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 Régional 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

Lead Organizations

- 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:

Item No.1:

(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).

<u>Lead Organizations</u>

- 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).

<u>List of potential collaborators and donors from the international community:</u>

(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.

Volta River Basin

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

<u>Lead Organizations</u>

- 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. Activities and Key Leaders

Lead Organizations

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.

Contributors: Likely funding agencies are ADB, JICA, WB etc.

5. Killer Factors and Mitigation Measures

Killer Factor	Mitigation Measures
Timely availability of sufficient fund.	Several donors may be explored
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

<u>Lead Organizations</u>

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

<u>Lead Organizations</u>

- 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

Lead Organizations

- 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

5. References

MNRE (2012), National Water Resources Policy. Ministry of Natural Resources and Environment Malaysia

MNRE (2011), Review of the National Water Resources Study (2000-2050) and Formulation of National Water Resources Policy. Ministry of Natural Resources and Environment Malaysia

Government of Malaysia, 2011. National Green Technology Policy. Ministry of Energy, Green Technology and Water

Government of Malaysia, 2010. National Policy on Climate Change. Ministry of Natural Resources and Environment Malaysia

Luis, J. et al., 2013. Sustainability of hydropower as source of renewable and clean energy. In IOP Conference Series: Earth and Environmental Science. p. 012050.

Othman Jaafar, M. et al., 2010. Modeling the Impacts of Ringlet Reservoir on Downstream Hydraulic Capacity of Bertam River Using XPSWMM in Cameron Highlands, Malaysia. Research Journal of Applied Sciences, 5(2), pp.47–53.

Sidek, L. et al., 2013. Probable Maximum Precipitation (PMP) over mountainous region of Cameron Highlands-Batang Padang Catchment of Malaysia. In IOP Conference Series: Earth and Environmental Science. p. 012049.

Teh, S.H., Soil Erosion Modeling Using RUSLE And GIS On Cameron Highlands, Malaysia For Hydropower Development.

Toriman, M.E. et al., 2010. Use of InfoWork RS in modeling the impact of urbanisation on sediment yield in Cameron Highlands Malaysia. Nat Sci, 201(8).

Wang, H. et al., 2007. Stepwise decreases of the Huanghe (Yellow River) sediment load (1950–2005): Impacts of climate change and human activities. Global and Planetary Change, 57(3), pp.331–354.

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.

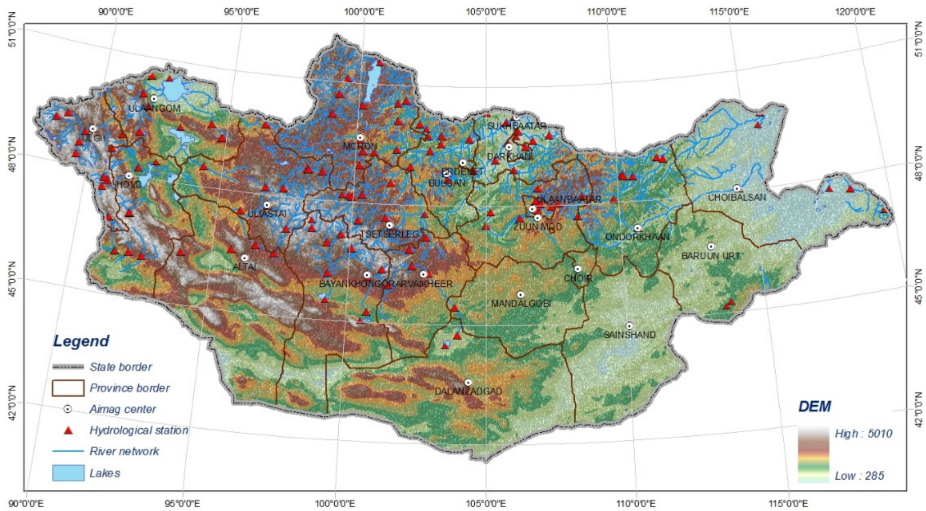

Fig. 1 Location of hydrological gauging stations in Mongolia

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).

