WORLD METEOROLOGICAL ORGANIZATION

REPORT OF THE THIRD MEETING OF THE WORKING GROUP ON HYDROLOGICAL SERVICES REGIONAL ASSOCIATION II (ASIA)

Seoul, Republic of Korea
25 to 27 October 2016

FINAL REPORT

October 2016

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1. OPENING OF THE MEETING

1.1 At the kind invitation of the Government of the Republic of Korea, the third meeting of the Working Group on Hydrological Services (WGHS) of the WMO Regional Association II (Asia) was held in Seoul, Republic of Korea, from 25 to 27 October 2016.

1.2 The meeting was opened at 09:30 on Tuesday 25 October 2016 at the Han River Flood Control Office, Seoul, Republic of Korea.

1.3 Mr Hajoon Park, Director General, Han River Flood Control Office, welcomed participants to the Republic of Korea and, in particular, to the Han River Flood Control Office. He noted the rising losses in the countries of Regional Association II (Asia) from natural disasters, with flooding being the largest contributor to losses from weather-related natural disasters. He stressed the importance of the Working Group on Hydrological Services (WGHS) efforts pertaining to Water Resources Assessment (WRA), as this allows a Member to track current water availability and its predicted states. As such, this assists disaster managers with knowledge of potential drought and flooding, allowing early actions to be taken to reduce losses. In closing, he wished everyone a pleasant stay in Seoul and for a successful meeting.

1.4 Mr Paul Pilon, WMO Secretariat, thanked the Republic of Korea and the Han River Flood Control Office (HRFCO) for hosting the third meeting of the RA II WGHS, and welcomed everyone to the third meeting on behalf of the Secretary-General WMO, Mr Petteri Taalas. He reiterated the importance of the work of the Regional Association and, in particular, the work of the WGHS, particular with respect to helping build the capabilities of Members to provide services. He concurred with Mr Park's comments on the rising losses attributed in the region to flooding and the growing importance it is playing to the social and economic well-being of Members in the Region. He indicated there were two complementary activities that when undertaken could combine to help manage disaster risk. These activities included integrated flood and drought management as well as the application of early warning systems. He noted that even with the adoption of aggressive flood and drought management measures, constant vigilance through early warning systems was needed to trigger and direct emergency response measures. He concluded by commented that additional efforts were needed to bridge the meteorological and hydrological communities to allow making best use of advances in meteorological science in hydrological forecasting, leading to more effective early warning systems.

1.5 In his welcoming remarks, Senior Research Fellow, KICT, Mr Sung Kim highlighted the importance of this third meeting the RA II WGHS, as it permitted reporting on final progress achieved in this four-year intersessional period, a shaping of its future work plan for the period 2016-2019, and a discussion on decisions stemming from current and possibly future work for consideration of the Sixteenth Session of RA II, to be held 12-16 February 2017 in Abu Dhabi, United Arab Emirates. Mr Kim reviewed the draft agenda noting the opportunity for experts to report on their activities and achievements, the brief Workshop on the morning of Wednesday 26 October for the Dynamic Water resources Assessment Tool (DWAT) that was developed by HRFCO and Korea Institute of Civil Engineering and Building Technology (KICT), and the opportunity to develop follow-up actions for the upcoming Sixteenth Session of RA II in

February 2017. He noted that these would be followed by further development of draft work plans consistent with the RA II Operating Plan for 2016-2019 and the development of specific activities for the WGHS for 2016-2019. He noted that in addition, there would be a field trip on Wednesday afternoon to the Kwater pumping station, which was the largest in the world. He recalled that there was a requirement to provide a final report for the WGHS associated with the RA II meeting, and he requested all experts to provide him with a brief summary of their major accomplishments and the revised final work plan for their area of endeavour.

2. ADOPTION OF THE AGENDA AND ORGANIZATION OF WORK

2.1 The meeting was attended by 13 participants from 5 countries of the RA II.

2.2 The list of participants is given in **Annex 1** to this report. Mr Paul Pilon acted as Secretary for the meeting and Mr Sung KIM, Senior Research Fellow, Korea Institute of Civil Engineering and Building Technology (KICT), chaired the sessions of the WGHS.

2.3 The WGHS discussed the agenda and adopted it (**Annex 2**). Mr Kim briefly mentioned that he had reported to the RA II Management Group on the activities of the WGHS during its meeting held 15 June 2016 . He also noted that he had provided the Management Group with the WGHS input to the RA II Operating Plan 2016-2019. It was also noted that all presentations made and material provided during the meeting can be downloaded from the following URL:

http://www.wmo.int/pages/prog/hwrp/RA2/RAII-WGH-III-Seoul.php

2.4 Mr Paul Pilon provided a presentation, which can be found on the URL above, on pertinent outcomes from the 2nd Meeting of the WMO Flood Forecasting Initiative – Advisory Group, which held its meeting in December 2015 in Geneva, and aspects of the Commission for Hydrology (CHy) as a result of the 3rd Meeting of its Advisory Working Group (AWG), which was held in Geneva in February 2016. He also presented on the outcomes directly of relevance to the WGHS stemming from the 68th Session of Executive Council (EC_68) held in June 2016. He noted as well the RA II Operating Plan for 2016-2019 and the upcoming 16th Session of the RA II in February 2017. He indicated that the group should consider what decisions should be placed before the next RA II Session pertaining to its work. This latter aspect would be discussed more fully Wednesday afternoon 26 October) and possibly Thursday morning (27 October).

3. REVIEW AND ADJUSTMENT OF WORK PROGRAMME

3.1 The work plans of all members present were reviewed and adjusted during the meeting. The revised work plans appear herein. The next section of this report provides a brief description of the progress made during the intersessional period. The work plans of those members who were absent, namely Messrs Muhammad Riaz, Sergey Borshch, Guoqing Wang, and Tran Thuc were revised by Mr Sung Kim through correspondence

with said members following the conclusion of the meeting. This was also undertaken by Mr Sung Kim for Mr Tai-Hoon Kim who had to leave the meeting for an urgent work-related matter. All revisions to their work plans are also contained herein.

