

## JE-HydroNet: Modern Methodologies for the Management, Monitoring and Planning of Integrated Water Resources in the Nile Delta of Egypt

S.A. Kantoush<sup>1</sup>, T. Sumi<sup>1</sup>, T. Kojiri<sup>1</sup>, M. Saber<sup>1</sup>, I. Elshennawy<sup>2</sup>, H. Awad<sup>3</sup> and A. Sefelnaser<sup>4</sup>

<sup>1</sup>Disaster Prevention Research Institute  
Kyoto University  
Gokasho, Uji-Shi, 611-0011  
JAPAN

<sup>2</sup>Coastal Research Institute (CoRI)  
National Water Research Center (NWRC)  
15 Al-Pharaana St., Al-Shallalat, Alexandria  
EGYPT

<sup>3</sup>Irrigation Engineering and Hydraulics Department, Faculty of Engineering  
Alexandria University  
Alexandria, 21544  
EGYPT

<sup>4</sup>Geology Department, Faculty of Science  
Assiut University  
Assiut, 71516  
EGYPT

E-mail: [kantoush@yahoo.com](mailto:kantoush@yahoo.com)

**Abstract:** *This article outlines the development of a shared hydraulic and hydrology-based network that seeks to bridge the gap between research, education and practice. This network base was developed from the contextualised problems facing the Nile delta, Nile River system, and coastal managements in Egypt. Under the umbrella of GCOE-ARS project at Kyoto University, a joint project for research and education was established between Kyoto University and three institutional research units in Egypt. Disaster Prevention Research Institute (DPRI), Kyoto University expert groups looked at problems of Nile Delta of Egypt related to their expertise and initiated Japan Egypt-Hydro Network (JE-HydroNet). In view of the challenges that Egypt is facing in the water resources and environmental issues, the project will help to mitigate the problems and its consequences. The exchange of qualitative and quantitative information between Japanese and Egyptian groups will contribute to the efforts of Egypt in development of innovative measures for water resources management.*

**Keywords:** *Joint project in science and technology, Nile River Basin, Delta of Egypt, Japan Egypt Hydro Network (JE-HydroNet), bridging research and practice.*

