaty Consultative Meeting for the first time at New Delhi, from 30th April to 11th May 2007. For this purpose, various time bound activities like constitution of Organizing Committees which starts active planning 12 months prior to the event; finalisation of interpretation and translation contract with the help of the Antarctic Treaty Secretariat; Website development; constitution of Working Committees to look after specific

tasks/activities such as logistics, protocol, documentation of ATCM Working Papers and Information Papers, Communication with Consultative Parties and other Expert Groups; setting up the ATCM administrative and ATS office at the venue; setting up updated e-mail national contact lists; coordinate and finalise with PMO, President's Office, Security Agencies, local bodies, etc. has been done. The ATCM meeting has approved approval for setting up 3rd Indian Antarctic Station at Larsseman Hills.

SUSTAINED OCEAN OBSERVATION NETWORK

The in-situ observations from the oceans are the backbone for any kind of operational services viz., storm surges, cyclones, monsoon variability, tsunami etc. and research development including validation of data collected by remote sensing satellites. The integrated ocean observations network consists of Data Buoys, Tide gauges, Weather Stations & Argo Floats deployed in sea for collection of data. There are three major programmes going on in this regard, details of which are given below:

(17) Data Buoy Programme

Data Buoy Programme has been started to design, develop, produce, deploy, operate and mainten a network of 40-buoys in the Seas around India for acquiring data in real-time to process it for dissemination to various stakeholders.

NIOT has designed and developed data buoys which are being produced in house except certain sensors. Indigenous version of Data Buoys which hitherto were being imported has been developed at NIOT and these indigenous data buoys are also being used to provide ocean related data. With his deep understanding of instrumentation and engineering, the new design is 1/6th of cost of imported system and easy to manufacture and deploy. So far NIOT has deployed 27 Data buoys and the 40-buoy network would be ready by March 2007. A dedicated research vessel TDV Sagar Manjusha has been acquired for operation and maintenance of buoys. During XI Plan, the major work planned in this area is as given below:

(i) integration of all the existing and planned observations network Data Buoys, Tide gauges, Drifters, HF Radar, XBT, Current meters, automatic Weather Stations, Argo Floats under one umbrella for wider utility,
(ii) upkeep of existing 40-buoy network & possibility of augmentation of the network using low cost buoys to meet the requirement of operational weather services,
(iii) setting up of 4 maintenance centres, 2 each on west coast and east coast of India for logistical operation and maintenance of observation network in addition to the routine work elements.

(18) Indian Argo Project:

The Indian Argo Project is a revolutionary concept that enhances the real-time capability for measurement of temperature and salinity through the upper 2000 metres of the ocean and it contributes to the global description of the seasonal and inter-annual variability of the upper ocean thermohaline circulation. It has been implemented by INCOIS jointly with National Institute of Ocean Technology (NIOT) and Centre for Atmospheric and Ocean Sciences, Indian Institute of Science with active participation from a network of other premier institutions. The Indian Argo Project envisages deployment of 150 Argo floats in the Tropical Indian Ocean, setting up and operation of Argo Data Reception and Processing System at National level, setting up and operation of Regional Argo Data Centre, regional coordination for deployment in the Indian Ocean, development of Ocean Data Assimilation System, analysis and utilization of Argo data and capacity building at National level. INCOIS has a lead role in the project as (i) National Argo Data Centre (ii) the Regional Argo Data Centre for the region and (iii) the Regional Coordinator for implementation of Argo programme in the Indian Ocean. The Argo Data Centre at INCOIS acquires temperature and salinity data from one hundred sixty Argo profiling floats deployed by India since 2002. Thus successfully achieved the target set under this programme. The temperature and salinity profiles acquired from five hundred and eighty six floats deployed in the Indian Ocean, including those deployed by other countries, have been archived at INCOIS and the data is made available to the global and Indian scientific community through INCOIS website. Besides, a set of 12 data products are being developed and made available in near real time through INCOIS website for wide range of user community. The Indian scientific community has fruitfully utilized the Argo data provided by INCOIS for several studies related to monsoon, cyclone and climate that were published and presented in national and international fora.

