6TH INTERNATIONAL CONFERENCE ON FLOOD MANAGEMENT
September 2014 - São Paulo - Brazil
ICFM6

FORESIGHT EVOLUTION TREND OF FLOOD RISK IN THE TAIHU BASIN AND ITS PROPER ADAPTATION STRATEGIES

CHENG Xiaotao[1], WU Haoyun[2], ZHANG Hanghui[2], HAN Song[1]

1. *China Institute of Water Resources and Hydropower Research(IWHR), Beijing 100038*
2. *Taihu Basin Authority of the Ministry of Water Resources (TBA), Shanghai 200434*

ABSTRACT: Taihu basin, located in the estuary areas of the Yangtze and Qiantang rivers, is one of the most important economic regions in China. It is easy to suffer from serious flood disasters caused by plum rains, typhoon and storm surge. Features of flood risk in the Taihu basin are very sensitive to both global warming and rapid urbanization. In order to provide the decision-making basis for adjusting flood management strategy in the Taihu basin, a flood risk scenario analysis system has been developed by joint efforts of China and UK experts from 2007 to 2010, consisting of a series of models of climate change impact analysis, social economic development forecast, flood losses assessment, hydrological analysis, flood simulation, dyke reliability evaluation and GIS based system integration. The results show that the flood risk growth will be faster than the economic growth in the Taihu basin during 2030 to 2050 because of the combined efforts of global warming and urbanization if we just continue the current flood control measures. The study has got continuing support by the National Key Technology R&D Program for the 12th Five-year Plan (2011-2015) to explore the proper adaptation strategies. The presentation will introduce the progress of this research project.

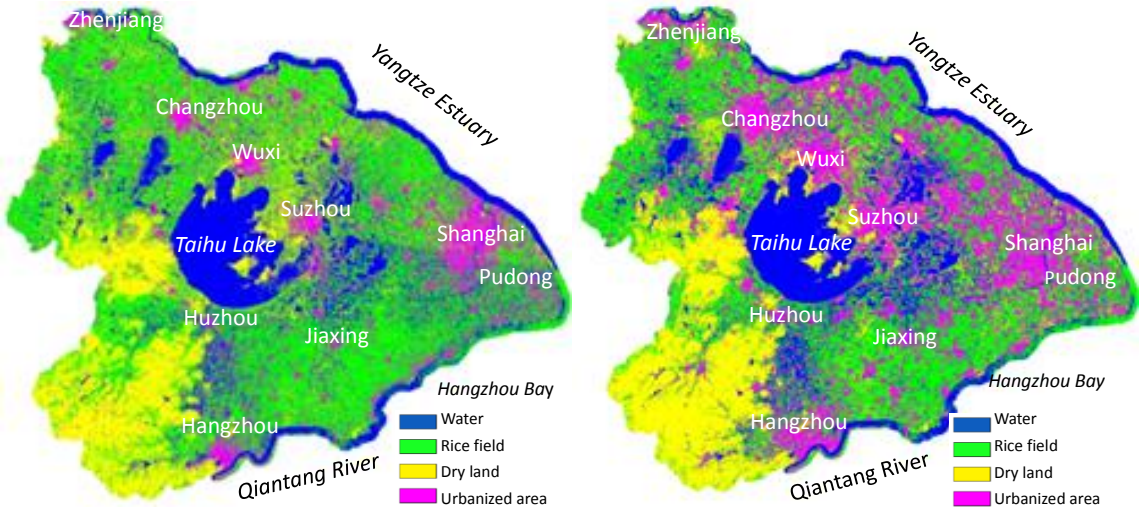
Key Words: flood risk; global warming; urbanization; scenario analysis; adaptation strategies.

