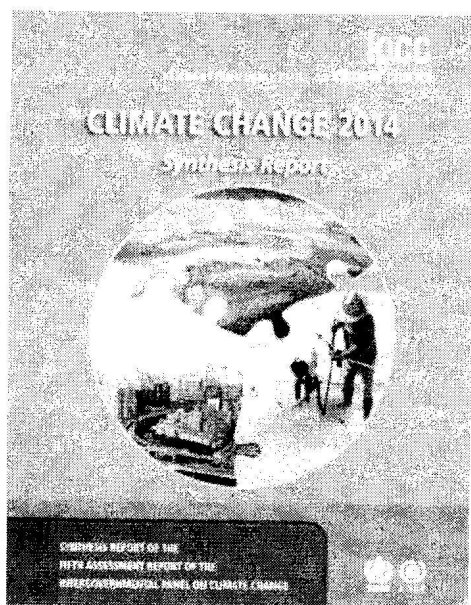




Climate Change 2014

Synthesis Report

**Contribution of Working Group I, II
and III to the Fifth Assessment Report of
the Intergovernmental Panel on Climate
Change by R. K. Pachauri et al (eds)
IPCC, Geneva, Switzerland, 151pp**

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This synthesis report has been drafted by a core writing team of fifty one authors headed by Rajendra K. Pachauri, the Chairman of the Intergovernmental Panel on Climate Change (IPCC) in 2014. This is the synthesis of the fifth assessment report of IPCC. The report consists of three comprehensive assessment reports, such as Physical Science Basis, Impact, Adaptation and Vulnerability and Mitigation of Climate Change. The synthesis has also incorporated two other special reports on renewable energy and managing risks. The assessment report is a result of careful study by eighty five expert reviewers of all literature pertaining to climate change published in the world. This report brings findings on the theme of Climate Change paying attention on publications particularly after its fourth assessment report in 2007. Unlike the previous assessment reports, this one has focused on risks posed by climate change and its management.

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The report consists of a summary for policy makers and four topics. The summary includes the most policy relevant material drawn from the comprehensive reports and entire fifth assessment report. The topic one *observed changes and their causes* integrates new information on changes in the climate system and sea levels, climate change drivers and observed impact including extreme events, and attribution of climate changes and impacts. the second topic *future climate changes, risks and impacts* covers key future drivers, relationship of temperature change with cumulative emissions, and projected changes in the global climate in the 21st century and beyond. The third topic *future pathways, for adaptation, mitigation and sustainable development* addresses issues of managing risks through integrating adaptation, mitigation and sustainability. The topic analyses various pathways of adaptation and mitigation for associated challenges, limits and benefits in various projected warming levels. The fourth topic *adaptation and mitigation* provides information on environmentally sound technologies and infrastructure, sustainable livelihoods, and behavior and lifestyle choices. Further, it shows potentials for integration of adaptation and mitigation with other societal needs. The logical order of the topics remain same with previous forth assessment report though the topics are arranged differently. Further, this report brings the most comprehensive and most recent information on the climate change issue from global literature.

The Topic one brings a clear understanding on observed changes as system components are addressed separately. Observed changes in atmosphere, ocean, cryosphere and sea level has been addressed. Past and recent drives of climate change and natural and human drives and attribution of the changes to those causes are addressed. Further, the topic includes impacts of climate change and resulting changes in extreme events. Issues of exposure and vulnerability and response adaptation and mitigation are also synthesized in to this topic. Accordingly, the first topic covers changes, causes of change, impacts, resultant risk factors and responses.

Anthropogenic greenhouse gas emission has been accelerated during 2000 -2010 period with temporary reduction in 2007/8 due to global economic crises. Present contributions are

as follows: CO₂ - 76, CH₄ - 16, N₂O - 6.2 and F- gases - 2%. Highest increase of GHG emission is recorded by building and industry while the same from agriculture remain same or reduced. Reduction of surface warming trend during 1998 to 2012 period was recorded which is attributed to cooling effect of volcanic eruption and cooling phase of solar cycle from 2000 to 2009. This information is a new contribution to the synthesis report after 2007.

