

## An Analysis of Knowledge Gaps in Climate Change Research

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### Introduction

Climate change has posed a serious threat to whole humanity en masse, and an effective and collaborative effort by all communities is required to address this serious challenge. Organizations, at regional and global scale, are striving to unify the scientific community for collaborative and synergetic efforts to deal with the issue of global warming and climate change. Such cooperation, based on sharing of knowledge and expertise among the scientific community, is need worthy to tackle the issues related to global warming and climate change. Pakistan, in pursuit of solutions regarding climate change, has also given a serious attention by making an apex body “The Task Force on Climate Change”. The said has been established by the Prime Minister, which assembles quarterly and semi-annually to discuss the issues related to climate change and their ramifications. These meeting are chaired by the Prime Minister himself. Its mandate includes organization of climate change based research, assemblage of research groups, identification of the knowledge gaps, and assessment of the capacity and compilation of unified research results for the guidance of planners and policy makers.

Initially, the eminent organizations of Pakistan working on climate change, impact assessment and adaptation were Pakistan Meteorological Department (PMD), Pakistan Agriculture Research Council (PARC), Pakistan Council of Research in Water Resources (PCRWR), and Pakistan Forest Institute (PFI), etc. But, as the situation went more grave many new organization were set up to contemplate on this issue dedicatedly. For instance, Global Change Impact Study Centre (GCISC) that was established in 2002, meanwhile Water and Power Development Authority (WAPDA), Pakistan Institute of Nuclear Science and Technology (PINSTECH), and Pakistan Institute of Engineering and Applied Sciences (PIEAS) also set up limited capacity for addressing issues of hazard mitigation, climate change and global warming in their own respective realms.

Climate change is a common challenge for humanity and a joint effort by different communities may yield desirable results to avert its adverse effects. Many global and regional organizations have been trying to bring the scientific community together for collaborative efforts to deal with the issues related to climate. Such cooperation will develop the exchange of knowledge and experience among the scientists to tackle the climate related issues at national and local scales. In Pakistan, climate change has attained the serious attention by higher command realizing its sensitivities and vulnerabilities. An apex body, The Task Force on Climate Change has been established by the Prime Minister which meets quarterly and six monthly meeting is chaired by the Prime Minister himself. Its mandate includes organization of climate change based research, assemblage of research groups, identification of the knowledge gaps, and assessment of the capacity and compilation of unified research results for the guidance of planners and policy makers. Although, all the organizations are quite competent to undertake such tasks effectively but lack training on new techniques, limitations of resources, limited access to data sources and poor coordination could not yield desired results. Furthermore, Universities have mandate to conduct research on different fragment of climate change, its ramifications and development of adaptation and mitigation strategies, but, among more than 60 national universities, there is only one institution which offers Master Degree in Meteorology; and none of them is available to educate the young generation on modeling the climate system dynamics and global change.

In the situation, where, said organizations are striving hard to meet the challenges posed by climate change and global warming, but they are experiencing, limitation of resources, access to advance datasets and capacity building, and poor inter-organization communication, as well, this manuscript is aimed to

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highlight analysis of gaps in knowledge, skills and capacity of concerning organization, that must be abridged to attain optimal results.

## **Profile of the organizations working on Climate Change**

### **Pakistan Meteorological Department**

The Pakistan Meteorological Department (PMD) is both a scientific and a service department, and functions under the Ministry of Defence, Pakistan. It is responsible for providing meteorological service, throughout Pakistan, to wide variety of interest and for numerous public activities and projects which require weather information. In its services to aviation the department's responsibility goes to some extent beyond national boundaries in fulfillment of accepted international agreements and obligations which include, among other things, the collection and rebroadcast of meteorological data.

Apart from meteorology, the department is also concerned with Agrometeorology, Hydrology, Astronomy and Astrophysics (including solar physics), Seismology, Geomagnetism, Atmospheric Electricity and studies of the Ionosphere and Cosmic Rays. Pakistan Meteorological Department shoulders the responsibility to investigate the factors responsible for global warming, climate change its impact assessment and adaptation strategies in various sectors of human activities.

