GROUP ON EARTH OBSERVATIONS

**GEOSS Joint Asia-Africa Water Cycle Symposium**
**Ito International Research Center, Ito Hall, University of Tokyo, Hongo Campus**
**25 – 27 November 2013**

**Summary Report**


Over the past several years, the Asian Water Cycle Initiative (AWCI) and the Africa Water Cycle Coordination Initiative (AfWCCI) have evolved as regional water resource management activities of the Global Earth Observation System of Systems (GEOSS), being implemented by the intergovernmental partnership of the Group on Earth Observations (GEO). Both initiatives have recently started the next phase of implementation planning and, for the mutual benefit of both initiatives, the University of Tokyo and the GEO Secretariat co-organized an international symposium entitled the "GEOSS Joint Asia – Africa Water Cycle Symposium" on 25-27 November 2013, at the campus of the University of Tokyo. The purpose of this meeting was to promote an exchange of ideas through a broadened discussion that included sharing of knowledge and experience, and to build upon the commonalities of approach by both the both the AWCI and the AfWCCI towards addressing integrated water resource management in the context of climate change as they adopt principles of the GEOSS Water Cycle Integrator (WCI).

Objectives of the joint Symposium included taking stock of accomplishments, and learning from past lessons in the development and execution of implementation plans for river basin management, (especially from the AWCI to the AfWCCI). The main themes of the Symposium deliberations included:

- Expected roles of Earth observations (EO) and data integration on water management and the Water-Energy-Food nexus in Asia and Africa;
- Introduction to the capacities of the science communities and Earth observation sectors;
- Possible contributions of Earth Observations to monitoring progress toward Water Sustainable Development goals; and
- River basin proposals of the 1st AfWCCI implementation plan in Africa; and Country proposals of the 2nd AWCI implementation plan in Asia.

Participants included members of the AWCI International Coordination Group and representatives of the AfWCCI river basins, as well as representatives of governmental sectors, GEO Participating Organizations, official development assistance (ODA) agencies, space agencies, scientific communities, and other key collaborators. In total 152 participants of 29 countries attended the Symposium.

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1. **Opening** *(Dr. P. Koudelova, Chair)*

Mr. D. Cripe (GEO Secretariat) provided a brief overview of GEO and the implementation of GEOSS, reminding the participants that Global Earth Observation System of Systems (GEOSS) is a coordinating and integrating network of Earth observing and information systems, contributed on a voluntary basis by Members and Participating Organizations of the intergovernmental Group on Earth Observations (GEO). GEOSS is designed to support informed decision making for society, including the implementation of international environmental treaty obligations. He then went on to highlight that, as the tend of the 10-Year GEOSS Implementation Plan draws to an end in 2015 and the GEO community goes to seek renewal from Ministers at the Geneva Ministerial in January 2014, the core functions of GEO post-2105 will include:

- Strengthening observation systems (space-based, airborne and particularly in-situ) and networks among observation systems;
- Advancing interoperability and integration of Earth observations;
- Promoting the GEOSS Data Sharing Principles;
- Building and sustaining an information system that provides access to the data and products of its Members and Participating Organizations;
- Developing capacity to collect and use Earth observations, and promoting regional GEOSS implementation;
- Supporting research and development of integrated applications of Earth observations; and
- Engaging with users and decision-makers.

Mr. K. Isogai, Ministry of Education, Culture, Sports, Science and Technology (MEXT) informed the audience that among the MEXT responsibilities is promotion of research and development of environment and energy and consulting service on exploiting science and technology for solving global environmental issues. This includes strong support of global as well as regional and local implementation of GEOSS, which is essential for addressing threats of increasing strength and frequency of extreme weather events associated with climate change that result in severe damages like recent mega-typhoon in Philippines or summer floods in the Kyoto area. The water resources management is recognized as a key theme connected to food security, health, energy and other societal benefits and international collaboration in observation and research activities is being promoted as the most effective approach towards addressing the global issues. At the same time, research outcomes need to be utilized in practical and operational applications to serve its purpose, which is a contribution to the better and sustainable welfare of humans. AWCI and AfWCCI have been established along these principles and are perceived as pioneering activities of the GEOSS approach in the water cycle and water resources management arena. In addition to the research activities, they provide valued platform for enhanced mutual cooperation by sharing data, knowledge and experiences. Gathering events such as this Symposium or GEOSS Asia-Pacific Symposium held annually since 2007 are meaningful and important efforts fostering further development of this platform and expanding the international and regional collaboration on water resources management.

Mr. S. Yamamoto, Japan Aerospace Exploration Agency (JAXA) recalled the main motivations for establishing the GEO and GEOSS as a response to the 2002 World Summit on Sustainable Development calls for actions, in particular to provide earth observation data for informed decision making for society. JAXA has contributed its satellite products to GEOSS for three Societal Benefit Areas, namely Disasters, Climate, and Water, and has been fulfilling its commitment since the GEOSS initiation in 2005, which also includes support of the AWCI activities. In 2012, JAXA launched the Global Climate Observation Mission satellite, GCOM W1, which observes water related quantities such as water vapor, clouds, liquid water content, sea surface temperature, wind above oceans, and soil moisture, and in 2014, JAXA and NASA will jointly launch the Global Precipitation Mission (GPM). Users can freely access these data on-line and JAXA hopes they will be best utilized to advance AWCI and AfWCCI activities. In January 2013 Japanese government established a basic plan on space policy that emphasizes the importance of expanding utilization of space for the purpose of creating new services and products for improving peoples' quality of life. In compliance with the basic plan statements, JAXA looks forward to further collaboration with AWCI and AfWCCI.

Mr. A. Takemoto, Asia Pacific Network for Global Change Research (APN) Secretariat, explained to the participants that APN is an inter-governmental network of 22 countries in the Asia-Pacific, established in 1966, aiming to foster global change research across the region. Financial contributions are provided by four donor countries: Japan (+ Hyogo), USA, Republic of Korea, and New Zealand. Recent major activities include funding regional research (ARCP) and capacity building/development projects (CAPaBLE), and strengthening science-policy linkages, while focusing activities through 3 frameworks: Low Carbon Initiatives (2012), Climate Adaptation (2013), and Biodiversity and Ecosystem Services (2013). APN has already provided over US$ 700,000 to projects supporting GEOSS implementation, and it is considering how APN could launch outreach activities to African networks thorough the Global Adaptation Network (GAN) recently established by UNEP.

Prof. T. Koike, the University of Tokyo, welcomed the participants at the venue and introduced the background and objectives of the Symposium. The AWCI framework was established through a series of meetings starting with the 1st Asia Water Cycle Symposium in Tokyo, November 2005 and recognized as a GEOSS regional initiative in 2007. The first phase of AWCI was completed in 2011, accomplishing a database of in-situ observations from 18 Asian river basins, hydrological models development in these basins and assessment of climate change impacts on hydrological regimes. The AWCI is opening its second phase that targets more operational applications. The first African Water Cycle Symposium was held in Tunisia, 2009, followed by further meetings resulting in agreement on implementation framework of AfWCCI. The present Symposium is the first opportunity for Asia and Africa country governmental representatives, river basin authority representatives, earth observation community and ODA donor community to meet together and discuss how to establish water security and water nexus security including food, energy, health and ecosystems and how to work together toward sustainable development.

## 2. GEOSS Capability and Needs of Stakeholders *(Dr. R. Lawford, Chair)*

His Excellency Mr. Farukh Amil, Ambassador of Pakistan stressed out that water is an essential component for sustaining quality of life, sustainable development and eradication of poverty. Water resources management is a socio-economic issue as well as scientific and technical challenge, and it is critical to deepen our understanding of water cycle phenomena. Climate change poses a fundamental threat for water resources and once water-plentiful societies may change into water-stressed regions, which is the case for Pakistan. Incentives of Earth observation organizations, ODA agencies and science communities to share knowledge, expertise and resources to meet this challenge are greatly appreciated. The JAXA SAFE project in Pakistan on monitoring water cycle variations and assessing the impacts of climate change was an excellent effort to promote space applications in the environmental field. The importance of building a strong regional and global collaboration platform for tackling the water resources issues under the climate change is reflected in the AWCI vision and much appreciated by Pakistan as an AWCI member country. It is critical to keep the momentum and build meaningful partnerships that actually address the issues scientifically and – most importantly – are backed by political resolve.

His Excellency Mr. Madan Kumar Bhattarai, Ambassador of Nepal concurred with preceding speakers that the optimum use of water and its management is one of the most challenging areas of development. In Nepal, there is a huge potential of exportable hydro-power, irrigation, pisciculture, drinking water and even navigation and waterways in some of the major rivers that can bring dramatic transformation in social and economic spheres. However, not even a fraction of it has been exploited so far with recurring problems of power failure, drought, shortage of potable water, which are amplified by natural disasters. Hence the major problem is a prudent water management and mechanisms like the GEOSS AWCI are essential in this process by providing valuable inputs for effective water strategies planning through improved understanding of the Asian water cycle and its variability. Within the framework of AWCI, Nepal has conducted collaborative research activities, which resulted in development and implementation of distributed snow and glacier melt hydrological model in Dudhkoshi and Narayani river basins to better analyze the impact of climate change in water resources of these regions. Capacity building opportunities available due to such frameworks are another key component necessary for successful development and management of water resources.

In his keynote presentation the *Needs of Stakeholders and GEOSS Capability*, Mr. D. Cripe (GEO Secretariat) discussed the various groups of end-users needing data and information about the water cycle, from scientists and researchers, to managers of not only water resources, but also managers of components within the agriculture, ecosystem, energy, transportation and tourism sectors. He also showed a list of "essential water variables" being advocated by the GEOSS Water Strategy Report that are considered as critical candidates for observation, monitoring and prediction for Integrated Water Resources Management (IWRM). In response to these needs, the GEO Work Plan has aligned its activities or "Tasks" into three major areas according to the key objectives of GEOSS implementation to which they contribute:

- *Infrastructure*: the physical cross-cutting components of an operational and useable GEOSS, including interoperable observing, modeling and dissemination systems;
- *Institutions and Development*: describing "GEO at work" and the community's efforts to ensure that GEOSS is sustainable, relevant and widely used, with a focus on data sharing, resource mobilization, capacity development, user engagement, and science and technology integration;
- *Information for Societal Benefits*: the information, tools, and end-to-end systems that will be made available through GEOSS to support decision-making across the nine Societal Benefit Areas.

In his keynote presentation on the GEOSS Water Cycle Integrator, Prof. T. Koike (UT) demonstrated how the WCI emphasizes the importance of data integration, interdisciplinarity and transdisciplinarity for, among other applications, sustainable development of water and environmental resources - particularly as they pertain to the "Water-Food-Energy nexus" - while promoting disaster risk reduction. The core of the WCI is the Data Integration and Analysis System (DIAS), which has been developed by UT, and he gave examples of where the WCI has been implemented in projects ranging from dam operation optimization for hydro-power generation and flood control, to rice production in Vietnam, Philippines and Indonesia.

The keynote addresses were followed by a panel discussion, during which panelists responded to one of the following questions:
1) Considering the overall area of responsibility and trends what would you say are the information needs in your geographic area that will increase in the future?
2) What types of decisions does your organization make in relation to water and water management? Where do you get your information to assist in making these decisions?
3) How could the existing information available in the local communities for decision making be improved (quantity, accuracy, timeliness, access, etc)?
4) In assessing the priorities for supporting water activities how does your agency decide which projects should receive funding?

Mr. M. Fuwa, Japan International Cooperation Agency (JICA) responded by noting that JICA is the implementing agency of Japanese bilateral Official Development Assistance (ODA) effort, and that an agreement between governments of a recipient country and Japan, based on an official request through the diplomatic channel, is a prerequisite for assistance. JICA's support to Water Resources Management include formulation of: a comprehensive WRM plan National water resources master plan for Kenya; a comprehensive WRM plan for Nigeria (more focus on capacity development and national water resources management); and a specific WRM plan Flood management plan in Medjerda River Basin, Tunisia.

Mr. V. Anbumozhi, Asian Development Bank Institute (ADBI) outlined its Strategies for Adaptive Capacity Building, which include 4 steps: 1) building scientific understanding & capacity; 2) targeted information & training for policy makers and planners; 3) pilot activities involving governments, private sectors & capacity building organizations; and 4) building lessons to policy to make adaptation part of "business as usual" (BAU). ADBI emphasizes regional cooperation for integrated approach in areas such as climate information, decision-making capacity, and adaptation finance.

Mr. M. Tamagawa, African Development Bank (AfDB) emphasized that sustainable use of water was a chief concern for its projects. To achieve this required effective storage of the resource; a multi-lateral master-plan for river basin management; and a comprehensive urban master plan integrating water usage. He noted it was important that policy makers embrace information as part of foresight and planning, which requires both the inputs of experts and the support of governments.

Mr. M. Ishiwatari, World Bank (WB), illustrated that poverty needs to decrease while prosperity needs to increase in order to attain environmental, social, and economic sustainability by 2030 (from the Sustainable Development Goals – SDGs). Therefore, access to social and economic data in addition to water resources is necessary, in order to make holistic decisions with respect to sustainable management of Earth's resources.

Mr. Y. Kinoshita, Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT), informed participants that Earth observations, projection, and integration were key components of MEXT's strategy for decision-making in local communities. This was exemplified by the approach taken by the Research Program on Climate Change Adaptation (RECCA) which promotes research & development to provide scientific knowledge obtained by climate change projections for adaptation at the regional level (such as prefectures or cities). At every point, discussions with end-users and stakeholders are critical to the success of such programs.

Mr. Y. Amano, Japan Ministry of Land Infrastructure and Tourism (MLIT), reviewed the goals, targets and indicators of the Millennium Development Goals (MDGs), and how they related to the current discussion on establishment of Sustainable Development Goals (SDGs). In particular, he highlighted the High-Level Panel recommendation for the Post-2015 Target for Disaster Risk Reduction, and how it could benefit from MLIT's suggestion to derive a more precise indicator for reducing fatalities and economic damage from natural disasters.

Mr. D. Cripe (GEO Secretariat) called for bridging the science to usable information gap in order to improve decision-making at the local level (weather forecasts are of interest, as opposed to projections of 850 hPA geopotential heights). A second area would be improving access to community portals of data and information through the GEOSS Portal and establishing appropriate interoperability arrangements.

Prof. T. Koike (University of Tokyo) illustrated the need to identify common problems across a region or continent which will then indicate the appropriate framework for collaboration, using the AWCI and AfWCCI as examples. He reiterated the need for collaboration with stakeholders from the first step in designing any program or initiative so that the end products and tools will be appropriate for their needs.

One question coming from the floor was posed by Mr. G. Rasul, Pakistan Meteorological Department (PMD). He expressed concern about the density of observation networks which were not sufficient to cater to needs of climate service providers. In his view there was a dire need to increase these observation networks, especially in regions of the cryosphere. He wanted to know what the policies of donor agencies were with respect to this issue.

Mr. Cripe responded that a new initiative was being forged within the GEO community, called the Global Network for Observations of Mountain Ecosystems (GEO-GNOME) that could hopefully raise the visibility of this issue. Mr. J. Oguntola suggested that improvement of observational networks, especially in-situ, should form an integral part of any of the Project Design Matrices (PDMs) that have been produced by the AWCI and AfWCCI. Mr. M. Fuwa, JICA, noted that one of the JICA's key cooperation areas is disaster risk reduction and the support by GEOSS in terms of necessary observations is expected. Mr. V. Anbumozhi, mentioned that ADB and ADBI have been supporting new information generation through funding for the knowledge institutes to collect data and information, and to develop networks for their sharing and dissemination at the local as well as national level. Mr. M. Ishiwatari, WB, voiced that the World Bank has been supporting observation and data integration activities. It was also noted that the issue of *in-situ* observations would be discussed in the following session.

**3. Water Cycle Observations and Integrated Water Resources Management** *(Dr. D. Cripe, Chair)*

His Excellency Mr. Francois OUBIDA, Ambassador of Burkina Faso, shared experiences of his country with addressing water resources management issues. As a country where annual water demands exceed natural availability of water resources, Burkina Faso has been facing a great challenge to meet these demands that include organizational, capacity, legislation, economic and technical constraints. In 1996, a strategic plan on water resources was developed that resulted into the action plan for IWRM, PAGIRE, scheduled from 2003 through 2015. Its objective is the implementation of IWRM in Burkina Faso by respecting the principles acknowledged on an international level in relation to sustainable and ecologically rational management of water resources while taking into account the local situation. The strategic framework focuses on restructuring of management to assure its efficient and stable functioning through establishment of appropriate water management entities at all levels from the local and city levels to the state. Establishment of the local water committees serving as a forum for consultation among all stakeholders and for communication with higher level entities has been one of the main achievements contributing to rationalization of water use. The government of Burkina Faso also maintains active cooperation at the international level addressing regional (drought in Sahel) and trans-boundary basin (Volta river basin) issues. Political risk, capacity and technical and financial assistance remain the main issues in the PAGIRE implementation and the Asia-Africa Water Cycle Symposium is considered as a contribution to help to countermeasure these issues and to reinforce public policies to the benefits of communities.

Dr. Sivaji Chadaram, Counsellor, Embassy of India, recalled that the unique feature of water – its continuous recycling – was being disturbed by human activities through increasing industrialization and water demands for agriculture as well as domestic use. Therefore forums such as this Symposium are very important to bring constructive recommendations to the policy makers and researchers that are useful to promote sustainable development of water resources. Due to its geographical situation, India is facing a number of water resources related issues that are further exacerbated by climate change. The government of India has launched important programs to address the issues associated with climate change and 5 out of 8 national missions are related to water resources. Among them, the National Mission on Water is being implemented by the Ministry of Water Resources, under which operate a large number of research institutes and governmental funding agencies supporting research in water sector.

Integrated Water Resources Management (IWRM) and Sustainability was the theme of the keynote speech by Prof. S. Herath, United Nations University (UNU). Using the World Commission on Environment and Development definition of sustainable development (1987), which states: "Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs", Mr. Herath explained that total capital for a given country is equal to its natural capital, plus capital created, plus human capital, and that sustainable endeavours should holistically consider the complexity, irreversibility, uncertainty and ethical predicaments intrinsic to the natural environment and its connections to humanity. Sustainability economics includes balancing the needs and wants of individuals through efficient resource allocation. Achieving sustainability must take ecological security into consideration, which encompasses assessment of threats to human living, health, basic rights, and guarantee of secure living, necessary resources, social order, and the ability to adapt to environmental change. Thus, the sustainability of the Earth system involves the interaction of the environment, society, and economic sectors. Against this backdrop:

- IWRM serves as an important tool in supporting sustainable development objectives.
- Consideration of environmental, economic and social dimensions helps in understanding constraints for sustainable development when we plan IWRM strategies.
- In addition to maximizing benefits, we need to link the effects of global change on local sustainability as well as impacts of local developments on global sustainability.

In his keynote presentation, Mr. Shigeo Ochi, Director-General of the Water Resources Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), spoke to the audience on Water Cycle Observations and Integrated Water Resources Management from MLIT's perspective. He showed examples of ways in which MLIT is cooperating with hydro-meteorological services in the Philippines and Mongolia, and how it has supported development of a Flood Forecasting and Warning System project for China. He also illustrated support given by MLIT to the Network of Asian River Basin Organizations (NARBO) in implementing IWRM guidelines, and inputs provided to both the Rio + 20 Outcome Document "The Future We Want" and to the WMO's High Level Meeting on National Drought

Policy Final Declaration. He concluded by reviewing MLIT's expectations for the GEOSS Joint AWCI/AfWCCI Symposium, which were that:

- the AWCI and AfWCCI will achieve their goals;
- MLIT, would like to collaborate with specialists of global Earth observation at international conferences related to water resources.

The keynote addresses were followed by a panel discussion, during which panelists responded to one of the following questions:

1) What can the Earth observation community do to address the needs of stakeholders in terms of providing information about the water cycle for IWRM?

2) What opportunities should be provided in terms of (1) developing Capacity Building Programs for practitioners, administrators and decision makers; and (2) harmonizing Earth observation missions in the area of IWRM with funding activities of stakeholders? What role do you see for GEO to play in facilitating these activities?

3) It goes without saying that in-situ networks for water cycle variables are critically important, both for the precise nature of the information they provide, and also as a means to validate satellite retrievals and model outputs. Yet, no comparable coordination body such as the Committee on Earth Observation Satellites (CEOS) exists for in-situ networks. Moreover, it is often said that in-situ networks worldwide are not only not keeping pace, but also most systems are actually in decline. How do we provide an international coordination body that would act to reverse this trend and draw attention to the importance of sustaining and expanding in-situ networks for water cycle variables? Are there specific items that AWCI and AfWCCI can address or implement to deal with this issue?

4) The concept of IWRM was refined subsequent to the World Summit on Sustainable Development in 2002, Johannesburg, and it was the Global Water Partnership's definition of IWRM that has been widely accepted. It states:

> "IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

In your opinion, is this definition still valid/relevant today? Why or why not? What can GEO do in terms of supplying Earth observations to support IWRM?

Prof. S. Herath (UNU) reiterated the need for integrating education, research and capacity development in a sustainable approach to IWRM. In his view, GEO can provide valuable support to this strategy by providing global to local connectivity, information on data repositories and their use, and supporting continuity through pilot projects (field stations).

Mr. T. Kawasaki (NARBO Secretariat / Japan Water Agency) reviewed water-related challenges across Asia in terms of too little water, too much water, and too dirty water. These challenges are compounded by urbanization, economic development and recent extreme hydrological events where lack of proper facilities, legislation and governance result in a negative spiral. To tackle these issues, IWRM is needed at the river basin level. Unfortunately, many NARBO members (practitioners of IWRM) don't have enough capacity to understand what will happen in the near future due to the impacts of climate change, and thus there is the need to bridge the gap between researchers and practitioners of IWRM at the field level through capacity development. This is where GEO and GEOSS can play a key role, in bringing together science and research to develop practical applications in IWRM and build capacity.

Mr. G. Rasul (Pakistan Meteorological Department) recalled that the Basic aim of the Asian and African Water Cycle Initiatives is conversant with IWRM in order to "maximize the economic and social welfare of the stakeholder communities by addressing the impacts of climate change in a sustainable manner". To accomplish this, data gaps resulting from insufficient in-situ networks, sparse observations of the cryosphere, and limited access to satellite data and unavailability of representative data sets need to be resolved. GEO can help through developing usable knowledge and coordinating efforts among the member governments and Participating Organizations.

Mr. R. Lawford addressed the issue of declining *in-situ* networks. He recalled their importance in providing critical inputs into decision making, especially at locations which cannot be modeled or measured well from space; providing important inputs for calibrating satellite data and the development of integrated data products; and providing essential long-term records for monitoring climate change and other types of changes. The reasons for this include national budget constraints and a lack of recognition of the importance of *in-situ* measurements at both governmental and donor agency levels. He suggested the AWCI and AfWCCI should form a small working group to explore ways to interact with the UN and Development agencies to raise the profile of *in-situ* observations and to advance an agenda that will document and make recommendations on the issues of in-situ networks.

Mr. C. Ishida (JAXA) recalled that the Committee on Earth Observation Satellites (CEOS) is the "space arm" of GEOSS, providing remotely-sensed data for a variety of activities across the GEO Work Plan. CEOS contributes to GEOSS in a variety of ways, including:

- the CEOS Water Portal for discovery and access of satellite, in-situ, and model output data;
- the Virtual Constellation for precipitation;
- participation in, and response to, the GEOSS Water Strategy document.

He also announced that JAXA is changing its data policy and business model: the data policy now allows open and free access for low/medium resolution environmental satellite data, and commercial distribution by the private sector for high resolution data. The business model now includes global initiatives with UN organizations, regional sustainable development with JICA and ADB; and local services with private sectors and end users.

## 4. Contributions by Earth Observation & Science Communities *(Prof. T. Koike, Chair)*

Session 4 provided the opportunity for the Earth observation and science/research communities to inform the Symposium of their activities and explore potential avenues for collaboration with the AWCI and AfWCCI.