3.2 WORKPLAN: Chairperson of WGHS — Sung KIM

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. In his capacity as Hydrological Adviser, to assist the president of RA II in accordance with the duties stipulated in Regulation 168 (b) of the WMO General Regulations	• Represent WGHS as and when required, (eg at MG and EC) • Attend meetings of chairpersons of Working Groups • Other duties as required of chairpersons WGHS (see General Regulation 168 (b))	• Hydrology and Water Resources issues remain a key aspect of the work of RAII • NMHSs are assisted in fulfilling their roles and responsibilities . • WGHS is adequately represented within the RAII environment.	• Resources are provided to meet the needs of the theme leaders in doing the work of the Working Group. • Secretariat support	• Meetings and other activities according to the WMO Schedule of meetings. • Report at WGHS meetings • Report at MG Sessions • Report to RAII-16 (2016).	• WGHS • RAII • MG • EC	• Attended RA II Management Group meetings • Attended RA II Chairs Meetings (2014, 2015) • Attended RA II Conference (2014)
2. To develop a Working Group implementation plan in consultation with the president and the Management Group of the	• Chair theme leaders meetings of the WGHS to develop implementation plan • Report to MG	• WGHS implementation plan	• Resources are provided to meet the needs of the theme leaders in doing the work of the WGHS	• WGHS meeting (Sept. 2014) • WGHS implementation plan (Oct 2014) • Report at MG Sessions for consultation and	• WGHS • RAII • MG	• Develop WGHS work plan and reported and updated (2013,

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
Association, with reference to the key performance indicators/targets and action plans under the respective expected results of the RA II Strategic Operating Plan, to undertake work on the various theme areas under the charge of the Working Group	meeting for consultation • Submit report			submit a report to RAII president (2014)		2014, 2015, 2016) Develop future WGHS activity plan (2016)
3. To participate in Executive Council sessions, when invited, representing the regional interests in relation to hydrology and water resources and to coordinate the WGHS activities with the Commission for Hydrology and other regional	• Attend EC meeting if required • Develop WGHS work plan in consideration of CHy and other regional WGHS activities • Organize WGHS meeting	• Meeting report • WGHS implementation plan	• Resources are provided to meet the needs of the theme leaders in doing the work of the WGHS	• WGHS meeting (Sept. 2014) • WGHS implementation plan (Oct 2014) • Report at MG Sessions for consultation and submit a report to RAII president (2014)	• WGHS • RAII • MG	• Attended EC65, EC68 • Attend Hydrological Advisors Meeting during EC meeting (2013, 2016) • Report of WGHS and implementation plan

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
Working Groups on Hydrology						
4. To submit to the president of the Association an annual report by 31 December every year and a final report in time for presentation to the sixteenth session of the Association, both copied to the WMO Secretariat, with inputs from theme leaders under the Working Group	• Develop WGHS activity report with input from theme leaders	• WGHS activity report	• Resources are provided to meet the needs of the WGHS theme leaders	• Submit annual report to RAII president and WMO Secretariat (Dec 2014, Dec 2015) • Submit final report to RAII president and WMO Secretariat (2016)	• WGHS • RAII • WMO	• Organize WGHS meetings and submitted report (2013, 2014, 2015, 2016) • Nov 2016 Final Activity Report submitted

3.3 WORKPLAN: Vice Chairperson of WGHS (RA II) Muhammad Riaz

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. To assist the chairperson WGHS in accomplishing his work related to the group activities	As delegated by the chairperson	Not Specified	As appropriate	As appropriate	Chairperson	• On-going
2. To review the reports sent by various Theme leaders through the Chairperson	Summary of review	Report	• Chairperson • Theme Leaders • RA II Secretariat • CHy	Not specified	• Chairperson • Theme leaders • RA II Secretariat • CHy	• On-going
3. To review and develop the Hydrological Parts of S.O.P.	Review if required	Review report	• RA II strategic operation Plan • RA II MG	Not specified	Chairperson	
4. To put up suggestions and collaboration in strengthening of Flood Forecasting &	Review related reports	Suggestions	• Theme Leaders reports in RA II • CHy report	Submission of report by 2016	RA II WGHS CHy	

Warning System amongst Member States						
5. To assist the Chairperson on matters related in combating marine pollution	Review S.O.P. and some suggestions	Suggestions	S.O.P	Suggestions by the end of 2014	S.O.P WGHS	

3.4 WORKPLAN: Water Resource Assessment GAO Ge and Hwirin KIM

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. Assessment of basin-wide water resources availability, including use of climate predictions (3.3.2)	• Prepare assessment and outlook of basin-wide availability water surplus and deficits on a national level in a regional context including the use of climate scenarios. (Priority C)		• RA II		• RA II • CHy	
2. Assessment of basin-wide water resources availability, including use of climate predictions (3.3.2)	• Set up knowledge base to adapt to changes in water resources availability (trends, outlook) (Priority A)	• Report related to the case studies	• RA II • Research documents • Han River Flood Control Office(HRFCO), Ministry of Land, Transport and Infrastructure(MOLIT), Republic of Korea • Korea Institute of Civil engineering Technology (KICT), Republic of Korea	• Develop new system by Dec 2016 • Collection case studies by the end of 2016 • Evaluate model performance by Dec 2016 • Final case study report on new model in Jan. 2017	• RA II • AWG	• Case studies being collected • Beta version of Dynamic Water Resources Assessment Tool(DWAT) using hydrologic components of KICT CAT(Catchment hydrologic cycle Assessment Tool)
3. Implementation of Water Resources Assessment (WRA) (3.3.3)	• Provide guidance materials for WRA linking to Climate extended range prediction - Downscaling - monthly and	• Guidance for WRA	• China • Korea	• Provide draft technical report by the end of 2016 • Provide draft technical manual of Dynamic Water	• RAII • CHy	Technical Report draft has been finished preliminarily.

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
	seasonally prediction WRA models - WRA (Priority B)			Resources Assessment Tool by the end of 2016 • Provide Final user's Guidance of DWAT system by the end of in Mar.2017 •		
4. Development of national and regional capacity building programmes and related training activities for hydrological services (3.3.4)	• Provide training material for a training course related to the advances in WRA: - Downscaling methods for extended range prediction - Data collection - WRA methods - WRA Information system (Priority B or C)	• Training Course	• WMO Regional Training Center in Nanjing	• Training Course in 2017		

3.5 WORKPLAN: Flood Forecasting — Sergey BORSHCH

Activities	Actions	Outputs	Resources	Milestones	Linkages	Activity report on 26/10/2016
1. Improvement in hydrological warnings capability through enhanced and effective cooperation with other NMHSs (2.1.1)	(a) To prepare recommendations on the use of numerical weather prediction outputs in flood forecasts (Priority A) (b) Document approaches to ascertain the deterministic error of each ensemble element of a NWP output, for example over the previous thirty day period, using this deterministic signal to provide a weighting on the confidence of the forecasted ensemble elements (Priority A) (c) Use WMO FFI as platform [for a and b above]	(a) Recommendations on the use of NWP outputs in flood forecasting systems (b) Document on the approaches to establishing the deterministic error in NWP outputs and for their use in establishing enhanced accuracy of hydrological forecasts	HMC of Russia	(a) Gathering of background material and documents on the FFI and associated activities - January 2015 Preparation of Draft Recommendations – June 2015 (b) Gathering of materials - September 2015 Preparation of Draft Report on procedures – February 2016	OPACHE's International Flood Initiative - WMO	At the 26/10/2016 1. *Recommendations for the development of forecast methods for the spring floods forecasting on the base of meteorological information (the experience of Roshydromet)* – S.Borshch, A. A. Gelfan, Y. Motovilov, Kristoforov, Y. Simonov, V. Belchikov, C. Leontieva and others, - Moscow, 2016, 65 p. (in Russian) 2. *Guidelines for verification of hydrological forecasts.* – S.Borshch, A. Khristoforov, C. Lieontieva. – Moscow, 2016, 84 p. (In English) 3. *Operational Hydrologic Forecast System in Russia (in the book "Flood forecasting: a global perspective". Chapter 7, edited by Thomas E. Adams, III and Thomas C. Pagano),* pp.169-181 (with Y. Simonov), Academic Press, ELSEVIER,