(19) Regional Alliance in Indian Ocean for GOOS (IOGOOS)

India is leading the process of establishing a regional alliance called the Indian Ocean – Global Ocean Observation System (IOGOOS) for the Indian Ocean, which will be able to focus on issues of common national or regional interest. The objectives of this program are given below:

- Enhance the Ocean Observing System in the region,
- Promote and facilitate efficient and effective management, exchange and utilisation of oceanographic data,
- Promote programmes and projects in operational oceanography and ocean services in the region meeting the requirements of end-users,
- Strengthen capacity building for enhancing the capabilities in the region,
- Encourage research to support the needs of Users,

- Develop synergies with other ocean programmes and regional GOOS bodies, and
- Contribute to international planning and promotion of GOOS

INCOIS, as the Secretariat for IOGOOS till 2008, has been effectively leading IOGOOS that has taken a place of pride among the nine such GOOS Regional Alliances. Since its formal launch at the First Indian Ocean Conference held at Mauritius on November 05, 2002, IOGOOS membership has grown from 19 to 25 institutions from 15 countries. Some of the major initiatives of IOGOOS are (i) the setting up of Indian Ocean Panel working towards a strategy and implementation plan for Indian Ocean Observations for Climate, (ii) Data & Information management, (iii) Remote Sensing Capacity Building Strategy, (iv) Prawn Pilot Project, (v) Keystone Ecosystems Project, (vi) Shoreline change monitoring project, etc. IOGOOS members have played a key role in Argo deployments and enhancing the tropical moored buoy array. The key institutions participating from India in this alliance are INCOIS, NIO, NIOT and NCAOR.

WARNING SYSTEMS

(20) Early Warning System for Tsunami & Storm Surges

The Government is setting up an Early Warning System for Tsunami and Storm Surges in Indian Ocean at a cost of Rs.125 crores having following components:

- strengthening of the existing seismological network to indicate, near real time occurrence of tsunamigenic earthquakes;
- installation of tsunami warning sensors close to the ocean bottom at appropriate locales in the Indian Ocean, with real time connectivity;
- Tide gauge and data buoys networking to validate arrival of tsunami waves at the coast;
- Modelling of the inundation scenarios for the entire coast and mapping of potential risk areas;
- collection of information, analysis and generating status advisories.

In October 2007, a Tsunami and storm surge early warning system was setup at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, Andhra Pradesh on a 24x7 basis. Since then, the system has been operational fully

17 nos. of tide gauges have been installed with GSM link and ISRO is working on two way communication. Two Coastal Radars have been installed off Chennai . A set of 6 Bottom Pressure Recorders, 2 in Bay of Bengal & 4 in the Arabian Sea were deployed to receive the realtime data on tsunami wave. Strengthened seismic network by establishing 17 broadband inter connected

seismic stations for near real time monitoring of Earthquakes. A Central Receiving Station has neem established at India Meteorological Department at New Delhi with parallel connectivity at INCOIS, Hyderabad. V-SAT Communication for receiving real time data from NIOT has been established. Action for procurement and installation of INMARSAT and INSAT reception facilities at INCOIS has been initiated.

Tide Gauge and Deep Ocean Assessment and Reporting System (DOARS) data for Tsunami would be received through INSAT. Testing of Tsunami modelling simulations for various domains and historical events is underway.

This Tsunami Warning Centre is now capable of giving warning round the clock within 30 minutes after the earth quake in Indian Ocean.

INFRASTRUCTURE

(21) Research Vessels

The Ministry has three vessels capable of research & investigations in the deep and open ocean and two vessels for undertaking research in coastal areas. A new multi-purpose vessel is under construction and is expected to be delivered by end of this year.

21.1 Oceanographic Research Vessel (ORV) Sagar Kanya

Oceanographic Research Vessel (ORV) Sagar Kanya was commissioned in 1983 which is being managed by NCAOR, Goa and run, operated and maintained by Shipping Corporation of India Ltd, Mumbai, at a cost of Rs.15-16 crores as per annum which is met under the Non-Plan (OCS).

The vessel is extensively utilized for oceanographic investigations and research in physical, chemical, geological, biological oceanography. The vessel is fitted with state of the art machinery and equipments to obtain & carry deep sea investigations. It is also equipped with multi beam Swath Echo sounder for continuous high resolutions bathymetry (mapping). With newly installed launching & retrieving system (12 tonnes capacity), the vessel has been recently used to test ROV and crawler. A Dynamic Positioning System enables the ship to maintain a designated position to launch ROV safely and efficiently. The vessel has completed 231 cruises since its inception.

21.2 Fishery Oceanographic Research Vessel (FORV) Sagar Sampada

FORV Sampada Research Vessel was commissioned in 1984 and is fully utilized for Marine Living Resources (MLR) surveys. The vessel for its scientific operations is managed by CMLRE, Kochi and its operation, maintenance and

running is done by Shipping Corporation of India Ltd, Mumbai with the total annual expenditure of rupees between Rs. 10-11 crores which is met from the Non –plan (OCS).