Ms. C. Lee, NASA Earth Science Division (ESD), presented the Applied Sciences Program (ASP) that works to maximize the benefit of breakthroughs in Earth system research by developing decision support tools and information products for end users (resource managers), and strengthening capacity to use them. She outlined the strategy and process by which ASP transforms research into operations and capacity with respect to water cycle science, using observations and information from various satellite missions such as the Gravity Recovery and Climate Experiment (GRACE), the Soil Moisture Active Passive (SMAP), and the upcoming Global Precipitation Measurement (GPM) in collaboration with JAXA. Applications are then disseminated and capacities developed through cooperative agreements with agencies such as USAID and its SERVIR program, as well as the World Bank, the US Water Partnership, Secure World Foundation and others.

Mr. M. Medina, NOAA Satellite and Information Service, spoke on Collaboration Opportunities for the Application of Earth Observations from Space in Water Activities. In his presentation, he reviewed the ways in which NOAA is meeting water related development needs with remote sensing through providing: access to Earth observation data; data dissemination infrastructures; number and scope of specialized products; and knowledge of how to interpret and assimilate data/products into decision making processes. Some of those products include datasets on precipitation, snow and ice cover, snow water content, vegetation health (a proxy for water surplus/deficit), soil moisture/surface wetness, and monitoring the phase of El Niño/La Niña. NOAA has also produced a flashflood guidance system for use in Africa, and supports GEONETCast as a means of disseminating environmental datasets and information for regions of the world lacking internet.

Mr. K. Umezawa presented JAXA's Contributions to the Water Cycle Observation by first reviewing current and planned satellite missions along with global datasets and products that are currently produced, such as integrated water vapor and cloud liquid water, precipitation, sea surface temperature and wind speed, sea ice concentration, soil moisture and snow depth. The JAXA Satellite Monitoring for Environmental Studies (JASMES) website provides visualization and access to a number of these data products for the water cycle. In terms of building capacity, the Space Application For Environment (SAFE) program aims to enhance the capability of satellite technology in the Asia Pacific region where implementation teams are expected to construct a prototype of operational use of Satellite technology within two years. SAFE accomplishments are then disseminated to stake holders to realize sustainable use of the technology.

Mr. B. Meyer, SANSA, outlined Earth observations for water available through the SANSA online catalogue, which includes functions for search, visualization and ordering of Earth observation data and information. He highlighted current and future activities, including development of EO-SAT 1, cubesats, unmanned aerial vehicles (UAVs), providing cal/val support for Sentinel 3 of the Copernicus project, and links to international agencies such as EUMETSAT and the WMO. Additionally, SANSA has been building water resource management capacity for several countries of the African continent through multi-institutional participation including TIGER, the Water Research Commission, South Africa's Department of of Water Affairs, and the Council for Scientific and Industrial Research (CSIR).

Mr. R. Lawford provided an introduction to the Integrated Global Water Cycle Observations (IGWCO) Community of Practice and the GEOSS Water Strategy Report it has recently produced. The IGWCO brings together water cycle stakeholders such as scientists, experts and end-users to explore ways of developing integrated water cycle data products, demonstrating tools and applications, developing capacity, and encouraging regional communities of practice. The purpose of the GEOSS Water Strategy Report is to:

- To update and synthesize the available information about the status of water observations and information systems since the IGWCO report of 2004;
- To describe a strategy for water cycle observations and information that will enable the short- term GEO objectives and the long-term community goals to be achieved;
- To provide CEOS, GEO, WMO and other agencies with guidance about strategies for water cycle observations, information systems, interoperability, capacity building, etc.; and
- To propose major initiatives that will advance these overall concepts.

He concluded his presentation by noting several new opportunities for the GEO Water SBA through addressing issues related to the Water-Energy-Food nexus.

Mr. O. Ochai gave an overview and live demonstration of the GEOSS Common Infrastructure (GCI), which enables sophisticated search and discovery of Earth observation datasets, products, services, and information contributed to GEOSS by the Member governments and Participating Organizations in GEO. Major improvements to the GCI include the Data Access Broker (DAB) which enables interoperable connections with existing data portals so that discovery can happen regardless of the entry point. As of this Symposium, there are over 20 brokered data providers (capacities, systems, communities) that allow access to over 65 million individual resources.

Mr. K. Onogi, Japan Meteorological Agency (JMA), reviewed production of "JRA-55", the recent reanalysis of global atmospheric and water cycle variables, covering more than 50 years since 1958 with 4D-var data assimilation system. He gave examples of the improvement in both quality and quantity from JRA-25, thanks to the integration of newly available data and reprocessed satellite data and the reduction of gaps. The data are openly available both through JMA and DIAS. M. Y. Izumikawa, JMA, followed with a presentation new meteorological satellites Himawari-8 (2014) and Himawari-9 (2016), which will replace the current MTSATs. The new satellites will feature 16 channels in visible, near-IR, and microwave wavelengths and be capable of providing images of Japan and Pacific typhoons every 2.5 minutes, and full disk every 10 minutes.

Mr. Y. Iwami, International Center for Water Hazard and Risk Management (ICHARM), informed the group of ICHARM's objectives, which include being the global center of excellence for providing/assisting implementation of the best practicable strategies to localities, nations, regions and the world to manage the risk of water related hazards including floods, droughts, land slides, debris flows and water contamination. ICHARM's philosophy is Localism: delivering best available knowledge to local practices. A major initiative of ICHARM is development of the early warning Integrated Flood Analysis System (IFAS) for 14 select river basins across Asia, for which sufficient hydrological monitoring does not exist. ICHARM also contributes to the Hyogo Framework for Action 2 & post-2015 MDGs through the development of proposed Global Risk Indices.

Mr. S. Benedict, Global Energy and Water Exchanges (GEWEX), informed the Symposium of the history and mission of GEWEX, which is:

> To measure and predict global and regional energy and water variations, trends, and extremes (such as heat waves, floods and droughts), through improved observations and modeling of land, atmosphere and their interactions; thereby providing the scientific underpinnings of climate services.

GEWEX, which is sponsored by the World Meteorological Organization (WMO), the International Council for Science (ICSU) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, has fixed as its objective for the next decade to respond to challenges in four water sectors:

1) Observations and Predictions of Precipitation (How can we better understand and predict precipitation variability and changes?);
2) Global Water Resource Systems (How do changes in land surface and hydrology influence past and future changes in water availability and security?);
3) Changes in Extremes;
4) Water and Energy Cycles and Processes.

Regional Hydroclimate Projects (RHPs) around the globe provide the platform and context for addressing GEWEX Imperatives: observations and data sets, their analyses, process studies, model development and exploitation, applications, technology transfer to operational results, and research capacity development and training of the next generation of scientists.

Ms. A. Johnson, Swiss Federal Institute of Aquatic Science and Technology (EAWAG) presented her work on modeling groundwater contamination based on surrounding geologic composition (“geogenic”), for both arsenic and fluoride. Global concentration probability maps are being produced on an ongoing basis, and the Groundwater Assessment Platform (GAP) is a user-friendly, open-source online platform for water quality information, available from EAWAG. Ms. Johnson saw linkages with the AWCI and AfWCCI in terms of:

1) Quantitative water resource issues:
    a. Locating alternative water resources
    b. Mapping of water points (model verification)
2) Partnering with other organizations:
    a. Establishing regional hubs to provide water-quality training, data management, modeling
    b. Mapping/modeling other water quality issues (e.g. salinity)
    c. Long-term hosting of data and information sharing platform

## 5. Poster Session

His Excellency Mr. Mohamed ELLOUMI, Charge d'Affaires a.i. Tunisia greeted the Symposium participants and noted with pleasure the role Tunisia had played in the foundation of the AfWCCI. He recalled that the First African Water Cycle Symposium had been held in Tunis, on 6-8 January 2009, and he was encouraged to see the progress that had been made since that time. He wished the participants a fruitful meeting and reiterated the support that Tunisia stood ready to provide support for activities of the AfWCCI.

## 6. African Session *(Prof. S.B. Weerakoon, Chair)*

Water security issues in Africa were the main theme of the keynote talk of Mr. Abou Amani, UNESCO Nairobi Regional Office and he opened his talk with the UN definition of water security:

> “The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.”

The key challenges to assure water security in Africa include:

- Economic water scarcity, i.e. human, institutional, and financial capital limit access to water even thought water in nature is available locally to meet human demands. 35% of population does not have access to safe drinking water.

- Sanitation and water quality aspect – less than 40% of sanitation coverage in many countries – associated with water born diseases.
- Security of water for food – limited irrigation capacity
- Water-energy nexus – high potential for hydropower development available
- Water-related disasters – flood and droughts with consequences on infrastructure and economy. Issue of outdated tools and formulas used for infrastructure design.
- Need to change current reactive crisis management approach towards proactive risk management approach.
- Transboundary water resources and urgent need for more cooperation among countries – most of the large basins and aquifers in Africa are transboundary.

Mr. Amani explained how IWRM could contribute to address these challenges and achieve water security in Africa by implementing individual stages of development in a gradual spiral process and emphasized the need of overall coordination among various sectors. For improved management, more information and data and better knowledge and its dissemination to end users is essential and this is where the main roles of AfWCCI are seen:

- improving the knowledge base for better water management at basin level,
- contributing to capacity building, education and awareness raising on earth observation and geo-information, and
- enhance cooperation, synergy and harmonization.

The keynote talk was followed by 6 presentations on African basin Project Design Matrices (PDMs). Revised PDM drafts are attached in the Annex at the end of this report.

## 7. Asian Session *(Prof. Z. Bargaoui and Dr. J. Oguntola, Chairs)*

In his keynote talk, Prof. D.-H. Bae, Sejong University, Korea, introduced the results of climate change impact assessment on water resources in the Asia-Pacific regions undertaken as a part of AWCI activities in 18 AWCI demonstration basins. The study combined global and local observation data for historical analysis and used CMIP3 A2 scenario climate model output for future analysis. Hydrological analysis in both, past and future was carried out using the Variable Infiltration Capacity (VIC) model and historical trends analysis employed Mann-Kendall test method. The results were analyzed on a regional scale and for each basin and the audience were referred to the final report of the project supporting this study for further details (http://www.apn-gcr.org/resources/archive/files/c3adab987b48a4490c4cb2c3224de5c3.pdf). In summary, the study provided historical climatic conditions over the region and in the basins during 30 years including annual average temperature, precipitation, runoff and runoff ratio of precipitation. The trend analysis of historical data showed (i) increasing temperature and decreasing precipitation and runoff over the Asia regions and (ii) opposite trends of temperature in northern regions of SE Asia and of precipitation and runoff in northern regions of SE Asia and northeastern regions of S Asia. The future projection analysis under A2 climate scenario indicated (i) increasing areal average of temperature and higher increase of temperature in high latitude areas, (ii) increasing areal average of precipitation and runoff over the region but decreasing in the northern part of SE Asia and northeastern part of Central Asia, (iii) change of runoff is highest at mid-latitude regions, and (iv) different trends of precipitation and runoff between the historical data and future projection.

The second keynote talk in this session was given by Prof. M. Kitsuregawa, University of Tokyo, Director of Earth Observation Data Integration & Fusion Research Initiative (EDITORIA), who introduced the Data Integration and Analysis System (DIAS), its purpose, architecture, activities and capabilities. DIAS has been developed for managing "big data" and the presentation explained how the key criteria for such system, namely volume, variety, velocity, and veracity of data, are fulfilled. The system consists of several nodes located at different places in Japan, providing together more than 20 petabytes of storage capacity. The wide data variety is addressed by advanced algorithms enriching data searching capability and providing integration and fusion functions across various disciplines. Velocity of data streaming is crucial for real-time operations and DIAS is supporting, for example, a decision support system for dam operation optimization in the Upper Tone basin in Japan, utilizing observation data from various sources and weather forecast arriving to DIAS on a real-time basis. Veracity or reliability data is assured by data quality control procedure and generation of adequate and standardized metadata. DIAS offers dedicated on-line tools for data providers to assist with these tasks. Prof. Kitsuregawa also introduced current directions of IT developments to achieve further automation in big data management and concluded that IT community will welcome new ideas and requirements on and innovative societal services

The Asian session introduced 14 country Project Design Matrices (PDMs). Revised PDM drafts are attached in the Annex at the end of this report.

## 8. Discussion for Implementation Planning *(Dr. R. Lawford, Chair)*

As moderator for this session, Dr. Lawford suggested focusing the discussion by considering a set of questions, one at a time. To stimulate discussion, several individuals would be called upon to respond to each question (from both Asian and African perspectives), followed by open discussion with interventions from the floor.

1) How can we realize the plan for AWCI and AfWCCI in terms of:
   a) gaining the commitment and technical support from national agencies and organizations;
   b) gaining financial support from the funding agencies (JICA, ODAs, World Bank);
   c) mainstreaming the PDM proposals into national priorities and plans?

Mr. G. Rasul made 3 observations: 1) a project proposal needed the support of the government to have a chance of success; 2) a consortium needed to first be developed before approaching a given ODA; and 3) in most cases, PDMs that have been presented are already well mainstreamed into national priorities.

Mr. A. Ali commented on the need to go through "mandatory" institutions, at the national level, since this was important for commitment and sustainability, and attainment of a critical mass in terms of human resources in order to be successful.

Mr. S. Sharma noted that the problems are often twofold in nature: there are several departments or different ministries looking after climate change and impacts, making coordination among them difficult. Also, since funding agencies they have their own sets of criteria and interests, it is not possible to generalize a process for funding.

Mr. J. Tumbulto echoed the remarks of Mr. Sharma and underscoring the need for support of national agencies. This is important for getting national institutions to step up and collect *in-situ* data as they need government support for rehabilitation of networks. In the WMO's World Hydrological Cycle Observing System (WHYCOS), the plan has been to obtain signed MOUs with participating countries to commit to supplying data. In addition, the MOUs, wherever possible, have indicated that improving networks should be included as part of the package.

Mr. M. Bila observed that, in his opinion, questions a) and c) are related. In mainstreaming the PDMs, he suggested keeping in view that, since the GEO framework is being used, Earth observations (EOs) will be providing the solutions to the challenges outlined. He further suggested considering how the plans and priorities are aligned with climate change, which will provide the opportunity to mainstream into those plans. It is important to show the benefits of EO as a contribution, emphasizing that new technology will help combat deficiencies of in-*situ* networks. He recalled the Nairobi workshop where the AfDB representative mentioned that money is available, but what are lacking are coherent plans. Thus, showing how these PDMs are useful in climate change impacts and disaster risk reduction (DRR) should be the approach to take with ODAs. The PDMs should also take into account how GEO works, along with relevant documents.

Mr. A. Nonguierma concurred, mentioning the PDMs could be aligned with the guidelines found in the *Mobilizing resources for implementing GEOSS: The Seville Roadmap*. In any event, there is not much choice other than aligning proposals with what donors want, and he suggested compiling an inventory of donors with their scopes of interest, followed by trying to mach proposals with the appropriate institution.

Ms. Z. Bargaoui noted that EO for DRR would be a highly relevant topic in its own right, one that would be sure to attract donor attention.

Prof. T. Koike agreed that questions a) and c) are closely related. He noted that water and weather sectors have different national priorities, and that water proposals currently have a higher priority with most governments. He said that demonstration projects are very important, as mentioned by the Pakistan Meteorological Department, and also that NASA and USAID agreed to incorporate remote sensing into their ODA projects. Thus, EO capability is an important component in projects presented to ODAs and he suggested making mention of the GEO framework and capabilities in project should enhance the PDM. He also noted that it was important to align with ODA objectives and find a specific, relevant topic for collaboration.

2. What is (are) the most effective framework(s) for advancing AWCI and AfWCCI activities and building bridges to national governments and international organizations:

a) Climate change;
b) Sustainable Development Goals;
c) UN Water;
d) Disaster reduction?

Please provide a rationale for your recommendation.

Mr. K. Labbassi suggested climate change was the appropriate framework, noting the importance of taking a more global perspective, what is happening on the large scale, and then examine impacts at the local scale.

Mr. A. Ali commented that a framework already exists in Africa and that helping research institutions would be a first step. Establishing links with international research organizations should be the first phase of any project.

Ms. C. Lee suggested an exchange between space agencies and ODAs would be very useful, sending someone with a technical background to work with and start to understand people in the ODA camp, and vice-versa, in order to build bridges.

Mr. M. Bila noted that it had not yet been demonstrated how to apply this new technology to solve real problems in the river basins. Moreover, transitioning to an operational phase is very important. To achieve the SDGs, there must be some sort of international cooperation, and working together on applications with immediate results would go a long ways towards boosting this cooperation.

Mr. R. Lawford observed perhaps a 2-pronged approach was needed: at a higher level, showing how the PDMs address the SDGs, and at a lower lever, providing examples of what we can do.

Mr. G. Rasul added that it was important to sensitize governments, on administration side, of the issues being worked on. In this manner, the awareness of policy-makers could be improved. He noted that Pakistan's PDM is in fact a national plan which has already obtained commitment from government.

3. How can we solve the infrastructure issues that may exist in order to:

a) Support data sharing i) within government departments, ii) among agencies and citizens, iii) government to government, and iv) to the world;
b) Put in place data transmission and information communications technologies;
c) Have a more coordinated approach to training and capacity development;
d) Provide the scientific information and models e.g., for downscaling needed to advance the projects?

Mr F. Mutua responded that, from a technological perspective, the main issue was how to effectively engage additional researchers in finding solutions. He also noted it remains a challenge in many parts of the world to connect with the internet, and thus any viable solutions need to make use of technologies that are locally possible and feasible. Finally, even though the concept of Spatial Data Infrastructure (SDI) was beginning to be accepted worldwide, and that data sharing is on the rise, there are still a lot of gaps in the data that are available.

Mr. C. Biney added that there are still instances where governments and departments sequester data and will not share them, and the data sharing principals of GEOSS need to be reinforced.

Ms. Z. Bargaoui also emphasized the fact that reliance on national research institutions was key for any long-term strategies in resolving these issues.

Mr. M. Bila commented that a basic need is the capability for users to communicate efficiently with servers containing data. Ideally, it should be possible to query a central server for data pertaining to just a portion of a basin of interest, not the whole of Africa. Also, since so many people have them, ways of making use of smartphones as a tool should be explored, and applications should be developed using open standards.

Prof. T. Koike summarized by noting that a university can contribute to issues of infrastructure in the areas of: 1) capacity building and training; and 2) research into the scientific information needed for water and food security, and water and energy security, as both water and economic prosperity are very important to national policies. Universities can also play a role in dissemination comprehensive knowledge.

4. Governments have a major need for assessment capabilities (e.g., for climate change, land use and other factors that affect the environment.) What key services should AWCI and AfWCCI projects offer to their governments? How will the PDM projects contribute to the governments? To what extent can PDM studies be transferred to other basins and generalized to the national scale? What steps can be taken to get government agencies to adopt and provide the services that will be developed from the PDM project?

Mr. A. Ali responded that the needs of governments is known (e.g. food security, flood management), and the AfWCCI should demonstrate how it will contribute to these needs through the provision of relevant information. In his opinion, the proposed PDMs are on the right track for fulfilling this important aspect.

5. AWCI and AfWCCI are components of GEO. Please define the interactions by identifying how:

- your project could support GEO;
- your project could benefit from specific GEO services (define which services).

Mr. B. Meyer commented that a critical service that GEO could provide would be data dissemination. This, coupled with the activities of the GEOSS Data Sharing Working Group (DWSG) to promote policies of open data sharing would be very effective.

Mr. O. Ochiai added that both the GEOSS Common Infrastructure (GCI) and GEONETCast facility are dissemination systems, and greater use of the latter in the developing world should be encouraged. In his view, the Water Cycle Community of Practice (IGWCO) should communicate more closely with the information technology (IT) side in GEOSS, and indicate its requirements for the GCI.

Mr. M. Bila: Service suggested the establishment of a specific forum whereby members within a given basin can communicate and collaborate as they seek to address the problems they are trying to solve within that basin. He noted that hosting services in this regard are almost non-existent within Africa.

Mr. R. Lawford responded that, as part of GEO, it should be relatively simple to create a working group to focus on this, and other issues related to hardware and software.

Mr. D. Cripe noted that AfriGEOSS, officially launched the preceding month at the Africa GIS 2013 and GSDI-14 Global Geospatial Conference in Addis Ababa, Ethiopia, provided an excellent vehicle to both advertise requirements and establish regional for a and platforms for solving problems at the basin scale.

Mr. G. Rasul commented that data related to the cryosphere should be made more readily available and at low cost, especially at fine resolution (which can be quite expensive).

Ms. S. Yabe responded by noting that JAXA had recently developed a new data policy, which included full access to medium- and coarse-resolution global datasets at no cost.

Mr. D. Cripe summarized by underscoring the importance of having the PDMs be aligned with SDGs as this would provide both relevance to GEO and its concerns for the post-2015 era, and a way of prioritizing activities. He commented that, in working on issues of post-2015 GEO and the approaching Geneva Ministerial Summit, one strategy for the renewal of GEO was to find out what interested Ministers and how GEO will make life easier for them. This approach makes clear the relevance of GEO to governments, essential for gaining public support for GEO activities. The AWCI/AfWCCI PDMs would do well to try to take a similar approach, by first discovering the objectives of governing bodies in regards to river basin management, then demonstrating how those objectives could be met via the PDMs. Finally, there is a lot of discussion regarding engaging the private sector in GEO in the post-2015 era. One way of connecting with the private sector might be through the provision of river basin data so that applications could be developed. Thus, perhaps each of the PDMs should address the need for development of a particular application (especially for smartphones) by the private sector, and explore what type of data exchange could be arranged as a stimulus.

## 9. Toward Implementation *(Dr. R. Lawford, Chair)*

R. Lawford prefaced the panel discussion by reminding the group that the objective of the session was to provide guidance on how we move from the current situation to future milestones. Themes to be covered included:

A. The current status of AWCI / AfWCCI activities: based on the presentation over the Symposium, what is the present situation with respect to current needs in different basins and nations, present programmes and capabilities, and our ability to coordinate and deliver on these programmes?

B. The future plans for AWCI and AfWCCI activities. Emphasis should be given to the PDMs that were circulated prior to the Symposium.

- What do we want to achieve in 10, 5, 2 years through the efforts of GEO activities in Asia and Africa? Special consideration should be given to the ways in which AWCI and AfWCCI could contribute to the SDGs.

C. Given the needs of stakeholders, the capabilities of participating organizations and the funding interests of ODAs, what steps do we need to take now? Specific issues that should be addressed in panel responses include:

1. the means of implementation (tools, data, funds and other resources, capacity building);
2. how to organize among agencies and on-going activities to address our needs;
3. identifying the ways in which AfWCCI can take advantage of linkages with AWCI and GEO infrastructure and vice versa.

A. Amani (UNESCO) responded by first noting he had had the opportunity to be involved in the AfWCCI since the beginning, and he was pleased to see that tremendous progress is being made. As to the question of how move forward, he suggested: 1) the PDMs need to be packaged in terms of comprehensive projects with all necessary elements, budgets, and implementation strategies in such a way that there is something concrete to share with donors; 2) the need to look at both the scientific aspect and operational aspects of the PDMs, in order to provide tools for decision makers (thus identify key partners at scientific, research institution, and operational agency levels, for each basin); 3) the need to put in place a core networking platform so that the "coordination aspect" can be strengthened and other initiatives brought on board, featuring capacity building and training, and a common database at the center (the GEO framework would be a useful entry point for different basins to download data from space agencies); and 4) the importance of not relying on one donor agency alone, but rather differentiate the needs of basins and donors, and match accordingly from among several agencies.

Y. Kinoshita (MEXT) noted that the Ministry is trying to move from a research to an operational phase, and thus contribute to the welfare of humankind. However, universities cannot reach people alone; there is the need for support from other agencies to establish operational systems. MEXT is thus looking to exchange ideas with stake-holders and learn about specific needs, helpful for pointing the way forward. He felt there are 2 important steps needed to accelerate progress: 1) discussion with stake-holders, especially with governments (primary stake-holders for scientists); and 2) regional cooperation – the AWCI is a good example in which more than 20 members are working together, producing good results, exchanging best-practices among participants, all of which are helpful for promoting the initiative and making the transition from science to operational phase.