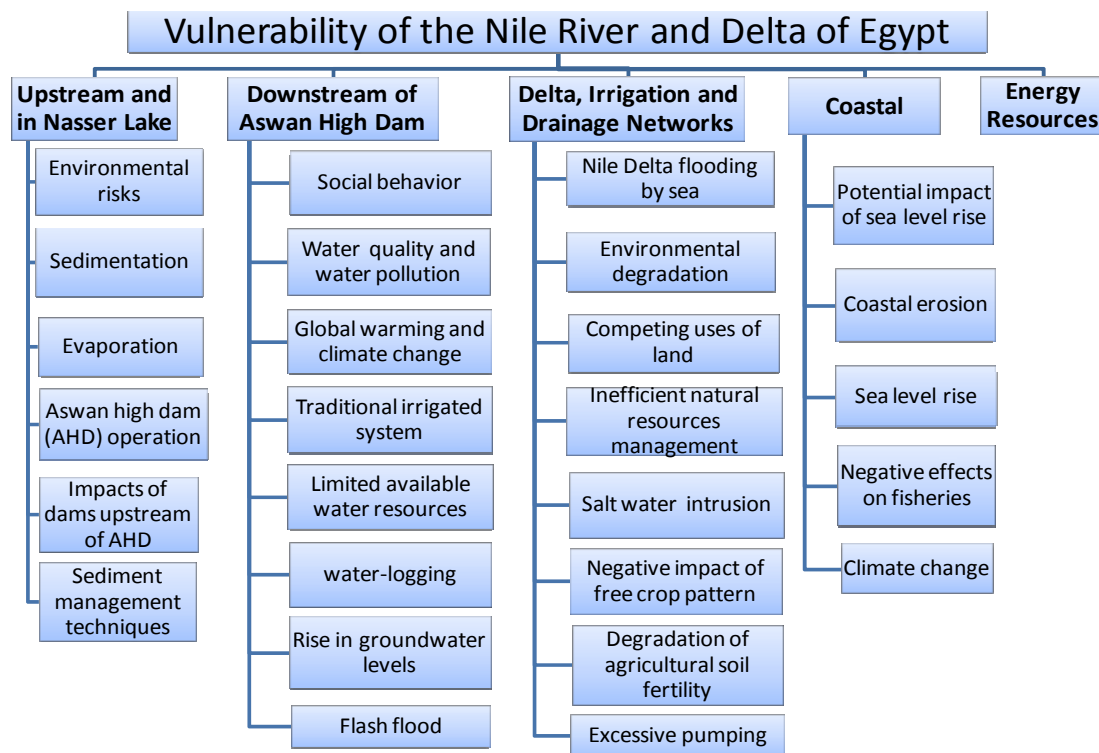
### 1. INTRODUCTION

The gap between education, research and practice in the hydraulics and hydrology field is recognized by many. Bridging the gap can be achieved by involving the practitioners in education and training and more particularly in the life-long learning processes. Hydro-Engineering projects are becoming more and more complex projects and have to be carried out in close cooperation by several experts from different disciplines and locations. Under the umbrella of Global Center Of Excellence - Adaptation and Resilience in a Sustainable/Survivable Society to extreme weather and water conditions (GCOE-ARS) project at Kyoto University, a joint project for research and education was established between Kyoto University and three institutional research units in Egypt (Assiut and Alexandria Universities, and National Water Research Center (NWRC), Ministry of Water Resources and Irrigation (MWRI)).

Japan Egypt-Hydro Network (JE-HydroNet) was initiated after the visit of DPRI research group on March 2009 to setup research projects concerning the Nile River and the Nile Delta of Egypt. On 26

October 2010 the first mini-symposium was organized at Uji campus, Kyoto University, Japan. The first symposium have served the exchange of information about the latest state of research of water resources problems facing Nile Delta and encouraged the discussion about joint research project activities and how to combine with consulting practitioners. Three main topics concerning to flash flood and water resources, groundwater, sediment and coastal managements in the Nile River of Egypt were discussed. Finally we discussed the importance of climate change impacts on the Nile River Basin and the Delta of Egypt. Kojiri et al. (2008) explored such global warming impacts by using distributed hydrological model of Hydro-BEAM (Hydrological Basin Environmental Assessment Model), developed by Kojiri et al. (2002).

Egypt's Nile delta with its coastal front on the Mediterranean is considered vulnerable to the impacts of Aswan High Dam (AHD) operation and climate change (Figure 1). These factors also produce stressful effects on water and agricultural resources, and social. The Northern Egyptian Lakes, which constitute about 25% of the total Mediterranean Wetlands and produce about 60% of the fish products, are also highly vulnerable to the impacts of climate change. Moreover, energy resources were ranked as least vulnerable because projections of higher temperatures in an arid climate are expected to boost energy demands, while any reduction in Nile waters would have a direct impact on hydroelectricity generation.



**Figure 1 Problems facing Nile River system and delta of Egypt**

Until today, no proper protection from flash floods proposed for all Wadi basins in Egypt. Flash floods are the result of short period heavy storms and the velocity of floodwater depends mainly on topography of the Wadi (height, slope, capacity of drainage network), and soil characteristics. Flash floods are a major threat to human life and infrastructures. Unfortunately, there is often a lack of data on key hydrological processes in arid areas (Gheith & Sultan, 2002). This limits the ability to understand the flooding process and use this knowledge to minimize its threat to human health and well-being. On the other hand, however, floodwater can be an important source of water replenishment in arid regions. The wise use of floodwater in these areas is therefore important for the sustainable management of water resources. An overall aim of the research project is to develop and implement an integrated flash flood management strategy for the Wadi El-Arish, Sinai Peninsula, Egypt, based on stakeholder and practitioners participation.

Another problem is the salt water intrusion to groundwater in Nile delta regions. With the decrease in the cyclic behaviour of groundwater that was taking place before the Aswan High Dam construction

and the increase in cropping intensities and perennial irrigation applications, drastic impacts on groundwater flow and its salinity which might be critical for sustainable development in delta area.