The vessel has undertaken 254 scientific cruises covering 25 thousand (approx) nautical miles and occupying 344 number of stations. Environment and productivity patterns are surveyed during the inter monsoon and summer monsoon periods in the Arabian Sea and winter monsoon in the Bay of Bengal and Andaman sea. Cruises are conducted for collection of sediments samples from the continental slope area for studies on benthos, for fishery survey, for plankton biodiversity. Universities have been involved with these investigations for Central Marine Fisheries Research Institute, Fisheries Survey of India, CIFT etc. CMLRE is the nodal agency managing the scientific operation of the vessel.

21.3 Coastal Research Vessels (two in number)

The Coastal Research Vessels Sagar Poorvi and Sagar Paschimi of the Ministry are managed by National Institute of Ocean Technology (NIOT) Chennai since its inception. These Research Vessels are used for investigations in the shallow coastal waters for various projects and programmes of the Ministry on east & west coasts.

21.4 Buoy Tender Vessel "Sagar Manjusha"

The construction of Buoy Tender cum Research Vessel Sagar Manjusha was completed at M/s. Hindustan Shipyard Ltd., Visakhapatnam, and the vessel was inducted into the services of National institute of Ocean Technology (NIOT) to support National Databuoy Programme (NDBP) on 14th June 2006.

21.5 Acquisition of new Research Vessel "Sagar Nidhi"

This new multipurpose vessel "Sagar Nidhi" will serve as a platform for the programme envisaged in the 11th Plan and serve as a multi-utility science vessel for marine living and non-living resources programme of the Ministry. The NIOT will operate and maintain the vessel. The Cabinet approved the acquisition in December, 2005. The ship was launched in water in June 2007 by completing the construction as per the schedule. The delivery of Sagar Nidhi was done as per the schedule in December 2007, which has been commissioned successfully.

CAPACITY BUILDING

(22) Marine Research and Capacity Building

The Marine Research and Capacity Building programme has been one of the pioneering schemes of the Ministry that has provided for infrastructure and funding support to Universities, in particular, and to the various National

Laboratories for undertaking research in oceanic and atmospheric sciences by establishing Ocean and Atmospheric Science & Technology Cells (OASTCs) and through Centre of Excellence (CoE) in particular knowledge domain. The objectives of the programme are:

- To encourage research on physical and chemical processes that govern the seas of India, impact of natural anthropogenic sources on global climate change;
- To generate reliable data and information system for development of suitable technologies for optimal utilisation of the ocean resources;
- To strengthen the Infrastructure facilities in selected universities/institutes to carry out basic research in Marine and Atmospheric Sciences;
- To create centres of excellence on ocean and atmospheric sciences – Ocean and Atmospheric Science and Technology Cells (OASTCs) at selected institutes/universities;
- To create a cadre of high-class ocean and atmospheric scientists and trained personnel/users

Major achievements

9 OASTCs set up at Andhra University, Annamalai University, Berhampur University, Bhavnagar University, Cochin University of Science & Technology, Goa University, Mangalore University, Tamil University, and at IIT, Kharagpur have executed over 200 research projects leading to better understanding in ocean sciences.

2 CoEs (Centre of Excellence) have been set up – one in 'Marine Biology' at Annamalai University, Parangipettai and the other in 'Marine Microbiology' at Goa University, Goa. These have taken up specific mission-mode projects in these frontier-areas of research. Ornamental fish breeding and rearing facility has been established at Annamalai Univ.

Over 200 fellowships were awarded to the Universities and academic institutions, out of which 81 fellowships were given to women researchers.
The research projects so far funded under this programme have provided useful results on the history of the sedimentation process; tectonic events before Miocene period including Himalayan drift; physical, chemical and biological oceanography of our sea; provided clues for development of potential drugs and chemicals from the marine organisms; etc.