In this topic the role of system components in energy accumulation has been demonstrated and high level of upper ocean energy accumulation is highlighted. This indicates long-term risk of unprecedented and irreversible changes in future as oceans are heating slowly. This analysis was not much clearly presented in former reports. Accordingly, 90% of energy from enhanced greenhouse effect is stored in the ocean whereas the same is 1% in the atmosphere. The 1% has made the global climate change; it would be difficult to predict impact from 90% of energy stored in the ocean.

The report provides clarified spatial and temporal distribution of changes in temperature, precipitation, sea ice extent and sea level rise. Another surprising finding is that Antarctic ice extent increases in the range of 1.2 to 1.8% per decade or 0.13 to 0.20 million km² per decade. The global trends in sea level rise and glacier melt remain same with further acceleration. However, it is reported that Western Pacific region sea level rise is three times higher than the average and the same of Eastern Pacific region is near zero and negative resulted by fluctuations of ocean circulation. During the last inter glacial period global mean sea level was five to ten meters higher than present with 2 C⁰ warmer conditions. The topic provides comprehensive information compared to the previous report.

Role of radiative forcing has been better estimated in this report. Emissions from 2000 to 2011 were recorded highest in history and are unprecedented in the last 800,000 years. Stability of CH₄ lasted in 1990s was broken down and regained increasing concentration. Total anthropogenic radiative forcing has been increased by 43% in estimates for 2011. This is partially due to better estimates of the role of aerosols. Dual role of aerosols - major cooling effect and minor heating effect resulted by black carbon - is better understood. This effect had

only 2% contribution in 2011 compared to 1750. Role of human activities in changes of radiative forcing is highlighted.

Role of various sectors in contribution to anthropogenic radiative forcing was better understood. The role of fossil fuel burning, cement production and flaring has been tripled. Forestry and other land use changes have been increased by 40%. Building and industry sector contribution has been increased. However, it is noted that 60% of anthropogenic emissions were removed from the atmosphere by sinks and stored. The ocean alone has absorbed 30% of anthropogenic CO² which caused ocean acidification. Accordingly, continued industrialization further has deepened the human role of climate change despite various international measures to mitigate climate change.

Warming of the atmosphere and the ocean, changes in the water cycle, reduction in snow and ice and global mean sea level rise are attributed mainly to human activities. Increase in atmospheric moisture and increased upper ocean (0 - 700m) heat content are two other impacts attributed to human activities.

Impacts attributed to climate change on natural and human systems on all continents and across the oceans are observed. This fact indicates the sensitivity of natural and human systems to changing climate. Changing precipitation pattern and melting ice and snow affects water in terms of quality and quantity. Changes in hydrological cycle and water resources will further effect on modifying both natural and human systems.

Impact of climate change on the ecosystems is presented with several new findings together with information provided in fourth assessment report. Shifting geographic range of some species of both terrestrial and marine ecosystems to high altitudes and higher latitudes are evident. Accordingly, marine fishes, invertebrates and phytoplankton have been shifted poleward and deeper cooler waters. Coral bleaching, thinning of pteropod and foraminiferen shells and expansion of oxygen minimum zones are been recorded. Increased tree mortality, drought, wind storm, fires and pest outbreaks are been recorded and some of them are attributed to climate change. Both marine and terrestrial environment in tropical region have

been degraded to reduce fish population and crop yields while in the mid and high latitude environment increases primary production gaining in both fish population and yield.

Analysis of extreme events as a part of observed changes and their causes has been modified in this report compared to the previous one. Extreme temperatures, sea levels and heavy precipitation are focused and resultant droughts, floods and cyclones shows low confidence. Human influence doubled the probability of occurrence of heat waves. Though the confidence is low on increased drought, associated losses have been increased due to increased exposure of people and assets. Lack of direct observations, definition of drought, inconsistency in trends across regions and decadal variability poses limitations to understand the reality on droughts. Unlike in the previous report tropical cyclone trends have also reported low confidence. However, it is noted that heat waves, droughts, floods, cyclones and wildfire poses significant vulnerability and exposure of some ecosystems and many human systems to current climate variability. *Limited understanding with the above mentioned uncertainties of droughts and floods it would be difficult to make proper management decisions for affected countries.* Intensive research would be the solution to fill the gap of knowledge on these issues. Otherwise, the countries facing those extreme events in Asia, Africa and Latin America will suffer most due to higher vulnerability and exposure.

