IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES

Central Water Commission,
New Delhi.

1. Climate and Climate Change

Climate is defined as “average weather”, describing in terms of mean and variability of relevant quantities of weather parameters over a period of time, say a classical period of 30 years, as defined by World Meteorological Organisation (WMO). These parameters are most often surface variables such as temperature, precipitation and wind. Intergovernmental Panel on Climate Change (IPCC) defines “any change in climate over time, whether due to natural variability or as a result of human activity” as Climate Change (CC). However, UN Framework Convention on Climate Change (UNFCCC) attributed Climate Change to human activity which directly or indirectly alters the composition of the global atmosphere in addition to natural climate variability observed over comparable time period. Whatever way we define, due to visibility of impact, Climate Change is not only a major global environmental problem, but also an issue of great concern to a developing country like India.

2. Global warming and India

The earth’s atmosphere - the layer of air that surrounds the earth - contains many gases. These greenhouse gases modify the heat balance by retaining long-wave radiation reflecting from earth surface that would otherwise be lost through the Earth's atmosphere to space. This effect is known as the greenhouse effect. Evidently, greenhouse gases have an important role in controlling the temperature of earth and an increase in their concentration in the atmosphere would increase the temperature of the Earth. The IPCC observed that global average air temperature near earth’s surface rose to 0.74 ± 0.18^0 C in the last century.

Studies have been carried out to analyze the trends of variation in temperature over India/Indian Sub-continent and to compare the results with global trend. An analysis of temperature data of 125 stations distributed all over India shows an increase of 0.42, 0.92 and 0.09^0 C in annual mean temperature, mean maximum temperature and mean minimum temperature respectively in last 100 years. However, the trends are varying on regional basis. It has been observed that the changes in temperature in India over last century are broadly consistent with global trend of increase in temperature. High-resolution climate change scenarios have been generated for different regions of India. Some of the major findings concerning water resources are:

- The rainfall scenarios are dependent on climate scenarios.
- There are substantial spatial variations in rain fall. The maximum expected increase in rainfall (10 to 30%) is likely over central India.
- There is no clear evidence of any substantial change in the year-to-year variability of rainfall.
- Surface air temperature shows comparable increasing trends by as much as 3 to 4° C towards the end of the 21st century.
- The warming is widespread over the country, and relatively more pronounced over northern parts of India.
- Observed Changes in Climate & Weather Events in India

There are some observed changes in climate parameters in India.

Temperature

An analysis of the seasonal and annual air temperatures from 1881 to 1997 shows that there has been an increasing trend of mean annual temperature at the rate of 0.57° C per 100 years. A higher rate of warming has been observed in some pockets. Majority of basins (7 river basins: Ganga, Indus-lower, Mahanadi, Mahi, Narmada, Brahamani & Subaranrekha, and Tapi) have experienced an increasing trend in mean annual temperature over the last century, while 2 basins (Sabarmati and Luni & other small rivers) have experienced cooling trends. For the warmer basins the range of increase in mean annual temperature varied between 0.40 to 0.64° C per 100 years and for the cooler basins it varied between –0.15 to -

0.44° C per 100 years. However it has been reported that the warming has been more pronounced from 1970's onwards.

Rainfall, Rainy days and Extreme Rainfall Events

Though the overall monsoon rainfall in India does not show any discernible trend over a long period of time, particularly on the all India scale, yet there are pockets of significant long-term rainfall changes. Majority of river basins have shown increasing trend (2 to 19%) both in annual rainfall and relative humidity (maximum increase reported in Indus and Tapi river basins). Seasonal analysis shows maximum increase in rainfall in the post-monsoon season followed by the pre-monsoon season. There were least variations in the monsoon rainfall during the last century and winter rainfall has shown decreasing trend. Most of the river basins have experienced decreasing trend in annual rainy days with maximum decrease in the Mahanadi basin. The heaviest rain of the year has increased by 9 to 27 mm per 100 years over different river basins (maximum increase in Brahamani & Subaranrekha river basins.) A combination of increase in heaviest rainfall and reduction in the number of rainy days suggest the possibility of increasing severity of floods.

River Runoff

Trend analysis of flows of major Indian rivers including Ganga, Brahmaputra, Chenab and Sone has been carried out at a few sites to understand the trend in monsoon and non-monsoon flows. The analysis & conclusion of the study, which should be considered only with its limitations detailed further below, is as follows:

(a) The analyses of flows based on linear regression of some of the sites in Ganga basin indicate a falling trend (except at few locations) during monsoon but rising trend during non-monsoon. However, the trend is falling on annual flow basis. To understand trend at upstream sites inputs from snow and glacier studies also need to be coupled.
(b) The Brahmaputra basin indicates a falling trend both in monsoon and non-monsoon.
(c) In the light of diverging analysis and the limitations it may be concluded that:
    i. There is a need for more comprehensive study by taking into account all available data.
    ii. There is need for identification of causes in case of change in flow pattern in the rivers distinctly attributable to the finer demarcation of climate change and variability.
    iii. There is a need for capacity building and exposure towards the standard practices being followed internationally.