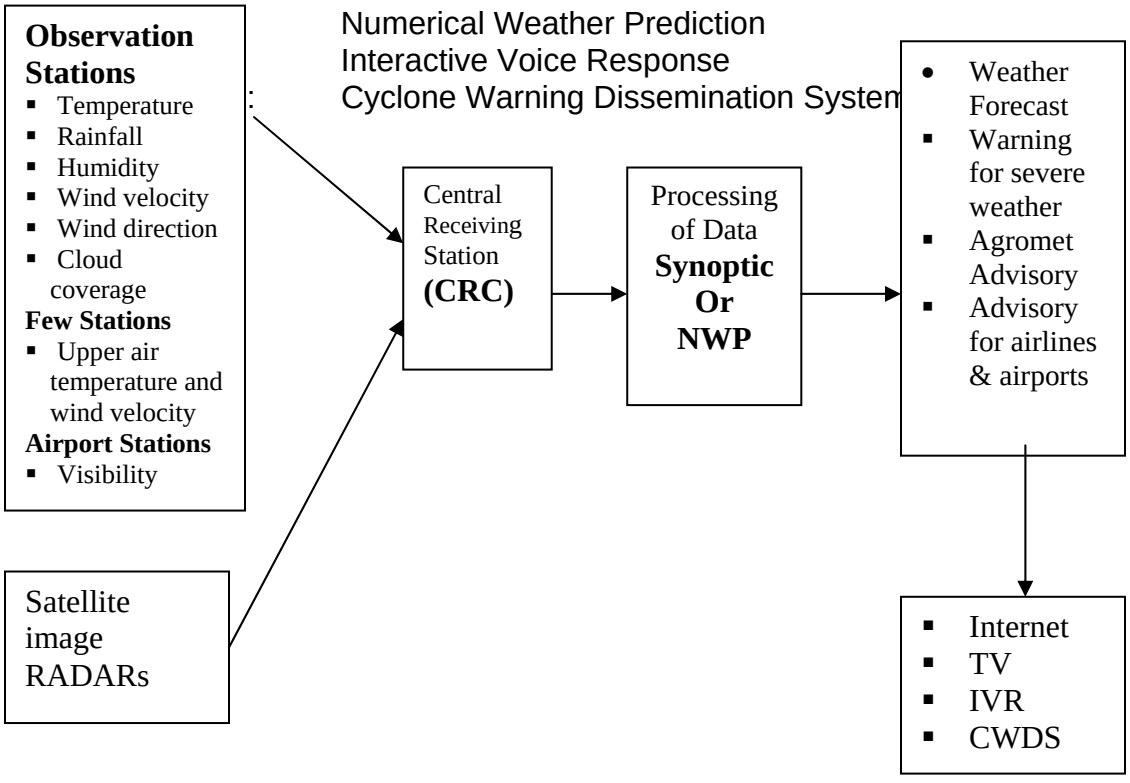
(B) ATMOSPHERIC SCIENCES

INDIA METEOROLOGICAL DEPARTMENT (IMD)

The India Meteorological Department (IMD) is the national meteorological service of the country and is mandated to take meteorological observations and

to provide current and forecast meteorological information for optimum operation of weather/sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc. It also generates warning against severe weather phenomena like tropical cyclones, north westerlies, dust storms, heavy rains and snow, cold and heat waves, etc. which cause destruction of life and property. The operation involved can be depicted in a schematic diagram as given below:

Data Collection	Data Transfer	Data Processing	Weather Products Generation and Dissemination



SERVICES RENDERED:

(1) **Agromet Advisory**:

IMD provides weather bulletins for farmers along with agro-meteorological advisory and crop weather calendars. However, these are provided for the whole State and not at the level of districts and talukas. Similar services is also being provided by NCMRWF in collaboration with State Agricultural Universities. Two

units of the same Ministry providing similar service is not advisable and hence the newly created Ministry has initiated steps to consolidate their efforts and have in place only one unit responsible for providing agromet services for each agro-climatic zone covering all the districts of the country.

(2) **Advisory to Civil Aviation Sector**:

IMD provides meteorological service to the national and international civil aviation sector in fulfillment of the requirements prescribed by the International Civil Aviation Organisation and the Director-General of Civil Aviation. For this it has aeronautical meteorological offices at the four international airports at New Delhi, Mumbai, Chennai and Calcutta, which work as forecasting offices and serve flights in their respective flight information regions. These offices provide forecasts of winds and temperature required for flight planning, prognostic weather charts, forecasts for aerodrome weather for landings and take-offs, and significant weather information for aviation operations. IMD also has aeronautical meteorological offices at all major national and international airports in the country. For observational support to the aviation services, IMD maintains 71 Current Weather Observatories within the country. The forecast is generated manually on charts based on data obtained from GTS. The system prevalent today is old and archaic and needs immediate improvement.

(3) **Weather Forecasts**:

IMD provides forecasts of storms, severe weather conditions and also provides climatological statistics for operation and planning in the field of agriculture, aviation and water conservation, etc. Synoptic forecasting is used as Numerical Weather Prediction models (NWP models) being used are of vintage. Also the department does not have high performance computing system for running global data using latest NWP models. The forecasting capability also gets limited on account of small number of observation stations. Increasing number of observation stations and use of NWP form part of modernization plan of IMD.

(4) **Hydro-meteorological Services**:

IMD provides meteorological support for flood warning and flood control operation by the field units of Central Water Commission. It maintains rainfall statistics, hydro-meteorological studies for different river catchments, probable impact precipitation, time distribution of rainfall, intensity-frequency analysis of rainfall which are used by design engineers for construction of dams, railways, road bridges, culverts for different Central and State Government organizations.