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.

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)

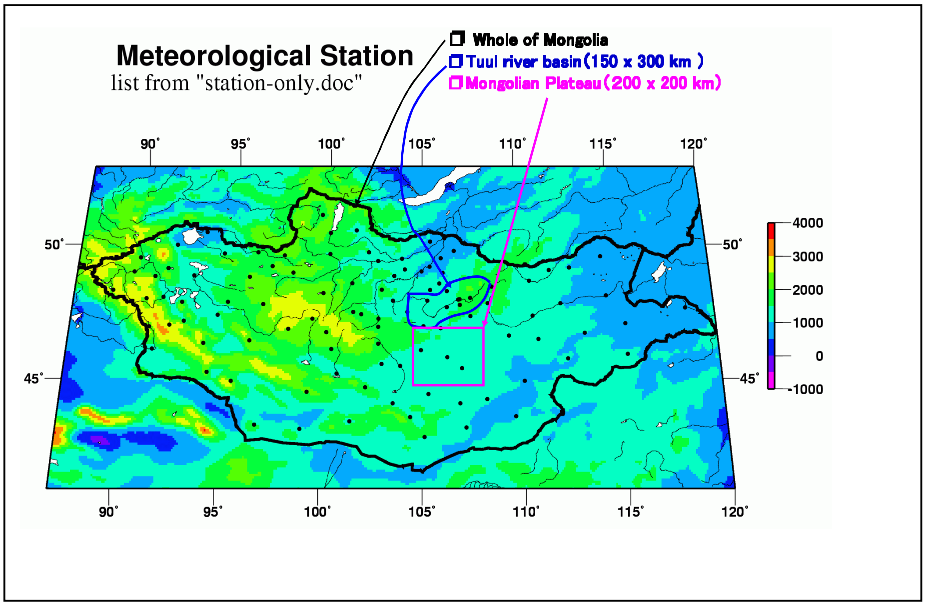

Fig. 2 Study areas

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.

<u>Lead Organizations</u>

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

<u>Supporting Organizations – local</u>

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

<u>Supporting Organizations – international</u>

- 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

<u>Lead Organization</u>

- 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

Lead Organizations

- 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

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.