	(Priority A) (d) Organize training course for Members (Priority C) (e) Organize training course for Members (Priority C)					2016 (in English). ISBN 978-0-12-801884-2. In the chapter briefly touches on the hydrologic forecast system of the Roshydromet: hydrological phenomena to forecast; forecasting techniques and models used operationally; the hydrometeorological data network; and automated forecast systems. 4. *Recommendations on objective evaluation of observational networks configuration in terms of their density and composition of observations, taking into account the impact on the accuracy of hydrological forecasts.* – S. Borshch, A. Khristoforov, Y. Simonov and others. – Moscow, 2016, 81 p. (in Russian)
2. Issuance of flood, flash and urban warnings and constantly improving upon them (2.2.5)	(a) To document experiences in the use of the Flash Flood Guidance System (FFGS) in various countries by reviewing use of	(a) Report documenting experiences, including recommendations on approaching implementation of FFGS and its use	(a) Working meeting with hydrologists and meteorolog	(a) Background material and documents on the FFGS and associated activities - April 2015	NMHSs OPACHE's WMO Hydrological Research Center in San Diego (USA)	1. *Flood forecasting and early warning system for rivers of the Black Sea shore of Caucasian region and the Kuban river basin* (S.V. Borsch, Y.A. Simonov, A.V. Khristoforov). - Proceedings of the Hydro-

	the Flash Flood Guidance System (FFGS) in the various countries (Priority A) (b) To investigate the potential use of FFGS in Central Asian countries and facilitate its understanding by operational hydrologists in the region (Priority A) (c) To develop recommendations on use of hydrological forecasts (including probabilistic forecasts) in flood management (Priority A) (d) Develop user-oriented flood forecasting products (Priority C)	(b) Recommended path forward for advancing the adoption of the FFGS in Central Asia. (c) Conduct kick-off meeting of senior meteorologists and hydrologists within Central Asia on the FFGS project (d) Report containing recommendations on use of hydrological forecasts (including probabilistic forecasts) in flood management, based on experiences of Roshydromet	ists of the Central Asia countries on use the FFGS in operative hydrologic al practice (b) Funding for kick-off meeting for Central Asia FFGS	Preparation of Draft Document – June 2015 (b) Discussions with potential collaborating NMHSs in Central Asia - March 2015 Preparation of Draft Recommendations – March 2015 Conduct kick-off meeting - May 2015 (c) Report prepared by February 2016		meteorological Research Center of Russian Federation. Special issue №356. – Moscow, 2015, 247 p. ISSN 0371 – 7089. (in Russian) Main aspects, methodology, principles of setup and operation of the flood forecasting and early warning system are described. Short-range forecast techniques of daily discharge on the hydrological river gauges of the Black Sea shore of the Caucasian region and the Kuban river basin are incorporated into the system. The main objective of the system is to increase quality and robustness of the operative decisions on flood prevention measures and water resources utilization. Developed structure and software of the forecasting system have universal nature and thus can be implemented in different regions of the Russian Federation. The special issue is addressed to specialists in hydrometeorological forecasting, hydrology, water resources, environmental monitoring and ecology.

	(e) Conduct mission visit(s) to Members in developing countries or least developed countries (Priority C)					
3. Improvement in capacity for water-related disaster management (hydrological extremes) [with theme on hydrological droughts] (2.1.3)	(a) Organize a workshop [or two workshops] on the provision of input and support to disaster management [on community-based flood and drought management including participation of NMHSs, emergency services and disaster management groups] (Priority B)	(a) Increased capacity for water-related disaster management	(a) Resources to conduct necessary workshop(s) through collaboration with APFM and IDMP	Training session on Integrated Flood Management dealing with development of community capacity - July 2016 Training session on Integrated Drought Management dealing with development of community capacity – November 2016	APFM IDMP NMHSs WMO	

3.6 WORKPLAN: Hydrological Aspects of Drought DERGACHEVA Irina

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. Monitoring and Warning Systems for Droughts (2.3.1.)	(a) Develop indicators for the determination of the onset of hydrological droughts: • Collection, analysis and systematization of data to identify indicators for the determination of the onset of hydrological droughts • Identify the types of Hydrological drought is characteristic of the Asian region • Study of the conditions of formation of hydrological drought (Priority A)	• Report on the Indicators for the determination of the onset of hydrological droughts	• Centre of Drought Monitoring of Uzbekistan • Uzbekistan experts • Materials for IDMP • Materials for HMNDP	• Preparing of the data and information to develop indicators for the determination of the onset of hydrological droughts - Oct 2015 • Draft Report – Dec 2015 • Report – November 2016	• OPACHE's • WGHS • RAII • WMO	• Report prepared on review of potential drought indices leading to selection of Pedya drought index, Standardized Precipitation Index SPI, Drought index for snow storage Sw. It also describes functions and design of an EWS for drought for Central Asian countries. • Uzhydromet established a National Centre for Monitoring of Drought to serve as a coordinating and consultative center for drought preparedness, monitoring, prevention and mitigation of the adverse effects of drought. Potential to expand for all CA countries. • Report also includes an analysis of the conditions leading to low water and drought and an analysis of the frequency of low water and drought for Uzbekistan. Could be used as template for other

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
						countries. • This EWS allows the calculation of snow storage, assessments of precipitation and temperature, enabling the analysis of the conditions for river runoff formation in the low water years and the factors for its formation for all drought indices for sub-basins in the runoff formation zone of the Amudarya and Syrdarya rivers (Aral Sea basins).
	(b) Prepare guidance for the development of drought monitoring networks : • Gathering information about the status of drought monitoring networks in Asian region • Identification of gaps and needs of the national hydrometeorological services to improve the drought monitoring networks (Priority B)	• Guidance materials for the development of drought monitoring networks	• WGHS RAII • OPACHE Uzbekistan experts • Materials for IDMP • Materials for HMNDP	• Information for the development of drought monitoring networks – April 2016 • Draft Report – November 2016	• OPACHE's • WGHS • RAII • WMO	Analysis was performed indicating the need to strengthen / further develop the hydrometeorological monitoring network to improve the early warning of drought. No formal report to be prepared. Analysis is being provided to World Bank project on strengthening hydrometeorological services in the region.