In recent years PMD has given considerable consideration to the impact of climate change on Pakistan. Significant research has been conducted to aware public and policy makers regarding potential scenarios of climate changes and its ramifications on hydrological resources, agriculture and ecology of the Pakistan. A detailed study is conducted regarding Climate Change Indicators that briefs the degree of variation in climate in twentieth century (Zaman. Q, Mahmood. A, Rasul. G, Afzal..M., 2009). Furthermore, investigations are being carried out to identify the impact of global warming on glaciers of Himalaya, Karakorum and Hindukush (HKH) ranges (Rasul G, Qin Dahe and Chaudhry Q. Z. 2008), and in recent years PMD teams are regularly visiting Glaciers like Baltoro, Biafo, Hinarchi, Passu and Batura to monitor impact on climate change on glaciated regime of Northern Pakistan (Chaudhry, Q. Z. and Rasul G. 2004)

### **Pakistan Agriculture Research Council**

Pakistan Agriculture Research Council (PARC), established in 1981, is an autonomous body with the mandate to undertake, aid, promote and coordinate research at the federal and provincial levels in the country to provide science based solutions for agricultural development. PARC, since its establishment, has performed many projects regarding improvement of crops growth by using different fertilizers and state of the art irrigation techniques. Further, PARC developed Agro-Environmental Atlas of Pakistan (Roohi, 2002) for dissemination of information on agriculture and natural resources for research and planning purposes. A breakthrough in dimension of climate change, by PARC, is "Glacier Inventory of Pakistan using Remote Sensing and GIS" (Mool, P., S. Bajracharya, Roohi, R., A.Ashraf and R. Naz, 2003) that delivers a good description of numbers of glaciers in Northern Pakistan, their respective lengths and total area coverage. Though, inventory is not as detailed as maintained by many developed countries, but still it provides a baseline introduction to the situation of the glacial ice reserves of the Northern Pakistan, and it facilitates any effort to analyze impact on climate changes on glaciers and water resources of Pakistan. Furthermore, this inventory identifies number of glacial lakes that may cause Glacial Lake Outburst Flooding (GLOF) to mitigate the potential hazard in case of disaster.

### **Pakistan Council of Research in Water Resources**

The PCRWR is an autonomous body established with the objective to conduct, organize, coordinate and promote research in all aspects of water resources. PCRWR has played its role as a national research organization by undertaking and promoting applied as well as basic research in various disciplines of water sector, more specifically, irrigation, drainage, surface and groundwater

management, groundwater recharge, watershed management, desertification control, rainwater harvesting, , water quality assessment and monitoring, and development of innovative water resource management, conservation and quality improvement technologies, etc.

The PCRWR is mandated to conduct, organized, co-ordinate and promote research in all fields of water resources engineering, planning and management, so as to optimally use the available land and water resources and to help achieve sustainability in the agricultural sector.

### **Pakistan Forest Institute**

The Forest Products Institute (PFI) is working under auspicious of Ministry of Environment Government of Pakistan. This division is providing research and training services to the Government and non-Governmental organizations in the field of Wood Anatomy (wood identification), Timber testing, Wood seasoning and preservation, Composite Wood Products and Pulp and Paper science and technology. PFI also concerned with impact of climate change on forests both quantitatively and qualitatively.

### **Global Change Impact Studies Centre**

The Global Change Impact Studies Centre (GCISC) was established in May 2002 on the initiative of Dr. Ishfaq Ahmad, then Special Advisor to the Chief Executive of Pakistan and now Special Advisor to the Prime Minister of Pakistan. In January 2005 the Centre was made an autonomous body with the Ministry of Environment and was assigned to serve as the Secretariat to the newly formed Prime Ministers Committee on Climate Change.

The main objectives of GCISC are, to keep a track of the current and likely future trends of climate change, globally and within Pakistan, to analyze and evaluate their likely impacts on the key socio-economic sectors in Pakistan, to identify how science and technology may be called upon to cope with the adverse impacts, if any, and to advise national planners on the appropriate strategic approaches, to enhance national capacity for climate change research, and to raise public awareness of climate change related issues.