1. INTRODUCTION

Flooding around the world is a growing challenge as climate change impacts and urban growth increases the pressures on the already existing flood risk situation (IPCC, 2012). River channelization, floodplain loss, urbanization, particularly in coastal areas, and changing land use are considered as major reasons for the increasing impacts of floods and droughts as well as growing vulnerability to those impacts(UNEP, 2012). However, the pressure on water security in developing countries is much larger because of their scale and speeds of urbanization. As predicted by the United Nations (2009), the world urban population is expected to increase from 3.4 billion in 2009 to 6.3 billion in 2050. Among them, almost all urban population growth will occur in cities of developing countries, increasing from 2.5 billion to almost 5.2 billion, while in the more developed regions, only from 0.9 billion to 1.1billion. Such a difference means that the latter is basically pursue sustainable development at almost equilibrium state, and the former have to seek proper adaptive strategies for building dynamic balance on the way of rapid development.

The Taihu Basin, located in the estuary areas of the Yangtze and Qiantang rivers, is one of the most important economic regions covering 36,895 km^2. Driven by the policy of opening-up in Pudong in early 1990s, the process of urbanization has been speeded up in the Taihu Basin, with the urbanized areas increasing 4.3 times from 2,206.8 km^2 in 1995 to 9,476.4 km^2 in 2010, and meanwhile, the cultivated areas decreased 42% from 22,468 km^2 to 12,999 km^2 (Xu Xibao and Yang Guishan, 2013). Population reached

57.24 million in 2010, increasing 17.71 million in only 10 years. Figure 1 shows the land use change (2001-2010) in the Taihu Basin.



a.Land use in 2000/2001 b. Land use in 2009/2010

Figure 1 Change of Land Use types from 2000 to 2010 in the Taihu Basin
Souse: Wang Chuanhai et al (2013).

The Taihu Basin suffers from flood disasters frequently caused by plum rains, typhoon and storm surge and its features of flooding is very sensitive to both global warming and rapid urbanization. The increase of flood risk in the short term is mainly caused by socio-economic development and land use change with rapid industrialization and urbanization, a huge influx of migrants, land subsidence in wide range (as large as 14,476 km^2) due to the over-pumping of groundwater in the context of surface water pollution, and a massive buildings of ring dikes, sluices and pump stations in river network regions etc.; and in the long term, which may be aggravated owing to the global warming with increase of rainfall intensity and sea level rising.

In order to provide the decision-making basis for adjusting flood management strategy in the Taihu basin, a flood risk scenario analysis system has been developed by joint efforts of China and UK experts from 2007 to 2010, consisting of a series of models of climate change impact analysis, social economic development forecast, flood losses assessment, hydrological analysis, flood simulation, dyke reliability evaluation and GIS based system integration. The results show that the flood risk growth will be faster than the economic growth in the Taihu basin in 2050 because of the combined efforts of global warming and urbanization if we just continue the current flood control measures. The outcomes can be found in a series of articles by X.T. Cheng, E.P. Evans, C. Yu, J.W. Hall, C.R. Thome et al in a special issue of Journal of Flood Management, Vol.6, No.1, 2013. The study has got continuing support by the National Key Technology R&D Program for the 12th Five-year Plan (2011-2015) to explore the proper adaptation strategies. The presentation will introduce the progress of this research project.

2. FRAMEWORKS OF THE RESEARCH PROJECT

2.1 Main Challenges for Flood Management in the Taihu Basin

Framework designed for the foresight flood risk scenarios should be targeted at the key problems to be solved. The major challenges in flood management in the Taihu Basin are as follows.

(1) Pros and cons of the ring dike building. Some 80% of the basin comprises a low-lying plain, which is 2-3 m lower than the highest water level at the river mouth of the Yangtze and 5-6 m lower than the highest tide in Hangzhou Bay. Along with the rapid urbanization, more and more cities, towns and village compete to extend protected areas and heighten their ring dikes with more sluices and pump stations, which cut off the connectivity of water bodies in river network region and have decreased the flood storage capacity in the basin. Such flood control measures have been ratcheting up pressure on flood risk in main channels and places out of protected polders, exacerbating regional conflicts on flood control and drainage.