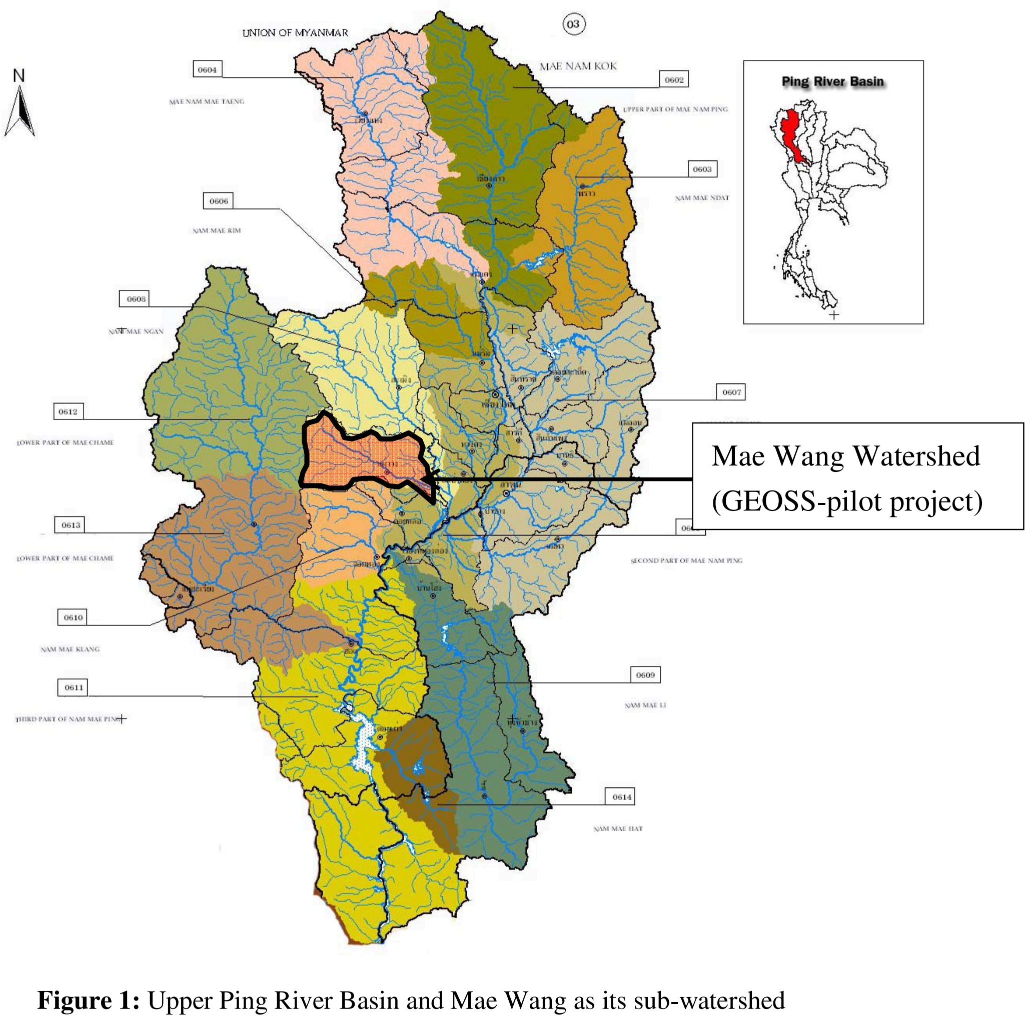

Figure 1: Upper Ping River Basin and Mae Wang as its sub-watershed

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
Researcher/ Co-advisors:

Project Leader	
Dr. Sutep Junkhiaw	Faculty of Geoinformatics, Burapha University , Thailand Email: sutep@buu.ac.th
Thailand:	
Mr. Thada Sukaphunaphun	Royal Irrigation Department Ministry of Agricultural and Cooperation Email: thada999@yahoo.com
Prof. Dr. Nipon Tangtham	Faculty of Forestry, Kasetsart University Email: ffornpt@ku.ac.th
Asst. Prof. Dr. Wirogana Ruenghrathuengsuka	Vice President of Burapha University Email: wirogana@buu.ac.th
Asst. Prof. Dr. Anond Sanidvongs	Executive Director of GISTDA Email: anond@gistda.or.th
Ms. Mallika Sisutham	Faculty of Agriculture, Khon Kaen University
Japan:	
Prof. Dr. Toshio KOIKE	University of Tokyo Email: tkoike@hydra.t.u-tokyo.ac.jp

Asst. Prof. Dr. Pongsak Suttinon Kochi University of Technology
Email: pongsak.suttinon@kochi-tech.ac.jp

Contributors:

- Burapha University (BUU)
- Royal Irrigation Department (RID)
- Geo-Informatics and Space Technology Development Agency (Public Organization): GISTDA
- Kasetsart University (KU)
- Khon Kean University (KKU)
- University of Tokyo
- Kochi University of Technology

References:

Bank of Thailand. 2012. Thailand floods 2011: Impact and recovery from business survey. Bangkok. Available from: [www.bot.or.th/EconomicConditions/Thai/BLP/Documents/ThaiFloodSurvey2011_eng.pdf]. [Sourced: January 17, 2013].

Junkhiaw, S., W. Arunpraparat, N. Tangtham, A. Sanidvong, and C. Yawudhi. 2013. Decision Support System for a Flash Flood and Landslide Warning System in an Upper Watershed. Thai Journal of Forestry. Vol.32, No.1 pp.35-50

Wongruang, P. 2010. Special report: Master plan looks good, on paper. Bangkok Post. Sunday , November 21,2010, pp.3-5

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

<u>Leading organizations</u>

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.