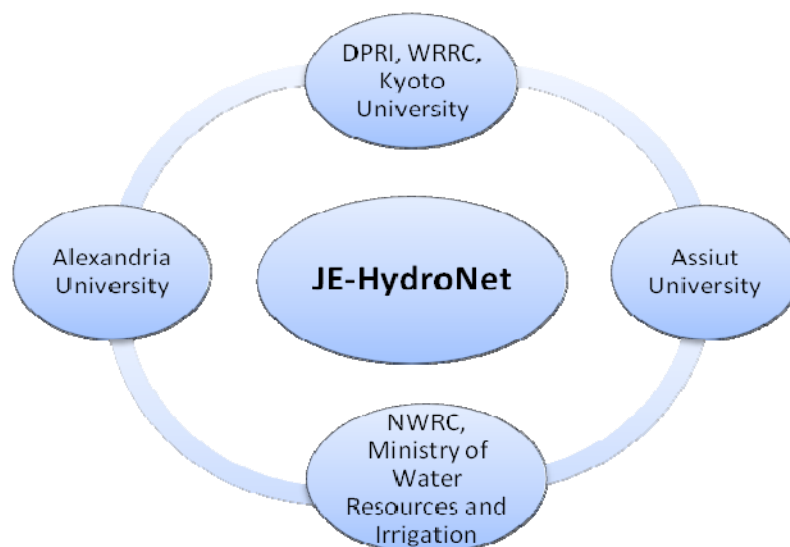
Lake Nasser is causing flow and sediment flow regimes, and reservoir sedimentation is causing serious impacts on river morphology and scouring of delta and coastal region (Abdelsalam, 2008). Moreover, it is important to predict the response of Aswan High Dam (AHD) reservoir and the Nile Delta of Egypt to reservoir sedimentations in the newly constructed or planned dams on the upstream regions of the Nile basin. Moreover, how these dams will affect on the sediment management and operation of AHD. The worldwide sediment management techniques consist of three basin strategies: sediment yield reduction, sediment routing, and sediment removal (Kantoush & Sumi, 2010).

The coastal area of the Nile delta is subjected to severe coastal erosion, even without accelerated sea level rise. The World Bank (2005) highlights the present coastal erosion and retreat of the Delta, which are aggravated by human interventions such as reduced sediment input, groundwater extraction, and hard engineering work in coastal strip. In addition to the current trends, Egypt's Mediterranean coast and the Nile Delta have been identified as highly vulnerable to climate change induced Sea Level Rise (SLR). Some parts along the Nile Delta coast have been protected by hard structures as well as artificial nourishment that have been applied at some sectors.

Accordingly, the main objective of the network is to assess the vulnerability of the Nile Delta coastal zone to climate change/sea level rise and to design an adaptation strategy based on adaptation policy framework. Climate Change Adaptation strategies will be vital for country as Egypt. Adaptation options for Egypt's water resources meanwhile are closely intertwined with Egypt's development choices and pathways. Adapting to climate change will have close resonance with adapting to water scarcity and is likely to require implementation of water demand management strategies which may require capacity building and awareness raising across institutions and society. Adaptation measures on the supply-side include ways to improve rain-harvesting techniques, increasing extraction of ground water, water recycling, desalination, and improving water transportation. In addition, regular reviewing and updating of drought responses and research into improved long-term forecasting is essential to enhance Egypt's ability to cope with prolonged drought.

## 2. CONCEPT OF THE NETWORK AND OBJECTIVES

Following Academic Exchange Agreements between Disaster Prevention Research Institute Kyoto University (Japan) and the Faculty of Science of Assiut University (Egypt), a sincere and friendly discussions with a view to strengthening the research and education, to promoting the cooperation on scientific exchange and the public understanding of science and technology, have been started between Kyoto University and two other institutional research in Egypt. The concept of the JE-HydroNet is illustrated in Figure 2.