#### Major Activities of GCISC are as follows:

1. Acquisition Implementation and Validation of various Mathematical Simulation Models:
  - (i) Regional Climate Models; RegCM3 (Pal et al. 2007), PRECIS (Saeed et al. 2006, Siraj et al. 2009)
  - (ii) Crop Simulation Models; CERES, CROPGROW, CROPSIM and INFOCROP
  - (iii) Watershed Models; DHSVM and HEC-HMS (Amir and Munir 2006)
  - (iv) Mesoscale Meteorological Model (MM5)
  - (v) Air Pollution Transport Models (CALPUFF, GAINS-ASIA)
2. Research on Various Aspects of Climate Change and its Impacts:
  - (i) Assessment of past climate changes in various parts of Pakistan using statistical analysis techniques.
  - (ii) Projection of future climate changes in Pakistan based on:
    - a) An ensemble of World level projections made by various Global Circulation Models (GCMs);
    - b) Dynamic and statistical downscaling of projections made by selected GCMs to obtain fine resolution projections.

- (iii) Study of the temporal changes in physical dimensions and volume of the main glaciers feeding Indus River System, using satellite imagery and GIS techniques.
- (iv) Assessment of the impacts of projected climate change on
  - a) Water flow in main rivers of Pakistan using different Watershed Simulation Models,
  - b) Productivity of various agricultural crops in different climate zones of the country using crop growth simulation models;
  - c) Other socio-economic sectors e.g. Health, Forestry, Biodiversity etc.
- (v) Use of meteorological prediction model (MM5, WRF) and the Long range dispersion models (CALPUFF, GAINS-ASIA) for assessment of the impact of trans-boundary air pollution on the climatic changes in Pakistan.
- (vi) Development of indicators and indices for extreme climate events in the South- Asia.
- (vii) Development of methodological tools for projecting frequency and intensity patterns of extreme climate events.
- (viii) Development of new crop growth and watershed simulation models designed to represent specific conditions prevailing in Pakistan..

GCISC has been working in collaboration with various relevant organizations in the country, in particular PMD, WAPDAs, NARC, University of Agriculture in Faisalabad, University of Arid Agriculture in Rawalpindi, SUPARCO etc. The Centre has also been engaged in enhancing the capacity of its scientists as well as those working in other relevant organizations by holding Training Workshops, particularly in the area of simulation modeling.

### **Lack of Technical Capacity**

PMD, WAPDA, PCRWR, SUPARCO, NARC and GCISC are the main organizations working on different aspects of Climate change and impact assessment. In this business modeling, regarding interaction of the atmosphere, oceans, land surface and ice, is essentially important tool which helps to integrate scientific ideas in quantitative and qualitative ways. As circulation model is a mathematical model of the general circulation of a planetary atmosphere or ocean and based on the equations related to rotating sphere with thermodynamic terms for various energy sources (radiation, latent heat). These equations are the basis for complex computer programs commonly used for simulating the atmosphere or ocean of the Earth. Models like

Among Pakistani organizations PMD and GCISC are involved in regional climate modeling by downscaling the output of global models. But, due to their computational limitations they are bound to either choose a limited domain or make a choice of coarse resolution so that the computer could sustain the load of heavy processing. Presently PMD has been using a 16 nodes blade server for running HRM, RegCM3, SDSM and PRECIS models whereas GCISC is using 16 PCs cluster. Each run takes months to be completed in a limited domain and at a larger time step.

Computer power has to be significantly enhanced to work in regional domain to reduce the bias at finer time steps for making more realistic assessments in shortest possible time. With enhanced computer capacity dynamical downscaling can also be exercised along with statistical downscaling.

### **An Organized Approach**

Although the scientists at organizational and individual level are struggling to contribute research in solving and understanding the problems yet an organized approach may prove fruitful. Organized modeling of the Indus Basin is a huge job and different research groups have to join at one platform

working on different tasks ranging from using outputs of GCMs to stream flow models and then translation of results into societal and economic impacts, finally suggesting the workable options for adaptation. This task oriented activity is not only meant for Government organizations rather the involvement of Non-Government Organizations and Academia may yield better results.