The main limitation of the preliminary study has been in not accounting for the various important factors like consumptive uses, affecting flow of the river over a long period of time including (i) Irrigation/agriculture development; (ii) Industrial development; (iii) Population growth; (iv) Improved life style; (v) Increased extraction of groundwater; (vi) Changes in precipitation; (vii) Changes in glacial regime etc. in the catchment of the river. The trend thus found may not be true reflection of the changes in the flow at the site of observation.

Rise in Sea Level

Studies of historical rates of relative sea-level rise in the South Asian region indicate an average annual relative sea-level rise of 0.67 mm/yr. Rising trend in the sea level on the west coast has been reported as more pronounced as compared to the east coast. Some studies have quantified this with records of more than 40 years as sea level rise between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC.

Impacts on Himalayan Glaciers

All the major north Indian rivers owe their origin to thousands of glaciers in the Himalayas. There are 9575 glaciers in the Indian Himalayas as per the latest updation of the glacier inventory maintained by the GSI. The Indus basin with its important tributaries flowing in Indian territory viz. Shyok, Nubra, Indus main, Satluj, Beas, Ravi, Chenab and Jhelum support majority of the Indian glaciers i.e. 7997 which is 83.52% of the total Indian glaciers. There are 967 glaciers, besides Gangotri in Ganga basin including its tributaries viz. Yamuna, Bhagirathi, Alaknanda and Ghaghra. Brahmaputra basin including Teesta supports 610

glaciers. The total area covered by the Indian glaciers is about 18054 km^2 whereas the volume is about 1291 km^3.

Average water yield per unit area of the Himalayan Rivers is almost double that of the south peninsular river systems, which indicates the importance of snow and glacier melt contribution from high mountains. GSI has monitored the glaciers in Indus and Ganga basins based on the long-term data ranging from 5 to 150 years and found that they are retreating in general. The observed retreat in the glaciers is varying from 2.5 to 48.8 m/year which works out to an average annual retreat of the majority of the glaciers by about 0.30% of their total length.

3. Some Projections of CC over India for the 21st Century

Some modelling and other studies have projected a rise in annual mean surface temperature by the end of century, ranging from 3 to 5° C under A2 scenario and 2.5 to 4° C under B2 scenario of IPCC, with warming more pronounced in the northern parts of India, from simulations by Indian Institute of Tropical Meteorology (IITM), Pune. This is likely to lead to an intensification of the hydrological cycle that will result in more rainfall of shorter duration due to increase in atmospheric GHG concentrations arising from increased global anthropogenic emissions. (A brief description of four scenarios A1, A2, B1 and B2 considered by the IPCC and other Organization for generating various climatic scenarios is given below.)

Economic emphasis

Global integration	Regional emphasis
A1 storyline World: market-oriented Economy: fastest per capita growth Population: 2050 peak, then decline Governance: strong regional interactions: income convergence Technology: three scenario groups: • A1F: fossile intensive • A1T: non-fossil energy sources • A1B: balanced across all sources	**A2 storyline** World: differentiated Economy: regionally oriented: lowest per capita growth Population: continuously increasing Governance: self reliance with preservation of local identities Technology: slowest and most fragmented development
B1 storyline World: convergent Economy: service and information based: lower growth than A1 Population: same as A1 Governance: global solutions to economic, social and environmental sustainability Technology: clean and resource efficient	**B2 storyline** World: local solutions Economy: intermediate growth Population: continuously increasing at lower rate than A2 Governance: local and regional solutions to environmental protection and social equity Technology: more rapid than A2: less rapid, more diverse than A1/B1

Environmental emphasis

Direct Impacts on Water Resources

IITM conducted an impact assessment of climate change on three of the country's major river basins: Krishna, Ganga, and Godavari.

- The hydrological cycle is predicted to be more intense, with higher annual average rainfall as well as increased drought.
- There is a predicted increase in extreme rainfall and rainfall intensity in all three river basins viz. Ganga, Krishna and Godavari towards the end of the 21st century. The Godavari basin is projected to have higher precipitation than the other two.
- The intensity of daily rainfall is also predicted to increase.
- Changes in the number of rainy days were also examined, with results indicating decreases in the western parts of the Ganga basin, but with increases over most parts of the Godavari and Krishna basins.
- Thus surface water availability showed a general increase over all 3 basins (though future populations projections would need to be considered to project per capita water availability.