3.7 WORKPLAN: Assessment of Changes in Climate Extremes, Their Impacts on Water Resources, and Translating Climate Information into Action in Water Resources Management

WANG Guoqing and TRAN Thuc

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. Improvement in adaptation capacity of water resources systems in a changing climate (2.1.2) 2. Assessment of basin-wide water resources availability, including use of climate predictions (3.3.2)	1) Assessment of changes in climate - Data and method of climate study: Data inventory, climate variables, methods – (Priority A) - Trend of some climate variables: temperature, rainfall and other extremes – (Priority A) - Changes in atmospheric circulation affecting climate extreme: e.g., Monsoon,	Assessment report on climate change for participating countries	• WGHs • WMO Secretariat • NHRI, China • CMA, China • IMHEN, Vietnam • Other countries	• Report to be submitted (May 2015) • Reports to: AWG-II • Documents as required • Workshop if needed	WGHs RA2 WMO Secretariat CHY	1. Data base establishment. Meteorological data at 758 stations within China and hydrological data recorded at 265 stations on major rivers in China were collected, and database was established. 2. Scientific report “climate change for major rivers in China”, by Drs. Guoqing Wang, Jianyun Zhang, Junliang Jin, etc. May, 2015. China (in Chinese with English abstract) 3. Scientific report “Sea level rise along China's Coast line”, by Drs. Guoqing Wang, Guowei Chen, etc. Feb, 2016. China (in Chinese with English abstract) 4. “Viet Nam Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation” (in Vietnamese (Nguyen Van Thang et al.) is being translated into English, and the report will be available by Nov 2016 5. Journal papers are as follows: ● Meixiu Yu, Xiaolong Liu, Li Wei, Qiongfang Li, Jianyun Zhang and Guoqing Wang. 2016. Drought assessment by a short-/long-term composited drought index in the upper Huaihe River basin, China. Advances in

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
3. Improvement in capacity for water-related disaster management (Hydrological extremes) (2.1.3)	typhoon and tropical depression, El Nino and Southern Oscillation – (Priority C) - Change in climate affecting natural physical environment: e.g., drought, extreme rainfall, flood, sea water level – (Priority C)					Meteorology. http://dx.doi.org/10.1155/2016/7986568 ● Binquan Li, Zhongmin Liang, Jianyun Zhang, and Guoqing Wang. 2016. A revised drought index based on precipitation and pan evaporation. International Journal of Climatology. DOI: 10.1002/joc.4740 ● Guoqing Wang, Cuishan Liu, Sicheng Wan, Zhenxin Bao and Yanli Liu. 2016. Variability in stream flows of the Xiang River in a changing climate. Int. J. Global Warming. http://www.inderscience.com/info/ingeneral/forthcoming.php?jcode=ijgw ● G.Q. Wang, J.Y. Zhang. 2015. Variation of water resources in the Huang-huai-hai areas and adaptive strategies to climate change. Quaternary International 380-381 (2015) 180-186. http://dx.doi.org/10.1016/j.quaint.2015.02.005 Song Xiaomeng, Zhang Jianyun, AghaKouchak Amir, Sen Roy S., Xuan Yunqing, Wang Guoqing, He Ruimin, Wang Xiaojun, Liu Cuishan. Rapid urbanization and changes in spatio-temporal characteristics of precipitation in Beijing metropolitan area. Journal of Geophysical Research: Atmosphere, 2014, 119(19): 11250-11271
	2) Conduct climate projections – (Priority A) - Statistical downscaling - Dynamic downscaling	Climate change scenarios for participating countries		Report to be submitted (May 2015)		1. Scientific Report “Analysis and production of Climate Scenarios for Jinsha River basin”, by Drs. Guoqing Wang, Junliang Jin, and Zhenxin Bao. Jan, 2016. China (in English) 2. Report of “Climate Chang and Sea level rise for Viet Nam” (in Vietnamese) (Tran Thuc, Nguyen Van Thang, Huynh Thi Lan Huong, Mai Van Khiem, Nguyen Xuan Hien, Doan Ha Phong), is being translated into English, and the report will be sent by Nov 2016

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
	3) Assessment of potential hydrological impacts of climate change on water resources of some selected river basins – (Priority A) - Temperature - Rainfall - Evapotranspiration - Flood and inundation - Drought - Water Resources	Report on the impacts of climate extremes and climate change to water resources		Report to be submitted (Dec 2015)		1. Scientific report "Impact of Climate change on water resources of China by using multiple GCMs projections", by Drs. Guoqing Wang, Junliang Jin, and Zhenxin Bao. Dec, 2015 (in Chinese), China 2. Report of "Changes in Climate Extreme and Impact on Water Resources in Viet Nam" (Tran Thuc, Nguyen Xuan Hien, Mai Van Khiem) was submitted on 25 Oct 2016 3. Report of "Projection of extreme temperature and precipitation and their impacts on water resources in Dong Nai river basin and vicinity – Viet Nam" (in Vietnamese) (Vu Thi Van Anh, Tran Thuc, Vu Hai Son, Truong Thi Thu Hang) is being translated into English, and the report will be sent by Dec 2016 4. Journal papers are as follows ● Guoqing Wang, Jianyun Zhang, Ruimin He, Cuishan Liu, Tao Ma, Zhenxin Bao, Yanli Liu. 2016. Runoff sensitivity to climate change for hydro-climatically different catchments in China. Stochastic Environmental Research and Risk Assessment. DOI 10.1007/s00477-016-1218-6 ● Guoqing Wang; Jianyun Zhang; Xuemei Li, Zhenxin Bao; Yanli Liu; Cuishan Liu; Ruimin He; Junsong Luo. 2016. Investigating causes of changes in runoff by using hydrological simulation approach. Applied Water Sciences. DOI: 10.1007/s13201-016-0396-1