**Figure 2 Concept of the seminar and partners**

A group of four researchers of Kyoto University made a preparatory field survey and meetings for establish of cooperative research project among institutes in JE-HydroNet, between 23rd to 30th of March 2010, in Aswan, Assiut, Alexandria, Rosetta, and Cairo in Egypt. During the visit, the two counterparts agreed to hold the first symposium on 26 October 2010 at Uji campus, Kyoto University, Japan. DPRI has invited three Egyptian researchers representing each group and the symposium was successfully held in Japan. Through this symposium, 66 participants mainly from Japan and Egypt with various background and field of interest have attended. Next year another planned joint conference is proposed to be continuation of these past meetings.

This network is first of all unique in the sense that groups of international experts from a priori very distant scientific fields (hydraulics, Hydrology, flash flood and hazard map, dam operation, coastal management, sediment management in reservoirs, numerical and experimental modelling) initiated the JE-HydroNet, as well as the strong extensive knowledge and decision making responsibility of NWRC, Ministry of Water Resources and Irrigation (MWRI). Second, a group of researchers at DPRI, Kyoto University have simulated flash flood and ground water problems in the Delta and the hydrology of the whole Nile Basin, by using integrated hydrological model of Hydro-BEAM (Hydrological Basin Environmental Assessment Model) (Kojiri et al., 2002). One example of these results is shown in section 4 hereafter. The flash flooding Simulation has been performed at Wadi basins of Nile River and Wadi El-Arish using Global Satellite Mapping of Precipitation (GSMaP product). There is no available data for calibration and validation most of these results, only the GSMaP product was calibrated with Global Precipitation Climatology Centre (GPCC) monitored product to estimate the bias of the rainfall data at eleven arid sectors. Therefore, the network will make it possible for the data sharing and set-up new measurement instruments by the help of NWRC.

There is a need to set up an innovative system for rainfall forecasting and early warning for flash-floods in the pilot area of one of Egyptian Wadis; for instance at Wadi El-Arish in Sinai peninsula. That aims at a sustainable management of water resources and wise use of floodwater in arid areas. Based on rainfall-runoff and hydrodynamic modelling, flood-risk maps will be created and best-storage options and suitable flood-protection measures will be identified. This project will help to install measurement station for validation. Moreover, to increase scientific and project based cooperation among the different institutional units of the network. The JE-HydroNet will be performed as the scientific network to exchange young researchers and information among related institutions towards a consistent standardized methodology for management, and propose mitigation projects.

## 2.1. Detailed Objectives

Improvement of flexibility, availability, sustainability and environmental impacts of water resources in Nile Delta by developing advanced methodology for operation, monitoring, planning and management of the water resources problem by focusing on:

- Set-up potential hazard map with a global flash flood warning system;
- Assessment and evaluating of Wadi basins during the flash flood events;
- Adaptation of climate change;
- Sustainable integrated sediment management;
- Coastal erosion;
- Optimizing the dam operation;
- Better Mobility of young researchers: To help the young researchers enhance their effectiveness as research group leaders, and to increase the results they achieve with modelling and measurements as well;
- To allow participants to practice and sharpen their skills of interpersonal communication;
- To analyse the problem of flash flood, climate changes, ground water modelling, sediment management and coastal problems.
- Final discussion about the continuation of the project, research methodology and exchange data and experiences methods will be clarified.

Additional benefits through cooperation are:

- Regular seminars to exchange experience;
- Exchange research students (Master, PhD and postdoctoral levels);
- International publications;
- Solution of local problems in Egypt and share its experiences with Japanese researchers.

JE-HydroNet will be performed as the scientific network to exchange young researchers and information among related institutions towards a consistent standardized methodology for management, and propose mitigation projects.

### 3. CASE STUDY ON FLASH FLOOD MANAGEMENT

To forecast flash floods in real-time, an early warning system for flash floods is planned to be implemented for Wadi El-Arish. To make a useful output for management decisions, a master plan of flash flood management and an emergency response plan will be developed by local authorities and helps of Japanese counterpart as shown in Figure 3. As flash floods are particularly common in arid and mountainous regions, it is the aim of MWRI to extend the system for all high-risk zones in Egypt.