4. Basin-wise Situation

All the 20 river basins in India are different from each other in terms of spatial and temporal water resources availability; topography; geo-morphological characteristics; meteorological behaviours etc. and therefore, need focused attention separately. But considering importance

of snow and glacier melt in the Himalayan Rivers and their vulnerability to climate change, special attention is needed for the Himalayan river basins. As such studies have already been undertaken for three regions/basins i.e. (a) Indus basin; (b) Ganga basin; and (c) Brahmaputra basin. Some results are discussed in following paras:

Indus Basin

The Indus basin is endowed with plenty of water resources particularly with the glacial wealth. The stage of irrigation potential created in co-basin States is about 87% which is better than potential created at national level of about 72%. Percentage of storage already created with respect to average annual flow of the basin is about 22% which is also better than the percentage at national level of about 11.7%. The stage of development of hydropower in the basin is in line with stage of development at national level. The basin is not considered as flood prone and the river water quality is comparatively better than the other Himalayan basins. The Himalayan Rivers generally carry high silt load and rivers in Indus basin is not an exception. The basin supports population of about 119 Million in its co-basin States.

The climate change is likely to affect identified aspects of hydrology of the basin and thus various sectors dependent of water resources are going to be affected but when and how much is the vital question to be answered. The various studies carried out by the scientists, academicians and research organizations and Government departments mainly concentrated on meteorological, hydrological including glaciology and snow sciences. It has broadly been brought out that:

(i) There is rising trend in temperature in the basin, however minimum temperature has shown falling trend. Further rise in temperature has been predicted. (*specific studies are further needed*);
(ii) There is falling trend in rainfall in the basin (IITM), whereas the Indus (lower) shows rising trend (NIH). Numbers of rainy days as well as heavy rain events are also increasing (NIH).
(iii) Glaciers of the basin are retreating with varying magnitude which depend on their size, orientation etc. (GSI).
(iv) Various what-if analysis scenarios have been generated for effect of rise in temperature by 1°/2°/3° C as well as change in precipitation by -10/-5/+5/+10% in Chenab, Satluj and Spiti sub-basins on snowmelt as well as on glacier melt runoff. It has been found that: (a) such changes would affect seasonal flows more prominently in comparison to annual flows; (b) rise in temperature would increase glacier melt runoff more in comparison to snowmelt runoff; (c) the scenarios are different for different sub-basins and even within a basin variations are there depending upon altitude in the same basin; (d) an estimate of runoff from glacier melt and snowmelt can be made based on prediction of air temperature.

These studies are based on short-term data collected for the purpose of study only and long-term data collected by the national agencies. Some of the investigators have found data inadequate also for the studies. Findings of one study indicate that reduction in rain gauge network gave substantially higher estimate of annual rainfall. An accurate and validated database from an optimized data collection network is essential for the credible studies and the actionable recommendations. With the ensuing worldwide phenomenon of climate change which is likely to affect water resources scenarios the data collection for different parameters involved in hydrological cycle becomes very important for better understanding and planning accordingly.

Ganga Basin

The Ganga basin is the richest basin in terms of availability of utilizable surface water resources and replenishable ground water resources. The basin also has rich glacier wealth in India while many of its tributaries, which originate from Nepal, are also fed by the glaciers. The stage of irrigation potential created in co-basin States is about 69%, which is slightly less than potential created at national level of about 72%. Percentage of storage already created with respect to average annual flow of the basin is about 8%, which is also less than the percentage at national level of about 11.7%. The stage of development of hydropower in the basin is better than the stage of development at national level. The basin is highly flood prone and about 20.4 MHa area (6.2% of geographical area of the country) of co-basin States is

identified as flood prone by the RBA which has been further increased to 24.25 MHa as reported by the States for XI Plan finalization. The river water quality is also a concern as about 14% of river length is considered to be severely polluted and about 28.5% is moderately polluted. The Ganga and its tributaries also carry high silt load. The basin supports population of about 544 Million in its co-basin States.

The various studies carried out for the Ganga basin also concentrated on meteorological, hydrological including glaciology and snow sciences as was the case with Indus basin. Some of the studies were carried out for sedimentation in rivers also. The summarized findings, in addition to the discussion made for Indus basin, have been listed below:

- There is a rising trend in temperature in the basin except minimum temperature in monsoon period which is showing falling trend. Further rise in temperature has been predicted.
- Rainfall trend studies have been carried out by IITM and NIH. It has been observed that the results are varying for the data periods taken. The results are also not consistent if the set of observation sites for which data has been considered in the studies are different. NIH has indicated rising trend in rainfall; falling trend in number of rainy days but rising trend in heavy rain events. IITM with DEFRA predicted a 12% rise in annual rainfall by 2071-2100 in the basin due to climate change. A similar rise has been predicted in the annual flows also.
- Glaciers of the basin are also retreating with varying magnitude (GSI).
- Various Studies conducted in Ganga basin show similar type of findings as were recorded for Indus basin. Much of the work has been done on Gangotri and Dokriani glaciers. Some additional work has been done on *suspended sediment transport.*
- Much of the upstream basin lies in the neighbouring country Nepal which is covered by snow and glaciers. Similar studies are needed for that catchment also. Government of Nepal and other scientists have done some studies and concluded almost on similar lines though the data considered for the studies was comparatively of lesser duration. No significant trend has been found in precipitation and river flows. GLOF has been identified as a problem to water resource development and proposed to adapt design considerations specific to GLOF.