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
						● GuoqingWang, Jianyun Zhang, Thomas C. Pagano, Yueping Xu, Zhenxin Bao, Yanli Liu, Junliang Jin, Cuishan Liu, Xiaomeng Song, Sicheng Wan. 2015. Simulating the hydrological responses to climate change of the Xiang River basin, China. Theor Appl Climatol. DOI 10.1007/s00704-015-1467-1 Guoqing Wang, Jianyun Zhang, Junliang Jin, Josh Weinberg, Zhenxin Bao, Cuishan Liu, Yanli Liu, Xiaolin Yan, Xiaomeng Song, Ran Zhai. 2015. Impacts of climate change on water resources in the Yellow River basin and identification of global adaptation strategies. Mitig Adapt Strateg Glob Change. DOI 10.1007/s11027-015-9664-x
	4) Translating climate and climate change information into actions in water resources development and management: – (Priority A) - Case study for a selected	Report of case study		Report to be submitted (Feb 2016)		1. *Recommendation report "Recommendations for China's adaptation strategy in water sector to climate change", submitted to Ministry of Water Resources by RCCC (Research Center for Climate Change, Ministry of Water Resources), drafted by Dr. Guoqing Wang and Jianyun Zhang, Dec, 2015. (in Chinese)* *Recommendation report "Recommendations on Sponge City Development of Zhenjiang City for better adaptation to climatic extremes", by Drs. Guoqing Wang, Cuishan Liu, and Yanli Liu. Feb, 2016 (in Chinese)*
4. Development of national and regional capacity building	5) Synthesize report from individual reports from participating countries in the RA II – (Priority A)			Report to be submitted (May 2016)		1. China's National Scientific Research and Development program "Scientific regulation and benefit sharing role of water resources for transboundary river, a case study of Mekong River basin", Dr. Guoqing Wang is the leader of sub-project of "Impact of climate change on eco-hydrology of the Mekong River", the project was approved in 2016 2. China's National Scientific Research and Development

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
programmes and related training activities for hydrological service (3.3.4)						program “Impact of changes in climate and society on global terrestrial water cycle”. Dr. Guoqing Wang is leading this project. The project was approved in 2016. Training workshop on improving environment protection awareness, was held in Nanjing during Apr 12-14, 2016, organizing by Dr. Guoqing Wang
	6) Lesson learn and experience sharing – (Priority B)					Training course for workshop on adaptation to climate change referencing experience from Japan and America, was held in Nanjing during March 12, 2015, organizing by Dr. Guoqing Wang.

3.8 WORKPLAN: Improved Accuracy of Hydrometric and Sediment Observations including Space-based Technologies — Youngsin ROH

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. Reliability of quality control procedure applied on data collected from hydrological stations (2.2.1)	a) assess the performance of hydrometric instruments and techniques of observations (Priority C)					
	b)Prepare documentation for the intercomparison of instruments and methods of observation (Priority C)					
2. Hydrometric measurements with quality and accuracy (2.2.2)	a) Provide guidance on the use of appropriate instruments and methods of observation in diverse conditions (Priority A) • Collection of existing technical information in IRDMIS ➢ Measurement instrumentation (ADVM) ➢ Methods of discharge calculation ➢ Construction and operation of IRDIMS • Case study on measurement by IRDMIS (52 sites) ➢ Measurement of tidal influenced discharge ➢ Measurement under backwater conditions caused by weirs, sluice gates, and river junctions ➢ Evaluation of measurement	• Technical report of related to IRDIMS With case studies in various conditions - Collection of the existing technical information of IRDIMS - Development for index rating - Installation and operation - Procedure on development of index rating • Development of Software tools to develop index rating	- Republic of Korea(ROK)	• Technical report and guideline with case studies DEC 2016 • Software System (EDpad, MCDpad) DEC 2016	- CHy - ROK	Translating Korean technical report into English version • *Technical information of IRDIMS* • *Installation and operation* • *Discharge calculation including development of index rating* • *Software tool for development of index rating* • *Case study on various conditions*

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
	results ➢ Development of index velocity ratings • Writing Technical report about construction and management by field characteristics					*1st draft by DEC 2016* *Final ver. will be completed by Feb 2017* Development of Software tools have been completed, and its manual will be ready by DEC. 2016
	b) Improve sediment measuring techniques (Priority B) • Collection of existing technical information ➢ The status of existing sediment measurement techniques ➢ The status of new technologies and their applications ➢ The status of analysis methods • Case studies on sediment measurements under various conditions (15 - 20 sites) ➢ Analysis of river construction effect on characteristics of sediment load, focused on 4 major river projects in Korea ➢ A comparative analysis on sediment load by sequence of	• Technical report on sediment measurement methods and with case studies in various conditions - Analysis on characteristics of sediment load during rising & falling water level(Loop) - Analysis on river construction effect on characteristic of sediment load, focused on 4major river project in Korea - A comparative analysis on sediment load by sequence of rainfall event.	- Republic of Korea(ROK)	• Provide technical report and guideline with case studies DEC 2016	- CHy - ROK	Translating Korean technical report into English version • *Technical information of sediment measurement* • *Case study on sediment measurement various conditions* *1st draft by DEC 2016* *Final ver. will be completed by 2017*

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
	rainfall event • Writing Technical report about sediment measurement method and analysis of field characteristics					
	c) assess the accuracy and use of space-based observation (Priority C)					
3. Calculation of runoff with quality and accuracy (2.2.3)	a) Focus on the development of rating curve(Priority B) • Collection of existing technical information ➢ On major procedures for rating curve development ➢ On tools for rating curve development • Case analysis with various field conditions ➢ On development of rating curves when backwater conditions exist (weir, junctions) • Writing technical report on rating curve development	• Report on methods to develop rating curves - *Status of flow measurement the past 3 years* - *Procedure of H-Q rating development* - *Software tools to develop & to manage of H-Q rating curve* - *Case study on development of H-Q rating curve in various conditions and its guideline (backwater by weir, bed change, vegetation)*	- Republic of Korea(ROK)	• Provide Technical report and guideline with case studies DEC 2016	- CHy - ROK	Translating Korean Technical Report into English version • *Status of flow measurement the past 3 years* • *Procedure of H-Q rating development* • *Software tools to develop & manage of H-Q rating curve* • *Case study on development of H-Q rating curve in various conditions and its guideline* • *(backwater by weir, bed change, vegetation)* *1st draft by DEC*

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
						2016 *Final ver. will be completed by 2017*
	b)detect trends and variability in selected river basin in the region (Priority C)					
	c) provide guidelines for calculating runoff data accuracy (Priority C)					
4. Establishment of Quality Management Frameworks for Hydrology using current guidance materials for hydrology and water resource management (3.3.3)	Encourage and facilitate exchange and training on relevant know-how (Priority C)					
5. Development of national and regional capacity building programmes and related training activities for hydrological services (3.3.4)	Encourage and facilitate exchange and training on relevant know-how (Priority C)					