(5) **Positional Astronomy**:

The Nautical Almanac Unit of IMD located at Kolkata meets the national needs for astronomical data for scientific and general purposes. The unit publishes Indian Astronomical Ephemeris, tables of sunrise and sunset and moonrise and moonset and Rastriya Panchang in 14 languages.

INFRASTRUCTURE:

The accuracy of forecast/advisory depends on following factors

- Number of observation stations and how dense they are.
- Quality of instruments being used for collection of data over ground as well as from upper air
- How quickly the data reaches CRC from all locations without any distortion
- Whether data transmission is manual or automated
- The methodology of processing data, i.e., whether Numerical Weather Prediction (NWP) Models are being used and quality of NWP models.
- The methodology adopted for dissemination of forecast or advisory
- Methodology of getting feedback from users to improve the models
- How quickly we adopt new technology.

(6) **Atmospheric Observation System:**

The collection of atmospheric observational data forms the backbone of IMD. The data is collected from 435 observation stations which are run manually providing data on temperature, rainfall, humidity, wind velocity and direction and cloud cover. The second set of data comes from few radars installed in the coastal areas, wind profilers installed at airports and radio-sonde/radio wind used at some of the observatories for collection of upper atmosphere data. The IMD also gets satellite image from dedicated meteorological satellite ‘ Kalpana’ and other satellites.

Out of 435 observations stations, 198 are run departmentally which collect data at 3-hour interval. The 237 non-departmental observatories are run by teachers, state government officials, etc. who work on part time basis and collect data twice a day. The data from these stations are collected through fax, telephone and telegram in the meteorological centres at state capitals and then transmitted through AMSS to regional telecom hub (RTH) at Delhi. The data in respect of 80 stations which are WMO stations are put on the GTS. Not only is the number of observation stations too small for a country like India which has more than 600 districts, the availability of data from them is also not regular.

Thus the number of observation points needs to be increased and the system of collection of data through telegram, tele-printer, fax, which is archaic and obsolete needs to be replaced with latest systems where observations taken are automatically transmitted through satellite or using GSM network or other automated system.

(7) **Computation Power**:

The computational power available with IMD is not capable of running global numerical models. This is a big handicap for IMD as a result of which it has to rely on synoptic method. High Performance Computing power alongwith latest NWP models are urgently required.

(8) **Dissemination of Information**:

Traditionally Doordarshan, All India Radio and print media have been the medium for dissemination of weather related information or advisories. Today, these are also being made available through the website of the Department. New medium of dissemination like cellular phone etc. are being worked out in addition to enhancement of quality of interactive voice response system (IVRS). The department is now working to provide weather forecast for next 5 days and the agromet advisory at district level.

(9) **Cyclone Warning Dissemination Service (CWDS)**:

CWDS of IMD does direct broadcast of cyclone warning in regional languages to the likely affected areas. There are 352 stations along Indian coast which are equipped to receive the cyclone warning. Cyclone warning centres located at Chennai, Mumbai and Kolkata are responsible for originating the warning through CWDS. This service is unique because the recipients can be selectively addressed through special CWDS receivers and area specific messages can be sent to the users. These receivers are unattended and get activated on receipt of warning. Even when all other means of communication break down, the CWDS keeps working via satellite and onboard battery power. This system is going to be integrated with the Tsunami Warning System for disseminating tsunami warning.

The description of services being provided by IMD today and the infrastructure available with it, brings out the inadequacies of the existing system and the need of a big push required to be given to make IMD a world class meteorological organization. A comprehensive modernization plan has been chalked out, brief of which is given below:

PROPOSED MODERNISATION PLAN:

(10) **Modernisation of India Meteorological Department**: Despite India's effort to keep pace with the advanced countries in learning how and why various geophysical parameters vary in space and time, our current system of atmospheric observations is fragmented and incomplete to meet the requirement of the country. Therefore, a new integrated approach is called for, which

improves the Atmospheric Observation System, which is an important component of Earth Observation System. This would enable full impact of the modern technology in realizing its benefits to the people, to the economy of the country and even for the planet Earth. The time is ripe and with the Meteorology being placed under the newly formed Ministry of Earth Sciences (MoES) a vigorous effort is under way to modernize the Atmospheric Observation System and integrate its different components to monitor the 4-dimensional structure of the atmosphere for global, regional and national levels on different spatio-temporal scale. A committee, appointed by the MoES has worked towards recommending the development of such an Integrated Atmospheric Observation System in the context of broad, crosscutting societal, scientific and economic imperatives with focus on specific and achievable benefits.