#### Schematic Diagram of a comprehensive Basin Scale Research

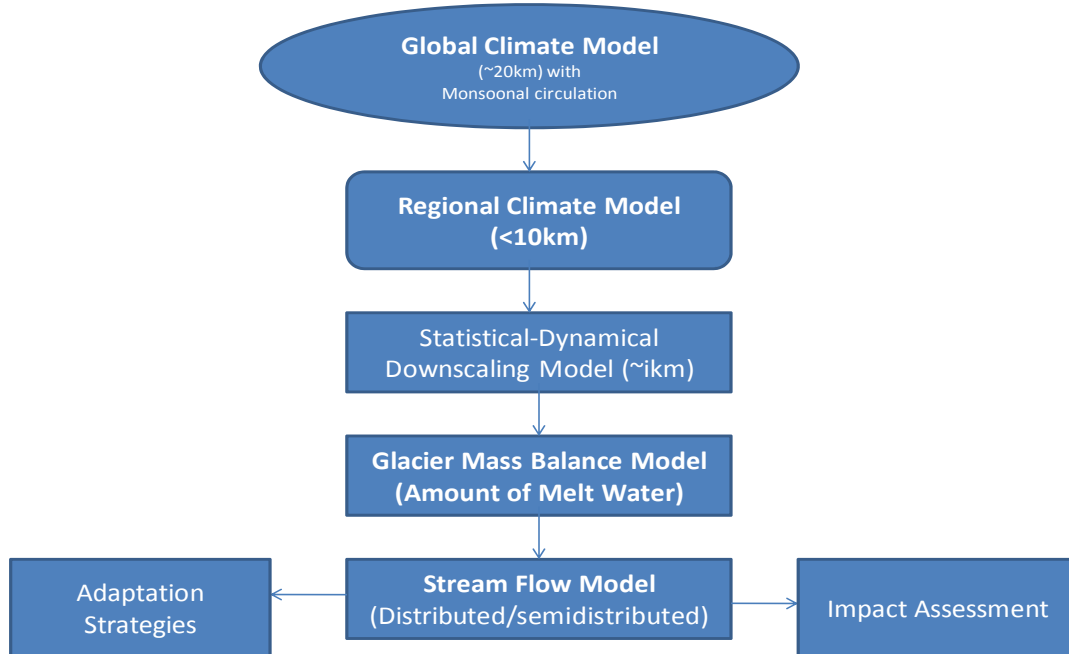


Figure 1

#### Lack of Trained Manpower

There is an acute shortage of well trained staff in national organizations which knows the climate change science and dynamics of the climate system because none of the national universities offer such courses at graduate or post-graduate level. Only PMD impart basic training to fresh intakes having post-graduate degrees in Mathematics, Physics or Computer Sciences. Climate change science demands high level of professional proficiency in theory and practice. In addition to that knowledge and expertise in numerical modeling is high desirable to work on a model in commanding way. There is a dire need to train the staff of PMD, GCISC and NARC on numerical modeling and climate system dynamics at International organizations that are playing a leading role in climate change science.

#### Density of Network

Present network altogether including local and international organizations does not serve the terrain representativeness. Climate varies not only at the valley scale rather hill top to hill top, aspect to aspect and orientation to orientation due diverse geological and geomorphological features of the region. To meet the optimum observational demands upto 4000m, at least 75 AWS and 35 Discharge measurement devices should be installed for effective modeling of hydrodynamic characteristics of this volatile portion of cryosphere going through drastic changes due to increasing temperatures.

## **Data Integration**

There are several national and international organizations such as PMD, WAPDA, Ev-K2-CNR and Prof. Winiger's which are involved in data collection and archiving. They all are running their own networks. PMD being the national meteorological service runs the largest network throughout Pakistan and it has close collaboration and sharing with WAPDA and Ev-K2-CNR. Prof. Winiger's network has been operational in Mountainous terrain of HKH but neither the data is shared with any national organization nor one has access to its data set. Such individual data collection efforts are required to be align with national meteorological service to avoid duplication of efforts and wastage of resources. Similarly SUPARCO, PCRWR, WAPDA and some other organization are involved in data collection, but due to lack of coordination and understanding between each other, data is not being shared properly. Such environment needs establishment of a central data bank where all concerned data will be archived and will be available conveniently to any interested party. In recent report of the Task Force on Climate Change, it has been proposed to make a data bank where all sorts of data should be available for research community.