3.9 WORKPLAN: Sediment Disasters and Mass Movements — Tai-Hoon KIM

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
1. Issuance of landslide/debris flow warnings and consistently improving upon them	• Collect and disseminate materials for assessment of sediment disasters (Priority A) • Investigate warning technologies based on adaptive concepts (Priority B) • Generate sediment disasters risk map (Priority C)	• Actual example for implementation of adaptive sediment disasters risk management tools with identification, reduction and evacuation	• Republic of Korea (ROK) • National Disaster Management Institute (NDMI)	• Case study report for present systems for sediment disasters management - May 2015 • Analyzing models for the integrating system - Oct 2015 • Report for adaptive sediment risk management tools - Aug 2016	• SOP 2.2.6 • RA II • WMO Secretariat • ROK (MPSS)	• <u>Governmental research reports</u> *1. National Disaster Management Institute (2014) A development of regional major disasters response scenarios and standards (I) focusing on urban flooding and drought, NDMI-PR-2014-07-01, 228p.(in Korean)* *2. National Disaster Management Institute (2014) Construction of fundamental technology for disaster risk assessment and response(I), Disaster risk assessment system in Korea, NDMI-PR-2014-07-02-01, 313p.(in Korean)* *3. National Disaster Management Institute (2014) Improvement of design element based on empirical experiments, NDMI-PR-2014-07-09-01, 262p.(in Korean)* *4. National Disaster Management Institute (2015) Enhancement of criteria for disaster mitigation through practical based cause analysis, NDMI-PR-2015-01-02, 130p.(in Korean)* *5. National Disaster Management Institute (2015) The reduction and management plans for risk factors of repeated structural disasters, NDMI-PR-2015-03-02-01, 200p.(in Korean)* *6. National Disaster Management Institute (2015) Establishment of foundation for regional urban flood response system, NDMI-PR-2014-07-02-01, 156p.(in Korean)* • <u>Professional research papers</u> *1. Lee, K.S., Jang, C-L., Lee, N.J., and Ahn, S.J.(2014). "Analysis of Flow Characteristics of the Improved-Pneumatic-Movable Weir through the Laboratory Experiments.", Journal of Korean Water Resources Association, Vol. 47, No. 11, pp.1007-1015.* *2. Lee, K.S., Ryu, J.K., and Ahn, S.J.(2014). "Change of regime coefficient due to dredging and dam construction.", Journal of Korean Environmental Dredging Society, Vol. 4, No. 1, pp.30-38.* *3. Lee, K.S., and Jang, C-L.(2014). "Estimation of erosion resistance of vegetation mat for protecting bank surface erosion by laboratory experiments.", Journal of Korea National University of Transportation, Vol. 49, No. 1, pp.205-210.* *4. Lee, K.S., and Jang, C-L.(2016). "Numerical investigation of space effects of*

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
						serial spur dikes on flow and bed changes by using Nays2D. ", Journal of Korean Water Resources Association, Vol. 49, No. 3, pp.241-251. *5. Lee, K.S., and Jang, C-L., and Lee, N.J.(2016). "Analysis of Submerged Flow Characteristics of the Improved-Pneumatic-Movable weir through the Laboratory Experiments. ", Journal of Korean Water Resources Association, Vol. 49, No. 7, pp.615-623.* *6. Song, Y.K., Kim, Y.U., Kim, K.J., and Lee, K.S.(2016). "Countermeasures on Safety Management of Decrepit Reservoir Based on the Comparative Analysis for Its Collapse Accidents.", Crisisonomy Vol. 12, No. 7, pp.615-623.*
2. Improvement in capacity for sediment disaster management (2.1.3 in OP)	• Attend seminars on sediment disasters in order to communicate and cooperate among member countries (Priority A) • Share and bring related technologies to developing countries (Priority B)	• Workshop on the provision of sharing knowledge for sediment disasters (e.g. attend workshop of TC DRR) • ODA projects which transplant knowhow to developing countries	• Republic of Korea (ROK) • National Disaster Management Institute (NDMI) • WMO/ESCAP Typhoon Committee, Disaster Risk Reduction (TC DRR)	• Report for feasibility survey for ODA projects by April 2016 • Attend Workshop of TC DRR on May 2015 • Attend International Workshop among Korea, Taiwan, and Japan	• SOP 2.1.3 • RA II • WMO Secretariat • TC DRR • ROK (MPSS and KOICA)	• <u>Governmental research reports</u> *1. National Disaster Management Institute (2014) Construction of Forecasting and Warning System for Disaster Mitigation in the Philippines-II, NDMI-ODA-2014-1, 150p. (in Korean and English)* *2. National Disaster Management Institute (2014) Regional Peer Learning Forum for Disaster Risk Reduction Capacity Building of Central Asia, NDMI-ODA-2014-02-01, 121p. (in Korean)* *3. National Disaster Management Institute (2014) Development of NDMI's Roadmap for Its International Cooperation Work: Through Promoting international research and ODA project, NDMI-PR-2015-03-02-07, 176p. (in Korean)* *4. National Disaster Management Institute (2015) Technical applicability analysis on disaster risk reduction technology transfer to strategic priority countries (I), Disaster risk assessment system in Korea, NDMI-PR-2014-07-02-01, 313p.(in Korean)* • <u>International cooperation</u> *1. Regional forum on space technology applications for drought monitoring and early warning, UN-ESCAP, July 1-2, Colombo, Sri Lanka, 2014.* *2. Expert mission for UNESCAP/WMO Typhoon Committee members, Oct. 21-25, 2014.* *3. MOA bet. NDMI-ESCAP, Oct. 20-24, 2014.* *4. NDMI Regional Peer Learning Forum (PLF) for Central Asia, Nov. 17-22, 2014.* *5. The 47th UNESCAP/WMO Typhoon Committee General Meeting, Thailand, Feb. 9-13, 2015.* *6. Expert mission for automatic rainfall warning system in Philippines Apr. 26-May 1, 2015.* *7. 2015 UNESCAP/WMO Typhoon Committee Working Group on Disaster Risk*

Activities	Actions	Outputs	Resources	Milestones	Linkages	Progress
						Reduction meeting, May 19-20, 2015. *8. Establishment of automatic rainfall warning system in Laos, Sept. 4-6, 2016.* *9. ADRC annual meeting, Thailand, Mar. 25-26, 2016.* *10. The 48th UNESCAP/WMO Typhoon Committee General Meeting, Hawaii, Feb. 22-25, 2016.*
3. Optimization of disseminating sediment disasters related information	• Collect and analyze disseminating methodologies and related policies for sediment disasters information that alarm people not to be involved to the designated areas	• Actual example for sediment disasters information by public broadcasting system and other media (e.g., Facebook, Twitter, etc.)	• Republic of Korea (ROK) • National Disaster Management Institute (NDMI)	• Summary report for present disseminating codes and regulations by June 2015 • Report about the effective disseminating framework by Dec. 2015	• Above SOP • RA II • WMO Secretariat • TC DRR • ROK (MPSS)	• <u>Governmental research reports</u> *1. National Disaster Management Institute (2014) Construction of heat wave risk map based on various heat wave-related information, NDMI-PR-2014-08, 87p. (in Korean)* *2. National Disaster Management Institute (2014) A study on the safe system and resilience circumstances to promote citizen's participation in safety improvement, NDMI-ER-2014-08, 346p. (in Korean)* *3. National Disaster Management Institute (2015) Research on improvement of the evacuation guidance system based on evacuation simulation, NDMI-PR-2015-02-01-01, 105.(in Korean)* • <u>Public services</u> *1. App for foreigners, Safety First, released, Nov, 2014.* *2. The second phased service of Safety Map is available, Jan. 26, 2015.*

4. DESCRIPTION OF PROGRESS MADE DURING THE INTERSESSIONAL PERIOD

4.1 Brief descriptions on progress made during the intersessional period are provided herein for the subject-matter topic areas.