S. Herath offered two practical suggestions for advancing implementation of the PDMs: 1) The minimum needs for water-resource management as expressed by various international bodies should be addressed, such as the UN-Water's World Water Day at UNU in Tokyo (March, 2014), featuring water-energy links; the AWCI/AfWCCI should consider sponsoring a booth to highlight recent activities.
2) Planning for capacity development in manner that is sustainable. The AWCI has worked to identify the best way to ensure capacity development on a regular basis, and one particular finding is that a good strategy is to engage a variety of possible partner and funding agencies for support, instead of thinking in terms of a single donor agency. This is important to reduce redundancies, and also to liberate funding from different sources, and to consider various approaches to training programs and lessons learned.
Lawford: Stockholm water week also a good venue

T. Koike responded that, with respect to the first issue, and after consideration of the Symposium discussions, a first step should be another round of ccompilation of the PDMs after tuning and revising by adding overall vision and scope, and regional strategies. Then, the documents should be circulated as widely as possible in order to raise awareness, and interact with possible collaborators and supporters. Regarding the second point, the AWCI and AfWCCI need to demonstrate the unique niche they can fill while supporting other initiatives through value-added outputs, and thus move towards fulfilling high-level goals such as the SDGs. Regarding the last point, he suggested sharing research and operational experiences and joint capacity building programmes by means of large-scale and high-level global, international frameworks, in order to foster collaboration and raise visibility. In this regard, timing is key. He noted that he had been invited to introduce the AWCI and AfWCCI at the World Water forum to be held in South Korea during April 2015.

D. Cripe recalled that the European Space Agency (ESA) TIGER project had been working in Africa since 2002 and it would be beneficial to find ways to learn from and collaborate with this initiative. TIGER has much experience with capacity building, and is also interested in supporting MDGs/SDGs in the African context. A similar close collaboration with the ESA's DRAGON (phase III) initiative in Asia should be explored. He also reiterated the significance of the recently-launched AfriGEOSS imitative to build GEOSS in Africa, and the need to use this as a framework, in the context of water resources management, to:

- coordinate and bring together relevant stakeholders, institutions and agencies across Africa that are involved in GEO and other Earth observation activities;
- provide a platform for countries to participate in GEO and to contribute to GEOSS;
- assist in knowledge sharing and global collaboration;
- identify challenges, gaps and opportunities for African contributions to GEO and GEOSS;
- leverage existing capacities and planned assets and resources; and
- develop an appropriate strategy and participatory model for achieving the above goals.

Finally, he encouraged closer cooperation with global water-related UN initiatives, such as UN-Water and the Global Water System Project (GWSP). He noted he had recently met the chief officer at the WMO for UN-Water and had established a dialogue for closer communication. He also mentioned he had attended the recent Budapest Water Summit (October 2013) where the role of GEO in helping monitor and assess progress towards achievement of the yet-to-be-defined SDGs for the water sector was discussed.

Y. Amano commented that in his experience working for JICA, he was often surprised at the poor status of *in-situ* monitoring networks. New gauges that had been installed as part of a development project were often broken or missing only a few years later, once the donor exited. Another recurring problem was overly restrictive budgets, a result of the importance of in-situ networks and observations not being understood at the political level. Thus, he felt that focusing on SDGs and providing a means to monitor progress towards them was key, since SDGs are important to the international community. In his view, it is possible to achieve water security and disaster risk reduction in all countries world wide, and thus water issues should take center stage in SDG discussions.

Comments from the floor:

J. Tumbulto agreed that coordination with TIGER was essential, and that now was probably the right time to renew contacts since the program is considering pilot projects for funding. He also noted that, with respect to the AfWCCI, mainly RBOs have been targeted for participation. However, the pilot projects contained within the PDMs could be constructed in such a way as to increase country participation GEO, while still working under the aegis of a particular RBO.

A. Nonguierma responded that, from the African perspective, he would like to emphasize what had been said by A. Amani and D. Cripe, that strengthening coordination mechanisms is essential. Solving issues of technology, data sharing, and human resources are all important, but at a more essential, fundamental level, appropriate national and international policies and institutional arrangements are needed. In this case, he echoes that AfriGEOSS can be a suitable framework for initiatives to set up a governance coordination mechanism. The next step should be to set up a dialogue with the African Ministers' Council on Water (AMCOW) to obtain buy-in from member states and governments, to give the AfWCCI the political umbrella needed to move forward with activities. He noted the African Union (AU) Commission has a strong initiative ongoing to develop African space policy, which should provide some strategic guidance on how relevant space-based activities will be coordinated in Africa (e.g. GPS, satellite communications, and astronomy). Thus, now is the time to try making stronger linkage with AU Commission, through initiatives such as Monitoring of Environment and Security (MESA). Linking with the AU Commission will be necessary to secure the institutional arrangements necessary sustainability in the long run.

A. Ali agreed that the coordination issue is very important: there are many water initiatives ongoing across Africa, such as AMESD, TIGER, MESA, and there clearly is a need to make links among them. Also, since these initiatives operate on both African and sub-regional levels, there needs to be a clear structure to within the AfWCCI to respond to these different levels.

R. Lawford asked, with this set of attractive basin initiatives, how best to package them so that they actually receive funding and can be implemented. In some instances, it appears the ODAs are mainly interested in supporting infrastructure and coordination, with investigators on their own to locate research funding.

T. Koike responded that already the APN had provide much support over the life of AWCI (since 2007), as had MEXT with funding for the Data Integration and Analysis System (DIAS). In other cases, individual researchers, such as Prof. D.H. Bae, have contributed their own funding the project. Until now, these sources have provided the “glue money” to hold together the AWCI. In his view, some of the PDM proposals are ready for review and acceptance by donor agencies. In the case of Africa, the European Commission has earmarked funding for cooperative research efforts between Europe and Africa. Similarly, MEXT has identified Africa as a priority area and continues to support DIAS in this regard. Close coordination with ODAs is essential. In the case of AfDB, the suggestion has been to plan a capacity building program for EO applications for IWRM. The plan could be reviewed and refined with AfDB before recommendation to GEF for funding.

C. Lee pointed out that ICIMOD had recently issued a call for small project proposals, and this could provide the opportunity to explore how to better connect with SERVIR.

S. Yabe noted that JAXA currently supports Space Applications For the Environment (SAFE), in cooperation with AWCI and the ADBI. These projects have included successful implementation of flood forecasting with dissemination of alerts to citizens, and JAXA would like to launch more such projects in the future.

D. Cripe asked for an indication of the next steps to be taken in the process, to which Prof. Koike responded that, based on several experiences, we have to first acknowledge that moving the projects forward will likely take time. Nevertheless, perhaps a good place to start would be to orient the proposals towards national governments, where the ministries of foreign affairs could take the responsibility to move the proposals forward and support their submission to donors such as JICA and AfDB. In parallel, from the international cooperation side, entities such as GEO, UNU and others can be used as a platform to negotiate with donors for each PDM. JICA, for example, maintains an office in most countries around the world, which means projects submitted for their consideration should contain activities with local relevance. The upcoming GEO Plenary will provide an opportunity to introduce AWCI/AfWCCI activates to the country delegations present, which should raise visibility and interest. Finally, he noted that embassy representatives had been invited to the Symposium, which is yet another approach to help advance the process. Communications will continue with the embassies in Japan, which can be an effective way to promote support for the PDMs.

R. Lawford concluded the session by expressing appreciation for the leadership of Prof. Koike and the University of Tokyo in organizing and promoting the AWCI and AfWCCI. He commented that the success of these initiatives relied on the engagement and participation of the group, and the authors of the PDMs needed to take ownership of the project and promote them within the appropriate national and institutional channels of each country. This approach will be the most effective way to make progress and increase the chances that a given project will receive funding.

**10. Summary and Closing** *(Dr. P. Koudelova, Chair)*

Representatives of co-hosting organizations, Douglas Cripe for GEO and Toshio Koike for the University of Tokyo, provided closing remarks to conclude the Symposium.

Douglas Cripe thanked all the attendees for their active participation in and excellent contributions to the Symposium. He recalled his involvement in AWCI and AfWCCI activities representing GEO Water and expressed his pleasure to work with the both communities and congratulate them on the progress they have made. He also encouraged the Asian and African country and river basin authority representatives to continue to finalize their Project Design Matrices and work on the proposed activities implementation. Douglas Cripe acknowledged and thanked the University of Tokyo and Prof. Koike and his team for excellent organization of the event and wished all the attendees a safe trip back home.

Toshio Koike thanked the GEO Secretariat for invaluable support in organizing the Symposium and also acknowledged special efforts as well as financial support of other sponsoring organizations including Asia Pacific Network for Global Change Research, Pakistan Meteorological Department, Japan Aerospace Exploration Agency, Japan Science and Technology Agency, and Japan International Cooperation Agency. Prof. Koike then reiterated and highlighted the main outcomes of the past three day deliberations for the implementation planning that included identification of the next step – revision and finalization of PDMs based on the Symposium discussion results, compilation and circulating it at the GEO Ministerial Summit in January 2014. The next meeting opportunities were mentioned, including the 7th GEOSS AP Symposium in Tokyo, Japan, May 2014 and World Water Forum in Korea, April 2015 for AWCI and possibly regular opportunity for AfWCCI that may be established in cooperation with ENIT, Tunisia and African Development Bank. Prof. Koike then expressed sincere thanks to other supporting organizations and individuals, whose efforts and contributions were indispensable for successful organization and realization of the Symposium: Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT), Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT), the Network of Asian River Basin Organizations (NARBO), and the members of the Symposium International Organizing Committee. Lastly, Prof. Koike thanked all the participants for their diligent work during the Symposium making it a great success and wished them safe journey back to their countries.

*Note: All presenters agreed with publishing their presentations in the pdf format on the Symposium website.*

**ANNEX**

# Plan of Implementation
# Project Design Matrix (PDM) Proposal

**Plan of Implementation**
**Project Design Matrix (PDM) Proposal**

### GEOSS Africa Water Cycle Coordination Initiative (AfWCCI)



### GEOSS Asia Water Cycle Initiative (AWCI)

## Kenya: Tana River Basin

**Project Title**: *Integrated Collaborative Research on Climate Change, Water Resources and Food Security in the Lower River basin, Kenya*

**Background**

The water resources issues in this catchment include:

- Acute water scarcity
- Catchment degradation especially on Mt. Kenya and on slopes of Aberdares Ranges
- Soil erosion and overgrazing in the lower parts of the region
- Human encroachments into the watershed
- High groundwater salinity in Lower Tana, in the coastal zone, due to over-exploitation
- Seawater intrusion affecting the quality of groundwater
- Increased water resource demand, urbanization and industrialization
- Early warning systems are almost inexistent
- Food production has been on the decline and droughts have become more prevalent
- Increased sediment loading in the lower Tana and in the dams along the Tana

Due to increasing encroachment in the water catchment areas of Aberdares and Mount Kenya, flash floods have continued to increase with more devastating effects in Lower Tana area. Coupled with this is siltation which has continued to choke the seven forks dams and reduce their capacity for power generation. Other effects of floods and droughts affect socio-economic activities in the catchment and other forms of livelihoods and health. These problems are quite diverse and need to be addressed through an integrated approach.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Reduction of meteorological/hydrological disasters and effective use of water resources in the Lower Tana River basin in Kenya for agriculture and hydro energy production

**2. Project Purpose**

To develop capacity for improvement of water and food security under climate change in the Lower Tana River basin in Kenya.

These are the urgent needs in the following areas:

- Recent and frequent floods in addition to drought damage on agriculture has led to food insecurity in the Tana basin which has exacerbated conflict for limited water resources
- The Lower Tana basin is poorly observed. There are few observation stations and those which exist are at coarse spatial and temporal resolutions
- Basin-wide and multi-sectoral coordination of water resources management among flood control, hydro-power and agricultural use is weak. Several irrigation schemes and power generation projects exist along the Tana river but their management is not coordinated and concerted as each is managed largely independently of the others.
- Early warning and extreme weather prediction capacity is very low in the basin and Kenya as a whole

Climate change makes these vulnerable situations more critical. To address these issues, we need to:

(1) Demonstrate quantitative and qualitative improvement of water cycle observations

(2) Demonstrate flood and drought early warning capability

(3) Assess climate change impacts on floods, droughts and crop production

(4) Prototype data and information integration and sharing systems
(5) Improve observational, modeling and application capacity

### 3. Outputs

The key outputs from this proposed project include but not limited to -:

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
   a) Prototype near-real time rainfall observation and data dissemination systems by coupling satellite and in-situ measurements which are used as inputs into flood prediction.
   b) Develop comprehensive in-situ and satellite observation data archive for improving monitoring capability of water cycle and developing hydrological models to be used for early warning.
   c) Develop long-term and comprehensive climate observation data archives which are used for climate change analysis climate projection model bias correction.

(2) Demonstrate early warning capability of water and **food security**
   a) Develop coupled hydrological – **crop** models for converting climatological and meteorological data and information to usable information of water resources and food management
   b) Prototype real-time data management, modeling and information dissemination systems.

(3) Evaluate climate change impacts on floods, droughts and **food production**
   a) Select GCMs which can express the regional climate properly.
   b) Implement bias correction and downscaling (statistical- and dynamic-) of the selected GCMs.
   c) Develop a socio-economic data archive
   d) Compare changes of frequency and intensity of flood, drought and food production.

(4) Prototype data and information integration and sharing systems
   a) Develop an integrated water portal for improving data accessibility and data sharing.
   b) Prototype a data integration and analysis and information dissemination system

(5) Improve observational, modeling and application capacity
   a) Develop training modules of satellite remote sensing, modeling, bias correction and downscaling, make design of training courses on integrated observations, early warning and climate change assessment, and offer the courses.
   b) Promote secondary educational programs in collaboration with universities.

### 4. Activities, Key Leaders and Contributors

It is a key objective of this initiative to bring on board as many stakeholders as possible. Based on a preliminary meeting held at the Jomo Kenyatta University of Agriculture and Technology (JKUAT) on the 16th August, 2013, the following organizations were identified as the probable candidates for the initial engagements.

<u>Lead Organizations</u>

- Water Resource management authority (WRMA)
- Kenya Meteorological Services Department (formerly KMD)
- Water and Sewerage Companies – Murang'a water, Nyeri Water and Sewerage Company (NYEWASCO), Embu Water and Sewerage Company (EWASCO)?
- Jomo Kenyatta University of Agriculture and Technology (JKUAT)
- The University of Tokyo
- Kyoto University
- Power Generating companies – KenGen, Geothermal Development Company (GDC)
- National Council of Science, Technology and Innovation (NACOSTI)
- Ministry of Environment and Mineral Resources
- Kenya National Bureau of Statistics (KNBS)

- Regional Center for Mapping of Resources for Development (RCMRD)
- Department of Resource Surveys and Remote Sensing (DRSRS)
- Tana Water Services Board, Tana Athi River Development Authority (TARDA)
- Kenya Agricultural Research Institute (KARI)

<u>Activities</u>

In addition to the Lead Organizations' capacity which will be developed, we will take following actions in collaboration with other organizations and initiatives as follows:

(1) Demonstrate quantitative and qualitative improvement of water cycle observation
   1) Transmitting rain gauge data to the Lead Organization Data Facility (KMS/WRMA) and sharing the data by Internet for producing bias-corrected satellite-based rainfall map to be disseminated to wide communities.
   2) In-situ and satellite observation data archive
   3) Climate data archive at least past 20 years which correspond to the availability of the GCM model outputs.

(2) Demonstrate flood and drought early warning capability
   1) Develop distributed physically-based hydrological models including simulation ability of evapotranspiration, soil moisture, ground water and **vegetation/crop** growth.
      *JKUAT, DIAS, science communities*
   2) Prototype real-time data integration systems for satellite data bias correction, hydrological modeling including data assimilation and information dissemination.
      *JKUAT, KMS, Univ. of Tokyo (DIAS)*

(3) Assess climate change impacts on floods, droughts and water-nexus
   1) Selection of GCMs which can express the regional climate.
      *JKUAT, KMS, Univ. of Tokyo (DIAS)*
   2) Bias correction and downscaling
      *JKUAT, KMS, Univ. of Tokyo (DIAS)*
   3) Socio-economic data archive
      *KNBS, NACOSTI*
   4) Assessment of the changes of flood, drought and water-nexus.
      *WRMA, JKUAT, Univ. of Tokyo, CORDEX, DIAS, science communities*

(4) Prototype data and information integration and sharing systems
   1) Develop an integrated water portal for improving data accessibility and data sharing.
      *DIAS*
   2) Prototype a data integration and analysis and information dissemination system
      *DIAS*

(5) Improve observational, modeling and application capacity
   1) Develop training modules and design and implement training courses
      *JKUAT, U. Tokyo, Kyoto Univ.*
   2) Promote secondary educational program in collaboration with universities.
      *JKUAT, U. Tokyo, Kyoto Univ.*

## Morocco: Oum Er Rbia Basin

**Project Title:** *Integration of geospatial and social data to set up and develop a water resources management system for the Oum Er Rbia basin (morocco): Contribution to climate change adaptation*

**Background**

The Oum Er Rbia hydraulic basin spreads on a surface of 50.000 $km^2$. The population is about 4,5 million inhabitants, of which 65% are rural. The zone has an economic activity enough varied including the irrigated and no irrigated agriculture, the mining industries, the agro-food industries, tourism and of numerous big transformation industries. The yearly middle rainfall on the basin is 550 mms; it varies between 1100 mms on the Middle Atlas and 300 mms in the downstream zone. The temperature varies between 10 and 50°C and the evaporation are 1600 mms per year in average on coasts and 2000 mms inside of the country with a monthly maximum of 300 mms in July and August. The storage of the basin is valued to 5750 $m^3$ and the volume of water mobilized is about 3200 $Mm^3$/year, which represents 30% of the country.

The observations of the past three decades (1970-2000) show signs warning of likely impact of climate change: frequency and intensity of droughts, devastating floods unusual change in the spatio-temporal distribution of rainfall. The water capital, already at the limit of water stress (840 $m^3$/capita/year in 2000) is in decline. The possibilities for mobilizing new resources are almost unexpected. The only deposit currently available is represented by the high water losses in networks of water transport as well as optimizing its use. In addition to the scarcity of resources, there are other problems of pollution related to urban and industrial worn-out water dismissals and the agricultural activity. This context requires optimal management of resources. The Moroccan authorities at the central level have been absolutely conscious of that, but it is essential that the local level mobilize more. This is one of the objectives of managers of water resources in the region under the plan "Green Morocco» launched by the Moroccan government in 2008.

Accordingly, the Chouaib Doukkali University in partnership with its scientific international partners and in collaboration with several other local partners and end-users (Regional Manager of Water Resources' ) has decided to take up research–action project in order to develop sustainable development' of water resources taking into account the climate change. The approach is based on a study of the biophysical vulnerability of the basin using the available scientific tools and techniques at the national and the international levels, particularly the remote sensing and the virtual reality technologies. These information's will be articulated with the socioeconomic data on Oum Er Rbia basin proceeding from participatory process in order to define the socioeconomic impacts on the water resources and to integrate them into the sustainable development's prospective scenarios.

Following this action-research, we will be able to synthesize the prospective development scenarios' in a simulator (website, portal), designed as an interactive tool for raising awareness during public information's campaign, awareness of stakeholders targeted groups, strategic politic thinking and process formulation's, planning and monitoring of investment development projects.

**Project Design Matrix (PDM)**

### 1. Overall Goal

The overall objective is to contribute to the establishment of an IWRM plan integrating the fight against climate change in both mitigation and adaptation aspects. The specific objective is to contribute, through action research project to improve the communication on climate issues, as well as the coordination between the different actors involved in issues related to water in the Ou Er Rbia basin.

### 2. Project Purpose

Include the purpose(s) here; use the bulleted list if necessary:

- Characterization of the resource: current status and prospective models to identify trends, according to natural (CC) and human impacts.
- Propose a plan for optimal management which will include a component to raise awareness of good practice for saving water
- Capacity building (operability): An important aspect of sustainability by transfers the gained knowledge to the beneficiaries in the basin. The project team Participates in various activities of training and coaching through the actions planned during the project. At the end, the local team should be able to make an operational and sustainable use of the project results. It is an action that could be considered as a springboard for the creation of a regional observatory in water resources (Observatoire Réginal de l'Eau d'Oum Rbia, OREOR).

To address the above issues the items below should be done:
(1) Biophysical vulnerability profile of the basin and assessment of water resources.
(2) Socio-economic vulnerability profile of the basin with regard to CC.
(3) Develop future scenarios for sustainable development of water resources, taking into account the CC and establishment of an interactive simulator.

**3. Outputs**

(1) Biophysical vulnerability profile of the basin and assessment of water resources
  a) Monitoring and assessing of the water level, water body mapping and monitoring (water level and volume), water quality monitoring, and underground water exploration by Use new satellite-based techniques with in situ measurements for inventory and monitoring of the variability of water resources:
  b) High to medium land cover / land use change and degradation mapping (inc. vegetation indices) and its implications on the territorial dynamics.
  c) Hydrological monitoring and water balance characterization: Hydrological modeling by scenario analysis and operational forecasting ; Flood forecasting and mapping of Erosion potential ; evapotranspiration estimation at the basin level with special focus on the irrigated area; monitoring of drought and irrigated agriculture

(2) Socio-economic vulnerability profile of the basin with regard to CC.
  a) Qualify and quantify of the competition for water between users and characterize the evolution of each use (Population, Agriculture, Industry, and Tourism).
  b) Relate water quality and types of pollution identified with a mapping and analysis of the impact of human activities.
  c) Mapping of sociological information.
  d) Analyzing self-adaptive capabilities to CC and quantification of the costs of adaptation and non adaptation

(3) Develop future scenarios for sustainable development of water resources, taking into account the CC and establishment of an interactive simulator.
  a) Compilation and synthesis of the biophysical and socio-economic data. A prototype system to evaluate vulnerabilities and identify options for adaptation.
  b) Defining highlights problems and opportunities, and subdivision of the basin into different zones according to their needs.
  c) Prospective climatology from the scenarios for emissions of Greenhouse Gases, Climatic models and local data (precipitation, temperature, topography ...).

**4. Activities and Key Leaders**

<u>Lead Organizations</u>

- Chouaib Doukkali University, Geosciences & Remote Sensing Group (GRS_CDU), Morocco.
- Moroccan Association of Remote Sensing of the Environment (MARSE), Morocco.

- University of Tokyo (UT), Japan.
- Delft University of technology (TUD), the Nederland.
- International Foundation for a Territorial Approach to Global Change Scientific Services and Knowledge Sharing Partnership (TASK), France.
- National Network of Geo- information Sciences (REGI), Morocco.
- Agence du Bassin Hydraulique de l'Oum Er-Rbia ( ABHOER), Morocco.
- Office de Mise en Valeur Agricole de Doukkala (ORMVAD), Morocco
- Office de Mise en Valeur Agricole de Tadla (ORMVAT), Morocco
- Office chérifien de Phosphate (OCP) Morocco

List of potential collaborators and donors from the international community:

(1) Biophysical vulnerability profile of the basin and assessment of water resources

1) Completion of a questionnaire to communicate with partners and regional actors, through a small survey to assess their recognition of problems and assess their information needs and capacity building.
   *Collaborators*: all partners.
   *Donors*: seeking donors
2) Collection and synthesis of existing data and identifying needs. Reconnaissance missions on the field
   *Collaborators*: GRS_CDU, REGI, TUD, UT, TASK, ORMVA, OCP.
   *Donors*: seeking donors
3) Satellite data analysis
   *Collaborators:* GRS_CDU, REGI, UT, TUD.
   *Donors*: NASA, ESA will provide some satellites data
4) Data field data which have been generated by terrestrial measurements and newly measured field data (meteorological, agronomic and social data)
   *Collaborators*: GRS_CDU, REGI, TASK, ABHOER, ORMVA, OCP.
   *Donors*: seeking donors
5) Hydrological modeling
   *Collaborators*: GRS_CDU, REGI, UT, TUD.
   *Donors*: seeking donors

(2) Socio-economic vulnerability profile of the basin with regard to CC

1) Produce spatially explicit maps of regional water vulnerability defining the ratio of the demand to supply of available water.
   *Collaborators*: GRS_CDU, REGI, TUD, TASK.
   *Donors*: seeking donors
2) Test of climate and socio-economic change scenarios with implications in terms of their impact on human production-activity and water use requirements.
   *Collaborators*: GRS_CDU, REGI, TASK.
   *Donors*: seeking donors
3) Estimates of change in water demand for various human activities as response to changes in local climate, demographic, and water availability.
   *Collaborators*: GRS_CDU, TASK, ABHOER, ORMVAD, ORMVAT, OCP.
   *Donors*: seeking donors

(3) Develop future scenarios for sustainable development of water resources, taking into account the CC and establishment of an interactive simulator.