## **Coordination among Research Groups**

Different organizations and research groups are working on different aspects of climate change and its impact on various sectors. There is a great probability of duplication of research efforts due to the lack of communication among the groups. Especially in cryospheric research many groups and individuals are involved to investigate changes in glaciers size and mass through remote sensing and at many occasions duplication appeared. To avoid the loss of time and effort, it is necessary that an apex body should organize the research assignments and research grants should be provided to research group capable to carry out the given task.

## **Field and Laboratory Training**

In glacier monitoring, the most of the research teams from Pakistani organizations are quite new or the old generations involved are retired. There is acute shortage of technical equipment and laboratory facilities as well as the lack of skill of the staff to carry out necessary analyses. A challenging task ahead is mass balance analysis to answer the controversies on surging and retreating glaciers. None of the organization (PMD, WAPDA, GCISC, SUPARCO, NARC) is capable to conduct this analyses. Firstly, the collaborative effort of national organizations with international groups may improve the field measurement and laboratory skills ad PMD has started with EV-K2-CNR (Italy), ICIMOD (Nepal) and CAREERI (China). Secondly, the training of staff at international training centers.

## **Establishment of National Institute of Cryospheric Sciences**

To train young scientists in field of cryospheric sciences for effective and articulate monitoring of snow and ice deposits can not be denied, thereof, a need of such institute that may instill training and research spirit in young scientists is highly stressed. There is no institution to impart research and monitoring training to young scientists entering this field with great enthusiasm, presently. Most of the learning programs are through collaborative work or small duration trainings at the International centers such as ICIMOD, SKLCS. Due to the unavailability of training and educational facilities at national institutions, young graduates are hesitant to choose such challenging careers which may make the difference in future. There is a dire need for establishment of a National Institute of Cryospheric Sciences with a degree awarding status and fully equipped with training facilities to prepare a work force for field investigations and laboratory research. Such institution will provide a common platform to the scientists of this discipline to share their knowledge and experience among themselves and with international colleagues. In this regard, success stories of [Cooperative Institute for Research in Environmental Science](#) (CIRES), University of Colorado at Boulder, USA, and The State Key Laboratory of Cryospheric Sciences (SKLCS) China can be taken as role model. Research activities like, Cryospheric distribution and

changes, Cold region hydrology and water resources, Regional cryosphere-atmosphere-hydrology-ecology interactions, Cryospheric disasters, Influences of Cryospheric changes on regional development, Frangibility and adaptability of cryosphere, and Mitigation and adaptive countermeasures on cryospheric changes must be studied in detail, indeed.

### **Mobilization of Academia**

Except one institute in Islamabad, no Pakistani University is offering meteorology or climate change science at graduate or post-graduate level as it is being offered in various universities both developing and developed universities (for instance, Florida State University, USA., and Nanjing Institute of Meteorology, Nanjing and China Meteorological Administration Training Centre, China). Here lacks the awareness of young generation which should be educated, trained and motivated to play their role as environmental leaders. Climate change will pose the complexities in the ongoing processes affecting all the socio-economic sectors at the same time. Every university meeting with curriculum of scientific disciplines may offer climate science as a subject at graduate or master level with its research oriented conclusion. Those which offer social sciences and humanities may introduce the socio-economic aspects of climate change as it being studied in Department of Economics at the University of Minnesota. Medical colleges and medical universities are supposed to take a leading role in emphasizing the impact of climate change on health sector including locally originated and vector borne diseases as discussed by University Department of Rural Health, University of Tasmania (Bell 2010). Similarly Agriculture Universities and Engineering Universities may produce young graduates to cater the needs of food security, water security and energy security.

### **Climate Change Policy**

It is a pity that Pakistan has no climate policy as yet. Most of the countries have made several revisions also according to the prevailing (for instance; China's National Climate Change Programme, U.S. Climate Policy and Actions ) situation but Pakistan has not yet come up with its first one. Such policies determine the right direction for ongoing and planned activities to move forward. The role and mandate of national institutions involved are defined in National Climate Change Policy which provides the road map for mitigation and adaptation efforts. Pakistan has to finalize its National Climate Change Policy, as it made its National Environmental Policy (2005), as soon as possible. An open debate among representatives of all walks of life may facilitate the policy makers to devise a realistic policy. Also the examples of other countries may be gone through.