4.2 Water Resources Assessment

4.2.1 Many achievements were obtained for the Activities in the Work Plan (see section 3) having the highest priority, specifically Activity 2 (Priority A) and Activity 3 (Priority B). Various case studies and documents on investigations and practices were reviewed. These were primarily on case studies related to climate change adaptation in water resources and its impact on availability. These covered different basins and regions in China during 2015-2016. These were thought to be helpful for providing guidance to users who may be considering studies on water resource assessment as well as adaption analysis. Suggestions are also given on how to present findings to decision makers.

4.2.2 A draft technical report was made available in September 2016 on water resources assessment linked to extended range climate forecasts. In the report, two methods of water resources prediction are introduced, one is hydrological prediction during the flood season based on a statistical method, and the other is a one-way coupling method based on a dynamic extended range climate forecast and hydrological model. Statistical downscaling methods as input to some hydrological models are also included. An introduction to the water resources assessment and prediction tool is made through its application to some basins in China. These applications include examples of major products, which are valuable as reference material. The report also can be used as a source of material for training.

4.2.3 During the meeting, Mr Mikhail Georgievsky provided a presentation informing the WGHS of the efforts being undertaken in the Russian Federation on Water Resources Assessment. His presentation is available on the webpage for the 3rd Meeting of the RA II WGHS.

4.3 Flood Forecasting

4.3.1 The basic direction of RA-II activities in the area of flood forecasting during the last intersessional period has been connected to the realization of the WMO Flood Forecasting Initiative (FFI). The FFI is the basic implementation framework related to hydrological forecasting and flood management. The main task of FFI is to improve the capacity of meteorological and hydrological services to jointly deliver timely and more accurate products and services required in flood forecasting and warning and to further collaboration with disaster managers, active in flood emergency preparedness and response. The goal of this task is to improve interaction and understanding of meteorologists and hydrologists in the effective use of numerical weather forecasts in hydrological modelling for flood forecasting.

4.3.2 In a number of National Meteorological and Hydrological Services there is valuable experience in creating Flood Forecasting Systems based on sharing of meteorological and

hydrological data and model outputs. Hydrologists and meteorologists take part in the development of these systems in common. However many flood forecasting systems have separate meteorological and hydrological modelling systems. In such cases, numerical weather forecasts are used as input to the hydrological modelling systems. When approached in this manner, it is necessary to develop requirements for the meteorological forecasts to mesh with the spatial and time resolution requirements of hydrological models, resulting in hydrological forecasts. Hence, it would be helpful to have general recommendations on the requirements of numerical weather forecasts for use in flood forecasting.

4.4.3 Now there are many meteorological models at the global, meso-, and regional scales which are used in flood forecasting systems. Some hydrological modelling systems are making use of ensemble meteorological forecasts. This leads to the development of ensemble hydrological forecasts. Sometimes, such hydrological forecasts have high variance, reflective of the uncertainty in the meteorological forecasts. In addition, analyses can be conducted to ascertain the deterministic error of each ensemble element, for example over the previous thirty day period, using this deterministic signal to provide a weighting on the confidence of the forecasted ensemble elements. This results in improvements in the accuracy of hydrological forecasts. To assist in this regard, a report has been prepared entitled "Guidelines for verification of hydrological forecasts." It is felt that this report will be useful for professionals involved in operational hydrological forecasting, as well as for professionals involved in the development of forecasting methods.

4.3.4 The Flash Flood Guidance System (FFGS) has been developed by the Hydrologic Research Center in San Diego (USA) under the direction of Dr K. Georgakakos. The Flash Flood Guidance System (FFGS) project with global coverage was endorsed by Resolution 21 (Cg-XV) as a Flood Forecasting Initiative component that had been developed by the WMO Commission for Hydrology (CHy) jointly with the WMO Commission for Basic Systems (CBS) and in collaboration with the US National Weather Service, and the Hydrologic Research Center in San Diego. This system provides a very useful tool for establishing guidance on the possibility of threats of flash floods occurring on small basins. The Flash Flood Guidance System is being implemented with the assistance of the USAID/OFDA, and it is now being used in several countries.

4.3.5 Currently there are three projects being implemented in RA II. These are the Mekong River Commission FFGS, the South Asia FFGS and the Central Asia Region FFGS. It would be beneficial to further expand the number of countries in RA II (Asia) being covered by the Flash Flood Guidance System. To assist in this regard, it would be advantageous to:

(a) disseminate broadly the experiences and benefits obtained through the use of the FFGS in various countries throughout Asia and the world; and

(b) investigate the potential use of FFGS in other Asian countries and facilitate its understanding by operational hydrologists in the region.

4.3.6. Flood management effectiveness depends not only on quality and timeliness of the hydrological forecast, but also on the ability of users to understand and use the various forecast products. Over the last decade, advances have been made in the use of probabilistic hydrological forecasts. The utility of such forecasts is highly related to the training of experts in their use, and such forecasts have greatly enhanced the utility of flood forecasting in the area of flood management. To further advance the use of probabilistic

forecasts and their utility in flood management, it is recommended that effort be undertaken to prepare guidance and training material on the use of hydrological forecasts (including probabilistic forecasts) in flood management.

4.4 Hydrological Aspects of Drought

4.4.1 Coverage areas and scope of the negative impacts on the population from drought is dominant among other natural disasters in Central Asia. Currently in Central Asia a lot of attention paid to the development of drought early warning systems. Early identification of drought is key to developing a set of measures aimed at mitigating the effects of drought and food security of the countries. In 2008, Uzhydromet established the National Centre for Drought Monitoring. Its purpose is to serve as a coordinating and consultative centre for drought preparedness, monitoring, prevention and mitigation of the adverse effects of drought. This Centre in Uzbekistan uses the infrastructure and scientific knowledge in the country as well as neighbouring ones to study the problem of drought. It also promotes informing stakeholders on various aspects of drought and its prevention. Center specialists developed and implement a drought early warning system.

4.4.2 A Drought Early Warning System is a tool for assessing, monitoring, warning, information sharing and decision making, supported by the necessary information platform and providing dissemination (warning) and exchange of necessary information. The objective of the Drought Early Warning System is to provide decision makers and population with early information about a possibility of drought occurrence with a view to reducing the drought risk as much as possible. Functional capabilities of the Drought Early Warning System are: assessment of water resources; analysis of low water availability and drought formation conditions; assessment of water resources conditions based on climate scenarios; and assessment of low water availability and drought occurrences possibilities based on climate scenarios.