1) Definition of a communication tool integrated delivered on various digital media, system of interactive maps and simulations
   *Collaborators*: GRS_CDU, TASK.

*Donors*: seeking donors

2) Organization of workshop-meeting for information, return the results. Set up a roadmap for sustainability.
   *Collaborators*: all partners.
   *Donors*: seeking donors
3) Setting up a forum or blog for the flow of information and communication between the different actors. Leading to the creation of regional observatory in water resources
   *Collaborators*: all partners.
   *Donors*: seeking donors

## Tunisia: Medjerda River Basin

**Project Title:** *Enhancement of Medjerda flood warning system*

**Background**

The region of study is the Medjerda river basin from the frontiers with Algeria to Jedaida city. It is called by High and Middle Medjerda Valley, with mean annual precipitation 400 – 800 mm / year. Medjerda is a Tran boundary river. The third of its watershed is located in Algeria. It is the Water tower of Tunisia and has huge importance for water drinking and Agriculture sector (irrigation as well as rain feed crops). Generalized floods occurred in the past (1969 and 1973) as well as in recent years (2000, 2003, 2004, 2005, 2009, et 2012). Flood generation processes are mainly heavy or even moderate rainfall with long durations and great spatial extent. The resulting soil saturation favors the occurrence of surface floods and enhances the flooding process. Recently, the most important flood with respect to flood peak was observed in January 2003. However, in February 2012, monthly rainfall exceeded two to three times the monthly averages across the Medjerda basin. As a result, high discharges were recorded (1500 $m^3$/s at the Algerian border Ghardimaou and 1160 $m^3$/s at Jendouba station) [2]. Inundations took place along the Medjerda bed.

Medjerda basin hosts several multi objectives dams with conflictive objectives: flood protection, drinking water furniture, irrigation with all maxima in summer season. Five upstream dams are interconnected in the Tunisian part, while upstream dams are also in operation in the Algerian part. Downstream Sidi Salem dam (reservoir capacity 750 $Mm^3$) is a flood plain (nearly 2 millions of people) with urbanization, agricultural and industrial activities. There is no basin authority but six regional authorities (CRDA) in the study region, under the national authority of Ministry of Agriculture.

Observation networks (rainfall, river and dams water levels, river discharges, water quality) are available but only ground data are used. Databases are maintained at regional and national scales. Some information systems (geology, hydrography, pedology, soil occupation maps as GIS) are available at regional levels. Water management is operated mainly by the Ministry of Agriculture. However, regulation tools and civil society are weak. Better governance is needed. International projects have been coordinated by the water division office (DGRE) such as: Piseau I : 2001-2007; 328 MDT (BIRD, AFD, AfDB) – Irrigation- Drinking water- Ground Water /SINEAU (information system); Piseau II : 2009-2014; 216 MDT (BIRD, AFD, AfDB) – Irrigation- Drinking water – WRM. A previous work was performed by JICA (2009) in order to find out some regulation rules to mitigate flood impacts.

Project aims to continue these efforts and to develop, with respect to flood management and mitigation, data, experiences and rules exchanges between both countries (Tunisia and Algeria).

**Project Design Matrix (PDM)**

### 1. Overall Goal

The overall goal is to enhance the Medjerda flood warning system of the hydrological division (DGRE) of the Tunisian Ministry of Agriculture (MARH) by providing numerical tools for flood forecasting. At the moment, the SYCOHTRAC project is designed for flood warning only. It is based on a network of telemeter raingauge stations together with a network of telemeter limnimetric stations. Warnings are operated with respect to some rainfall intensity thresholds and water levels thresholds. Also they take into account how quick the changes in observed discharges are. A previous work was performed by JICA [1] in order to find out some regulation rules to mitigate flood impacts.

### 2. Project Purpose

The project purpose is to:

- Improve the Medjerda river flood monitoring system,

- Put into service the use of rainfall satellite information,
- To implement a rainfall-runoff model and flood routing model for runoff prediction and forecasting,
- To develop with respect to flood management and mitigation, data, experiences and rules exchanges with the Algerian part.
- To develop a capacity building program.

The main items what should be done to address the above issues are:
(1) To install new observation stations
(2) To enhance the numerical and building capacities of the flood forecast services with respect to satellite data acquisition
(3) To enhance the numerical and building capacities of the flood forecast services with respect to flood modeling
(4) To develop a mechanism of information exchange between Tunisian and Algerian Medjerda managers
(5) To develop a capacity building program

**3. Outputs**

(1) Improve the Medjerda river flood monitoring system
  a) Extension of the river runoff monitoring system by installing six new gauging stations.
  b) Development of a daily and hourly rainfall database which will serve as reference to evaluate the performances of satellite data
  c) Integration of the geographical information systems available at the regional level into a unique system for the Medjerda watershed

(2) Put into service the use of rainfall satellite information
  a) Acquisition of rainfall satellite data
  b) Evaluation of rainfall satellite data
  c) Development of the computer capacity of DGRE.

(3) Calibration of a distributed hydrological model and a flood routing model
  a) Calibration of a flood routing model
  b) Calibration of a rainfall runoff model
  c) Use satellite data for models calibration
  d) Use satellite data for flood forecasting
  e) Evaluation of forecast performance

(4) To develop a mechanism of information exchange between Tunisian and Algerian Medjerda managers.
  a) Better understanding of the actual experience of exchanges and its limits
  b) Development of a Tran boundary partnership for a heavy rainfall and flood data assessment

(5) To develop a capacity building program
  a) Flood routing model such as HEC-RAS,
  b) Distributed rainfall runoff models;
  c) SIG elaboration and flood inundation mapping ,
  d) Satellite data import and use,
  e) Water survey monitoring.

**4. Activities and Key Leaders**

**Activities:**

(1) Improve the Medjerda river flood monitoring system.

For the extension of the observation system, activities are the identification of stations locations. The new locations are selected in order to facilitate the flood forecasting and taking into account the present gauging stations network. For the database extension, at the moment, a daily rainfall database is operational in the hydrological office DGRE. This data base was used to study regional climate simulations [3]. In fact, it is not properly a database. It is just under EXCEL tables. Thus, a GIS should to be implemented under ArcGIS to deal with those data. For hourly rainfall data, there is no structured database. Observations are not really at numerical form, unless exceptionally. So, it should be interesting to elaborate such a database, in order to help forecasting for example using the Analog method. For the moment, a SIG system is operational at regional level. The present information contain in particular data about pedology and soil texture, as well as soil occupation. These are very important information for flood prediction and forecasting using rainfall-runoff modeling. It is aimed to aggregate this information in order to arrange a single GIS system which will be helpful and a key step in case of establishing (in the future) a High and Middle Valley Medjerda basin. Recent river bed elevation data have been performed by JICA [1] along the Medjerda path and for rivers crossing Bou Salem city. Such information will be helpful for the flood routing model calibration.

(2) Put into service the use of rainfall satellite information.
Rainfall satellite information is nowadays currently used by hydrologic services worldwide. However, it is not very developed in Tunisia. A first attempt was developed in Université de Tunis El Manar in collaboration with ITC [4]. The degree of matching of some satellite products with ground data will be analyzed. The objective is to gather satellite data as rainfall runoff model inputs and to see to what extent the results are sensitive. Some reference rainfall events will be selected. Maps provided according to ground data will be elaborated and compared to maps originating from the satellite products. A bias correction approach should be developed in order to make this information tractable and appropriate to the structure of rainfall-runoff outputs.

(3) Calibration of a distributed hydrological model and a flood routing model aiming an accurate estimation of flood discharges at the hourly time step.
Till now, the hydrological service of DGRE does not comprise a flood routing model neither a rainfall – runoff model. It is aimed to fill this gap by providing a flood routing model for the Medjerda River as well as distributed rainfall runoff model for main sub basins. Models will take into account the available rainfall and river discharge networks as well as the structure of the present regional GISs and the Medjerda river bed characteristics. These models should be operated at the hourly time step. The degree to which the rainfall runoff model is distributed will be discussed with project collaborators such as dam service, agriculture representatives, municipalities' representatives as well as in junction with the SYCOTRACH project. These models will be calibrated using the most important flood events occurring in the Medjerda during the last fifty years. Also, a data assimilation procedure should be included to help runoff forecast. The flood routing model will help delineation and prediction of flooding and inundating areas.

(4) To develop a mechanism of information exchange between Tunisian and Algerian Medjerda managers.
Flood management and mitigation of a Trans Boundary river requires building data and experience exchanges between countries. Although, a committee exists at present to discuss such issues, tools and means of developing a permanent secretary with appropriate data bases and management and emergency schemes might be developed during this project. Some examples from African Trans Boundary Rivers (like Niger and Volta) might be analyzed. Tunisia signed in 1997 UN Water Convention. This project may contribute to enhance the capacity to go forward. Mechanisms of data exchanges, building of a comprehensive groundwater model for the Sahara Aquifers have been developed between Tunisia and Algeria under OSS. Such an experience led by DGRE may benefit to Medjerda basin management.

(5) To organize workshops and short courses.
A capacity building program will be proposed to improve the model outputs sustainability. Beneficiaries are the staff of hydrological services at national and regional levels as well as post graduate engineering students that might be involved in the future in the system (private or public).

Lead Organizations

- The national hydrological service (DGRE)
- University of Tunis El Manar (Ecole Nationale d'Ingénieurs de Tunis, ENIT)
- Upper and Middle Medjerda regional services of the Ministry of Agriculture (CRDA)
- national dam service
- Infrastructure service (DHU),
- Agriculture representatives (water users)
- Municipalities (population representatives).

List of potential collaborators and donors from the international community:

(1) Improve the Medjerda river flood monitoring system

1) Extension of the river runoff monitoring system by installing six new gauging stations.
*JICA, AfDB, AFD*

2) Development of a daily and hourly rainfall database which will serve as reference to evaluate the performances of satellite data
*NASA, ESA, University of Tokyo, OSS*

3) Integration of the geographical information systems available at the regional level into a unique system for the Medjerda watershed
*ITC, University of Tokyo, NASA*

(2) Put into service the use of rainfall satellite information

1) Acquisition of rainfall satellite data
*JAXA; ESA; NASA, ITC*

2) Evaluation of rainfall satellite data
*JAXA; ESA; NASA, ITC*

(3) Calibration of a distributed hydrological model and a flood routing model

1) Activity for outputs 3a) to 3e)
*University of Tokyo; JICA, NASA, IRD*

(4) To develop a mechanism of information exchange between Tunisian and Algerian Medjerda managers.

1) Development of a Tran boundary partnership for a heavy rainfall and flood data assessment
*OSS; AMCOW, AfDB*

(5) To develop a capacity building program

*ESA; ITC, NASA, University of Tokyo, UNU, AfDB*

## Niger River Basin

**Background**

In the Niger River Basin, the meteorological disasters such as floods and droughts become more and more frequent and their economic and human losses are rapidly increasing. Monitoring the current situation and assessing the future conditions in the basin are of huge concerns for national agencies of the member countries, the River Basin Authority and the regional and international Governmental and Nongovernmental Organizations and other stakeholders.

Also, the current climate condition in the basin is characterized by a strong intra-seasonal and inter-annual alternating drought and inundation conditions. This situation condition complicates the adaptation to climate impacts, because adaptation is not only in way.

On the other hand, a strong population growth in the basin (one of the greatest in the world) leads to a significant change in land surface and hydrological conditions.

The existing current hydro-meteorological ground-based measurement network is in many cases obsolete. After the severe drought started in the year 1973 in the Niger River basin region, there was a strong commitment of countries in strengthening hydro-meteorological measurement networks in the basin. But, because of some economic difficulties faced by countries in the years 1990, the networks had decreased. Now, it is well known that the existing operational network is not enough in terms of density of the stations and also in terms of rapid access to the data to allow early warning on rapid hydro-meteorological phenomena in the basin.

So, there is a strong need to upgrade the networks and to take benefit from new available techniques and tools to face the issue of monitoring of droughts and flood in the basin and also to assess the future conditions of these phenomena.

The hole Niger Basin is facing to these challenges, but the situation is more critical in some specific areas. For example, flood has become more challenging issue for Niamey area, the capital of Niger. Also, the future conditions of the water resources in the Upper part of the basin are critical issue for irrigation and hydropower generation in the remaining part of the basin.

The sustainability of the Project in a policy aspect is very high because both Niger Basin Authority and AGRHYMET Regional Center are permanent institutions and the objectives of this project are explicitly targeted in their mandates. Both of these two institutions works on these issues in the Niger for now more the 30 years and have well established national component. The sustainability of the Project in a financial aspect is also high because the activities of the project will be part of permanent activities of these two institutions and even after the project phase, these activities will be funded on their own budget. Even, further funds will be expected in order to extend to the project activities to cover the whole basin. In technical aspect, both AGRHYMET and NBA are research and technical institutions with scientist with permanent positions. They will continue to be involved and lead further development of the project. As part of their mandate, they will transfer tools and methods developed in the projects to countries through a participatory implementation of the project and a continuous training for national experts.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Hydrometeorological disaster is reduced in the Niger River Basin.

**2. Project Purpose**

An operational flood forecasting system is built to predict flood in Niamey, the capital of Niger and the future conditions of climate and land-surface changes in the upper Niger is accessed and their impacts on irrigation and hydropower production in the downstream of the basin are evaluated.

**3. Outputs**

(1) An on-line integrated meteorological and hydrological (rainfall, evapotranspiration and discharge) observation network of 15 stations in the Sirba tributary, 2 stations in the Kory of Gounteyena and 2 stations in the Kory of Boubon is established to contribute to flood forecasting in Niamey.
(2) An integrated meteorological and hydrological (rainfall, evapotranspiration and discharge) observation network of 30 stations covering the upper Niger is established.
(3) Deep studies to characterize land charge surface changes in the Sirba tributary and in the upper Niger is carried out.
(4) Deep studies to quantify current and future deforestation in the upper-Niger are carried out.
(5) Operational satellite meteorological products (rainfall, evapotranspiration) are assessed and used for flood forecasting in addition to ground-based measurement network.
(6) Distributed hydrological rainfall-runoff model is calibrated both for Sirba tributary and other small kory contributing to flood in Niamey area and the Upper basin of the Niger River.
(7) Understanding hydrological variation mechanisms in Sirba tributary and the Upper Niger for flood forecasting and climate and environmental changes impacts on water resources is enhanced.
(8) An operational experimental flood forecasting system based on the integration hydrological, satellite products and on-line ground based measurement data is established for Niamey area.
(9) The future characteristics of the water resources in the Upper Niger are characterized, taking into account deforestation and land-surface changes.
(10) The impacts of the future water resources characteristics on irrigation and hydropower generation in the downstream of the basin are determined.
(11) Two stakeholders in the basin workshops are organized.

**<u>Volta River Basin</u>**

**Project Design Matrix (PDM)**

## 1. Overall Goal

The overall goal of the project is to ensure a reduction of meteorological and hydrological disasters and improve upon effective use of water resources in the Volta River basin.

## 2. Project Purpose

- The purpose of the project is to improve upon the quantitative and qualitative data in the basin with the view to improving upon the modeling and the management of the water resources in the basin to meet various uses in support of the socio-economic development of the basin population.
- Increasing intensity and frequency of natural disasters, floods and droughts affect the resilience capacity of communities in the Volta River basin. It is necessary to focus on the prevention and integrated risk management of these disasters.
- It is necessary to improve upon the food security situation in the basin by moving from subsistence to growth agriculture in the basin. For climate smart agriculture, we need more attention on dry land agriculture and greater focus on risk management.
- Climate Change impacts negatively on economic growth and erodes the gains from the countries' development. Therefore, we need to strengthen climatic database and information systems as well as promoting the use of climatology and meteorology in multi-sectoral planning and the setup of early warning systems. We also need to promote an integrated approach to environmental issues in particular articulating climate change adaptation as well as disaster risk reduction efforts.
- There is the need for basin-wide and multi-sectoral coordination of water resources management among flood control, hydro-power and agricultural water use in the Volta Basin. However quantitative and qualitative data needed to enhance the coordination in the basin is lacking.

To address these issues, we need to:

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
(2) Demonstrate flood and drought early warning capability
(3) Assess climate change impacts on floods, droughts and water-nexus
(4) Prototype data and information integration and sharing systems
(5) Improve upon observational data collection, modeling and application capacity

## 3. Outputs

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
  a) Prototype near-real time rainfall observation and data dissemination systems by coupling satellite and in-situ measurements which is used as inputs into flood prediction models.
  b) Develop comprehensive in-situ and satellite observation data archive for improving monitoring capability of water cycle and developing hydrological models to be used for early warning.
  c) Develop long-term and comprehensive climate observation data archive, which are used for climate change analysis and climate projection model bias correction.
  d) An integrated meteorological observation network covering the parts of the Volta basin is established.

(2) Demonstrate flood and drought early warning capability
  a) Develop hydrological models for converting meteorological data to hydrological information.
  b) Prototype real-time data management, modeling and information dissemination systems,

(3) Assess climate change impacts on floods, droughts and water-nexus

a) Select GCMs which can express the regional climate properly.
b) Implement bias correction and downscaling (statistical- and dynamic-) of the selected GCMs.
c) Develop socio-economic data archive
d) Compare changes of frequency and intensity of flood, drought and water-nexus.

(4) Prototype data and information integration and sharing systems
a) Develop an integrated water portal for improving data accessibility and data sharing by building on the existing infrastructure in the Volta Basin Authority.
b) Prototype a data integration and analysis and information dissemination system

(5) Improve observational, modeling and application capacity
a) Develop training modules of satellite remote sensing, modeling, bias correction and downscaling, make design of training courses on integrated observations, early warning and climate change assessment, and offer the courses.
b) Promote secondary educational programs in collaboration with the universities.

**4. Activities and Key Leaders and Contributors**

Lead Organizations

- Volta Basin Authority (VBA)/ AGRHYMET

In addition to the Lead Organizations' capacity which will be developed, there will be collaboration with the following organizations and projects as listed below:

(1) Demonstrate quantitative and qualitative improvement of water cycle observation
1) Transmitting rain gauge data to the Lead Organization Data Facility and sharing the data by Internet for producing bias-corrected satellite-based rainfall map to be disseminated to wide communities
*WMO/HYCOS, ESA, TIGER-NET, NASA, NOAA, JAXA, DIAS*
2) In-situ and satellite observation data archive
*WMO/HYCOS, UNEP/GMES, UNESCO/G-WADI, UNESC-WMO/IGRAC, Tiger heritage, ODA project heritage, AMMA, Reanalysis (ECMWF, NCEP, JMA), ESA, NASA, NOAA, JAXA, CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*
3) Climate data archive at least past 20 years which correspond to the availability of the GCM model outputs.
*WMO/HYCOS, Reanalysis (ECMWF, NCEP, JMA), ESA, NASA, NOAA, JAXA, CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*
4) Acquisition and installation of integrated meteorological observation network covering the parts of the Volta basin.
*WMO/HYCOS, AfDB, EU, JICA.*

(2) Demonstrate flood and drought early warning capability
1) Develop distributed physically-based hydrological models including simulation ability for runoff, evapotranspiration, soil moisture, ground water and vegetation growth.
*CREST, DIAS, science community*
2) Prototype real-time data integration systems for satellite data bias correction, hydrological modeling including data assimilation and information dissemination.
*ACMAD, ECMWF, National Weather Services, GEOWOW, NASA-SERVIR, UNESCO-IFI, UNESCO-Princeton Univ., DIAS*

(3) Assess climate change impacts on floods, droughts and water-nexus
1) Selection of GCMs which can express the regional climate.
*PCMDI, DIAS, science communities*
2) Bias correction and downscaling
*PCMDI, CORDEX, DIAS, science communities*

3） Socio-economic data archive
*GLOASIS*

4） Assessment of the changes of flood, drought and water-nexus.
*GLOWASIS, CORDEX, DIAS, science communities*

(4) Prototype data and information integration and sharing systems

1） Develop an integrated water portal for improving data accessibility and data sharing.
*CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*

2） Prototype a data integration and analysis and information dissemination system
*CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*

(5) Improve observational, modeling and application capacity

1） Develop training modules and design and implement training courses
*Tiger, UNESCO, NASA-SERVIR, RCMRD, ITC, UNU, UTokyo,*

2） Promote secondary educational program in collaboration with universities.
*ITC, UNU, UTokyo*

**Lake Chad Basin**

Project Title: *Lake Chad Basin Flood and Drought Early Warning System*

**Background**

The recent hydrological history of the Lake Chad Basin can be classified into the wet period (1950 to 1972) and the dry period which begins in the year 1973 with a two year drought that desiccated the north pool of the Lake Chad. During the past 14 years, the Lake Chad Basin has been experiencing an increase in rainfall. The sudden resurgence of rainfall has resulted in four major floods that has resulted in economic loss in the years 1999, 2004, 2010 and 2012. The pattern of this resurgence in rainfall and its spatial impact is not clearly understood because of the deterioration in the hydro-meteorological observation network occasioned by conflict, poor maintenance, and lack of investment. The low observation density in the region has led to an inability to implement a flood forecasting system that will help to minimize the impacts of meteorological and flood disasters over the Lake Chad Basin. The two distinct periods of wet and dry climates were the result of climate change. Since climate change is expected to continue, it is necessary for scientist in the Lake Chad Basin to have access to a downscaled regional climatic model to allow them simulate different climate scenarios that are necessary for developing climate adaptation action plans.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Reduction of meteorological and hydrological disasters and the promotion of effective use of water resources in the Lake Chad Basin.

**2. Project Purpose**

An operational forecasting system is established and made operational in the Lake Chad Basin to support flood and drought disaster prediction and to provide the knowledge to adapt to climate change in water resources management.

**3. Outputs**

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
(2) Operational flood and drought early warning system is established for the Lake Chad Basin
(3) Assess climate change impacts on floods, droughts and water-nexus
(4) Prototype data and information integration and sharing systems
(5) Improve observational, modeling and application capacity

**4. Activities and Key Leaders**

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
  1) Setup the receiving system for rain gauge data from data provider to the LCBC for producing bias-corrected satellite-based rainfall map.
  2) Build a database of time series of In-situ and satellite observation data archive
  3) Create a climate data archive at least past 20 years
  4) Develop an online query and retrieval tool accessible through the internet for the dissemination of climate data to the stakeholders of the Lake Chad Basin.

(2) Operational flood and drought early warning system is established for the Lake Chad Basin.
  1) Develop distributed physically-based hydrological models including simulation ability of evapotranspiration, soil moisture, ground water and vegetation growth.

2) Prototype real-time data integration systems for satellite data bias correction, hydrological modeling including data assimilation and information dissemination.
3) Produce and distribute the forecast information on water related hazard resulting from the execution of the prototype application for early warning system to the stakeholders of the Lake Chad Basin.