- The planning and design of flash flood control will be the responsibility of the Ministry of Water Resources and Irrigation (MWRI), Egypt.
- The main result of the project will be protection of the city of El-Arish from flood hazard, by reducing the frequency and minimizing the damages produced by Flash Flood.
- The project will set up an innovative system for rainfall forecasting and early warning for flash-floods in the pilot area of Wadi El-Arish.
- Based on rainfall-runoff and hydrodynamic modelling, flood-risk maps will be derived and best-storage options and suitable flood-protection measures will be identified.
- The project will develop a master plan for flash-flood management and an emergency-response plan with the local authorities in the pilot area.
- Constructing of flood retention structures such as dry dam by using innovative Japanese updated technology and other new construction methodology as CSG can be applied.

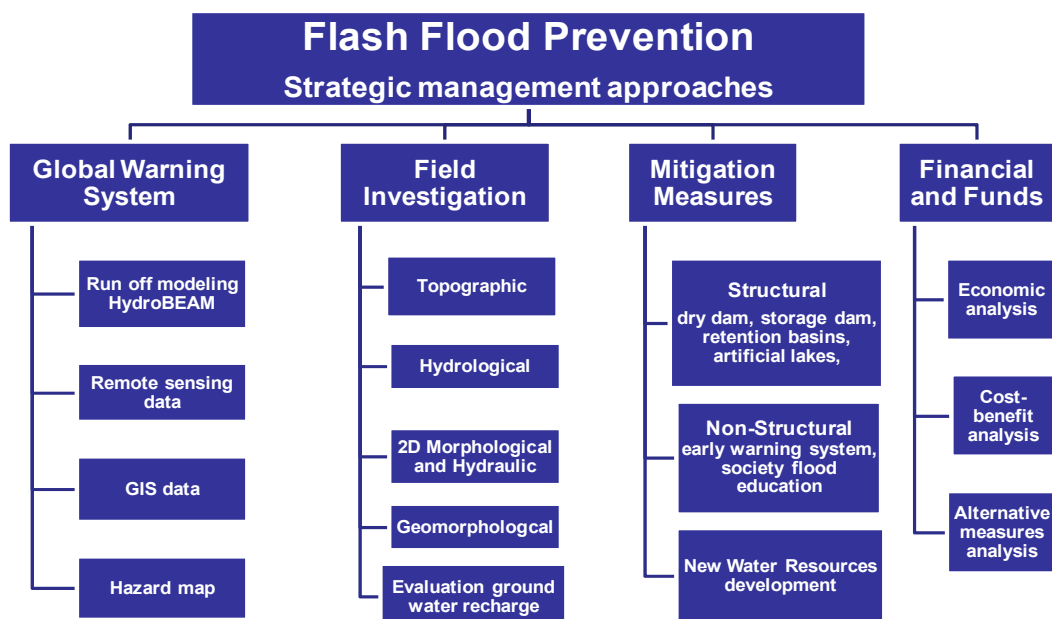
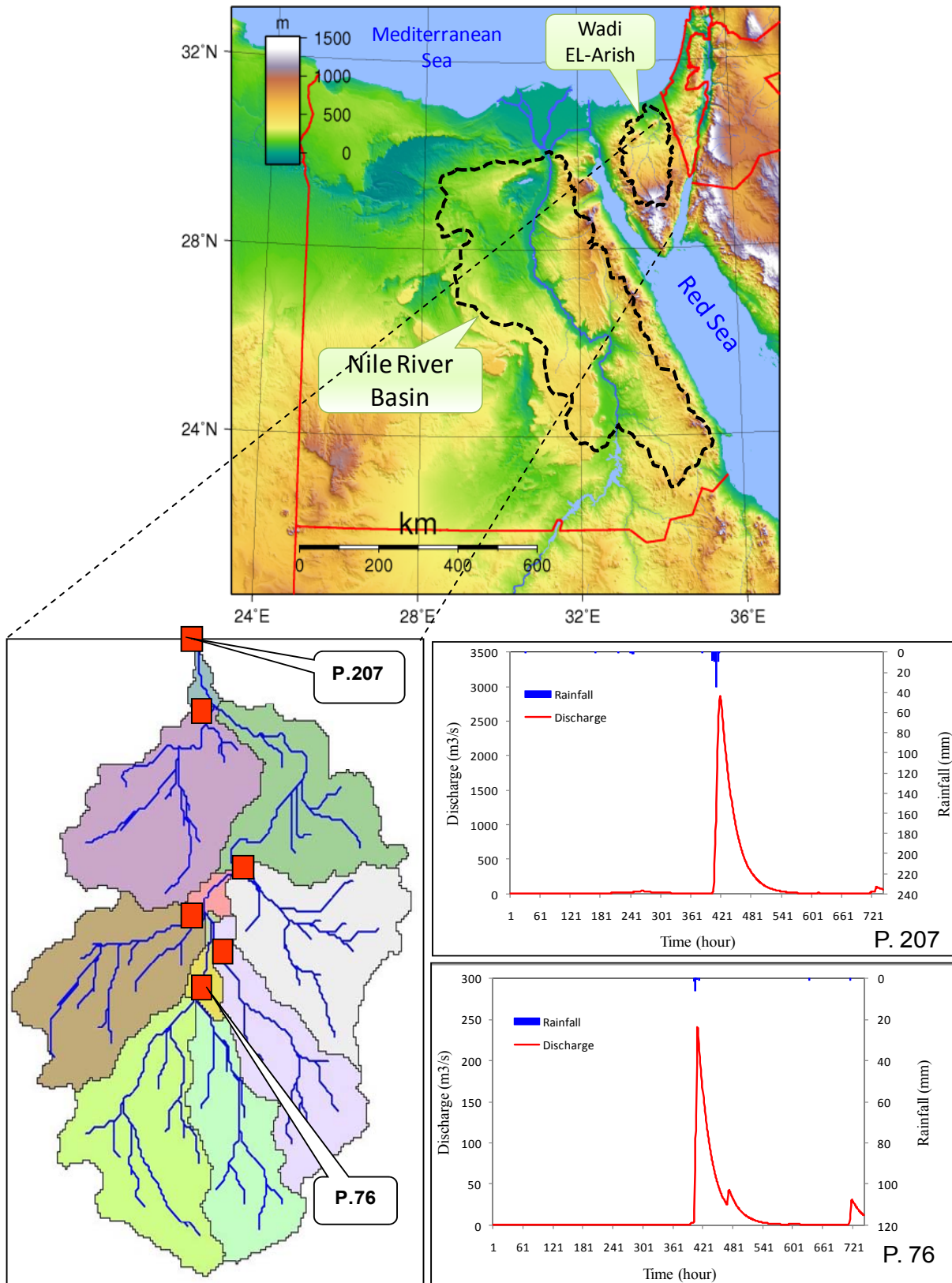