An **Integrated Atmospheric Observation System** is needed which would consist of an optimized network to provide comprehensive atmospheric, hydrological, land surface and oceanic data to meet the expanding needs of diverse client communities. At present there is no capability in IMD to automatically receive all the observations from about 20000 sensors planned to be installed by different organizations in the country in the next five years. These include Doppler Weather Radars and INSAT cloud imageries that are planned to be received at a central location viz. Central Information Processing System that would have 20 Tera bytes of on-line storage to receive, decode, quality check and store all data and meta data information. This would provide information for nowcasting services as well as provide input to the numerical models for various operational and research activities. It is proposed to have high band connectivity from various observational platforms to the central information processing system as well as to all the meteorological centres and forecasting offices over the entire country. This will **enable creation of an environment where the forecasters would have all the relevant information (including NWP products, synoptic information with proper visualization packages etc.) for effective forecasting within a very short span of time**.

It is emphasized that the Atmospheric Observation System must continue to evolve in the subsequent years succeeding the 11th five year plan to meet the changing needs of the society taking into account emerging technologies and scientific advances. There has been an escalation in the demands from various user agencies for accurate weather forecasts and provide services for (i) warnings for hazardous weather phenomena and tropical cyclone track predictions (ii) hydrological services including flood warnings and (iii) climate information and advice in the application of meteorological knowledge and data. There are varieties of specialized services which require meteorological observations and measurements in short- medium - and long-range scale, warnings against adverse events and environmental protection purposes.

To meet these requirements, IMD proposes to operate an advanced **Global Data Processing System (GDPS)** driven by regional and global models.

Using all conventional and non-conventional data available from weather satellites, aircrafts and Doppler Weather Radar (DWR) in round the clock mode, the GDPS operations will update the forecasts in at least six hourly cycles.Weather and climate predictions are increasingly becoming important components of decision support system in various sectors of economy of the country. Over last two decades significant progress has been achieved in reliability of weather prediction through **Numerical Weather Prediction (NWP)** in the developed world. NWP makes use of laws of atmospheric motions, thermodynamic laws etc. to provide prediction of weather from hours to days and months in advance. Such a system includes data acquisition from different observational platforms around the globe, their pre-processing and assimilation for preparation of appropriate initial conditions for the global and regional models. These in turn predict the future state of the atmosphere that is analyzed through appropriate post-processing and visualization processes. Preparation of initial conditions is key to accurate numerical prediction. Use of various data, particularly from satellite is crucial, for which the special efforts are made. Since NWP activities involve voluminous global data handling along with exhaustive numerical calculations including data archival etc., high end computing facility becomes an integral part of the whole system to cater to the needs of running high-resolution models with high-density network of observations.

In order to cater to the demands, it is required that very high resolution models (global models of 50 km resolution, and about 10-5Km resolution mesoscale models) are run daily more than once. In view of the above requirements of running these models along with GDPS requirements for data storage a **strong need exists for acquiring HPC system with peak performance of about 10TF** in New Delhi. It is estimated that a system of peak performance of about 1TF shall meet IMD, Pune's requirement where a mirror image of the data centre is planned to be set up.

Agromet Services is one of the crucial and important aspects that the National Weather Service addresses. For this it is pertinent that forecast based Agromet Advisory Services(AAS) are developed. To develop the AAS network, the country has been divided into 127 agro-climatic zones with each zone covering about 4 to 5 districts. So far, a network for 107 AAS units has been set up. Location specific forecasts using numerical weather prediction techniques for next 4 days are issued to these AAS units. Based on the 4 day forecasts, the AAS units prepare agro-advisories for their agro-climatic zones on every Tuesday and Friday. The Agricultural advisories are in turn disseminated to the farmers through media and also through personal contact. The service is run at present from NCMRWF in collaboration with State Agricultural Universities, Indian Council of Agricultural Research (ICAR). On the other hand, IMD in collaboration with State Departments of Agriculture (SDA) jointly prepares Agro-met Advisory Bulletins (AABs) for the entire State from its 23 State Agro-met Service Centres. The bulletins are prepared on every Monday & Thursday and are disseminated through AIR, Doordarshan, Print media and IMD website.

Real time detailed bulletin is prepared regularly that comprise of observational facts of various crop related weather information for the previous week along with weekly weather forecasts and forecast based agro-advisories. These are prepared on weekly basis and provided to concerned Govt. Depts./agencies/planners during the monsoon seasons since 2004.

At the national level, there has been great demand from Ministries of Agriculture and Home Affairs etc. that this service be integrated to provide seamless weather forecast to the farming community of the country so that they can for take tactical and strategic decisions. The AAS has to address information requirements for different cropping systems and arrange to provide the same online, with minimum time loss between preparation of weather forecast to its delivery in the form of agro-met advisory to the end user. This service requires strengthening and a committee has been set up specifically to address this issue. The committee recommends the integration of agro-met advisory services of IMD and NCMRWF with more farmer-centric approach having wider outreach along with integration of available manpower and other resources. It is planned to have a strong IT enabled communication link upto the final user level. The committee also recommends organization of the service under MoES in a five-tier structure, which may operate as per recommended roles and responsibilities. The committee proposes to form a close liaison with number of departments/agencies to issue need based agro advisories on real time basis at agro climatic zone level (with due address to district level variability) and subsequently at improved spatial resolutions.