(3) Knowledge on climate change impacts on floods, droughts and water-nexus developed for the Lake Chad Basin
1) Study and selection of GCMs which fully simulate the regional climate of the Lake Chad Basin.
2) Perform bias correction and downscaling of the applicable climate model.
3) Establish socio-economic database of the Lake Chad Basin.
4) Conduct an assessment of the changes of flood, drought and water-nexus as a result of climate change and disseminate report.

(4) Prototype data and information integration and sharing system is established for the Lake Chad Basin.
1) Develop an integrated water portal for improving data accessibility and data sharing.
2) Develop an online prototype data integration, analysis and information dissemination system for the Lake Chad Basin.

(5) Observational, modeling and application capacity of the Lake Chad Basin Commission and its stakeholders strengthened.
1) Develop training modules and design and implement training courses.
2) Promote secondary educational program in collaboration with universities.

**Bangladesh**

**1. Overall Goal**

Assessment of Climate Change Impacts on Water Resources and Adaptation Measures for Sustainable Water Resources Management in Barind Area of Bangladesh

**2. Project Purpose**

The main purpose/objective of the project is to assess the impact of climate change on water resources in the North West (NW) region of Bangladesh and to develop adaptation measures for sustainable management of the water resources leading to socio-economic development of the area. The specific objectives of this project are:

- Assessment of the present state of water resources.
- Assessment of Surface Water (SW) and Ground Water(GW) availability under present and future climate change condition.
- Assessment of water demand for different sectors.
- Formulation of suitable options for sustainable water resources management.
- Capacity building of related organizations.

**3. Outputs**

(1) Assessment of the present state of water resources.
   a) Trend of groundwater level variation.
   b) Trend of river flow and water level variation.
   c) Assessment of water quality.
   d) Assessment of flooding characteristics e.g. flood duration, flood depth, areal extent etc.

(2) Assessment of SW and GW availability under present and future climate change condition.
   a) Assessment of SW availability at key location of the perennial rivers.
   b) Upazila-wise groundwater resources for the project area.

(3) Assessment of water demand for different sectors.
   a) Present and future water demand assessment for different sectors e.g. agriculture, domestic and industrial, forestry, fisheries and in-stream needs.

(4) Formulation of suitable options for sustainable water resources management.
   a) Impact assessment of different SW development options on GW resources.
   b) Socio-economic and environmental impact assessment of different options.
   c) Automatic GW level monitoring network in a pilot area.
   d) An Interactive Information System (IIS) to facilitate better resources management.
   e) Performance evaluation of artificial GW recharge in a pilot area.

(5) Capacity building of related organization.
   Trained professionals on:
   a) Mathematical modeling
   b) Water demand assessment
   c) IIS
   d) Water quality modeling
   e) Climate change assessment

**4. <u>Activities and Key Leaders</u>**

<u>Lead Organizations</u>

Leading Organization: Ministry of Defense, Government of Bangladesh

It is anticipated that the following organization may be involved in implementation of the study:

- Ministry of Water Resources (MoWR),

- Ministry of Agriculture (MoA),
- Ministry of Environment and Forest (MoEF),
- Bangladesh Water Development Board (BWDB),
- Barind Multipurpose Development Authority (BMDA),
- Bangladesh Agricultural Development Corporation (BADC),
- Bangladesh University of Engineering and Technology (BUET),
- Institute of Water Modeling (IWM) etc.

(1) Assessment of the present state of water resources.
  1) Collection of different hydrological and hydro-meteorological data from different organizations e.g. BWDB, WARPO, BADC, BMDA, BMD, DPHE, IWM etc.
  2) Quality checking of the collected data.
  3) Trend analysis of GW level, surface generation for pre and post monsoon season.
  4) Statistical analysis of river Water Level (WL) and flow.
  5) Collection and analysis of water quality data to assess seasonal and yearly variation.
  6) Development and application of flood model to determine extent and duration of flooding.

(2) Assessment of SW and GW availability under present and future climate change condition.
  1) Development and application of SW model using MIKE-11.
  2) Statistical analysis of river flow data for different dependability.
  3) Development and application of GW model using MIKE-SHE/MODFLOW.
  4) Analysis of GW model data for GW resources assessment.
  5) Select GCMs which can express the regional climatic property.
  6) Implement bias correction and down-scaling of the selected GCMs.

(3) Assessment of water demand for different sectors.
  1) Collection and analysis of cropped, forest and fishery area, soil properties, population etc. from BWDB, DAE, SRDI, BBS etc.

(4) Formulation of development option for sustainable water resources management.
  1) Identification of options in consultation with local people, professional communities and review of existing reports
  2) Technical evaluation of different options using mathematical model.
  3) Collection and analysis of socio-economic and environmental data
  4) Need assessment and installation of automatic GW level monitoring stations
  5) Institutionalization of the automatic network.
  6) Need assessment and development of the IIS
  7) Installation of artificial recharge well.
  8) Performance evaluation of the recharge wells using mathematical model.

(5) Capacity building of related organization.
  1) Assess training need.
  2) Develop training modules
  3) Design and implement training courses in collaboration with national and institutions and organizations.

<u>Contributors:</u> Likely funding agencies are ADB, JICA, WB etc.

## 5. Killer Factors and Mitigation Measures

| Killer Factor | Mitigation Measures |
|---|---|
| Timely availability of sufficient | Several donors may be explored |

| | |
|---|---|
| fund. | |
| Coordination and cooperation amongst different agencies. | A steering committee comprising representatives from concerned agencies may be formed. |
| Knowledge gap | There are certain areas e.g. climate change, environmental flow requirement etc. in which case the physical processes are not yet fully clear. In such cases expert's support may be sought. |
| Discontinuity of related activities. | Suitable organization may be employed to continue it. |

**6. Reference:** The proposed project planning has been formulated by the Ministry of Defense through a study carried out by IWM a government owned trust organization.

# Cambodia: Sangker River Basin

**Project Design Matrix (PDM)**

## 1. Overall Goal

Operational implementation of Integrated Water Resources Management approaches.

## 2. Project Purpose

Specific issues/needs in Cambodia:

- In-situ observation network and data access and sharing platform not sufficient.
- Lack of flood/drought forecasting and early warning systems for operational applications.
- Climate change impact assessment on water nexus.

To address these issues, we need to:

(1) Improve water cycle observation network and data management and information dissemination systems.

(2) Develop capability of flood and drought forecast and early warning on an operational basis including:
   a) Accessibility to numerical weather prediction data.
   b) Suitable hydrological models for operational use.
   c) Decision support and information dissemination tools.

(3) Understand the current situation and assess climate change impacts on seasonal patterns of water cycle variables, floods, droughts and water-nexus (food and health in particular) and provide recommendation for adaptation measures.

## 3. Outputs

(1) Demonstrate improvement of water cycle observations data management systems and information dissemination systems.
   a) Develop/improve near-real time rainfall and water level observation network by (i) installing new stations and (ii) coupling satellite and in-situ measurements.
   b) Develop/improve comprehensive in-situ and satellite observation data archive for improving monitoring capability of water cycle and enhance data dissemination systems, which is then used for flood and drought forecasting and early warning.
   c) Develop/improve long-term and comprehensive climate observation data archives, which are used for climate change analysis.
   d) Improve observational, modeling and application capacity in the country (education and training).

(2) Demonstrate capability of flood and drought forecast and early warning on an operational basis, starting with the Sangker river basin and then follow up with wider areas.
   a) Establish easy and real-time access to numerical weather prediction data (Met./Hydro services) for operational purposes.
   b) Develop distributed, physically-based hydrological model(s) (e.g. WEB-DHM) for converting meteorological (weather prediction) data into hydrological information and capable of coupling with further modules, e.g. inundation, vegetation growth and crop production,…).
   c) Develop inundation model and update flood hazard maps.
   d) Develop drought assessment tools based on drought indices.
   e) Couple hydrological model with a crop model.
   f) Prototype real-time data management, operational modeling and information dissemination (early warning) systems (including information relevant for end users, i.e. decision makers and local people).
   g) Promote research achievements to decision makers and improve awareness of decision makers and local

people.

(3) Understand the current situation and assess climate change impacts on seasonal patterns of water cycle variables, floods, droughts and water-nexus (agriculture, in particular) and provide recommendation for adaptation measures based on IWRM practices, , starting with the Sangker river basin and then follow up with wider areas:
   a) Review/conduct research on and assess current situation of regional and local water cycle phenomena and water nexus.
   b) Select GCMs which can express the regional climate properly (CMIP5 models).
   c) Carry out bias correction and downscaling (statistical- and dynamic-) of the selected GCMs to regional and basin scales.
   d) Methodology for assessment of hydrological changes using the CMIP5 climate projection data (corrected and downscaled) and suitable hydrological model(s).
   e) Assess changes in water budgets (precipitation, flow, soil moisture).
   f) Assess changes in seasonal patterns (precipitation, flow regime).
   g) Assess impacts of these changes on water nexus, primarily food (agriculture: rice production) and health (water quality – surface water, groundwater).
   h) Propose adaptation measures compatible with IWRM approaches based on the climate change assessment results.

**4. Activities and Key Leaders and Contributors**

**Lead Organizations**

- Governmental sector: Ministry of Water Resources and Meteorology (Meteorology and Hydrology department services), Ministry of Agriculture, Forestry and Fishery, Ministry of Environment
- Tonle Sap Authority
- High-level Coordination Body among the Ministries and Tonle Sap Authority (to be established)
- Cambodian Academia
- …?

In addition to the Lead Organizations' capacity which has been developed, we will take following actions in collaboration with the organizations and projects as follows:

(1) Demonstrate improvement of water cycle observation
   1) Transmitting rain gauge data to the Lead Organization Data Facility and sharing the data by Internet for producing bias-corrected satellite-based rainfall map to be disseminated to wide communities
      *NASA, NOAA, JAXA, DIAS*
   2) Satellite observation data archive
      *NASA, NOAA, JAXA, CEOS Water Portal, DIAS, AWCI*
   3) Climate data archive at least past 20 years which correspond to the availability of the GCM model outputs.
      *Reanalysis (ECMWF, NCEP, JMA), NASA, NOAA, JAXA, CEOS Water Portal, NASA-SERVIR, DIAS, AWCI*
   4) Improve observational, modeling and application capacity
      a) Develop training modules and design and implement training courses
         *UNU, UN-CECAR, University of Tokyo (UT), AIT, JAXA*
      b) Promote secondary educational program in collaboration with universities
         *UNU, UN-CECAR, UT*

(2) Demonstrate capability of flood and drought forecast and early warning on an operational basis

1) Establish easy and real-time access to numerical weather prediction data (Met./Hydro services) for operational purposes
   *NWP centers, AWCI, DIAS*
2) Develop distributed physically-based hydrological models including simulation ability of evapotranspiration, soil moisture, ground water and vegetation growth (WEB-DHM) for the Sangker river basin.
   *AWCI, DIAS, science communities*
3) Develop inundation model(s) and update flood hazard maps
   *AWCI, DIAS, science communities*
4) Couple hydrological model with a crop model
   *AWCI, DIAS, science communities*
5) Prototype real-time data integration systems for hydrological modeling including data assimilation and information dissemination.
   *Meteorology Department, NASA-SERVIR, DIAS*

(3) Assess climate change impacts on floods, droughts and water-nexus

1) Selection of GCMs which can express the regional climate.
   *AWCI, DIAS, science communities*
2) Bias correction and downscaling
   *AWCI, DIAS, science communities*
3) Socio-economic data archive
   *GLOWASIS?*
4) Assessment of the changes of flood, drought and water-nexus.
   *AWCI, DIAS, science communities*
5) Propose adaptation measures
   *?*

## India: Upper Bhima Basin

### Background

The Upper Bhima Basin has a geographical area of 14,712 $km^2$ and lies in western India in the state of Maharashtra. Length of the Bhima River up to Ujjani Dam is 275 km. Across the basin the average annual rainfall is 700 mm. The rainfall generally decreases from west to east with three regions of varying rainfall: the extreme western region of heavy annual rainfall (2,300 mm), the foot hill region where annual rainfall is moderate (800 to 1,000 mm) and the central and eastern region of lowest annual rainfall (400 to 600 mm). About 25% of the area in the Basin is hilly and highly dissected, 55% is plateau and 20% plain and valley filled. Forestry covers 10.1% of the basin and agricultural use in the basin makes up 76.3 %. Of the crops grown in the basin, 64.8% are under irrigation. Soils in the basin range from reddish brown on sloping land (basalt 38%), coarse shallow soils (12%), medium black soils (26%), and Deep black soil (24%).

Under the CCAA study, the rainfall and temperature data of Upper Bhima basin has been entered in the DIAS network of Tokyo University for AOGCM quantitative evaluation. The suitable GCM output for the region would be accepted after gap filling and bias correction of historical simulation precipitation output and future projection precipitation output of selected models using observed precipitation data. These future scenarios would be linked with hydrological model for assessing the impact of climate change on water resources. Studies are required to be taken up for developing the modified methodologies for the assessment of water resources, hydrological design practices, flood risk assessment and flood management and drought management, operation policies for some of the existing as well as proposed water resources projects and assessment of available water for irrigation including the land uses and cropping patterns. Quantification of the impacts and vulnerabilities and assessment of adaption strategies with combination of climate projections and integrated assessment models by utilizing comprehensive data of climate water cycle and resources are required for integrated water resources development and management of water resources of the upper Bhima basin.

### Project Design Matrix (PDM)

#### 1. Overall Goal

Holistic approach for sustainable development and management of water resources in India.

#### 2. Project Purpose

Include the purpose(s) here; use the bulleted list if necessary:

- Water availability is likely to get affected by the impact of climate change.
- Increased intensity and frequency of extreme events including rainfall, floods, droughts and cyclones due to climate change.
- Increase in design flood estimates of the existing hydraulic structures and the hydraulic structures to be constructed in future is expected due the impact of climate change.
- Increasing water demands and utilization due to population growth and developmental activities in the country.
- Modification/ Change in the existing water resources planning, development and management practices of water resources projects including operation policies of the reservoirs due to impact of climate change.
- Gap between developed advanced technologies and their field applications and lack of IWRM approaches in operational practices.

**To address these issues/needs, we need to:**

(1) Demonstrate improved capacity in modeling techniques for climate change impact studies.
(2) Estimate the present water availability and future water availability considering the impact of climate change

for the study area.

(3) Assess climate change impacts on extreme events for some regions of India.

(4) Estimate design floods for various types of hydraulic structures considering impact of climate change.

(5) Estimate flood inundation for the present situation and future considering impact of climate change.

(6) Assess water availability and demands under the changed climatic conditions and update water allocation policies and operation rules for the reservoirs of the study area.

(7) Promote implementation of the advanced technologies and IWRM approaches in field applications and decision-making process considering impact of climate change.Item 2

**3. Outputs**

(1) Demonstrate improved capacity in modeling techniques for climate change impact studies.
   a) Improve techniques for GCM output (CMIP5) bias correction and downscaling.
   b) Develop downscaled and bias corrected products of GCM outputs (CMIP5) over India.
   c) Select GCMs which can represent the regional climate appropriately.

(2) Estimate the present water availability and future water availability considering the impact of climate change for the study area.
   a) Applications of distributed hydrological model(s) (DHM) for converting meteorological data to hydrological information and capable of coupling with GCM outputs.
   b) Simulation of distributed hydrological model(s) (DHM) with present and future meteorological, LULC data to estimate water availability at selected locations.

(3) Assess climate change impacts on extreme events for some regions of India.
   a) Carry out DHM(s) simulations using the corrected and downscaled GCM outputs for some regions of India.
   b) Compare changes in frequency and intensity of rainfall, flood, drought, and water-nexus in between present and future.

(4) Estimate design floods for various types of hydraulic structures considering impact of climate change.
   a) Estimate floods of various return periods using the L-moments approach of flood frequency analysis for present condition.
   b) Estimate floods of various return periods using the L-moments approach of flood frequency analysis for future considering the impact of climate change.
   c) Compare changes in frequency and intensity of rainfall, flood, drought, and water-nexus in between present and future.

(5) Estimate flood inundation and flood hazard for the present situation and future considering impact of climate change.
   a) Estimate flood inundation due to floods of various return periods for the present.
   b) Estimate flood inundation due to floods of various return periods in future considering impact of climate change.
   c) Estimate flood hazard and develop flood hazard classification scheme based on extent, depth, elevation and duration of flooding as well as the maximum flow velocity for various return periods using coupled (1-D & 2-D) hydrodynamic flow modelling for the present.
   d) Estimate flood hazard and develop flood hazard classification scheme based on extent, depth, elevation and duration of flooding as well as the maximum flow velocity for various return periods using coupled (1-D & 2-D) hydrodynamic flow modelling for the future considering impact of climate change.

(6) Assess water availability and demands under the present and changed climatic scenarios and update water allocation policies and operation rules for the reservoirs of the study area.
   a) Estimate water demands of various sectors under the present and changed climatic scenarios.
   b) Analyse the simulated water availability for hydrologic extremes, inter annual and inter decadal variations to meet the water demands from various sectors.

c) Propose adaptation practices considering major social, economic, and institutional factors under the changed climatic scenarios.

(7) Promote implementation of the advanced technologies and IWRM approaches in field applications and decision-making process.

a) Organization of training programs and workshops for promotion and dissemination of the downscaling techniques, assessement of water avalability, hydrologic design practices, development of flood hazard maps and operation polices for reservoirs and IWRM approaches considering the climate change scenarios.

**4. Activities and Key Leaders**

Lead Organizations

- National Institute of Hydrology, Roorkee, India.
- Water Resources Department , Govt. of Maharastra, India (subject to consent)
- Indian Institute of Teshnology, Kharaghpur, India (Dr. C. Chatterjee, Asst. Professor)

In addition, provide list of potential collaborators and donors from the international community – specify for each Purpose Item:

(1) Improve observational, modeling and application capacity

1) Develop training modules and design and implement training courses
*UNU, UN-CECAR, UTokyo, AIT, JAXA, National Institute of Hydrology, Roorkee.*

2) Promote secondary educational program in collaboration with universities
*UNU, UN-CECAR, UT Tokyo, National Institute of Hydrology, Roorkee.*

(2) Demonstrate improved capacity in modeling techniques for climate change impact studies

1) Improve techniques for GCM output bias correction and downscaling.
*AWCI, DIAS, Science communities, National Institute of Hydrology, Roorkee.*

2) Apply distributed hydrological model(s) (DHM) for converting meteorological data to hydrological information and capable of coupling with GCM outputs
*AWCI, DIAS, Science communities, National Institute of Hydrology, Roorkee.*

(3) Assess climate change impacts on extreme events for some regions of India.

1) Selection of GCMs which can express the regional climate, bias correction, downscaling.
*AWCI, DIAS, Science communities, National Institute of Hydrology, Roorkee.*

2) Carry out DHM(s) simulations using the corrected and downscaled GCM outputs for some regions of India.
*AWCI, DIAS, Science communities, National Institute of Hydrology, Roorkee.*

3) Compare changes of frequency and intensity of rainfall, flood, drought and water-nexus in between present and future.
*AWCI, DIAS, Science communities, National Institute of Hydrology, Roorkee.*

4) Assessment of the changes of flood, drought and water-nexus.
*AWCI, DIAS, Science communities, National Institute of Hydrology, Roorkee.*

(4) Promote implementation of the advanced technologies and IWRM approaches in field applications and decision-making process
*AWCI,National Institute of Hydrology, Roorkee.*

*The PDM is subject to approval from Ministry of Water Resources, Govt. of India.*

**Indonesia: Citarum River Basin**

**Project Title:** *Evaluation of Water Resources Management System for Climate Change Adaptation*

**Background**

Indonesia is an archipelago country which consists of 17,000 tropical islands where some of them are vulnerable to flood and drought due to the impact of both land use change and climate change. Therefore some areas in Indonesia experience anomalies in climate condition, such as flood event in the period of dry season, and drought event in the period of wet season.

In terms of climate change adaptation and mitigation, in November 2007 the Indonesian Government published the National Action Plan on Climate Change (RAN-PI), which contains initial guidance for a multi-sectors coordination effort, designed to address jointly the challenges of mitigation and adaptation to climate change. In December 2007, Bappenas (National Development Planning Agency) also published a document titled "National Development Planning: Indonesian Responses to Climate Change 1", which is intended to strengthen and reinforce the RPJMN (National Medium-Term Development Plan) 2010-2014.

Citarum River Basin plays an important role in economic development of Indonesia as it provides raw water supply for about 75% of the Jakarta municipal water demand, most of strategic industrial development in JABEKA (Jakarta, Bekasi Karawang), 242.000 hectares or irrigated rice field in its downstream (Karawang, Subang, Purwakarta and Indramayu) and hydro power plant in its three cascade dams (Saguling,Cirata, and Jatiluhur). That's why water allocation becomes a very complex decision making problem in its water resources management. Furthermore, the above issues of land use and climate change which is also observed in this river. Therefore water resources management in Citarum River Basin needs to be evaluated based on not only land use change but also climate change.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Risk reduction of hydrometeorological disaster and effective water consumption in Citarum River for supporting economic development in the Greater Jakarta area, Indonesia.