Figure 3 Project methodology and approaches for flash flood prevention

#### 3.1. Flash flood simulation at Wadi Al-Arish, Sinai Peninsula, Egypt

GSMaP data, the main input of rainfall, is used for flash flood simulation at Wadi El-Arish, Sinai Peninsula. The simulation of flash flood event of January 18-20 of 2010 is discussed in this part due to its importance as the last event in Egypt which has big effect on residents and their properties at Wadi El-Arish. Six outlet points have been selected based on the sub-catchments for this simulation as shown in Figure 4. The results of simulation of the event of Jan. 18-20, 2010 show that flash flood characteristics are highly variable from one outlet to the others in terms of flow rate and time to reach the maximum peak within the whole watershed (Figure 4). For instance, at the downstream outlet at the Mediterranean Sea of Wadi El-Arish the flow is very severe, about 2860 m<sup>3</sup>/s.



**Figure 4** Location Map of the Nile River Basin and Wadi El-Arish catchment, Sinai Peninsula, Egypt, showing the target outlets for flash flood simulation on 18-22 January, 2010, at upstream and downstream catchments of Wadi El-Arish (Saber, 2010)



The simulation has been successfully carried out to the flash flood event which hit Egypt on Jan. 18-20, 2010, using GSMaP precipitation (Saber *et al.*, 2010). The simulated results exhibit that hydrographs of flash flood are reaching to the maximum peak flow within a few hours as well as the flow period is so short. The spatiotemporal distribution maps of flash flood events reveal that there is high variability of discharge distribution due to the spatiotemporal variability of rainfall during that flash flood event in the Wadi sub-catchments. Towards the target of water resources management, the flash floods of Wadi sub-catchments can be estimated and evaluated as additional water resources.