Aviation sector is witnessing a tremendous growth mainly owing to the advancements in computation and communication technologies, coupled with the increased private participation and competitiveness among the airlines. To keep in pace with these activities, it necessitates that the meteorological support to aviation should also have commensurate improvement in the facilities. Hence, for re-looking and revamping the meteorological support to aviation aiming at a cost effective, seamless and globally harmonized air navigation, a committee was constituted by the MoES. The important mandates of the committee were to arrive at a methodology to make the aviation met services more professional and tailor- made to user specific requirements. It was also aimed to introduce improved modern observational and product delivery systems to make it at par with the services provided at state-of –art airports at other parts of the globe.

The committee has suggested a comprehensive set of recommendations that include improvement in observational aids, establishment of a fool-proof information dissemination system to all user agencies, establishment of a National Aviation Meteorological Centre (NAMC) integrating all the aviation met activities along with proper quality Management and ISO Certification for all the aviation meteorological services.

(11) **Instrumentation Development at IMD:** IMD is producing atmospheric data instruments which have obsolete technology and do not provide accurate data. A comprehensive plan to undertake the development of upper atmosphere instrumentation, automatic rain gauges, and automatic weather stations has been taken up and good progress is already seen in past few months. It is also proposed to set up R&D centers for instrumentation at New Delhi and Pune and upgrade the test, calibration and standardization facilities. The Radar Laboratory at New Delhi will be equipped with facilities in tune with the new types of radars that are being installed and would have to be maintained. The workshops at Delhi and Pune would be modernized with fully automatic/semi-automatic machines which will help to turn out quality products in a more efficient manner.

(12) **NWP Activity at National Centre for Medium Range Weather Forecasting (NCMRWF)**

Numerical Weather Prediction, a technique which uses Numerical Models for predicting weather. It has been at the core of weather and climate predictions. NWP makes use of laws of atmospheric motions, thermodynamic laws etc. to provide prediction of weather from hours to days in advance.

National Centre for Medium Range Weather Forecasting (NCMRWF) is a project of the MoES and at present is the only Centre which has an end-to-end global and regional NWP system in place. The Centre generates numerical prediction in real time for operational use, particularly to provide location weather prediction for agriculture sector and for extreme weather events relevant to early warnings related to disaster events such as tropical cyclones, heavy rainfall, flood, drought, heat/cold waves etc. Such a system includes data acquisition from different observational platforms from around the globe, pre-processing of observational data, data assimilation to prepare appropriate initial conditions, global and regional models to predict future state of atmosphere and weather, post-processing, visualization, and dissemination. Preparation of initial conditions is key to accurate numerical prediction. Use of various data, particularly satellite data in preparation of initial conditions is crucial. The Centre makes special effort to prepare accurate initial conditions. The Centre also carries out diagnostic studies to improve the performance of the models and verification of forecasts. The NWP requires use of very high end computing facility. The Centre maintains such a supercomputing facility. The data and products from the Centre are disseminated to user agencies and are also kept on its web page. The Center is being further strengthened so to enable it to engage in development of futuristic models and data assimilation techniques, to develop innovative techniques such as ensemble, coupled, and earth system framework modeling for providing prediction over all time ranges and spatial domains.

(13) **Research in Tropical Meteorology:**

Basic and applied research in monsoon meteorology of the tropics in general with special reference to monsoon meteorology in India and neighbourhood is being carried out at Indian Institute of Tropical Meteorology, Pune with following objectives:

- To conduct basic research in all the aspects of atmosphere-ocean-land system with special reference to the tropics required to improve prediction of weather and climate in the region.
- To build trained human resource in the field of atmospheric and oceanic sciences required by the country.