The report provides insufficient analysis on positive impacts of climate change attributed to extension of growing season, reduction of heating costs and improving human recreational capacity in mid and high latitudes. Further, the report do not provide sufficient information to understand which economies are more and which economies are less responsible for causing climate change. Analysis of characteristics in economies in relation to emissions would give essential message to decide which development pathway to be followed to suit with sustainability goals. This information would have had important meaning for policy making in both global and national levels.

The topic two, future climate changes, risk and impacts, synthesises the information on the basis of climate change projections, projected changes in effects and on future risks and impact. The basis of climate change projections remained same as amount of greenhouse

gases concentration though there are improvements in understanding on both causes and effects yet with limitations. Resulted scenarios are called Representative Concentration Pathways (RCP).

Climate projections for the 21st century and beyond are based on four Representative Concentration Pathways (RCP): namely *stringent mitigation*, two *intermediate* and very *high GHG emission* scenarios. Stringent mitigation scenario includes implementation of climate policy and therefore no such comparison with the scenarios presented in the fourth assessment report in 2007. Accordingly, air temperature will increase 0.3 to 0.7C⁰ during the period between 2016 and 2035. Precipitation will be increased in the mid latitude wet regions and decreased in the dry intermediate and subtropical dry regions. Monsoon region will be expanded and rainfall will be intensified according to the predictions based on the scenarios. Deep ocean circulation will be slowdown though it will not turn to an abrupt change during the 21st century while sea surface temperature keep increasing. Carbon cycle may disturb and more carbon will released to atmosphere as a result of climate change while oxygen level in some areas in the ocean will be reduced.

The risks posed by climate change will be increased in areas of human health, livelihoods, risks associated with extreme whether events, food insecurity, poverty and ecosystem services and goods. Fisheries productivity specially in the low latitudes will be challenged nevertheless high and mid latitude fish productivity will be increased. The report provides tables depicting key risks, adaptation issues and prospects and other important information. Further, five reasons for concerns are summarized: unique and threaten systems, extreme weather events, distribution of impacts, global aggregate impacts and large-scale singular events.

The third topic integrates future pathways for adaptation, mitigation with sustainable development. Foundation for decision-making, risks reduced by adaptation and mitigation, characteristics of adaptation and mitigation pathways and interaction among adaptation, mitigation and sustainable development are the focus areas under this topic. The topic highlights essential components of integration climate actions (integrated approach).

Foundation in decision-making lays on five principles. The first, management of climate change is necessary for assuring sustainable development and *equity* (systems theory). The second, the management requires global collective action (participatory or partnership approach). The third, diverse values need to be mediated by several normative disciplines (Multidisciplinary approach). The forth, Information on the consequences of emission pathways to alternative climate goals and risk levels to be properly assessed (systems theory). The fifth, strategies for managing can often be adjusted with new knowledge arrives during the implementation (learning process approach). Accordingly, the foundation for climate change management lays on principles those are necessary for management of any environmental issues. Therefore, it is possible to supplement another two principles, namely, holistic approach in planning and action research approach during implementation.

Adaptation is one of the two major components of climate change management. Adaptation contributes to well-being, security and maintenance of systems and it is place and context specific and no single approach. The same is dependent upon societal values, objectives and risk perception. Adaptation considers indigenous, local and traditional knowledge systems and practices and communities holistic view of community and environment. It is expected to reduce vulnerability and exposure through synergy in the planning process. However, adaptation is not without constrains such as limited financial and human resources, limited integration and coordination, uncertainty of projections and expected outcome and variation in perception of risk. Absence of key adaptation leaders, limited tools for monitoring effectiveness, insufficient research are the other constrains. Economic, social, technological and political transformation would require to overcome limitations and to build adaptive capacity of human and natural systems. Accordingly, adaptation needs to be integrated with mitigation so that those sectors and countries more responsible for enhancing greenhouse gases would hold responsibility for success in adaptation as well.