**2. Project Purpose**

Adaptation of water resources management system in Citarum River Basin based on evaluation of land use and climate change impact to flood and drought index by using improved datasets and analytical methodology. There are three priority study area of Citarum River:

- Upper Part (Bandung Basin) : Annual and extreme flood
- Downstream Citarum River (JaBeKa): Annual flood and drought
- Middle Part (three cascade dam ) : Annual water allocation for energy, irrigation, domestic and industry

Climate change makes the current situations in Citarum River Basin more critical. Therefore, some analyses need to be conducted to:

(1) Update hydrological data and analysis method to identify flood and drought trend in Citarum River Basin
(2) Demonstrate climate change impacts on floods and droughts based on the updated data and analysis method
(3) Improve the use of observational data and modeling to develop water resources management strategies in the future and its application capacity

**3. Outputs**

(1) Update hydrological data and analysis method to identify flood and drought trend in Citarum River Basin
   a) Updated observation data of rainfall, climatology, river discharge, and land cover in Citarum River Basin

   b) Updated analysis method for flood and drought assessment
(2) Demonstrate climate change impacts on floods and droughts based on the updated data and analysis method
   a) Updated flood and drought assessment through implementing of bias correction and statistical downscaling of the selected GCMs
   b) To develop near-real time rainfall-run off data observation/assessment and data dissemination systems based on ground data and satellite coupling which would be used as inputs into flood and drought prediction
   c) To develop comprehensive climate observation data archives including land cover satellite image which are used for climate and land cover change analysis
(3) Improvement the use of observational data and modeling to develop water resources management strategies in the future and its application capacity
   a) Improvement the appropriate unit hydrograph method and drought indices for flood/drought assessment in Citarum River Basin / Indonesia
   b) Dissemination of water resources management strategies, data sharing and technology among institutions
   c) Improvement of the curriculum for undergraduate program in the topics of water resources engineering and management, sub-topics of flood and drought assessment

**4. Activities and Key Leaders**

Lead Organizations

ITB (Institut Teknologi Bandung)

In addition, provide list of potential collaborators and donors from the international community – specify for each Purpose Item:

The potential activities and collaboration with other organizations are as follow:

(1) Updating hydrological and analysis method to identify flood and drought trend in Citarum River Basin
   1) Updating observation data of rainfall, climatology, river discharge, and land cover in Citarum River Basin:

      Expected collaborators:
      - *BBWSC (Citarum River Basin Organization)*
      - *BMKG (Indonesian Agency for Meteorology, Climatology and Geophysics)*
      - *PJT-II (Jatiluhur Dam Authority)*
      - *Dinas PSDA Jawa Barat (West Java Water Resources Development Agency)*
      - *Puslitbang SDA (Research Centre for Water Resources, Ministry of Public Works)*
      - *AWCI (Asian Water Cycle Initiative) and DIAS (Data Integration and Analysis System)*
      - *GEOSS (Global Earth Observation System of Systems)*
      - *MP3EI (Masterplan for Acceleration and Expansion of Economic Development, Coordinating Ministry of Economic Affairs)*
   2) Updating analysis method for flood and drought assessment

      Expected collaborators:
      - *AWCI (Asian Water Cycle Initiative) and DIAS (Data Integration and Analysis System)*
      - *BMKG (Indonesian Agency for Meteorology, Climatology and Geophysics)*
      - *Puslitbang SDA (Research Centre for Water Resources, Ministry of Public Works)*
      - *Directorate General of Higher Education (DIKTI)*
      - *BBWSC (Citarum River Basin Organization)*
      - *PJT-II (Jatiluhur Dam Authority)*

(2) Demonstrating climate change impacts on floods and droughts based on the updated data and analysis method
   1) Updating flood and drought assessment through implementing of bias correction and statistical

downscaling of the selected GCMs

Expected collaborators:

- *AWCI (Asian Water Cycle Initiative), DIAS (Data Integration and Analysis System) and University of Tokyo*
- *BMKG (Indonesian Agency for Meteorology, Climatology and Geophysics)*

2) Developing near-real time rainfall-run off data observation/assessment and data dissemination systems based on ground data and satellite coupling which would be used as inputs into flood and drought prediction

Expected collaborators:

- *AWCI (Asian Water Cycle Initiative), DIAS (Data Integration and Analysis System) and University of Tokyo*
- *BBWSC (Citarum River Basin Organization)*
- *PJT-II (Jatiluhur Dam Authority)*

3) Developing comprehensive climate observation data archives including land cover satellite image which are used for climate and land cover change analysis

Expected collaborators:

- *GEOSS (Global Earth Observation System of Systems)*
- *AWCI (Asian Water Cycle Initiative), DIAS (Data Integration and Analysis System) and University of Tokyo*
- *BBWSC (Citarum River Basin Organization)*
- *PJT-II (Jatiluhur Dam Authority)*
- *BMKG (Indonesian Agency for Meteorology, Climatology and Geophysics)*

(3) Improving the use of observational data and modeling to develop water resources management strategies in the future and its application capacity

1) Improving the appropriate unit hydrograph method and drought indices for flood/drought assessment in Citarum River Basin / Indonesia

Expected collaborators:

- *Puslitbang SDA (Research Centre for Water Resources, Ministry of Public Works)*
- *Directorate General of Higher Education (DIKTI)*
- *BBWSC (Citarum River Basin Organization)*
- *PJT-II (Jatiluhur Dam Authority)*
- *AWCI (Asian Water Cycle Initiative), DIAS (Data Integration and Analysis System) and University of Tokyo*

2) Disseminating water resources management strategies, data sharing and technology among institutions

Expected collaborators:

- *BAPPENAS (State Ministry of National Development Planning)*
- *Ministry of Public Work*
- *BMKG (Indonesian Agency for Meteorology, Climatology and Geophysics)*
- *Local Government*
- *BBWSC (Citarum River Basin Organization)*
- *PJT-II (Jatiluhur Dam Authority)*
- *Puslitbang SDA (Research Centre for Water Resources, Ministry of Public Works)*
- *AWCI (Asian Water Cycle Initiative)*
- *Other potential institution (future implementation for other river basin)*

3) Improving the curriculum for undergraduate program in the topics of water resources engineering and

management, sub-topics of flood and drought assessment

Expected collaborators:

- *Directorate General of Higher Education (DIKTI)*

**Lao PDR: Xe Bangfai and Xe Banghieng River Basins**

**Project Title***: Reduction of natural disaster by using meteorological and hydrological forecasts and early warning system*

**Background**

Lao PDR is a landlocked country, which located in the Southeast Asia between latitude 14 and 23 degree north, and longitude 100 and 108 degree east. The Country covers an area of 236,800 square kilometers and has bordered with China in the North, Myanmar in the Northwest, Kingdom of Thailand in the west, socialist of Vietnam in the East and Kingdom of Cambodia in the South.

Lao PDR is also lying along middle part of the Mekong, which is the twelfth longest river in the world. It flows through Lao territory from North to the South almost 1,860 Kilometers and forms one of the mightiest river systems of the region. Due to territory of Lao PDR approximately 70% comprises of mountains and plateaus. The topography of Lao with combination between mountains and plateaus is form almost 202,000 square kilometers watershed and catchment areas, which are more than 35%, contribute of the whole Lower Mekong Basin runoff. These geographical features with combination of the storm and monsoon that bring the flood hazards to properties also lives of the people living along the Mekong River and its tributaries in Lao PDR from past until now.

In Lao PDR droughts and floods are the most common natural disasters. Floods have the greatest macro-economic impact on the country and affect a greater number of people, as the areas affected are the primary locations of economic activity and contain 63% of the country population. Floods mostly affected central and southern provinces of the country. 27 major floods have occurred over the past 35 years with an average reoccurrence of one every 1.5 years.

In the past 5 years, communities from Lao PDR suffered from the damaging effects of extreme weather events. Climate change will increase frequency and intensity of these events and the inadequate capacity of institutions and vulnerability of socially excluded households can contribute to worsening of disaster risks. The big flood was occurred over the Xe Bangfai and Xe Banhieng River Basins.

In this regard, the Government of Lao PDR efforts in strengthening the meteorological and hydrological observation networks over the central and southern parts of Lao PDR. Under this circumstance, in order to improve the atmospheric comprehensive observation system in these areas and to enhance the prediction of weather, meteorological and hydrological disaster. It's urgent need improving the meteorological and hydrological forecast (models) and early warning system in these areas.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Reduction of natural disaster by using meteorological and hydrological forecasts and early warning system in Lao PDR

**2. Project Purpose**

There are urgent needs in the following river basins and flood-plain areas:

- Xe Bangfai and Xe Banghieng River Basins: recent and severe frequent floods in addition to drought damage on food security

Climate change makes the venerable situations more critical. To address these issues, we need to:

(1) Demonstrate quantitative and qualitative improvement of weather and water cycle observations
(2) Demonstrate flood and drought early warning capability
(3) Assess climate change impacts on floods, droughts and water-nexus
(4) Prototype data and information integration and sharing systems

(5) Improve observational, modeling and application capacity

**3. Outputs**

(1) Demonstrate quantitative and qualitative improvement of meteorological and hydrological observation networks

   a) Prototype near-real time meteorological and hydrological observation and data dissemination systems by coupling in-situ measurements which is used as inputs into weather and flood predictions.
   b) Develop comprehensive in-situ observation data archive for improving monitoring capability of weather and water cycle, and developing meteorological and hydrological models to be used for early warning.
   c) Develop long-term and comprehensive climate observation data archive which is used for climate change analysis, climate projection model bias correction.

(2) Demonstrate flood and drought early warning capability

   a) Develop hydrological models for forecasting and converting meteorological data to hydrological information.
   b) Prototype real-time data management, modeling and information dissemination systems.

(3) Assess climate change impacts on floods, droughts and water-nexus

   a) Select GCMs which can express the regional climate properly.
   b) Implement bias correction and downscaling (statistical- and dynamic-) of the selected GCMs.
   c) Develop socio-economic data archive
   d) Compare changes of frequency and intensity of flood, drought and water-nexus.

(4) Prototype data and information integration and sharing systems

   a) Develop an integrated weather and water portal for improving data accessibility and data sharing.
   b) Prototype a data integration and analysis and information dissemination system

(5) Improve observational, modeling and application capacity

   a) Develop training modules of satellite remote sensing, modeling, bias correction and downscaling, make design of training courses on integrated observations, early warning and climate change assessment, and offer the courses.
   b) Promote secondary educational programs in collaboration with universities.

**4. Activities and Key Leaders**

Lead Organizations

- Xe Bangfai and Xe Banghieng River Basins: Ministry of Natural Resources and Environment (Department of Meteorology and Hydrology (DMH), Department of Disaster Management and Climate Change (DDMC)).

In addition to the Lead Organizations' capacity which has been developed, we will take following actions in collaboration with the organizations and projects as follows:

(1) Demonstrate quantitative and qualitative improvement of water cycle observation

   1) Transmitting rain gauge data to the Lead Organization Data Facility and sharing the data by Internet for producing bias-corrected satellite-based rainfall map to be disseminated to wide communities
      *WMO/HyCOS, ESA, NASA, NOAA, JAXA, DIAS*
   2) In-situ and satellite observation data archive
      *WMO/HyCOS, UNEP/GMES, UNESCO/G-WADI, UNESC-WMO/IGRAC, Tiger heritage, ODA project heritage, AMMA, Reanalysis (ECMWF, NCEP, JMA), ESA, NASA, NOAA, JAXA, CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*

3) Climate data archive at least past 20 years which correspond to the availability of the GCM model outputs.
   *WMO/HyCOS, Reanalysis (ECMWF, NCEP, JMA), ESA, NASA, NOAA, JAXA, CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*

(2) Demonstrate flood and drought early warning capability
1) Develop distributed physically-based hydrological models including simulation ability of evapotranspiration, soil moisture, ground water and vegetation growth.
   *CREST, DIAS, science communities*
2) Prototype real-time data integration systems for satellite data bias correction, hydrological modeling including data assimilation and information dissemination.
   *ACMAD, ECMWF, National Weather Services, GEOWOW, NASA-SERVIR, UNESCO-IFI, UNESCO-Princeton Univ., DIAS*

(3) Assess climate change impacts on floods, droughts and water-nexus
1) Selection of GCMs which can express the regional climate.
   *PCMDI, DIAS, science communities*
2) Bias correction and downscaling
   *PCMDI, CORDEX, DIAS, science communities*
3) Socio-economic data archive
   *GLOWASIS*
4) Assessment of the changes of flood, drought and water-nexus.
   *GLOWASIS, CORDEX, DIAS, science communities*

(4) Prototype data and information integration and sharing systems
1) Develop an integrated weather and water portal for improving data accessibility and data sharing.
   *CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*
2) Prototype a data integration and analysis and information dissemination system
   *CEOS Water Portal, GEOWOW, NASA-SERVIR, DIAS*

(5) Improve observational, modeling and application capacity
1) Develop training modules and design and implement training courses
   *Tiger, UNESCO, NASA-SERVIR, RCMRD, ITC, UNU, UTokyo,*
2) Promote secondary educational program in collaboration with universities.
   *ITC, UNU, UTokyo*

**Malaysia**

**Project Title:** *Sustainable water and land management plan*

**Background**

The Ringlet Reservoir is a man-made lake covering 60 hectares created upstream of Sultan Abu Bakar Dam on Bertam River. Located at Cameron Highlands catchment area in the northwest of the state of Pahang, Malaysia, it is a mountainous terrain having various mountain peaks ranging from 1524m to 2032m. Cameron highlands is one the largest hill resorts in Malaysia, also referred to as 'green bowls', growing a wide variety of vegetables, flowers and other ornamental plants. It also provides many tourist attractions such as tea plantations, tea factories, rose gardens, strawberry farms and aging colonial-style homes. The Ringlet reservoir has a maximum live storage of 4.7 million cubic meters and the main features of the storage is connected to the 100MW underground power station which consists of four small run-of-river and storage hydro projects and has five power stations. However, due to various reasons such as land erosion, uncontrolled development, legal and illegal land clearing, deforestation, and reckless farming practices, rubbish, silt and sediment have clogged up the dam and caused the reservoir capacity to decrease to a mere 1.5 million cubic meters. As recently as 23 Oct 2013, continuous rainfall and subsequent dam release caused the river to overflow and mud flood to inundate a downstream village, killing 3 people. Prior to this disaster, fatal landslides had occurred in this area in years 1996, 2000, and 2008. With the onset of climate change, the situation in Bertam valley is looking dire.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Reducing water related disaster (man-made and natural); and improving water resources management in the context of water nexus and climate change

**2. Project Purpose**

This study aims to quantify and minimize the impact of climatic and non-climatic factor on sedimentation in Ringlet Reservoir and water nexus issues within the vicinity of Cameron Highlands. To address these issues, there is a need to:

(1) Establish a hydro-meteorological observation and real-time monitoring network covering the whole Cameron Highlands
(2) Development of integrated land-use and GIS database to monitor atmosphere-land interaction in upper Cameron Highlands
(3) Establish and improve soil erosion model/sediment transport model for accurate simulation of sedimentation in Ringlet Reservoir.
(4) Projection of climate change impacts on potential risk or disaster on water resources and water-nexus in Cameron Highlands
(5) Develop numerical model for inflow forecasting, early warning system and Decision Support System (DSS) for local authorities and decision-makers.

**3. Outputs**

(1) Establish a hydro-meteorological observation and real-time monitoring network covering the whole Cameron Highlands
    a) Precipitation, temperature, evapotranspiration, soil moisture, and flow observation network throughout Cameron Highlands.
(2) Development of integrated land-use and GIS database to monitor atmosphere-land interaction in Cameron Highlands

a) Land-use change monitoring using satellite images.
b) Past, present and future (projected) land-use maps.
c) GIS database comprising of topography, fine resolution (sub-meter) DEM, river network and profile; and landuse characteristics

(3) Establish and improve soil erosion model/sediment transport model for accurate simulation of sedimentation in Ringlet Reservoir
a) Develop soil erosion or sediment transport model to determine soil loss rate, sediment load and reservoir bed level changes for current and future period.
b) Produce high accuracy precipitation data by integrating radar, satellite and ground gauges.
c) Estimate the Revised Universal Soil Loss Equation (RUSLE) and using Infoworks RS for river modeling.
d) Understanding relationship between precipitation, landuse change and sediment load
e) Revise the storage-elevation relationship of Sultan Abu Bakar Dam

(4) Projection of climate change impacts on potential risk or disaster on water resources and water-nexus in Cameron Highlands
a) Selection of GCMs, bias-correction and downscaling.
b) Compare changes of frequency and intensity of flood and drought,
c) Derive and develop climate change factor
d) Determine the impacts of climate change to water-nexus (water – energy and water – agriculture activity)
e) Propose adaptation options for addressing climate change impacts

(5) Develop numerical model for inflow forecasting, early warning system and Decision Support System (DSS) for local authorities and decision-makers
a) Develop a numerical inflow forecasting model
b) Develop building capacity, training and short course modules of satellite and remote sensing, floods and droughts, GIS, early warning system, and to design and develop integrated system corresponding to climate change impacts assessment;
c) To develop Standard Operation Procedure (SOP) for the proposed system.

## 4. Activities and Key Leaders

<u>Lead Organizations</u>

- National Hydraulic Research Institute of Malaysia (NAHRIM), Ministry of Natural Resources and Environment – Team Leader
- Tenaga Nasional Berhad (TNB) – Government Link Company (GLC)
- Local authorities - Cameron Highlands District Council, State of Pahang
- National Security Council (NSC)

In addition to the Lead Organizations' capacity which has been developed, we will take following actions in collaboration with the organizations and projects as follows:

(1) Establish a hydro-meteorological observation and real-time monitoring network covering the whole Cameron Highlands
1) Produce high accuracy precipitation data by integrating radar, satellite and ground gauges
*Department of Irrigation and Drainage Malaysia (DID), Malaysian Meteorological Department (MMD), Department of Agriculture (DOA), TNB, JAXA, NOAA, USGS, NASA, UT*
2) Collect precipitation and other climatic and non-climatic parameter (groundwater, temperature, radiation) dataset from global data archive
*UNESCO/G-WADI, UNESCO-WMO/IGRAC, Reanalysis (ECMWF, NCEP, JMA), CEOS Water Portal, GEOWOW, NOAA, JAXA, DIAS*

(2) Development of integrated land-use and GIS database to monitor atmosphere-land interaction in Cameron Highlands

1) Land-use change monitoring using satellite images
*Malaysian Remote Sensing Agency (ARSM), JAXA, NOAA, USGS, NASA*
2) Past, present and future (projected) land-use maps
*DOA, Department of Town and Country Planning Peninsular Malaysia (JPBD), local authorities*
3) GIS database comprising of topography, fine resolution DEM (sub-meter resolution), river network and profile
*USGS, Department of Survey and Mapping Malaysia, JAXA*

(3) Establish and improve soil erosion model/sediment transport model for accurate simulation of sedimentation in Ringlet Reservoir
1) Determine soil loss rate, sediment load and reservoir bed level changes for current and future period.
*DID, DOA, TNB, JPBD, local authorities, UT*

(4) Projection of climate change impacts on potential risk or disaster on water resources and water-nexus in Cameron Highlands
1) Selection of GCMs, bias-correction and downscaling
*UT-DIAS, science communities*
2) Analysis of GCM projection data for upper Bertam catchment and Cameron Highlands
*CMIP3, CMIP5, UT-DIAS*
3) Assessment of potential risk or disaster and effect on water-nexus.
*Tenaga Nasional Berhad Research (TNBR), UNITEN, DID, MMD, DOA, DIAS*

(6) Develop numerical model for inflow forecasting, early warning system and Decision Support System (DSS) for local authorities and decision-makers
1) Assessment of climate change impact on reservoir
*DID, MMD, DOA, ARSM, TNBR, UNITEN, DIAS, UT, USGS, USBR*
2) Development of forecasting, early warning system and DSS
*TNBR, UNITEN, DID, MMD, local communities, NGOs, DIAS, UT, USGS, USBR*

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# Mongolia

## 1. Background

Mongolia is located in the middle of northeastern Eurasia between the Siberian taiga forest and the Gobi desert. It is well-known that the region is associated with the largest warming rate over the past century. The 4th assessment report of IPCC (Intergovernmental Panel on Climate Change) projects that, as an perspective of the global average, rainfall likely to increase at the high latitudes, while the subtropical region likely to become drier. Therefore, future climate of Mongolia can be highly variable in time and space with great uncertainties. Moreover, frequently-occurred droughts in the last decades threaten the people of the country that is highly dependent on the natural resources.

To solve different complicated environmental situation in the country, the optimal, harmonized, unified and advanced hydrological and meteorological network must be very useful under support of developed countries.

In consideration of the importance of the hydrometeorolgical service and observation network for development of the national economy and defence issues, the Soviet Union and the People's Republic of Mongolia have signed the Joint agreement on Cooperation on Development of Hydrometeorological service in Mongolia on the 19th of July, 1935. According to the agreement, first permanent hydrological gauging station have been installed on the Orkhon river near Sukhbaatar town in 17the of September of 1942. Nowadays, 134 hydrological gauging stations on 80 rivers and 15 lakes are operating within the Hydro-meteorological service of Mongolia which is 15 times greater than network of 1942 and 5.2 times greater if compare with hydrological network of 1960. Moreover, 4 glacier monitoring stations, 30 sites for permafrost, 24 sites for groundwater regime, 74 sites for hydrobiological sampling and 142 points for water quality control and chemical sampling exist within the above mentioned national network.

All hydrological stations are stuff gauge and hydrological monitoring network density is one gauging station per 5500 $km^2$ in the country scale, which several times less than WMO recommended density. In case of the Mongolia it is needed to increase density of hydrological network twice or about 200-230 gauging station could provide for better and accurate estimation of water resources and supply different demands on data and information. The main responsibilities of the hydrological network in terms of water resources studies are: **hydrological service** (management and maintenance of hydrological network, technology for observation and data processing, control measurement and inspections, hydrological yearbook, data base system management, flood control, short and long-term forecasting etc.) and **research studies** (flood frequency and hydrograph analysis, hydrological modeling, lake water balance, glacier dynamics, mass balance, observation and data processing methodology, and hydro -biological and water quality analysis etc).

Concerning meteorological network, the first meteorological observation stations were established in the country in 1936. Currently there are 130 meteorological stations, 186 meteorological posts, 6 upper-air stations, 13 solar radiation stations are operating in observation network of NAMEM. Recently, 64 automatic meteorological stations operated since 2000 in our meteorological observation network, 30 of the stations have been set up in 2011. In order to control and monitor fast developing natural and climate events such as heavy rainfall, flash flooding we need to extend our monitoring network in space and in time with modern instrumentations.

In order to predict change of water and energy cycle, the numerical model analysis is useful and indispensable. We need to use recent models such as GCM (global climate model), RCM (regional climate model), WEB-DHM (Water and Energy Budget-based Distributed Hydrological Model), and SiBUC (Simple Biosphere including Urban Canopy) for studying climate change and global warming in Mongolia.

There has been affected by global change of climate and water cycle and global warming in Mongolia. As results of such changes observed unstable change of precipitation and increase of occurrence of severe drought and flood and change and shortage of water resources in the future (especially in Ulaanbaatar).

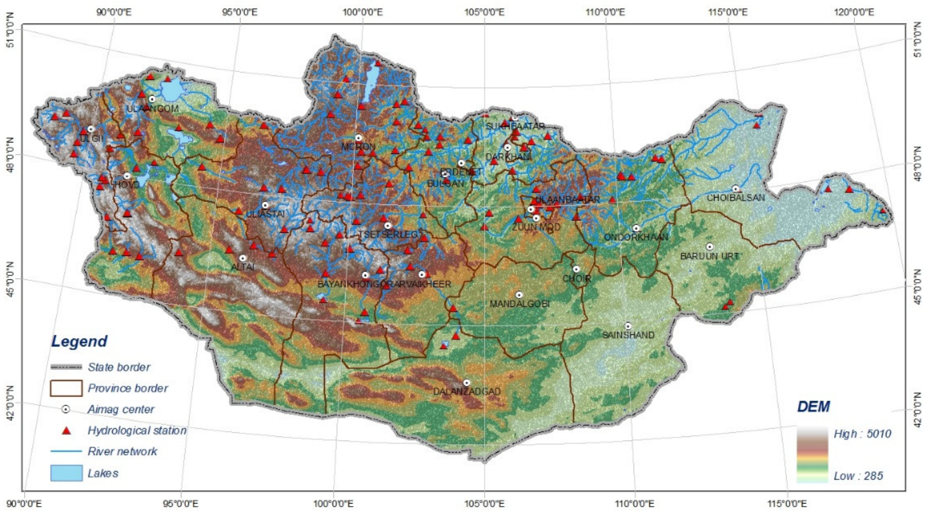


**Fig. 1 Location of hydrological gauging stations in Mongolia**

Therefore, IMHE, NAMEM need high class level instruments, advanced Automated weather station (AWS) for River Hydrological Automatic Station (RHAS), Water and Energy Cycle Station (WECS), and Flux WECS in order to understand change in conditions of water and energy cycle and to estimate water and energy balance for elements with more accurate measurement data. Especially, Flux WECS has a high measurement accuracy sensor to measure turbulent flux for estimating evapotranspiration and CO2 flux with high representativeness. Furthermore, NAMEM needs to have an automatic soil moisture measurement system with the high measurement accuracy. It is very useful and effective to install these stations in the Tuul river basin and study area on the Mongolian Plateau.

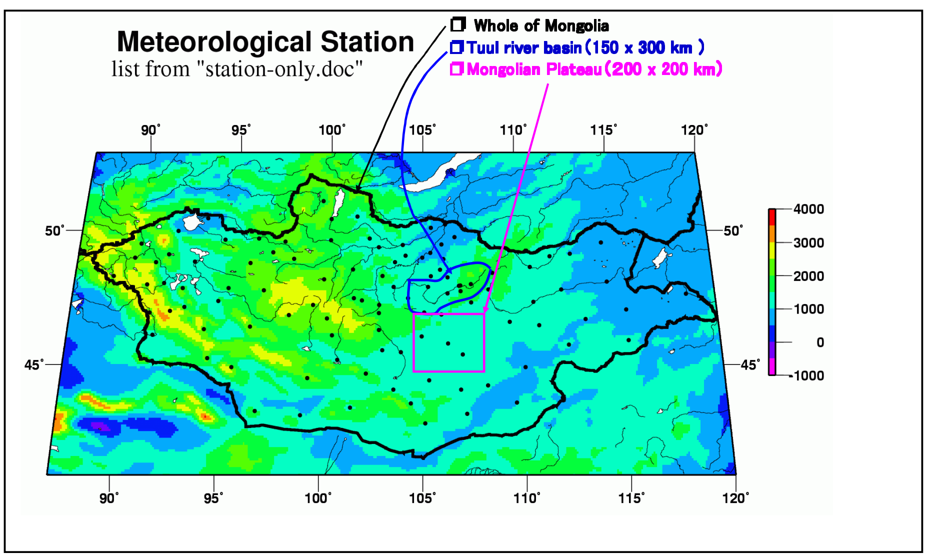


**Fig. 2 Study areas**

**Area to be covered by the Project**

Multi-scale area

A. Whole of Mongolia

B. Tuul river basin (150 x 300 km)

C. Central Mongolian Plateau (200 x 200 km)

**Project Design Matrix (PDM)**

## 1. Overall Goal

To enhance hydrological and meteorological network in Mongolia to support network's optimization, harmonization and unification requirements, rising from weather forecasting, hydrological and climate modeling techniques. Namely, to provide better service, knowledge, awareness to people of Mongolia in field of environmental protection, water resources supply, weather forecasting and disasters prediction and adaptation to the climate change.