(2) Inadequate flood control capacity at the whole basin level. The Taihu Basin plays a special important role in national economic development with its GDP and Financial Revenue more than 10% and 20% of the whole nation, respectively. Flood control activities at basin level, regional level and city's level have both focus of each other and strong correlation among them. Along with the increment of drainage volume of cities and sea level rising, the flood control and drainage capacities at the basin level become relatively lower, and a globally optimal solution for the maximum benefits of flood mitigation might be opposed by all regions involved because it does not meet the maximum expectations of each one.

(3) Lack of coping strategies and mechanisms for variable combination of fluvial and pluvial floods, typhoon, storm surge and high tide in extreme weather conditions. In the past ten years, the Taihu Basin has suffered some powerful typhoons such as Matsa (2005), Saomai (2006), Wipha and Krosa (2007) , Kalmaegi (2008), Morakot (2009), Haikui (2012) and Fitow (2013), which caused great economic losses with combined adverse effects and increased pressure of flood fighting in the basin (Wu Haoyun and Jin Ke, 2012). It is necessary to explore further on how to cope with extreme events through approaches to urban flood resilience in the Taihu basin.

(4) Flood management activities in the Taihu Basin have to consider the multiple demands not only in flood control, but also in safeguard of water supply and water environment, and the conflicts on the water security among the relevant regions become more difficult to coordinate. The constructed flood control systems have to be adjusted the major function and operation rule in frequently occurring emergency cases of water shortage and water pollution events.

2.2 The Frameworks of the Continued Research Project

During the 12th National Five-year Plan (2011-2015) the foresight study on flood risk has got continuing support by the National Key Technology R & D Program to explore the proper adaptation strategies based on the progress of China/UK scientific cooperation project Scenario Analysis Technology for Flood Risk Management in the Taihu Basin. Figure 2 shows the frameworks of the seven work packages (WP) and the logical relationships among them.

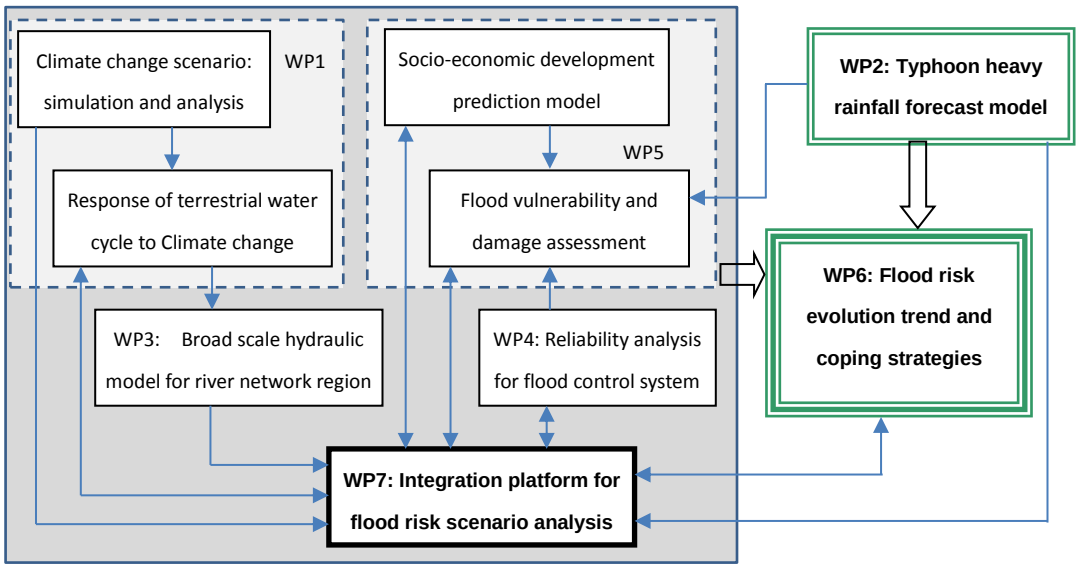


Figure 2 Frameworks of the work packages and their linkages

WP1 deals with the qualitative analysis and assessment of the applicability of the 23 climate scenarios general circulation models (GCM), selects GCM and RCM suitable to the Taihu Basin and the downscaling techniques, creates climate change scenarios in the study area and analyzes its uncertainty, and develops a distributed hydrological model for the highly urbanized region.