Climate change is projected to increase temperature which in turn reduces heating requirements, cold related health problems and deceases, increased yield by longer growing

period and recreational conditions and increased precipitation will improve water availability of some regions. These benefits of climate change are obscured in the report. Profit out of these benefits to be shared to cover losses from risks. This report has not attempted to suggest how to promote benefit sharing for managing climate change risk.

Population growth has been considered as a factor of increasing greenhouse gases and their by increasing temperature and is projected to increase in future pathways. However the report was not able to synthesis literature on how per-head energy consumption has been increased. Per-head energy consumption increase assumes that per head demand for energy has been increased. Demand control is to be address as an aspect of integrating both mitigation and adaptation. In other words, increased per head demand can increase the risk posed by climate change in addition to growth of total population.

Various mitigation options are considered in the report in order to reduce GHG. Actions for mitigation by 2020 are formulated as Cancún Pledges: developed countries as their *economy-wide targets* while developing countries as their *plan of actions*. These plans pose substantial technological, economic, social and institutional challenges. Meanwhile, the conditions of climate change dictate immediate actions: delay may increase costs up to impossibility. Though the report highlights required stringency of mitigation measures, various economies uses different pathways of development making difficult to work out ways to direct stringent mitigation pathway. This fact highlights the need for achieving economic equity among nations sharing benefits of development in order to reach successful agreement for most required stringent mitigation pathway.

Fourth topic on adaptation and mitigation stresses the need for integrated responses that link mitigation and adaptation with other societal objectives. However the chapter keeps analyzing responses separately for mitigation and adaptation. Moreover, they are separated for various sectors of economy. Integration approach has been disturbed by such analysis. In contrary, it would be better if examples of economic activities which integrate institutions, environmental and societal goals and benefits were synthesized to the topic. For example, experiences of planting fruit trees in areas where reduction of rainfall impedes growth of some

high water demanding crops could be highlighted. Because, planting tree reduces CO², by carbon sequestration, reduces temperature, require less water, increase income, help improve food security, better water management, and produce healthy food. Another region where such experience would gain is from areas where increased precipitation offer opportunity to grow trees in place of grassland in the world. Synthesis of literature from such experiences and literature showing potentials for integrating mitigation and adaptation with other societal objectives would be more useful for successful management of climate change. Furthermore, sharing benefits of climate change and interaction among countries with various levels of development needs to be more focused than it appears in the report for successful management of climate change.

Adaptation and mitigation are the two complimentary approaches of climate change management. Therefore all issues in successful implementations of adaptation and mitigation demonstrates success of climate change management. In this context it is useful to note that successful implementation of environmental management activities requires various approaches such as participatory approach and consideration of indigenous knowledge and practices. Hence it would be better to arrange material integrating adaptation and mitigation in to one concept of climate change management.

The synthesis report integrates considerable number of publicly available literature related to climate change. It is difficult to decide which literature is relevant and which is not when we are dealing with unprecedented hazard where multidisciplinary is a must. As many of the impacts of climate change are considered as hazards, adaptation to and mitigation of climate change requires adoption of management, particularly, disaster management principles rather than top-down hierarchical administrative principles. Consequently, literature related to management of climate change associated issues would be useful to include with adaptation and mitigation literature.

The report has integrated literature exhaustively covering the materials on the topics stated in the second paragraph of this review. This information is useful and extremely valuable for policy makers to design climate change policies in both global and national

levels. The summary for policy makers consisting 31 pages provides quick guide enabling identification of risks and risk reduction potentials. This report along with the summary serves as a reading material for those who are been trained to become climate change policy makers. However, the reading should be supplemented with materials to overcome limitations stated in the above paragraphs. Therefore, the report can be highly rated for its coverage of literature on topics defined and low rated for its approach in climate change risk management.