Data inadequacy for the studies is also an issue in this basin. GoI stakes are highest in this basin as about half of the interlinking schemes are planned for transferring of water either to or from this basin. To have a better and optimized planning of schemes that are highly capital intensive, an accurate and validated database is essential.

There is already a substantial increase of about 19% over flood prone area as assessed by the RBA in the co-basin States and the same as reported by the States for formulation of XI Plan. As the flood events and intensity are likely to increase due to climate change phenomenon the flood prone area is further likely to increase. The likely increased sediment flow may affect the morphology of the rivers.

Brahmaputra, Barak and other Basins

The basin has glacier wealth in India but large part of the glaciers lies in China and Bhutan. Almost all water resources development indicators show relatively less development including irrigation potential created in co-basin States; storage already created; development of hydropower etc. This basin is also flood prone like Ganga basin with about 3.58 MHa area of co-basin States (except West Bengal) identified as flood prone by the RBA which has been further increased to 4.49 MHa as reported by the States for XI Plan finalization. The entire Brahmaputra river length comes under relatively clean status. The rivers in the basin carry high silt load like other basins in the Himalayas. The basin supports population of about 39 Million in its co-basin States (except West Bengal).

However, by and large the discussions summarized for Ganga basin holds good for this basin also. Data inadequacy for the studies is a serious issue in this basin. GoI stakes are also very high in this basin as it is richest in terms of hydropower potential and proposed interlinking schemes are planned for this basin. Accordingly, the need described for creation of river basin organizations for all the river basins in the country is further strengthened. Other flood management related issues are similar to those of Ganga basin.

5. National Action Plan for Climate Change

The National Action Plan on Climate Change (NAPCC) was released by the Prime Minister on 30-06-08. It outlines a national strategy that aims to enable the country adapt to climate change and enhances the ecological sustainability of India's development path. It stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability of the impacts of climate change.

Eight National Missions form the core of the National Action Plan, representing multi-pronged, long term and integrate strategies for achieving key goals in the context of climate change. These Missions are:

1. National Solar Mission:
2. National Mission for Enhanced Energy Efficiency:
3. National Mission on Sustainable Habitat:
4. National Water Mission:
5. National Mission for Sustaining the Himalayan Ecosystem:
6. National Mission for a "Green India":
7. National Mission for Sustainable Agriculture:
8. National Mission on Strategic Knowledge for Climate Change:

Ministries with lead responsibility for each of the missions were directed to develop objectives, implementation strategies, timelines, and monitoring and evaluation criteria, to be submitted to the Prime Minister's Council on Climate Change. The Council will also be responsible for periodically reviewing and reporting on each mission's progress. To be able to quantify progress, appropriate indicators and methodologies will be developed to assess both avoided emissions and adaptation benefits.

6. National Water Mission

Ministry of Water Resources is the nodal ministry for National Water Mission. Water Resource schemes and projects are multidisciplinary in nature and are implemented by several departments and agencies of State Governments and various ministries/departments of Central Government. Therefore, it was been considered necessary to examine all related issues through a consultative process. Accordingly, Ministry of Water Resource (MoWR) constituted six Sub-Committees to examine all related aspects in the field of:

(a) Policy and Institutional Framework;
(b) Surface Water Management;
(c) Ground Water Management
(d) Domestic and Industries Water Management;
(e) Efficient Use of Water for Various Purposes; and
(f) Basin Level Planning and Management.

Based on the objectives of the National Water Mission, identified key areas to be addressed, and recommendations of these Sub-Committees, a Comprehensive Mission Document for National Water Mission was prepared.

The "National Water Mission" was approved by Hon'ble Prime Minister's Council on 30-08-10 and by the Union Cabinet on 06-04-11 with the objectives of "conservation of water, minimizing wastage and ensuring its equitable distribution both across and within States through integrated water resources development and management". The Mission has set five goals to achieve the above objective, which are:

1. Comprehensive water data base in public domain and assessment of the impact of climate change on water resource
2. Promotion of citizen and state actions for water conservation, augmentation and preservation
3. Focused attention on vulnerable areas including over-exploited areas
4. Increasing water use efficiency by 20%
5. Promotion of basin level integrated water resources management

Various strategies for achieving the goals have been indentified which lead to integrated planning for sustainable development and efficient management with active participation of the stakeholders.

Although the impact of climate change on water resources has not been accurately quantified, various studies indicate that the likely impact of climate change on water resources could contribute to further intensification of the extreme events. The likely impact of climate change on water resources could be in the form of:

- Decline in the glaciers and the snowfields in the Himalayas;
- Increased drought like situations due to overall decrease in the number of rainy days in many parts of the country;
- Increase flood events due to overall increase in the rainy day intensity;
- Effect in ground water quality in alluvial aquifer due to increased flood and drought events;
- Influence on groundwater recharge due to changes in precipitation and evapo-transpiration; and
- Increased saline intrusion of coastal and island aquifers due to rising sea levels.