The achievements made so far under existing programme are given below:

- Unravelled several aspects of monsoon variability and teleconnection with global climate such as ENSO using theoretical, experimental and observational techniques.
- Provided long-term quality controlled data sets on all-India and sub-divisional rainfall and surface temperature to many researchers in India and abroad for monsoon variability and global teleconnection studies.
- Discovered predictors for long range prediction of monsoon that have been used by IMD for monsoon prediction.
- Reconstructed for the first time, tree ring chronologies for reconstruction of monsoon climate in India spanning more than 5 centuries.
- Estimated projection of monsoon under climate change scenarios and provided to researchers working on agriculture, water resources and human heath related problems.
- Provided tailor-made Hydrometeorological products to several central and state agencies dealing with water resources management, flood control and hydropower generation.
- Provided technical guidance to various State Governments in their operational rain enhancement programmes based on experience gained during Institute's 11-year long warm cloud modification experiments.
- Gained important insight on rain formation processes via cloud electricity through laboratory experiments and field observations. Also studied direct and indirect effects of aerosols on climate through observations and modeling.
- Produced 15 Ph.D.s, 26 M.Tech. (through collaboration with Pune Univ.) and published 301 papers in refereed journals (cumulative impact factor 356.322**)** during last 5 years. IITM scientists are decorated with S.S. Bhatnagar Award 2006 and WMO Award 2005.

The institute has chalked out a new program called "Climate Dynamics and Extended Range Prediction of Monsoon" to meet the important national need of reliable extended range prediction of monsoon and to establish India's stand on a variety of issues related to global warming and climate change. This will include following major new focused activities:

- Long-range prediction of seasonal mean monsoon and extended range prediction of active/break spells, involving atmospheric, oceanic and coupled ocean-atmosphere models.
- Estimation of uncertainty of monsoon projection under climate change scenarios.

- Unravelling science of climate variability and climate change and application of the knowledge for societal benefits and policy making.
- Observational and modelling study of interaction between clouds and environment leading to precipitation, involving a mobile Doppler precipitation cum weather radar, GPS radiosonde and a lightning discharge network.
- Development of infrastructure (e.g. high performance computer, modern information system in meteorology and atmospheric sciences, stable isotope laboratory, instrumented tower.). It also involves renovation of existing office buildings and residential quarters, and construction of a students' hostel and new residential quarter.
- Development of a comprehensive training programme to meet the requirement of experienced manpower for improving weather and climate prediction in the country.

(C) EARTHQUAKE and SEISMIC HAZARD RELATED

(1) Earthquake Risk Evaluation and Seismic Hazard and Risk Microzonation

Earthquake is the most dreaded natural disaster especially for its intrinsic nature to unleash devastation instantaneously in large area without leaving much scope for prevention of hazard after the occurrence of the event. Surveys of earthquake affected areas reveal that apart from physical damages to terrain and man made structures, the impact of earthquake becomes part of the social psyche. Hence, compared to other natural disasters, earthquake calls for better pre-disaster prevention and preparedness rather than resorting to fateful measures of 'Rescue', 'Relief' and 'Rehabilitation' (3R). Emphasis is now laid on proactive pre-disaster plans action using appropriate Prevention, Mitigation and Preparedness (PMP) for vulnerability reduction.

In this endeavor, Earthquake Risk Evaluation Center (EREC) has been setup in February 2004 to provide earthquake risk related *knowledge products,* develop suitably distributed *Information Systems and* vibrant *user Interface* to constantly interact with various agencies to communicate the knowledge products and their implications, *articulate* well considered regulatory and legislative measures for effective mitigation of risk, *catalyze* development of *evermore-effective* risk assessment and mitigation approaches and systems, undertake/sponsor user based training programs of scientists and other relevant members of the concerned community.

EREC has framed long term and short-term programs in this regrad. The long-term programs are targeted to collate multi-thematic database for providing inputs to disaster mitigation for scenario earthquakes and event incidences based on regional appraisal of seismic hazard, vulnerability and exposure factors. The other goal of long-term programs would be "Earthquake awareness" through multimedia interactions. The short-term programs are focused to

generate “Seismic Hazard and Risk Microzonation Map” for targeted cities in stipulated times frame.

Seismic Hazard and Risk Microzonation (SHRM) which is a process of classifying the given geographic domain into small units of likely uniform Hazard level (Peak Ground Acceleration), hazard nature (liquefaction and slope failure) and Risk, offers the most effective tool for earthquake risk evaluation and generates database for planning pre-earthquake disaster management. As a short-term program, EREC has evolved 1st level Seismic Hazard Microzonation of NCT Delhi on 1:50000 scale and a total 15 multi-thematic maps pertaining to ‘Geoscientific’, ‘Geotechnical’ and ‘Site-Response’ characterizations have been generated and integrated in GIS base. The 1st level microzonation map divides the territory of NCT of Delhi in 9 units. These products have been made public by the Hon’ble Minister of Science & Technology and Ministry of Earth Sciences in December 2005. Further studies of Seismic Microzonation of NCT Delhi with higher precision on 1:10,000 scale for more societal use has been started. This would provide attributes of hazard for all microzones with site-specific details. The ‘Hazard’ would be integrated with results of collateral studies on ‘Vulnerability Analysis’ for final risk microzonation.

For detailed information please refer to Ministry’s website www.moes.gov.in.