## 2. Project Purpose

(1) To build up an advanced observation system (with a nearly real time data acquisition system of monitoring elements of water and energy cycle: NAS) of water and energy cycle change by integrating satellites (*e.g.,* AMSR2 and SMAP) and in situ water and energy cycle stations (RHAS: River Hydrological Automatic Station and WECS: Water and Energy Cycle Station, Flux WECS)
(2) To improve and develop NAMEM monitoring system (To upgrade some NAMEM stations)
(3) To carry out intensive observations and monitoring elements of water cycle and water quality using the advanced observation system in strong cooperation with the partly developed NAMEM monitoring system
(4) To know mechanism of unstable change of rainfall on the multi scale in space and time (considering climate change and global warming)
(5) To evaluate influence of precipitation change on water/energy cycle and vegetation in study areas (including also support for the Green Development activity in Mongolia)
(6) To calculate monthly and yearly more precise water balance in the Tuul river mid-upper basin
(7) To provide output data of simulation and prediction of water cycle using WEB-DHM and/or SiBUC numerical model and GCM(Global Climate Model) and/or RCM (Regional Climate Model) for supporting to build up a high accuracy prediction model of weather forecasting
(8) To show preliminary models of early warning of drought and storm rainfall/flood
(9) To try opening the data of observation/monitoring
(10)To boost self-reliant research and development capacity (Capacity building: training course, WS, etc.)

## 3. Outputs

(1) Advanced monitoring system of water and energy cycle with satellite observation and in situ water cycle stations with nearly real time data acquisition system (NAS)
(2) More precise monitoring by advanced AWS of NAMEM and NAS
(3) Showing unstable change mechanism of rainfall on the multi scale in space and time
(4) Multi scale evaluation of climate change and/or global warming
(5) Early warning systems of drought and flood
(6) Better and precise estimation of water resources and optimal operation system of water resources for future
(7) Prediction of water cycle and climate change considering hydrological conditions
(8) High class level researchers for monitoring and analysis
(9) Support for sustainable and green developments and JCM( Joint Crediting Mechanism) /BOCM(Bilateral Offset Crediting mechanism) between Japan and Mongolia

## 4. Activities and Key Leaders

Project Activities

(1) Monitoring and Intensive observations by Advanced monitoring system to produce water and energy cycle information with satellite observation and in situ water cycle parameters
(2) Data analysis of the existing data for development and calibration of multi scale evaluation of climate change models

(3) Numerical model studies to understand better and precise estimation of water resources, unstable change mechanism of rainfall and prediction of water cycle and climate change considering hydrological conditions and also to support early warning systems of drought
(4) Data base for optimal operation system of water resources for future
(5) Training courses and WS, to enchase self-reliant research capacity building of the Mongolian hydro-meteorological service and to provide project sustainability.

Lead Organizations
- Institute of Meteorology, Hydrology, and Environment (IMHE)

Supporting Organizations – local
- National University of Mongolia (NUM)
- Mongol University of Science and Technology (MUST)
- Ulaanbaatar City Government

Supporting Organizations – international
- Hiroshima University, Japan
- Kyoto University, Japan
- Hokkaido University, Japan
- University of Tsukuba
- Obihiro Chikusan University, Japan
- Toyama Prefectural University, Japan
- Japan Marine Science and Technology Center (JAMSTEC)
- Japan Aerospace Exploration Agency (JAXA)
- Hydrology & Water Management Center for Central Region, Royal Irrigation Department, Thailand
- Aalborg University, Denmark
- US Department of Agriculture (USDA)

## Myanmar: Ayeyarwady and Chindwin River Basins

**Background**

The Ayeyarwaddy and Chindwin river basins are the most important river basins in Myanmar which receives very high rainfalls at upper part of basin and has higher discharges. Due to its hydrological and topographical characteristics, the lower plain suffers from frequent floods and it affects socio-economic profile greatly. The dry zone which is the central area of Myanmar is the area vulnerable to droughts as compared to other parts of the country. This region is characterized by low rainfall, low water availability, intense heat and degraded soil conditions, affecting social and economic situations of the communities living in this region. Floods and droughts are generated by the random coincidence of several meteorological factors, but man's use of river catchments also has an impact upon the severity and consequences of the events. Moreover, stream flow records are reflective of both climatic variations over a river basin as well as changes in land use, land cover, and stream characteristics. Understanding the effects of climate change on spatial and temporal rainfall characteristics is therefore necessary for planning responsive measures.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Reduction the hydrometeorological disasters, and assessment of water resources information and the potential effects of climatic changes on the water resources

**2. Project Purpose**

The objectives are to demonstrate flood and drought early warning capability, to analyze the recent experience in climate variability and extreme hydrological events, to establish the fully operational water resources information system that will serve as an effective decision-making tool for the sustainable management of water resources of Myanmar river basins, to identify the impact of Climate Change on the river flow in Ayeyarwady and Chindwin Rivers, to improve observational, modeling and application capacity

**3. Outputs**

(1) Develop hydrological models for flood and drought early warning
(2) Improve the real time data management, modeling and information dissemination systems
(3) Develop the current status of climate change and variability in precipitation and hydrological events of Ayeyarwady and Chindwin Basins
(4) Develop the water resources information system for the sustainable management as an effective decision-making tool
(5) Select Global Climate Models which can perform the regional climate properly.
(6) Implement bias correction and downscaling (statistical- and dynamic-) of the selected GCMs
(7) Develop SWAT model in order to assess the impact of the uncertainties in future climate models
(8) Improve the data for the generation of climate and socioeconomic scenarios
(9) Compare changes of frequency and intensity of flood and drought, and water resources
(10) Develop training modules of satellite remote sensing, modeling, bias correction and downscaling, make design of training courses on integrated observations, early warning and climate change assessment

**4. Activities and Key Leaders**

The main activities to be conducted include:

(1) Installation the automatic hydrological and meteorological equipments such as automatic water level gauges, automatic weather observation systems
(2) Developing distributed physically-based hydrological models including training

(3) Developing real-time data integration systems for satellite data bias correction, hydrological modeling including data assimilation and information dissemination.
(4) Developing the current status of climate change and variability in precipitation and hydrological events of Ayeyarwady and Chindwin Basins
(5) Promote the public awareness activities for general public, water agencies and decision-makers on hydrological forecasting and warning services
(6) Assessment of the current institutional capacities and the needs of the collaborating national institutions and recommend, as appropriate, any institutional linkages and cooperative mechanisms required for effective operation of a regional water resources information system
(7) Installation of equipments such as River Surveyor for discharge measurements
(8) Training of personnel of National Hydrological and Meteorological Services
(9) Developing the hydrological model for water resources management
(10) Selection Global Climate Models which can perform the regional climate properly.
(11) Upgrade computer hardware through the procurement of equipment and software for National Hydrological Services and provision of technical support and training
(12) Implementation bias correction and downscaling (statistical- and dynamic-) of the selected GCMs
(13) Developing SWAT model in order to assess the impact of the uncertainties in future climate models
(14) Improvement the data for the generation of climate and socioeconomic scenarios
(15) Comparing changes of frequency and intensity of flood and drought, and water resources
(16) Developing training modules of satellite remote sensing, modeling, bias correction and downscaling, make design of training courses on integrated observations, early warning

Lead Organization

- Department of Meteorology and Hydrology, Myanmar

# Nepal: Bagmati River Basin

## Background

Nepal has proposed two river basins namely Bagmati River Basin as demonstration basin and Narayani River Basin as CCAA study basin. Bagmati basin is a basin of national priority since capital city Kathmandu as well as number of national heritage places is located in this basin. Therefore, Bagmati basin as demonstration basin has been selected for 2nd phase of AWCI and Project Design Matrix (PDM) is prepared for this basin.

## Bagmati River Basin

Bagmati River is a medium river of Nepal with drainage area of 3700 Km2. It originates from Shivapuri Hill (2731 m) and flows down to south through Kathmandu valley up to Indo – Nepal border. Nakhhu, Kulekhani, Kokhajor, Marin and Chandi rivers are its major tributaries. Flood damages; landslides, bank erosion and water pollution are acute problems in the river basin. There are 21 numbers of meteorological stations and two hydrometric stations within and around the basin.

Dense human settlement area like Kathmandu, Capital of Nepal is located along the bank of this river. The upper reach of the river basin is facing acute problem of water pollution, landslides and bank erosion whereas the tail reach of the river basin is facing problem of bank erosion, river bed rising and flooding and inundation.

The comprehensive atmospheric observation system in this river basin is needed to be established to enhance the prediction of meteorological and hydrological disasters.

## Project Design Matrix (PDM)

### 1. Overall Goal

Reduction of meteorological and hydrological disasters and effective use of water resources in Bagmati basin.

### 2. Project Purpose

There are severe problems to be addressed in the Bagmati river basin:

- Flood water management system,
- Maintaining minimum regular flow particularly in dry season period,
- Water quality improvement,
- Water resources management,
- Drought impact on food security.

Climate change makes the venerable situations more critical. To address these issues, we need to:

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
(2) Demonstrate flood and drought early warning capability
(3) Assess climate change impacts on glacier retreat, floods, droughts and water-nexus
(4) Prototype data and information integration and sharing systems
(5) Improve observational, modeling and application capacity
(6) Contribute to the national climate change adaptation policy

### 3. Outputs

(1) Demonstrate quantitative and qualitative improvement of water cycle observations
  a) Prototype near-real time rainfall observation and data dissemination systems by coupling satellite and in-situ measurements which is used as inputs into flood prediction.
  b) Develop comprehensive in-situ and satellite observation data archive for improving monitoring capability of water cycle and developing hydrological models to be used for early warning.
  c) Develop long-term and comprehensive climate observation data archive which is used for climate change analysis climate projection model bias correction.

(2) Demonstrate flood and drought early warning capability
   a) Develop hydrological models for converting meteorological data to hydrological information.
   b) Prototype real-time data management, modeling and information dissemination systems.

(3) Assess climate change impacts on floods, droughts and water-nexus
   a) Select GCMs which can express the regional climate properly.
   b) Implement bias correction and downscaling (statistical- and dynamic-) of the selected GCMs.
   c) Develop socio-economic data archive
   d) Compare changes of frequency and intensity of flood, drought and water-nexus.

(4) Prototype data and information integration and sharing systems
   a) Develop an integrated water portal for improving data accessibility and data sharing.
   b) Prototype a data integration and analysis and information dissemination system

(5) Improve observational, modeling and application capacity
   a) Develop training modules of satellite remote sensing, modeling, bias correction and downscaling, make design of training courses on integrated observations, early warning and climate change assessment, and offer the courses.
   b) Promote secondary educational programs in collaboration with universities.

(6) Contribute to the national climate change adaptation policy
   a) Enhancement of crop water requirement estimation, evapo-transpiration, design discharge estimation, estimation of dependable discharge for hydro power generation
   b) Application of models to estimate design flood discharge for hydraulic structures and flood water management

**4. Activities and Key Leaders**

<u>Lead Organizations</u>

- Ministry of Irrigation (DOI, DWIDP)
- Ministry of Urban Development (Bagmati River Basin Improvement Project)
- Department of Hydrology and Meteorology

In addition to the Lead Organizations' capacity which has been developed, we will take following actions in collaboration with the organizations and projects as follows:

(1) Demonstrate quantitative and qualitative improvement of water cycle observation
   1) Transmitting rain gauge data to the Lead Organization Data Facility and sharing the data by Internet for producing bias-corrected satellite-based rainfall map to be disseminated to wide communities
   *WMO/HyCOS, JAXA, DIAS*
   2) In-situ and satellite observation data archive
   *WMO/HyCOS, JAXA, CEOS Water Portal, DIAS*
   3) Climate data archive at least past 20 years which correspond to the availability of the GCM model outputs.
   *WMO/HyCOS, JAXA, CEOS Water Portal, DIAS*

(2) Demonstrate flood and drought early warning capability
   1) Develop distributed physically-based hydrological models including simulation ability of evapotranspiration, soil moisture, ground water and vegetation growth.
   *DIAS, science communities*
   2) Prototype real-time data integration systems for satellite data bias correction, hydrological modeling including data assimilation and information dissemination.
   *UNESCO-IFI, DIAS*

(3) Assess climate change impacts on floods, droughts and water-nexus
   1) Selection of GCMs which can express the regional climate.

*DIAS, science communities*

2) Bias correction and downscaling
   *DIAS, science Communities*
3) Socio-economic data archive
4) Assessment of the changes of flood, drought and water-nexus.
   *DIAS, science communities*

(4) Prototype data and information integration and sharing systems

1) Develop an integrated water portal for improving data accessibility and data sharing.
   *CEOS Water Portal, DIAS*
2) Prototype a data integration and analysis and information dissemination system
   *CEOS Water Portal, DIAS*

(5) Improve observational, modeling and application capacity

1) Develop training modules and design and implement training courses
   *UNESCO, ITC, UNU, UTokyo,*
2) Promote secondary educational program in collaboration with universities.
   *ITC, UNU, UTokyo, TU*

(6) Contribute to the national climate change adaptation policy

1) Enhancement of crop water requirement estimation, evapo-transpiration, design discharge estimation, estimation of dependable discharge for hydro power generation
   *DOI, DOA, TU, DWIDP, NEA, KU*
2) Application of models to estimate design flood discharge for hydraulic structures and flood water management
   *DOI, DOA, TU, DWIDP, NEA, KU*

**5. Recent Ongoing Activities in context of Climate Change prospective**

- Incorporation of Mainstreaming of climate change in Irrigation Policy 2013;
- Establishment of Focal Desk for climate change in Ministry of Environment, Science and Technology. TA 7984: Mainstreaming of Climate Change Risk Management in Development study has been carrying out by MOEST with various line agencies and DoI is one of them.
- Proposed to improve discharge estimation method for un-gauged catchment under recently kicked off Water Resources Preparatory Facilities Project (WRPPF) financed by ADB;
- Study of Impact of Climate Change in Kalleritar Irrigatn Project by DoI with UNDP, ADB, YALE UNIVERSITY, USAID.
- Adaptation to Global change Agriculture practices: A case study of Indrawati Basin Nepal by DoI with support from UNESCO-IHE and AIT
- Institutional set up in DoI to take care of climate change and social issues and build its capacity under WRPPF
- Climate Change impact study for Koshi Basin by Water Energy Commission Secretariat (WECS)
- Digital Inventory of Irrigation system and updating Irrigation Master Plan under WRPPF

Documents prepared by The Government of Nepal with regards to Climate Change

- National Adaptation Program of Action (NAPA), 2010
- Climate Change Policy 2011
- Local Adaptation Program of Action 2012

## Pakistan

**Project Design Matrix (PDM)**

**1. Overall Goal**

Improving water cycle observations and prediction of meteorological and hydrological disasters in Pakistan

**2. Project Purpose**

Specific issues/needs in country:

- Improve monitoring capacity in the country
- Data access and sharing
- Distributed hydrological modeling to improve forecasting of floods/drought
- Climate change impact assessment on drought, floods and GLOF

To address these issues, we need to:

(1) Demonstrate improvement of water cycle observations.
(2) Demonstrate capability of flood and drought forecast and early warning.
(3) Assess climate change impacts on floods, droughts, water-nexus and food security (agriculture, in particular)

**3. Outputs**

(1) Demonstrate improvement of water cycle observations.
  1) Prototype near-real time rainfall observation and data dissemination systems by coupling satellite and in-situ measurements which is used as inputs into flood prediction and drought advisories.
  2) Develop/improve comprehensive in-situ and satellite observation data archive for improving monitoring capability of water cycle.
  3) Develop/improve long-term and comprehensive climate observation data archives, which are used for climate change assessment, climate projections and model bias corrections.
  4) Improve observational, modeling and application capacity in the country.

(2) Demonstrate capability of flood and drought forecast and early warning
  1) Develop hydrological model (WEB-DHM) for converting meteorological data to hydrological information.
  2) Develop inundation model and update flood hazard maps.
  3) Couple hydrological model with a crop model.
  4) Develop and disseminate agro-climate predictions (soil moisture, crop water requirement, timings of field operations) for crop water management
  5) Develop a Decision Support System (DSS) by using observations and model outputs.
  6) Prototype real-time data management, modeling and information dissemination systems.

(3) Assess climate change impacts on floods, droughts and water-Food nexus (agriculture, in particular)
  1) Select GCMs which can express the regional climate properly.
  2) Apply bias correction and downscaling (statistical- and dynamic-) of the selected GCMs by Regional Climate Models.
  3) Develop/improve socio-economic data archive
  4) Analyse changing climatic extreme's trend in terms of frequency and intensity of flood, drought.
  5) Propose improved methods/strategies for early warning systems and workable adaptation measures

**4. Activities and Key Leaders**

(1) To develop long-term climate trends and short-term climate variability

Methodology/Activities

1) Improve hydro-met observational, modeling and application capacity in the country
2) Improvement of near-real time rainfall observation and data dissemination systems
3) Coupling satellite and in-situ measurements of cryosphere to be input to hydrological models
4) Develop/improve hydrometeorological data archive to analyze the past behavior and recent trends for monitoring capability of water cycle.
5) Integrate climate observation/model data archives, which are used for climate change assessment, climate projections and model bias correction.

(2) To improve cryosphere monitoring using in-situ observations and remote sensing data for better understanding of its dynamics and spatial variability

Major Activities

1) The seasonal snow cover dynamics, the typology of glaciers (e.g. debris covered, debris free), spatial characteristics and cloud systems dynamics etc. will preferably be derived from respective satellite systems and flagship stations.
2) Updating/refinement of glaciers inventory of using high resolution RS data
3) Selection of benchmark glaciers and their monitoring for long-term glacio-hydrological characteristics
4) Development of high resolution Remote Sensing based Digital Elevation Model data sets for application to the distributed hydrological model
5) High resolution topographic data sets (grid resolution < 30m) for spatial dynamics of seasonal snow cover and topography-dependent characteristics of glaciers.
6) Promote field measurements on glaciers for mass balance, surface velocity, changes of moraine/terminus and behavior of ablation and accumulation zones.

(3) Distributed hydrological modeling to improve forecasting of Floods/Drought modeling

Outcome

Improved current and future water availability and demand scenarios for policy makers and water resource managers leading to better development planning and management

Outputs

1) Improved hydro-meteorological data collection system
2) Better understanding and representation of hydrological and meteorological processes/dynamics in the upper Indus Basin
3) Operational basin and sub-basin hydrological and water demand models to analyze the water availability and demand scenarios

Activities

1) Develop distributed hydrological model (WEB-DHM) for hydrological forecasting (water availability, flood. Droughts)
2) Couple hydrological-crop-economic model for improved understanding of socioeconomic impacts of water cycle variability.
3) Strengthening of field based monitoring of hydro-meteorological variables at high elevation areas
4) Hydrological modeling to derive water availability and demand scenarios at the basin, sub-basin and catchment scales.
5) Quantification of contributions of rainfall, snow-melt, glacial-melt to runoff through hydrological modeling
6) Impact of climate change on each runoff component (rainfall, snow-melt, glacial-melt, permafrost-melt)
7) Future water demand and availability scenarios based on demographic scenarios, increased crop water

requirement etc.

(4) Risk assessment of climate induced hazards Climate change impact assessment on drought, floods and GLOF

Activities

1) Selection of suitable GCMs and assessing their data sets.
2) Bias correction and downscaling (statistical- and dynamic-) of GCMs by RCMs.
3) Collection of socio-economic data and its archiving
4) Identification of changes in frequency and intensity of hydrometeorological extremes.
5) Land use changes, Inundation modeling and revision of flood hazard maps
6) Updation of inventory of lakes, GLOFs and promote indigenous knowledge to manage GLOF risks
7) Investigate the adaptive capacity to adverse climate change impacts due to lack of technical knowhow and low financial resources

(5) Impact of hydrologic extremes on food security and socio-economic conditions of community

Outputs

1) Assessment of the future water availability for agriculture under different climate scenarios;
2) Improved knowledge about the links between climate change and water-related issues in agricultural production at basin and sub-basin scale;
3) A set of adaptation options (anticipatory and reactive) proposed to reduce the vulnerability to floods and droughts.

Methodologies / Activities

1) Study/simulate climate change impacts on agriculture and local crop production pattern
2) Simulate evapo-transpiration and irrigation water requirement of major crops (wheat, rice, cotton, sugar cane)
3) Assess the impacts of climate change on crop water requirements and crop production
4) Estimation of crop water requirement under future climate change scenarios
5) Development of a Decision Support System (DSS) incorporating crop-water-climate-socioeconomic scenarios.
6) To identify and propose potential adaptation measures

Lead Organizations

- Pakistan Meteorological Department (PMD), Islamabad
- Pakistan Agricultural Research Council (PARC), Islamabad
- University of Agriculture Faisalabad (UAF)
- National University of Science and Technology (NUST), Islamabad
- Foreman Christian College Charted (FCC) University, Lahore
- Water and Power Development Authority (WAPDA), Lahore
- Global Change Impact Studies Center (GCISC), Islamabad

In addition to the Lead Organizations' capacity which has been developed, we will take following actions in collaboration with the organizations and projects as follows:

(1) Demonstrate improvement of water cycle observation

1) Transmitting rain gauge data to the Lead Organization Data Facility and sharing the data by Internet for producing bias-corrected satellite-based rainfall map to be disseminated to wide communities
*NASA, NOAA, JAXA, DIAS*
2) Satellite observation data archive
*NASA, NOAA, JAXA, CEOS Water Portal, DIAS, AWCI*
3) Climate data archive at least past 20 years which correspond to the availability of the GCM and RCM model outputs.

*Reanalysis (ECMWF, NCEP, JMA), NASA, NOAA, JAXA, CEOS Water Portal, NASA-SERVIR, DIAS, AWCI*

4) Improve observational, modeling and application capacity
   a) Develop training modules and design/implement training courses
      *UNU, UN-CECAR, UTokyo, AIT, JAXA*
   b) Promote secondary educational program in collaboration with universities
      *UNU, UN-CECAR, UTokyo*

(2) Demonstrate capability of flood and drought forecasting and early warning

1) Develop distributed physically-based hydrological models including simulation ability of evapotranspiration, soil moisture, ground water and vegetation growth (WEB-DHM) for the Indus basin.
   *AWCI, DIAS, science communities*
2) Develop inundation model(s) and update flood hazard maps
   *AWCI, DIAS, science communities*
3) Couple hydrological model with a crop and economic models
   *AWCI, DIAS, science communities*
4) Prototype real-time data integration systems for hydrological modeling including data assimilation and information dissemination.
   *PMD, NASA-SERVIR, DIAS*

(3) Assess climate change impacts on floods, droughts and water-nexus

1) Selection of GCMs which can express the regional climate.
   *AWCI, DIAS, PMD, GCISC, PARC, science communities*
2) Bias correction and downscaling
   *AWCI, DIAS, PMD, GCISC, science communities*
3) Socio-economic data archive
   *GLOWASIS, Statistical Division, Planning Division, SDPI, FCC*
4) Assessment of the changes of flood, drought and water-nexus.
   *AWCI, DIAS, WAPDA, PMD, Irrigation départements, FFC, science communities*

GROUP ON EARTH OBSERVATIONS

## Sri Lanka: Kelani River Basin

**Project Title:** *Flood mitigation in Greater Colombo region*

**Background**

The Kelani River is the second largest River in Sri Lanka which flows to the west coast from the central hills through Colombo city. Extreme precipitation events are becoming more frequent in Sri Lanka and are attributed to climate change and the Kelani River basin is one of the most vulnerable river basins for floods and costly flood damages.