For achieving the objectives of the National Water Mission, long-term sustained efforts both in terms of time bound completion of identified activities and ensuring the implementation of identified policies and enactment of necessary legislation through persuasion at different levels with the State Governments have been envisaged.

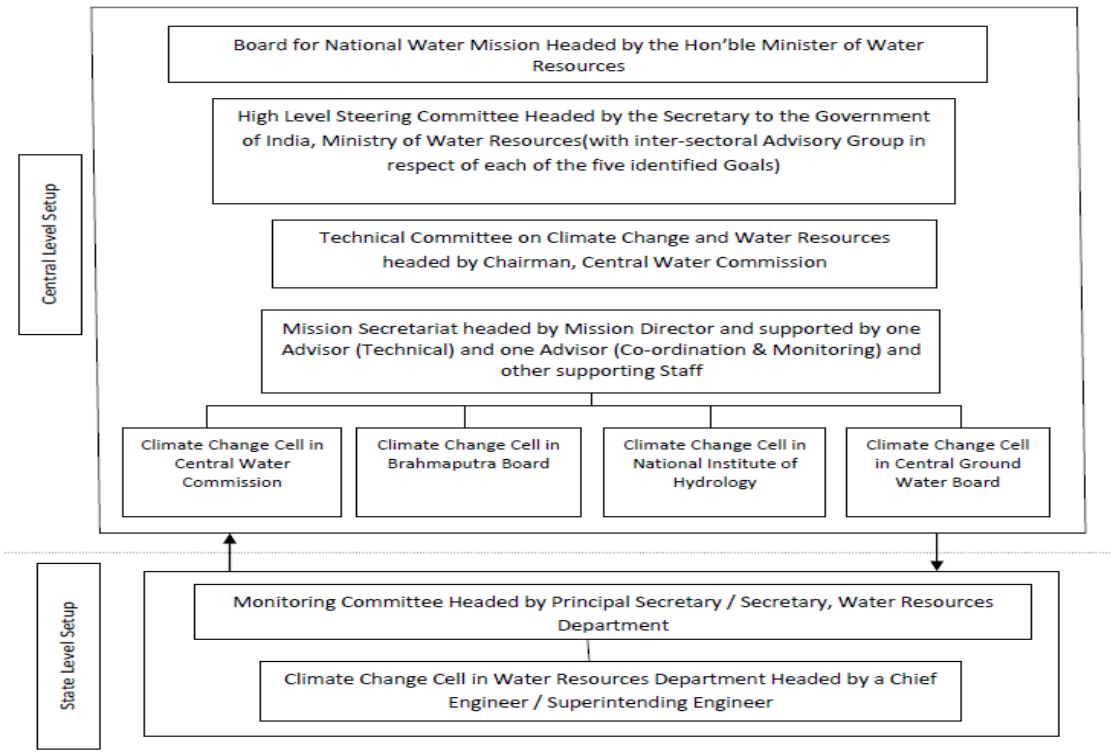
Most of the programmes related to water resources come under the purview of the State Governments and are being implemented by them. Further several Central Ministries and Organisations are responsible for implementation of activities related to water resources. A two-tier setup has been proposed one at Central level and the other at State level to implement the Strategies of National Water Mission as given below:

Goal 1: Comprehensive water data base in public domain and assessment of the impact of climate change on water resource

The key areas identified in the NAPCC in respect of data base & assessment of impact of climate change on water resources and the identified strategies to achieve the objectives are given below:

1. Review and establishment of network for collection of additional necessary data.
2. Development of Water Resources Information System and development of Web enabled Ground Water Information System and placing them in public domain.
3. Development / implementation of modern technology for measurement of various data.
4. Developing inventory of wetland.
5. Research and studies on all aspects related to impact of climate change on Water resources including quality aspects of water resources with active Collaboration of all research organizations working in the area of climate change.
6. Reassessment of basin wise water situation.
7. Projection of the impact of climate change on water resources - Projection of water resources availability as a result of impact of climate change Which would inter-alia include the likely changes in the characteristics of water availability time and space.

Institutional Setup for National Water Mission



CWC has reviewed the hydro-meteorological network requirement for adequate data collection for water resources planning with a view to strengthen data base for continuing studies w.r.t. to impacts of Climate Change on Water Resources. Accordingly, proposal for expansion of hydro-meteorological network of CWC from present 878 sites to about 2008 G&D sites had been made for the 12th Five Year Plan.

The CWC has development of water resources information system with NRSC Hyderabad and the upgraded India-WRIS Web GIS version 3.0 launched in Dec 2012 (World Water Day) at New Delhi. Further development is under progress.