### **National Glacier Inventory**

National Agriculture Research Center (NARC) in collaboration with ICIMOD prepared first glacier inventory in 2005 which has been widely referred and appreciated. It was a marvelous effort to collect and compile the data using Remote Sensing and Global Information System with a virgin experience. With the passage of time, changes have taken place in the ground state and dimensions of glaciers as well as new technologies have replaced the old techniques, where as all fields of data (for instance; glacier number, glacier name, latitude, longitude, coordinates, number of basins, topographic year, topographic scale, photo year, total area, area accuracy, area in state, area exposed, mean width, mean length, maximum length, maximum length exposed, maximum length ablation, orientation of the accumulation area, orientation of the ablation area, maximum altitude, mean altitude, minimum altitude, minimum altitude exposed, mean altitude accumulation, mean altitude ablation, and classification type as maintained in standard glacier inventories in developed world) should be filled with relevant knowledge, duly. It is extremely desirable that second inventory should be prepared to provide updated information to scientists to use in their research work. In this regard, technical support from international organizations such as WGI, ICIMOD, SKLCS may be sought to complete this important task as early as possible. Then a regular schedule of up gradation after 5 years may be followed.

## Conclusions:

As climate change is one of the most serious challenges being face by the humanity in current epoch. And impact of climate change is more exacerbated for developing country like Pakistan. To deal with this imminent menace need of collaborative efforts by the national and international organizations is highly stressed. A brief account of Pakistan national organizations working for climate change adaptation and mitigation is made. These organizations and institutions include Pakistan Meteorological Department (PMD), Pakistan Agriculture Research Council (PARC), Pakistan Council of Research in Water Resources (PCRWR), Pakistan Forest Institute (PFI), Global Change Impact Study Centre (GCISC), Water and Power Development Authority (WAPDA), Nuclear Science and Technology (PINSTECH), and Pakistan Institute of Engineering and Applied Sciences (PIEAS). Furthermore, a brief description of eminent organization working on climate change is made. Moreover, lack of technical capacity of national organizations is pointed out and atmospheric circulation modeling is taken as case study in this case. Further, a need of an organized approach is stressed and hydrological modeling in Indus Basin is taken as prototype. Besides this, problems of national organizations are discussed in terms of lack of trained and skilled manpower, and density of observation units. Moreover, need of data integration is discussed and arguments are made in favor of central data archives and repository. In this connection, need to train manpower working on climate change is underscored and different suggestions are made.

## References:

**International Joint Conference by the CliC and IACS, August 12--14, 2010;** Cryospheric Changes and Influences —Cryospheric Issues in Regional Sustainable Development, Lijiang, China

**Erica J Bell, 2010;** Climate change: what competencies and which medical education and training approaches?, BMC Medical Education, 10:31doi:10.1186/1472-6920-10-31, <http://www.biomedcentral.com/1472-6920/10/31>

**China's National Climate Change Programme, June 2007:** Prepared under the Auspices of National Development and Reform Commission, People's Republic of China.

**CNA Military Advisory Board. (2007)** National Security and the Threat of Climate Change. CNA Corporation: Washington, DC. 35.

**Luers, et al (2006)** Our Changing Climate: Assessing the Risks to California. Sacramento: California Energy Commission. CEC-500-2006-077. 16.

**National Environmental Policy (2005),** <http://www.environment.gov.pk/nep/policy.pdf>

Roohi, R., P., Ashraf A., Bajracharya S., Amjad S. and Naz R. 2005. InventGlaciers, Glacial lakes the Identification of Potential Glacial lake Outburst Floods, Affected by Global Warming in the Mountains of Himalyan Region, Pakistan. ICIMOD, Nepal & PARC, Pakistan (CD).

**Task Force on Climate Change, February 2010:** Final Report, Planning Commission, Government of Pakistan.

**Majewski, D. (2001):** "HRM User's Guide", available from the author (detlev.majewski@dwd.de)

**Afzaal. M , Hussain. A., (2006);** NUMERICAL SIMULATION OF SUMMER MONSOON PRECIPITATION OF 1992 OVER PAKISTAN, Pakistan Journal of Meteorology Vol. 3: Issue 5, June 2006, pp 57-67.