WP2 is newly set up to build a high-resolution mesoscale numerical typhoon forecast system for the Taihu Basin, which will enhance the ability to qualitatively evaluate the impact of short-term heavy rainfall on flooding in the Taihu Basin.

WP3 develops a large scale hydraulic model with intellectual-property rights of our own to better reflect the flood characteristics varying with rapid urbanization in river network region protected by ring dikes, which will be able to simulate the distribution of flooding in the Taihu Basin, taking into account the land subsidence and sea level rising, etc .

WP4 studies the distribution rule of the hydraulic load and resistance parameters of different types of flood control works in the Taihu Basin, and puts forward evaluation method for the reliability of flood control systems.

WP5 downscales the predicted values of some key social and economic variables to the county level, sets up relevant scenarios of socio-economic development in the Taihu Basin combined with the latest climate change emissions scenarios and the features of rapid urbanization and economic development.

WP6 is also a new work package to distinguish the flood risk drivers separated time periods, to set up an index system and model for evaluating the flood prevention and mitigation capacities in the Taihu Basin., and to put forward effective coping strategies to inhibit the growth of the flood risks in the basin.

WP7 is to enhance the spatial analysis function of the Taihu Basin Flood Risk Scenario Analysis System, providing an effective platform for running the relevant models; and to simulate the flood risk evolution trend in context of different scenarios of climate change and socio-economic development in the Taihu

Basin and to evaluate the effectiveness of the proposed adaptive strategies.

The models have been basically developed well, and it is now entered the stage of system integration and scenarios design.

3. BASIC CONCEPTS INVOLVED IN FORESIGHT FUTURE FLOOD RISKS

Foresight future flooding (Evans et al, 2004) by scenario analysis does not just simply predict what will happen in the future, but assists decision makers to choose a sensible strategy at present in coping with increasing flood risk, which may ensure the long-term sustainable development. Basic concepts involved in foresight future flood risks in the Taihu Basin are shown in Figure 3.