Topographically, the Kelani River basin can be distinctly characterized as upper and lower basins. The mountainous upper basin, that lies upstream of Hanwella river gauging station, is about 1740 km2 and ridges rise beyond 2000 m above Mean Sea Level with several peaks. The lower basin, downstream of Hanwella, which is on a flat-terrain, is about 500 km2.The upper basin is mainly covered with the vegetation types such as tea, rubber, grass and forest while the lower basin is heavily urbanized. The lower basin of the Kelani River which is vulnerable to frequent floods.

Flood discharge and inundation along the Kelani River reach below Hanwella were simulated by the application of two-dimensional flood simulation model (FLO-2D) to 250m x 250m grids covering the lower basin. Inflow hydrograph at Hanwella was estimated by using the Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) model under identified future extreme rainfall events from the rainfall downscaled up to 2099 under the A2 and B2 scenarios (De Silva et al).

Discharge at Hanwella gauging station was calculated by using HEC-HMS.Annual maximum daily discharge will be increase from 500-1000 m3/s range to 2000-2500 m3/s range from 2010th decade to 2090th decade under both A2 and B2 scenarios. FLO-2D software was used to compute flood hydrographs and generate inundation maps in the lower Kelani basin and corresponding to rainfalls of 100 year and 50 year return periods and hazard vulnerability and risk factors were calculated to evaluate the exposure to disaster. Colombo, Thimbirigasyaya, Kesbewa and Sri Jayawardanapura Kotte DS divisions were the high risk areas for inundation correspond to 50 year return period rainfalls under both A2 and B2 scenarios. The risk expands to Kelaniya, Kolonnawa, Wattala and Kaduwela DS divisions for 100 year return period rainfall under A2 and B2 scenarios.

According to the investigation, by introducing a levee along the river and detention basins together would reduce the average risk over the catchment about 65% and 40%, correspond to 50 year return period rainfall under A2 and B2 scenarios, respectively, and 32% and 25%, correspond to 100 year return period rainfall under A2 and B2 scenarios, respectively (De Silva et al)..

**Project Design Matrix (PDM)**

### 1. Overall Goal

Reduction of future flood inundation damage in the lower Kelani River basin

### 2. Project Purpose

The climate change impact downscaling from GCMs carried out show an increase trend in extreme rainfall events in the Kelani River basin. The lower Kelani basin is a plain area and has high population and also contains the Greater Colombo area with high economic input. The project purposes are to provide structural and non-structural adaptation strategies to reduce flood inundation risk in the lower Kelani basin.

To address these issues, it is necessary to:

(1) Carry out critical assessment of floods and inundation risk in the lower basin under climate change

(2) Propose structural and nonstructural flood mitigation options and investigate the best options considering societal benefit

(3) Implement of item (2) above

**3. Outputs**

(1) Critical assessment of floods and inundation risk in the lower basin under climate change
   a) Future probable rainfall and flood inundation extents under ongoing climate change based on downscaling of GCM results
   b) Socio-economic impact of the estimated floods

(2) Proposal of structural and nonstructural flood mitigation options and investigate the best options considering societal benefit
   a) Awareness of flood risk, incorporation/mainstreaming of non-structural measures to design and construction practices to reduce disasters/flood damage
   b) Various structural measures to flood control/flood damage/ reduce disasters. Long term and short term solutions.

(3) Implementation of item (2) above
   a) Implementation Plan and structural components/ measures, and reduction in flood inundation

**4. Activities and Key Leaders**

Lead Organizations

- Ministry of Water Resources (Irrigation Department of Sri Lanka)
- Meteorology Department of Sri Lanka
- Ministry of Disaster Management (Disaster Mitigation Centre)
- Ministry of Urban Development (Urban Development Authority)

Activities and collaborators from international community

(1) Critical assessment of floods and inundation risk in the lower basin under climate change
   1) Using GCM downscaled data by using recent advancement of model outputs and downscaling tools.
      *AWCI & DIAS, GEOSS, WB, ADB*
   2) Development of a socio-economic data base of the low lying areas of the basin
      *UN Organizations, Habitat*

(2) Proposal of structural and nonstructural flood mitigation options and investigate the best options considering societal benefit
   1) Refined two-dimensional flood modeling for identification of vulnerable areas and risk factors
      *AWCI, UTokyo, JAXA, ADB, WB, JICA, KOICA*
   2) Awareness programmes to stake holders on potential increased risk
      *ADPC*
   3) Short term solutions for disaster reduction
      a. Warning systems based on real-time weather predictions and flood modeling
         *JAXA, ISPRO(India), GEOSS, DIAS, JICA, KOICA, USAID..*
   4) Long term solutions for disaster reduction

(3) Implementation of item (2) above
   1) Introduction of non-structural measures through planning agencies
      *JICA, KOICA, USAID, ODA, MDG*
   2) Planning and implementation of structural measures- alternative proposal and evaluation
      *JICA, KOICA, USAID, ODA, WB, ADB, MDG*

## Thailand: Upper Ping River Basin

**Project Title:** *Flood Forecasting and Early Warning System for Upper Ping River Basin using Hydro-Meteorological Models and Remote Sensing Techniques.*

**Background**

Over the last decade (2001-2010), more than 891 people died in floods and landslides with casualties of 216 in 2002, 446 in 2006, and 229 in 2010 (Wongruang, 2010). Flooding and landslides cause widespread damage and suffering. Bank of Thailand (2011) reported that in 2011, Thailand suffered major flooding with 63 provinces directly involved affecting 12.8 million people, involving 698 deaths and 3 missing presumed dead. More than 24 million hectares of agricultural land was damaged as well as most of the industrial estates in the central part of the country. Economic losses were estimated at 45 thousand million dollars. Flash flooding and landslides caused by heavy rainfall in the head watershed overloaded the soil carrying capacity, as its ability to absorb the heavy rainfall was reduced as result of the conversion of the hill slopes from forest to agriculture.

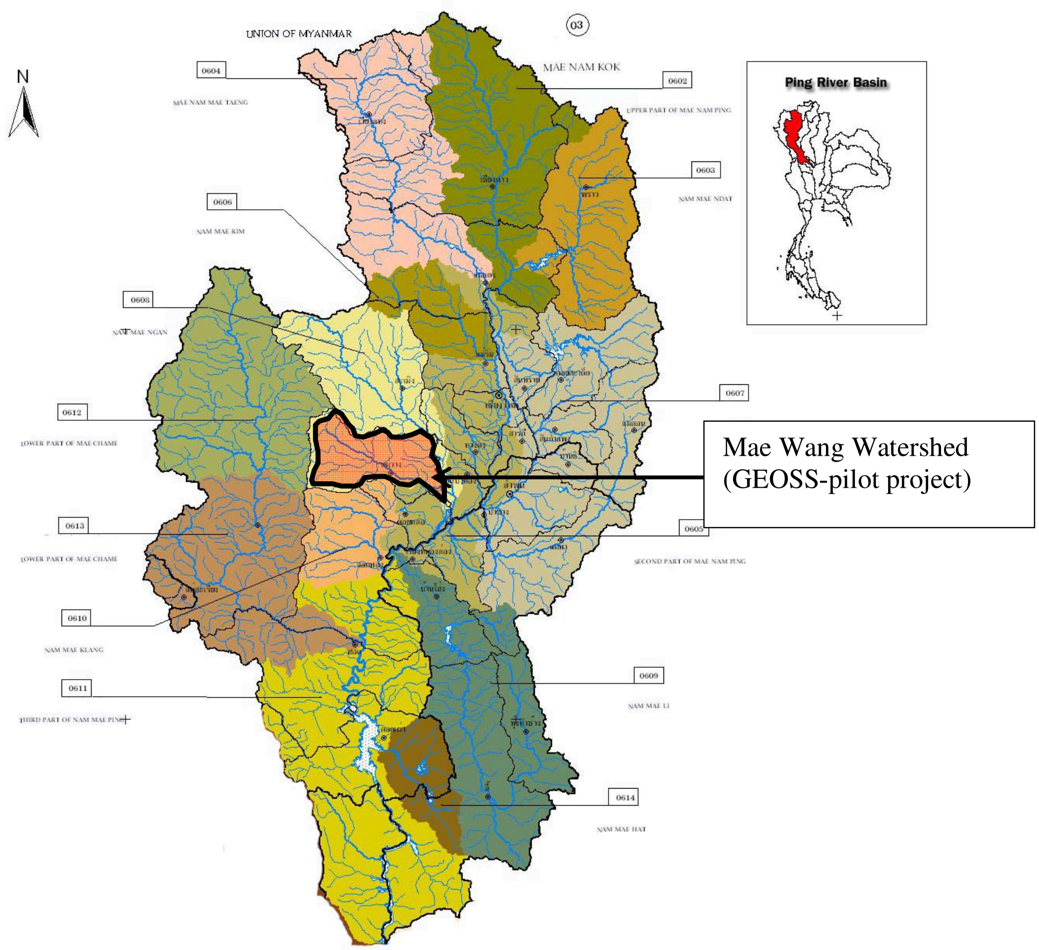


**Figure 1:** Upper Ping River Basin and Mae Wang as its sub-watershed

Since deep in Thai history, general broad scale flooding and flash flooding have caused damage to both life and property. Engineering structures and also non-structural measures can be used to reduce flood damage. One of the non-engineering measures is a flood warning system that can immediately inform the people living downstream to take precautions before the floodwaters reach them. With this system, the people can make a decision on when the flood discharge is likely to arrive and how much time they have to evacuate to safe locations.

From 2009 to 2013, Thailand has been researching and collecting hydro-metrological data under the GAME-T project and has installed more monitoring stations in the Mae Wang watershed under a GEOSS project (Figure 1) and these are now operational. Junkhiaw et al. (2013) used data from the GAME-T and GEOSS projects to develop models and an early warning system for the Mae Wang watershed. The model can be used for early warning prediction as well. The researchers have to import data, which is used in the models, and the outputs are then applied for forecasting and early warning decision making in the Upper Ping River Basin which is larger than the Mae Wang River Basin (Mae Wang is 543 sq.km and Upper Ping is 22,135.36 sq.km).

The Upper Ping river basin area covers 22,135.36 sq.km and consists of 12 sub-watersheds. The Mae Wang watershed (the pilot project of GEOSS) is part of the Nam Mae Khan watershed and is subjected to regular flooding as the Mae Chaem and Nam Li watersheds are, in the Chiang Mai and Lamphun provinces, respectively. The model and data, including an automatic climatic station protocol, GAME-T and GEOSS will be used to develop a model that is accurate for this large basin.

**Project Design Matrix (PDM)**

**1. Overall Goal**

Increase the accuracy and efficiency of the flood and landslide warning process using hydrological modeling and satellite data.

**2. Project Purpose**

- To study the structure and function of the basin, which is related to the hydrological characteristics and causes of the water disaster.
- To select the appropriate models and satellite data application for forecasting and warning in Upper Ping River Basin.
- To prepare the database and services to be available online.

**3. Outputs**

(1) Based on the study of the structure and functions of the basin, which is related to the hydrological characteristics and causes of the water disaster, the following outputs will be produced:
   a) Status of the Upper Ping River basin areas including the structure and functions that control the amount of water, duration of irrigation and water quality.
   b) Patterns of land use change.
   c) Impact of land use changes on hydrological characteristics of the watershed.
   d) Problems from flooding and landslides in the watershed.

(2) The selection of the appropriate models and satellite data application to implement a forecasting and warning system in the Upper Ping River Basin will produce:
   a) An appropriate model for a large basin in Thailand recruited from various models such as models from AWCI, ICHARM, SWAT or/and other models which can then be applied to forecasting and warning in the Upper Ping River Basin.
   b) A model to estimate rainfall from satellite imagery (from NOAA, NASA, JAXA, GISTDA or other) that can be calibrated using measured rainfall data from Royal Irrigation Department stations.

(3) To prepare the database and services to be available online.
   a) The GIS and satellite database for the basin can be downloaded for no charge.

b) A website will be developed that provides access to the meteorological and hydrological data for the watershed.

**4. Activities and Key Leaders**

Lead Organizations

- Burapha University (BUU)
  - ➢ Faculty of Geoinformatics
- Ministry of Agricultural and Cooperative
  - ➢ Royal Irrigation Department (RID)
- Geo-Informatics and Space Technology Development Agency (Public Organization(GISTDA)
- Kasetsart University(KU)
  - ➢ Faculty of Forestry
- Khon Kaen University (KKU)
  - ➢ Faculty of Agriculture
- University of Tokyo
- Kochi University of Technology

Potential collaborators

(1) Watershed analysis

1) Watershed status (Structure and Functions)
   - Faculty of Geoinformatics, BUU
   - Faculty of Forestry, KU
   - Royal Irrigation Department (RID)
   - Kochi University of Technology
2) Land use changes and effects
   - Faculty of Agriculture , KKU
   - Faculty of Forestry, KU
   - GISTDA
   - Kochi University of Technology
3) Relationship between watershed characteristics and hydrography
   - Faculty of Geoinformatics, BUU
   - Royal Irrigation Department (RID)
   - University of Tokyo

(2) Model selection and training

1) Selecting and training for the hydro-metrological models
   - University of Tokyo
   - Kochi University of Technology
   - Royal Irrigation Department
2) Satellite data and application to predict rainfall and soil moisture
   - GISTDA
   - Faculty of Geoinformatics , BUU
   - University of Tokyo
   - Kochi University of Technology

(3) Data sharing and data services

1) Database and Data sharing system

- Faculty of Geoinformatics, BUU
- GISTDA
- University of Tokyo
- Kochi University of Technology

2) Training and Services
   - Faculty of Geoinformatics, BUU
   - GISTDA

**Key Leader**
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## Uzbekistan: Chirchiq - Akhangaran River Basins

### 1. Background

Uzbekistan is prone to climate-related disasters such as floods, mudflows and landslides, drought. Climate change is expected to make the country even more vulnerable. Uzbekistan is already facing a number of serious ecological problems related to changes in the water cycle aggravated by negative impacts of global warming.

The Chirchiq - Akhangaran river basins has a great strategic importance for Uzbekistan. There are two rivers - Chirchiq (161 km) and Akhangaron (223 km). The basin has 67 lakes with different types of origin, 19 hydropower plants, the population - more than 2.5 million people.

The whole area of Chirchiq-Akhangaran river basin occupies the north-eastern part of Uzbekistan, has a great diversity of landforms and features in the distribution of precipitation and humidity. The main power source of the rivers of the district are considered melt water seasonal snow cover, less significant volume of water ice, and rain water. Snowmelt induced runoff rivers Chirchiq - Akhangaran river basins were 60-80% of the total runoff.

Chirchiq - Akhangaran river basins is well studied, meteorological and hydrological stations located in the basin have long continuous data series, which is very important for the research. In the Chirchiq - Akhangaran river basin and in neighboring countries there are many potentially dangerous and developing objects - glacial lakes and outbreaking lakes, and monitoring are difficult because of inaccessibility. Objects themselves are often small in size but have an enormous potential threat in the event of their destruction.

**Project Design Matrix (PDM)**

### 1. Overall Goal

Reduction of hydrometeorological disasters in the Chirchik - Akhangaran river basin considering climate change and water cycle changes.

### 2. Project Purpose

In accordance with research it was concluded that, in relation to climate change in the Chirchik- Akhangaran river basin, main issues are:

- Reduction of snow cover, increasing seasonal snow line;
- Degradation of glaciers;
- Reduction of available water resources;
- Strengthening of natural variability and the overall trend increase in extreme water availability in years.

At the same time there is a lack of information and methodological support not only for the country but also the neighboring countries, and thus it is necessary to better ensure the data. Proceeding from the above, we need to conduct research in the following areas:

(1) Improved monitoring of snow and ice resources;
(2) Assessment of Vulnerability Chirchiq - Akhangaran river basin from the effects of dangerous hydrometeorological phenomena;
(3) Improved forecasting and early warning of dangerous hydrometeorological phenomena;
(4) Development of adaptive strategies and measures.

### 3. Outputs

(1) Improved monitoring of snow and ice resources:
  a) Assessment of the dynamics of glaciers in the upper Chirchiq - Akhangaran river basin.
  b) Assessment of the dynamics of high mountain outbursting lakes, due to the fact that the retreat of the glaciers - a phenomenon that can cause a breakout of glacial lakes that threaten serious flooding in the lower reaches of the rivers.

   c) Creating an archive of high resolution satellite data for system monitoring high mountain outbursting lakes. Satellite images have many advantages, they can be used to monitor the potential danger of objects located in the territory of neighboring countries, which is very important for the study basin.

(2) Assessment of Vulnerability Chirchiq - Akhangaran river basin from the effects of dangerous hydrometeorological phenomena.
   a) Analysis of the current variability of extreme hydrometeorological phenomena (probability of occurrence, duration of hazardous period by the territory) and their after-effects for vulnerability assessment.
   b) Selection of methods of an estimation of vulnerability of water resources of a Chirchiq - Akhangaran river basin in conditions of climatic change.
   c) Future risk assessment in line with the Climate Scenarios and application of the advanced methods and tools.
   d) Generation of vulnerability and hazard zonation maps and provide information for planning disaster mitigation measures

(3) Improved forecasting and early warning of dangerous hydrometeorological phenomena
   a) The development of hydrological models.
   b) Creation of an Archive of satellite remote sensing data for the characteristics of the hydrological modeling.
   c) The creation and maintenance of an information database.

(4) Development of adaptive strategies and measures
   a) Since it is not possible to completely avoid natural hazards like floods, mudslides, etc., you need to build capacity for adaptation related to prevention (keeping), the softening effect (protection) and a reduction of damage (insurance).

**4. Activities and Key Leaders**

Leading organizations

NIGMI, Uzhydromet.

In addition, collaboration with following international organizations will be sought:

(1) Improved monitoring of snow and ice resources
*WMO/HyCOS – ARAL HyCOS, ESA, NOAA, JAXA, DIAS*

(2) Assessment of Vulnerability Chirchiq - Akhangaran river basin from the effects of dangerous hydrometeorological phenomena
*WMO/HyCOS – ARAL HyCOS, GEF/UNCCD/UNFCC*

(3) Improved forecasting and early warning of dangerous hydrometeorological phenomena
*DIAS, JACA, GEF/UNCCD/UNFCC, UTokyo, ESA, NOAA, JAXA*

(4) Development of adaptive strategies and measures
*WMO/ARAL HyCOS, JACA, GEF/UNCCD/UNFCC, UTokyo*

# Vietnam: Thai Binh River Basin

**Project Title:** *Utilizing satellite data, numerical rainfall forecasts, combining with ground observations in flood forecasting for the Thai Binh river system*

**Background**

Despite exists several national and international projects which are conducted on flood forecasting in Vietnam, Thai Binh river system is less invested and flood forecasting accuracy and lead time for this river system have still a lot of limitations.

The Thai Binh River system is second big river system after the Red river system in the Northern Vietnam with basin area 17580km$^2$ (to Pha Lai station) and length of main stream 1650km. Available near real time data for flood forecasting purpose from upstream to Pha Lai come only from 35 rain gauges, 14 water level gauges and 2 discharge gauges. For the Thai Binh river system now exists only 12-24 hour flood forecast with low accuracy because of data lack and without of advanced forecasting technique. Development of a flood forecasting and warning system using satellite data is highly expected, especially for developing countries where the collection of real time data on rainfall and water level in river basins faces on technical and financial difficulties.

By using rainfall data from earth observation satellites (EOS) and implementing runoff calculation and flood prediction, combining with numerical rainfall forecast and ground observation hydrological data, it is possible to promote the development and improvement in flood forecasting and warning system on river basin level. It is planes to utilize satellite data like GSMaP_NRT from JAXA (Japan), numerical rainfall forecasts like ECMWF, GSM; combining with hydro-meteorological ground observation data in flood forecasting for the Thai Binh River system. For this purpose, the Integrated Flood Analysis System (IFAS) is used for calculating runoff on upstream sub-basins without hydro-meteorological data or with insufficient hydrological and geophysical information. This runoff is considered as inputs or lateral inflows into downstream mainstream. For downstream where there are enough ground data, the hydrodynamic model Mike 11 (DHI) used for flood forecasting. The forecasting system will increase lead time to 2-day flood forecast with improved and acceptable accuracy for the Thai Binh river system. It is reliable with development purpose and plan of National Hydro-Meteorological Service.

**1. Overall Goal**

Effective utilizing available satellite data in flood forecasting

**2. Project Purpose**

Utilizing all available satellite data combining with numerical rainfall forecasts and ground observations in operational flood forecasting for Vietnam rivers (in case of the Thai Binh river system

To address these issues, we need to carry out:

(1) Data collection
(2) Data processing and archiving
(3) Calibration, verification of hydrological model (IFAS)
(4) Calibration, verification of hydraulic model (Mike DHI)
(5) Calibration, verification of forecasting system by combining hydrological model (IFAS) and hydraulic model (Mike DHI)
(6) Final reporting

**3. Outputs**

(1) Two-day flood forecast for main rivers of the Thai Binh river system
(2) Technical transfer to local forecasters at regional and provincial levels to operate the flood forecasting system.

**4. Activities and Key Leaders**

Lead Organizations

- National Hydro-Meteorological Service (NHMS), Ministry of Natural Resources and Environment (MONRE), Executing Agency
- The National Centre for Hydro-Meteorological Forecasting (NCHMF), Implementing Agency
- International Centre for Water Hazard and Risk Management under the auspices of UNESCO (UNESCO-ICHARM), Technical support, advanced training of IFAS
- The Japan Aerospace Exploration Agency (JAXA), Satellite data provider, Financial support from JAXA where possible (travel, per diem... for experts, training from ICHARM, kick-off meeting, workshop attending etc...)
- Regional Hydro-Meteorological Centre for North-East (RHM CNE), Ground Data provider and End-User
- Standing Office (SO) of Central Committee for Flood and Storm Control (CCFSC), End-User

Activities

(1) Data collection
 1) Available satellite data from JAXA such as DEM, Land use or Land cover (new data after 2009, preferable of 2011 or 2012 year), GSMaP_NRT for last 6 years (2008-2013) from FTP server
 Collaborators: JAXA
 2) DEM, Land use or Land cover, river network, GIS products. from Vietnamese Mapping organization
 Collaborators: Department of Remote Sensing - MONRE
 3) Hydro-meteorological ground data: rainfall, water level, discharge for the Thai Binh river system from 2008-2013
 Collaborators: Regional Hydro-Meteorological Centre for North-East of Vietnam (RHM CNE)
 4) Geographical data: cross sections, hydraulic constructions, lakes, reservoirs… in the basin
 Collaborators: Regional Hydro-Meteorological Centre for North-East of Vietnam (RHM CNE)
 5) Numerical Rainfall forecast from GSM, ECMWF
 Collaborators: Research and Development Division -NCHMF
 6) Reporting

(2) Data processing and archiving
 1) Processing DEM, Land use, Land cover to build correct basin boundary, river network
 2) Processing and archiving hydro-meteorological and geographical data in required format for hydrological and hydraulic models
 3) Reporting

(3) Calibration, verification of hydrological model (IFAS)
 1) Set up IFAS model for the Thai Binh river basin
 2) Calibration of IFAS model parameters, collaborator:
 Collaborator: ICHARM
 3) Verification of IFAS model
 4) Reporting

(4) Calibration, verification of hydraulic model (Mike DHI)
 1) Set up Mike model for the Thai Binh basin
 2) Calibration of Mike model parameters
 3) Verification of Mike model
 4) Reporting

(5) Calibration, verification of forecasting system by combining hydrological model (IFAS) and hydraulic model (Mike DHI)

1) Set up forecasting system of hydrological-hydraulic models
2) Calibration of forecasting system
3) Verification of forecasting system
4) Reporting

(6) Final reporting.