CWC has taken up the work of "Inventory and Monitoring of Glacial Lakes/Water Bodies in the Himalayan Region of Indian River Basins" with NRSC, Hyderabad during the 11th plan period continuing in 12th Plan. "Inventory of Glacial Lakes/Water Bodies in the Himalayan Region of Indian River Basins" with spatial extent greater than 10 hectare has already been prepared covering Indus, Ganga and Brahmaputra basins and also been placed on Water Resources Information System. Monitoring of Glacial Lakes/Water Bodies size more than 50ha has started thereafter on regular basis during monsoon periods. A customized one week training for CWC Officers was organized at NRSC, Hyderabad during October 2012.
CWC has completed re-assessment of two pilot basins viz. Godavari, Brahmani and Baitarani associating with NRSC, Hyderabad and now taking up full scale work for all the basins of the country.

It is proposed to downscale climate change and assess impact of climate change on water resources in each of 2o major river basins. There are about 23 Global circulation Models (GCM) at 200-300 km grids available worldwide to forecast future climate change scenario. Some Regional Circulation Models (RCMs) at 50 km grids have also been developed to suit regional climate pattern. These global/regional models need to be downscaled and translating them to a finer spatial scale, say at 10 km grids, to assess the likely impact of climate change on water resources scenario in each of the 20 major river basins. Such downscaling will enable taking appropriate decisions about water utilization, etc.

An exclusive committee Indian National Committee for Climate Change (INCCC) has been formed under the chairmanship of Additional Secretary (Water Resources) & Mission Director. The committee has recommended 17 proposals covering 18 basins (out of 20 basins as identified by CWC) from 27 academic & research institutes including IITs NITs NIH & others

for taking up these studies. One study for statistical down scaling impacts from Global scale has also been recommended.

Goal 2: Promotion of citizen and state actions for water conservation, augmentation and preservation

The "Promotion of citizen and state action for water conservation, augmentation and preservation" becomes an important goal of the Mission. The identified strategies to achieve the objectives are given below:

1. Empowerment and involvement of Panchayati Raj Institutions, urban water bodies, Water Users' Associations and primary stake holders in management of water resources with focus on water conservation, augmentation and preservation.
2. Promote participatory irrigation management.
3. Sensitization of elected representatives of over exploited areas on Dimensions of the problems and to orient investment under MNREGP towards water conservation.
4. Provide incentives for water neutral and water-positive technologies in industry.
5. Encourage participation of NGOs in various activities related to water Resources management, particularly in planning, capacity building and mass awareness.
6. Involve and encourage corporate sector / industries to take up, support and Promote water conservation, augmentation and preservation within the industry and as part of corporate social responsibility.

The above work of sensitization and capacity building in all parts of the country is a gigantic task, requiring evolving a hierarchy of NGOs/VOs. A few lead national level NGOs/VOs will be selected, who, in turn, would network with a large number of grass-root level NGOs/VOs to implement the above activities on the ground. The lead NGOs/VOs would have wide national level coverage, broad perspective and deep rooted sense of commitment towards water conservation and management. Accreditation and evaluation of prospective NGOs/VOs would be prime requisite to ensure success in achieving the goals/strategy of National Water Mission.

Department of Public Enterprises has created a National Corporate Social Responsibility (CSR) Hub through Tata Institute of Social Sciences (TISS), Mumbai and has authorized them to invite proposals, scrutinize and award the work to selected NGOs/VOs and monitor /evaluate their work as part of fulfilment of CSR responsibility for the public sector enterprises and interested private sector industries. A majority of CSR activities are related to water conservation, augmentation and preservation. It has been proposed to associate TISS, Mumbai in this regard.

Goal 3: Focused attention to vulnerable areas including over-exploited areas

The strategies identified to achieve the objectives for the goal "Focused attention to vulnerable areas including over-exploited areas" are given below:

1. Expeditious implementation of water resources projects particularly the multipurpose projects with carry over storages benefiting drought prone areas and rain deficient areas.
2. Promotion of traditional system of water conservation – expeditious Implementation of programme for repair, renovation and restoration of water bodies in areas /situations sensitive to climate change by (i) Increasing capacity of minor tanks, and (ii) Rehabilitating water bodies, with changed focus.
3. Physical sustainability of ground water resources.
4. Intensive program for ground water recharge in overexploited, critical and Semi-critical areas.
5. Conservation and preservation of wetlands.
6. Intensive programme for addressing the quality aspects of drinking water particularly in rural area.
7. Promotion of water purification and desalination.
8. Systematic approach for coping with floods.

Systematic approach for coping with flood inter alia aims at strengthening of resilience of the communities against floods. So far focus has been on either structural measures which are

designed to keep flood waters away from the people or non-structural measures like flood forecasting to keep people away from flood waters. Flood Plain Zoning was proposed by this Ministry, but success could not be achieved primarily due to population pressure and the need of economic activities adjacent to river banks. Integrated Flood Risk Management provides a holistic way of addressing flood risk taking into account the need for cooperation of all stakeholders and ensuring linkages to sustainable economic development and the management of flood events.