**Roohi, R. Ahmed, S., and A. Ashraf. (2002).** Characterization and Classification of agro-climates of Pakistan. Pakistan Journal of Agriculture Research., 17: 245-254.

**Dr. Qamar-uz-Zaman Ch, Arif Mahmood, Dr. Ghulam Rasul, and Muhammad Afzal.(2009).** Climate Change Indicators of Pakistan, Technical Report No. PMD-22/2009, Pakistan Meteorological Department.



- Rasul G, Qin Dahe and Chaudhry Q. Z. 2008:** Global Warming and Melting Glaciers along Southern Slopes of HKH Range. *Pakistan Journal of Meteorology*, Vol. 6; Issue 11, July 2009, Pp 63 – 76.
- Chaudhry, Q. Z. and Rasul G. 2004:** Climatic Classification of Pakistan. *Science Vision*, Vol. 9 No. 1-2 (Jul-Dec, 2003) & No. 3-4 (Jan-Jun, 2004). Pp. 59-66.
- Mool, P., S. Bajracharya, Roohi, R., A.Ashraf and R. Naz, (2003).** Inventory of Glaciers, Glacial lakes and the Identification of Potential Glacial lake Outburst Floods Affected by Global Warming in the Mountains of Himalyan Region, Astor basin, Pakistan. ICIMOD, Nepal & PARC, Pakistan (CD).
- Kazmi, D.H, Rasul. G, Tong. J, Ali. G, Cheema. S.B, 2010.** Statistical downscaling and future scenario generation of air temperature, for Pakistan.. In Press (PJOM).
- Hussain, S. S. and Mudasser, M. 2007.** Prospects for Wheat Production under Changing Climate in Mountain Areas of Pakistan – An Econometric Analysis. *Science Direct, Agricultural Systems*, 94(2), 494-501.
- Pal, J., Giorgi, F., Ashfaq, M., Saiyed, F. et.al. 2007.** Regional Climate Modeling for the Developing World: The ICTP RegCM3 and RegCNET. *Bulletin of the American Meteorological Society*, September 2007, 1396-1409.
- Amir, P. and Munir Sheikh, M. 2006.** Droughts in Pakistan: Causes, Impacts and Remedial Measures. In Muhammad, A., Monirul, M., Mirza, O. and Stewart, B. (Eds), *Climate and Water Resources in South Asia: Vulnerability and Adaptation (78-94)*. Asianics Agro Dev. International/APN/START/HIWP.
- Saeed, S., Munir Sheikh, M. and Faisal, S. 2006.** Simulations of 1992 Flood in River Jhelum Using High Resolution Regional Climate Model, PRECIS to Study the Underlying Physical Processes Involved in the Extreme Precipitation Event. *Pakistan Journal of Meteorology*, 3 (6).
- Syed, F., Giorgi, F., Pal, J., and King, M. P. 2006.** Effect of Remote Forcings on Winter Precipitation of Central Southwest Asia Part 1: Observations. *Theoretical and Applied Climatology*, 86, 147-160.
- Hussain, S., Muddasser, M., Munir Sheikh, M., and Naeem, M. 2005.** Climate Variability in Mountain Areas of Pakistan - Implications for Water Resources and Agriculture. *Pakistan Journal of Meteorology*.
- Climate Change: Global and OIC Perspective. 2004.** Global Change Impact Studies Centre (GCISC), Pakistan.
- Energy Strategies for the OIC Member States. 2004.** Global Change Impact Studies Centre (GCISC), Pakistan.
- Syed, F. and Younas, A. 2004.** Variation in Fog Intensity/Duration and El Nino. *Pakistan Journal of Meteorology*, 1 (1), 1- 49.
- Siraj ul Islam, Nadia Rehman, M. Munir Sheikh, Arshad M.Kahn. June 2009:** Assessment of Future Changes in Temperature Related Extreme Indices over Pakistan using Regional Climate Model PRECIS. Research Report GCISC-RP-05.
- Siraj ul Islam, Nadia Rehman, M. Munir Sheikh, Arshad M.Kahn, June 2009:** High Resolution Climate Change Scenarios over South Asia Region Downscaled by Regional Climate Model PRECIS for IPCC SRES A2 Scenario. Research Report GCISC-RP-06.