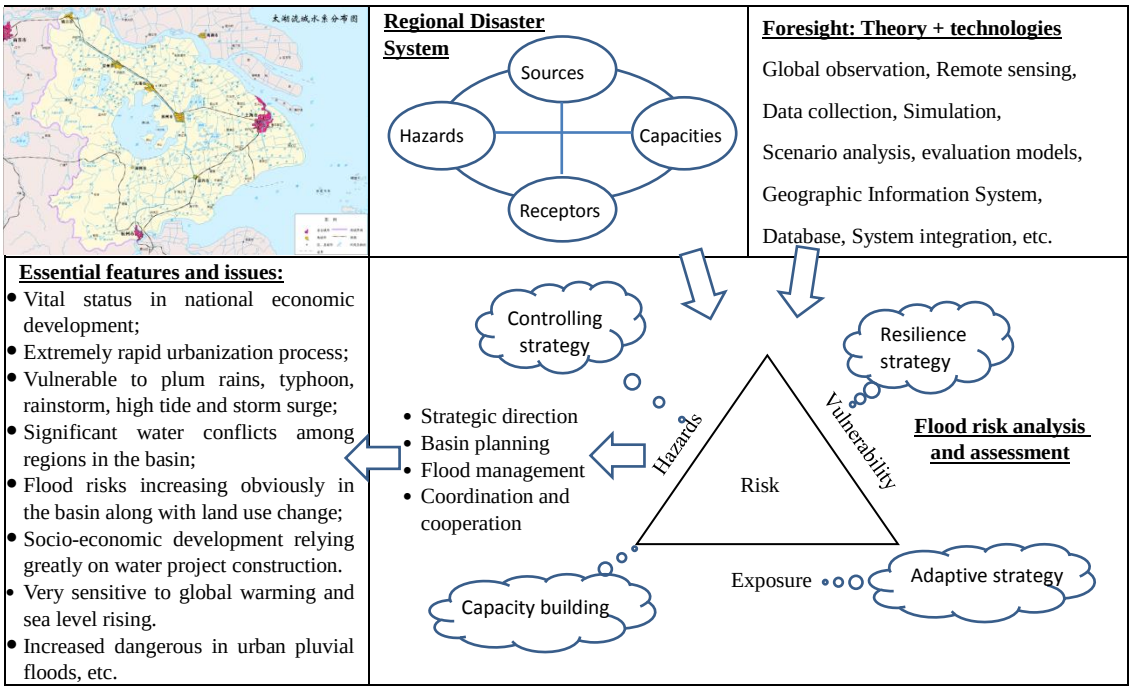


Figure 3 Basic concepts involved in foresight future flood risks in the Taihu Basin

The Regional Disaster System is composed of Sources, Hazards, Receptors and Capacities (SHRC), using for describing the objects of risk analysis. Comparing with the Source-Pathway- Receptor (SPR) model (DETR et al, 2000), SHRC decomposed the Pathway into Hazards and Capacities in order to emphasize the importance of capacity building in flood prevention and emergency response.

On the theory of foresight flood risk, one of the key links is to grasp the stage characteristics of the social and economic development. For the regions at high economic level with low speed of development, the major problem is how to maintain the existing balance and to ensure the sustainable development, and for the regions developing from low level to high level, the more pressing problem is how to build dynamic balance step by step to meet the demands of fast and smooth development. Such distinctions also lead to the differences of technical requirements.

The risk triangle (Crichton, 1999) has been widely used in flood risk analysis and assessment over the world, by which controlling, adaptive and resilience strategies can be made corresponding to hazard,

exposure and vulnerability specifically. Meanwhile, capacity building should also be enhanced in setting strategic direction, making proactive flood prevention plans at basin, regional and city's levels, and carrying out more effective measures in flood management that may coordinate flood fighting activities in the basin.

4. DISCUSSION ON ITS PROPER ADAPTATION STRATEGIES

Enhancing flood control and drainage capacities by structural measures have always been the basic strategy in China. Since the big basin floods in 1991, 11 backbone flood control projects had been completed in the Taihu Basin, which played a powerful role in fighting against the 1999 flood in Taihu Basin. Along with the rapid development and urbanization, almost all the cities and towns in the plain river network region have paid great efforts in build ring dikes around them and more sluices and pump stations. However such effective strategy faces severe challenges with new demands on water security and in its sustainability.

In the first decade of the 21st Century, the total annual water use in the Taihu Basin increased 20.6% to 35.33 billion m^3, leading more seriousness of water shortage especially in the context of severe water pollution. From 2002, a test was started to divert water from the Yangtze River to the Taihu Lake through the Wangyu Canal, one of the 11 backbone projects originally built for draining flood water from Taihu Lake to the Yangtze River, and turn to normal operation in 2005 to meet the demands of water supply (Wu Haoyun and Sun Haitao, 2012). Operation in an opposite way of the Wangyu Canal has exerted well effect in relieving the crisis of water shortage and water pollution in the basin, but also, caused some troubles. For example, the drainage waters from surrounding areas have to drain through the Grand Canal, increasing flood risk in Changzhou and Suzhou cities. In order to bring the role of its flood control system into full play in water security, it is necessary to explore remedial measures for resolving conflicts among regions based on risk evaluation in foresight future flood study.