A MoU has been signed with Asian Development Bank for a proposed Technical Assistance with the objective to undertake operationally relevant research to identify and test integrated flood mitigation and flood plain management strategies prepared for flood issues in India. One flood prone area would be taken under this Technical Assistance to evolve an action plan comprising of both structural and non-structural measures. This action plan would be implemented as a pilot project on coping with floods.

Goal – 4: Increasing Water Use Efficiency by 20%

One of the most important goals of the National Water Mission is to improve the efficiency of water use at least by 20%. The objective can be achieved by ensuring improved efficiency both on the demand side as well as the supply side. The identified strategies to achieve the objectives are given below:

1. Research in area of increasing water use efficiency and maintaining its quality in agriculture, industry and domestic sector
2. Incentivize recycling of water including waste water.
3. Development of Eco-friendly sanitation system
4. Improve efficiency of urban water supply system.
5. Efficiency labelling of water appliances and fixtures.
6. Promotion of water efficient techniques and technologies.
7. Undertake Pilot projects for improvement in water use efficiency in collaboration with States.
8. Promote Water Regulatory Authorities for ensuring equitable water Distribution and rational charges for water facilities.
9. Promote mandatory water audit including those for drinking water purposes.
10. Adequate provision for operation & maintenance of water resources projects. Provision for operation and maintenance of the projects to be appropriately enhanced.
11. Incentive through award for water conservation & efficient use of water.
12. Incentivize use of efficient irrigation practices and fully utilize the created Facilities.

Ministry of Water Resources prepared an outline of the Action Plan for increasing water use efficiency by 20%.

A list of the Major & Medium Irrigation Projects, completed in post plan period till IX plan, has been prepared (State wise) for taking up Baseline study for increasing Water Use Efficiency. State Governments have been requested to take up related Base line studies through WALMIs, WALMATARI, NERIWALM and retired engineers of water resources departments."Handbook for computing the Water Use Efficiency for Irrigation Projects" – 2010 prepared by CWC has already been shared with the States for guidance.

Central Water Commission has identified 138 Major and 73 Medium Irrigation Projects for baseline study of water use efficiency. The State Governments are being encouraged to take up these baseline studies. A training programme has also been evolved by the National Water Academy, Pune.

Increase in water use efficiency can be achieved by implementing various engineering and non-engineering measures, such as;

(a) Increasing conveyance and distribution efficiencies by lining and proper maintenance of canal system, using pipes as field channels, etc.
(b) Command Area Development by proper distribution of flied channels, drainage, etc.
(c) Use of Micro-irrigation methods, such as drip, sprinkler irrigation method.
(d) Implementing water supply on volumetric basis.

(e) Improving water governance by empowering Water Users Association to collect water charges and maintain water resource infrastructure.
(f) Promoting conjunctive use of surface and ground water including re-use of irrigation drainage water etc.

It has been proposed to select five irrigation projects in different parts of the country to act as demonstrative projects, where all approaches for increasing water use efficiency would be implemented. This would help identity important factors contribution towards water use efficiency and their relative contributions, which would facilitate prioritization in evolving investment strategies for Extension, renovation and Modernization Projects under the Accelerated Irrigation Programme (AIBP) scheme, to promote water use efficiency. State Government were requested to propose major/medium irrigation projects.

Goal – 5: Promotion of basin level integrated water resources management

Promotion of basin level integrated water resources management is a very important goal identified for national water Mission. Various strategies identified under the goal are:

1. Review of National Water Policy
2. Review of State Water Policy
3. Guidelines for different uses of water e.g., irrigation, drinking, industrial etc particularly in context of basin wise situations.
4. Planning on principle of integrated water resources development and management.
5. Inter-basin integration particularly for augmenting water by converting surplus flood water into utilizable water – Expeditious formulation of the projects for utilization of surplus flood water for beneficial use of the society and implementation of projects after evaluating costs and land acquisition problems.
6. Ensuring convergence among various water resources programmes.
   Convergence among various programmes related to water resources development and management particularly (i) CAD&WM, RRR of Water Bodies, Ground water recharge through dug wells programmes of Ministry of water resources, (ii) NREGA of Ministry of Rural Development, (iii) Drinking water supply of Department of Drinking Water & Sanitation (Ministry of Rural Development), (iv) Integrated watershed development programme of Ministry of Agriculture, (v) various water conservation programmes of Ministry of Environment and Forests.

Ministry of Water Resources reviewed the national water policy after multi stake holder's consultations and finding in the meeting of National Water Resources Council headed by Hon'ble Prime Minister. The revised policy was unveiled by Hon'ble President of India in April 2013.