Although, the difficulty to apply preventive and mitigating strategies for flash flood risk reduction in the arid regions, strategies for flash flood mitigation have been proposed leading to risk reduction in such regions. In order to achieve our target, analysis of geography, geomorphology, geology, hydrology and hydraulics, vegetation, land use, flash flood history, and flash flood characteristics has been performed throughout GIS and Remote sensing data integrating with the physical based hydrological model. In conclusion, the developed methodology to forecast flash floods considering preventive and mitigating strategies can be used in advance for taking the emergency actions for evacuating the people so that their lives and properties may be saved and minimized. For more details about the flash flood simulations, see Saber (2010).

#### **4. DESCRIPTION OF THE ROAD MAP FOR FUTURE COOPERATION**

There are five groups of researchers from both counterparts. The five groups agreed to study the following points under each group. Moreover, the closing session of the symposium consisted of a brainstorming session during which participants expressed their views concerning the most important open questions that the network should address in the near future. The following is a summary of the main points made:

- Impacts of climate changes on the Nile Basin and the Delta of Egypt;
  - Regional climate change and rainfall pattern;
  - Verification of Global Satellite Mapping of Precipitation (GSMaP) output;
  - Implementation on Nile Basin and Coastal zones in Egypt;
  - Impacts of climate change on Lake Nasser reservoir inflow budget;
  - Social change.
- Integrated water resources managements including irrigation and ground water;
  - Cooperation with Nile Basin countries;
  - Training courses for Nile Basin countries;
  - Water Quality/quantity management;
  - Water requirements policies and laws;
  - Drought and Wetting forecasting;
  - Surface/ground water interaction and recharge quantities;
  - Salt water intrusion.
- Reservoir sustainability management;
  - Assessment of Aswan High Dam alternatives operation;
  - Impacts of upstream dams (constructed and proposed) in Ethiopia and Sudan on flow and sediment budget to Nasser Lake;
  - Applicability for new types of hydropower schemes (i.e pumping up storage);
  - Reservoir training;
- Coastal management;
  - Hydrodynamic coastal erosion management;
  - Sea Level Rise (SLR);
  - Climate change impacts on waves and currents;
  - Soft measures by using Wetlands and Lakes as a barrier;
  - Compaction and subsidence of coastal sediments.
- Flash flood disaster management;
  - Warning System and Public awareness (control, management, and forecasting)
  - Monitoring system and observational field stations (maintenance).

Finally there was widespread sentiment that we should built a data sharing website for exchange the data and starting a real cooperation between groups, before the next get-together conference on 2011. Some of the roadmaps for future steps are summarized as following:

- Establishment of JE-HydroNet data sharing, and observational station for measurements;
  - Constructing a new website for data sharing information system;
  - HydroBeam development and providing to Egyptian researchers;
  - Establishing Japanese measurement stations in Egypt.

## 5. CONCLUSIONS

This paper has tried to weave together ideas drawn from research, education and from practice in supporting the development of international hydro network. Among several proposed topics a case study of flash flood management is presented. We need more focused research approach on collaboration and measurement development in areas of interest that are underpinned by complex relations to a variety of work-related practices. We need much more data and field measurement stations for validation and accurate simulations.

The JE-HydroNet was formed with the aim of bringing together the leading researchers from various disciplines and institutional units that are active in the area of water resources in Egypt, together with people from industry who are responsible for practical implementations from Japanese companies. The network helps us better understand problems facing Nile River System and Delta of Egypt and how these various groups of researcher connect to one another and how, together, they can contribute to the design and implementation of better improvement of flexibility, availability, sustainability and environmental impacts of water resources in Nile Delta by developing advanced methodology for operation, monitoring, planning and management of the water resources problem. This initiative represents an exciting opportunity to create an inclusive and dynamic research group of interest bridging the gap between guidance research and practice. It will enable us to examine the ways in which learning about guidance is created and shared (beliefs, concepts, ideas, theories, actions) as well as providing a potentially powerful engine to assist with the search for new understandings of effective guidance to benefit all groups.

## 6. ACKNOWLEDGMENTS

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