As for the flood control standard, it is not the higher the better. Figure 4 shows the scenario analysis results of the Expected Annual Damage (EAD) in the Taihu Basin, which indicates that the maximum contribution comes from the flood events with return periods between 20- to 50-year. Meanwhile, the mutability of the flood damages as shown in Figure 5 should be considered in view of economic development, rising flood

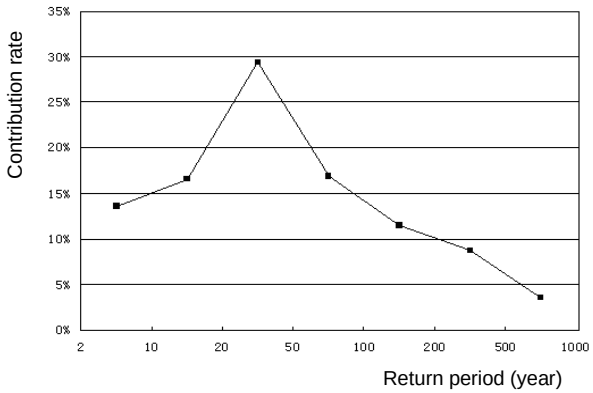


Figure 4 Contribution rates of flood events with different return period to the EAD

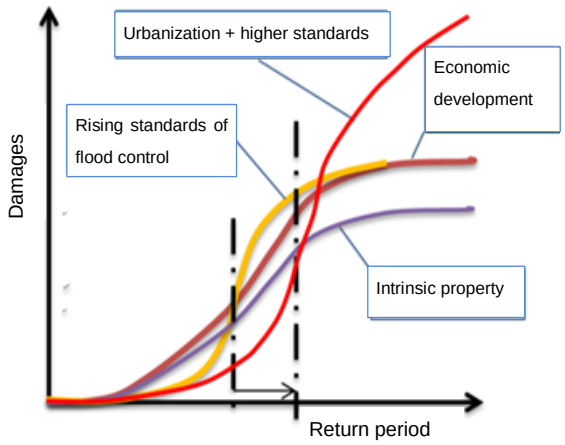


Figure 5 Mutability of flood damages

control standards and urbanization. Once the rainfall intensity and the flood scale beyond the capacity flood control and drainage system, the flood damages may present a mutability of sharp rising. For the increasing vulnerability of the basin, the resilience strategy becomes more important to enhance the capacities of emergency response, adaption and recovery. In further research, the integrated measures combining with controlling, adaptive and resilience strategies will be explored according to the flood risk scenario analysis and assessment for major sub-regions in the Taihu Basin.

5. CONCLUSIONS

The raid urbanization process has and will continue to change the features of flood risks in the Taihu Basin. Structural measures as controlling strategy is still the basic and major means to build dynamic balance among the regional development and between man and nature. Adaptive and resilience strategies will play more and more important role in the integrated flood risk management in the future.

REFERENCE

Chrichton D ,1999: The risk triangle. In: Ingleton J (ed) Natural disaster management. Tudor Rose, London, pp 102–103

DETR, 2000: Guidelines for Environmental Risk Assessment and Management. Institute for Environment and Health. http://www.defra.gov.uk/envionment/risk/eramguide/index.htm

IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA.

UNEP, 2012: GEO5: Global Environmental Outlook. New York, Earthscan.

United Nations, 2009: Urban and Rural Areas 2009. DESA Report. New York.

Wang Chuanhai et al, 2013: “Key Technologies for real time hydrological forecasting and hydraulic simulation in a plain river network region [R]”. The Special Scientific Research Fund Project of the Ministry of Water Resources, December, 2013

Wu Haoyun, Jin Ke, 2012: “Emergency measures for water disaster reduction in Taihu Basin”. *China Water Resources*, 2012 (13), 40-43.(in Chinese)

Wu Haoyun, Sun Haitao, 2012: ”Regulation scheme making of the flood and water quality in the Taihu Baihu Basin” *China Flood and Drought Management*, 22:2, 5-7(in Chinese)

X.T. Cheng, E.P. Evans, H.Y. Wu, C.R. Thorne, S. Han, J.D. Simm, J.W. Hall, 2013: “A framework for long-term scenario analysis in the Taihu Basin, China”. *Journal of Flood Risk Management*, 6:1, 3–13.

Xu Xibao, Yang Guishan, 2013: “Spatial and temporal changes of multiple cropping index in 1995-2010 in Taihu Lake basin, China”. *Transactions of the Chinese Society of Agricultural Engineering* 29:3, 148-155.(in Chinese)