India is a Union of State, and therefore, actions need to be initiated concurrently in State also to achieve full success. Though the States are preparing their State Action Plans for Climate Change, there is a need to prepare State Specific Action Plans for implementation of goals/strategies of National Water Mission. This is more important since water is primarily a State subject. Following activities are proposed for preparation of State Specific Action Plan;

(a) Organising Regional as well as State level workshops on the National Water Mission and its gaols covering all the States, UTs and Non Governmental Organizations dealing with related activities.
(b) Identifying key concern in water resource sector in each State/UT.
(c) Evolution of interventions required to address those concerns in consultation with Central/State/UT Government Institutions, Local Government Bodies (Corporations/Municipalities/Panchayat Raj Institutions)
(d) Preparation of State Specific Action Plans keeping in view the goals of National Water Mission and initiatives made by State Planning Boards.
(e) Needs assessment for sensitization, training and capacity building of Panchayat Raj Institutions, Urban Local Bodies, Water Users' Associations and other stake holders throughout India for equitable and sustainable management of water resources with focus on water conservation, augmentation, preservation and efficient use. The State Specific Plan will include a detailed plan of action based on the needs assessment.
(f) Development of region and target group wise modules/training materials/audio-visuals as per the findings of above needs assessment.

Action has been initiative to engage a consultant for undertaking the above exercises for which 15 consultants have been shortlisted through the process of expression of internet.

For achieving the objectives of the National Water Mission, long-term sustained efforts both in terms of time bound completion of identified activities and ensuring implementation of identified policies and enactment of necessary legislation through persuasion at different levels with the State Governments have been envisaged.

7. Restructuring of CWC

Restructuring of CWC has been proposed to expand the activities in the field and reorient the setup at Head Quarters to address the emerging challenges in the water sector like:

- Need to address likely impact of Climate change
- Need for holistic planning & development of water resources considering river basin as a unit
- Effective coordination among planners one hand and stakeholders at other hand

Activities envisaged for Regional Offices:

New activities of CWC

- ❖ Preparation of basin wise integrated water resources development and management plans (20 major basins)
- ❖ Ensuring convergences among various water resources programmes.
- ❖ AIBP CAB&WM RRR of Water Bodies, Ground water recharge, integrated watershed development programme, etc.
- ❖ Focused attention on Research related to activities identified under National Water Mission (NWM)
- ❖ To encourage PIM and promote participation of NGOs
- ❖ Guideline for efficient irrigation practices

Expansion of activities:

- ❖ Expansion of Hydrological Data Network
- ❖ Modernisation of Flood forecasting network & Expansion of inflow forecasting for major reservoirs in the country
- ❖ Development of water resources information system
- ❖ Appraisal, monitoring and finance related services for water resources projects & flood management schemes at level
- ❖ Issues related to Dam Safety at basin level
- ❖ Coastal Management

The 20 river basins of the country are proposed to be served by 8 Regional offices, each headed by a Member level Officer supported by Chief Engineer and the related set up inclusive of personnel from multi-disciplinary field such as environment and social agriculture, economics, groundwater etc. as per requirement.

Basin Plan will be a tool in the hand of the Govt. which would:

- ➢ Help to achieve Optimal Utilisation of Water Resources through Integrated Development and Management of Water Resources
- ➢ Provide comprehensive information about availability, utilisation and demand of water in the Basin which shall lead to meaningful dialogue among the Stakeholders for resolving various issues.
- ➢ Help in optimal planning to address temporal and spatial variation of water availability (intra-basin as well as inter-basin)
- ➢ Lead to comprehensive planning of all the related aspects of water sector, such as conjunctive use, water quality ecology environment etc.
- ➢ Focused attention to Water Management aspects which would lead efficient use of water
- ➢ Set-up in the field closer to the states would help in speedy implementation of the programmes and policies of Ministry of Water Resources

- Focused attention to dam safety issues would play a major role in disaster management
- Provide a platform addressing Coastal Erosion related issues

The above would provide enormous benefits to the Nation in terms of economic and social development and will far outweigh the financial implication of Restructuring of CWC.

8. Establishment of Six Chairs in Academic institutes

MoWR has established Six Chairs in Academic institutes - IIT Kanpur, IIT Kharagpur, IIT Guwahati, IIT Roorkee, NIT Patna and NIT Srinagar with the objective of carrying out studies and research on "Impact of climate change on Water Resources". Chair Professors have been selected in four institutes out of the six and selection at remaining two Institutes [IIT Roorkee and NIT Srinagar] has seriously delayed. Research work at IIT Roorkee and NIT Srinagar would be focusing on Indus basin, at IIT Kanpur and NIT Patna would be focusing on Ganga basin, while at IIT Kharagpur and IIT Guwahati would focus on Brahmaputra basin. Management Committees have been constituted under the Chairman, CWC for each of the Institute separately which has to meet once in a year.

9. Conclusion

Considering the Government level efforts, which have started now, it is clear that no definitive conclusions can be drawn with respect to likely Impacts of Climate Change on Water Resources as of now. The country is having on one hand a large area serviced by glacier fed river system and on other hand large coast line and dependant population, both are likely to be affected by the Climate Change phenomenon though other remaining areas would also be affected. The studies are required to ascertain the likely impacts at local scale say basin scale using sufficient and reliable database so as to consider viable adaptation or mitigation measures at various desired levels ie. individual level, community level, local Government level and at nation level.