4.4.3 To identify the on-set of drought, the Drought Early Warning System uses three indices: Pedya drought index; Standardized Precipitation Index (SPI); and the Drought index for snow storage (Sw). Using the Pedya drought index has a number of advantages because it gives a degree of deviation of temperature and precipitation from the normal (multi-year) value and allows one to objectively classify all cases according to the degree of aridity or lack of moisture. This index is suitable for any natural area for any length of time (decade, month, season). This indicator does not depend explicitly on the main climatic characteristics: the mean and the variance of temperature and precipitation. The advantage of the SPI is that it can be used over different time intervals (up to several decades) to assess the severity of the drought. It also allows the comparison of moisture conditions at various points in the region. For river basins having snow and snow-glacier regimes, water availability should reflect the accumulation of snow in the mountains in winter. In such cases, it is advisable to use the accumulation of snow in the mountains for a certain period of time as a criterion (index) of the water availability, termed Sw.

4.4.4 These three indices within the EWS allow the calculation of snow storage with assessments of precipitation and temperature, thereby enabling the analysis of the conditions for river runoff formation in the low water years and the factors for its formation for all drought indices for sub-basins in the runoff formation zone. These would be most valuable for assessing the early on-set of drought in the Amudarya and Syrdarya rivers within the Aral Sea basin.

4.5 Assessment of Changes in Climate Extremes, their Impacts on Water Resources, and Translating Climate Information into Action in Water Resources

4.5.1 The activities include: (1) Assessment of change in climate extremes; (2) Climate projections; (3) Assessment of potential impacts of climate extremes and climate change on water resources of selected river basins; (4) Translating climate and climate change information into actions in water resources development and management for selected river basins; (5) Compilation of reports; and (6) Experience sharing and lesson learned. The participating countries developed their case studies and compiled reports.

4.5.2 In the activities in China, scientific studies of "climate changes for major rivers", "sea level rise along China's Coastal line", and "Impact of climate change on water resources of China by using multiple GCMs projections" were conducted and reported. In addition, recommendation reports for "China's adaptation strategy in water sector to climate change" (in Chinese) and "Sponge City Development of Zhenjiang City for better adaptation to climatic extremes" (in Chinese) were conducted.

4.5.3 In the activities in Vietnam, scientific studies of "Changes in Climate Extremes and Impacts on the Natural Physical Environment", "Climate Change and Sea level rise for Viet Nam", and "Projection of extreme temperature and precipitation and their impacts on water resources in Dong Nai river basin and vicinity – Viet Nam" were conducted and reported in Vietnamese and being translated into English. The report shows that Extreme climatic events in Viet Nam are expected to increase in both frequency and intensity due to climate change.

4.5.4 During the meeting, Mr Nguyen Xuan Hien provided a presentation entitled "Changes in Climate Extreme and Impact on Water Resources in Viet Nam". As well, he provided the report entitled "Changes in Climate Extreme and Impact on Water Resources in Viet Nam" as a contribution to the efforts within this thematic area. The presentation and the report are available on the webpage for the 3rd Meeting of the RA II WGHS.

4.6 Improved Accuracy of Hydrometric and Sediment Observations including Space-based Technologies

4.6.1 In order to improve the accuracy of field measurements, it is necessary to review and research relevant techniques. It is also very important to use appropriate instrumentation and analytical techniques for specific flow conditions. The main objective of the activity is to provide a technical report or guideline, based on case studies for various conditions, comprising three parts: hydrological observation techniques; real-time discharge measurements (IRDIMS, Integrated Real-time Discharge Measurement System); and sediment measurement and development of rating curves.

4.6.2 In the activities on hydrometric measurements with quality and accuracy, the first action is to **'Provide guidance on the use of appropriate instruments and methods of observation in diverse conditions'**. In terms of the use of appropriate instruments and methods of observation in diverse conditions, the actions have focused on IRDIMS (Integrated Real-time Discharge Measurement System), which has been used to guide the design and construction and subsequently the operation for difficult sites. This was for measuring discharge under backwater and tidal effects in the Republic of Korea. The main

purpose of this action is to provide technical information and guidance on the application of real-time discharge measurements for difficult to monitor sites.

4.6.3 Two sub-actions were conducted in this action plan: (1) Collection of the existing technical information of IRDIMS and (2) Case studies on the measurement of IRDIMS for 52 sites. Technical information related to real-time measurement include measurement instruments, method of discharge calculation, and the construction and operation of IRDIMS. Case studies were used to assess the result of measurements attained using IRDIMS for various specific conditions categorized on characteristics of flow conditions, such as tidal affected areas and backwater affected areas caused by weir, sluice gate, junctions, etc. These case studies also include an evaluation of the results by a comparative analysis using individual measurements and assessment of runoff between upstream and downstream stations. In regards to the development of index ratings, the procedure and software tools (EDpad, MCDpad) have been introduced including analysis of the available measurement range of the ADVM and development of index rating curves, which have been developed using Microsoft Excel. These will be provided to other members to help standardize and facilitate developing index ratings for real-time discharge measurement.

4.6.4 The 2nd action to **'Improve sediment measuring techniques'** is achieved by providing technical information related to sediment measurement and a case study of how to do so reflecting various conditions. Two sub-actions were conducted in this action plan : (1) Collection of the technical information related to measurement and analysis of sediment and (2) Case studies on sediment measurement under various conditions. The collected technical information about sediment measurement included existing and advanced new technologies and their application. Case studies focused on sediment measurement under various conditions, which included an analysis of the characteristic of suspended sediment in rising and falling flow conditions (known as a loop in the concentration-discharge or C-Q rating curve), comparative analysis before and after construction using 4 major river projects, and the characteristic of suspended sediment for successive rainfall event.

4.6.5 In the activity of Calculation of runoff with quality and accuracy, the main action was entitled **'Focus on the development of H-Q rating curve'**. This action aimed to provide a report outlining procedures for developing the optimal H-Q rating curve under various conditions in the Republic of Korea and providing technical information about improved development procedures and introducing a development tool for establishing the H-Q rating curve. Two sub-actions were conducted in this action plan: (1) Collection of the existing technical information and (2) Case studies on development of the H-Q rating curve under various field conditions. For the first sub-activity, the procedure of discharge measurement and its calculation, the evaluation of the measurement and its data quality control (QC), and procedures for the development and evaluation of rating curves were introduced in software tool being used in Hydrological Survey Centre (HSC) of the Republic of Korea. Case studies were used to illustrate the proper development of H-Q rating curves under various fields conditions based on practical experience. The case studies also recommended methodologies and introduced the evaluation using the basin's water balance The case studies focused on developing rating curves for backwater affected areas as caused by weirs and stream junctions. Consideration was also given to the development of H-Q rating curves that reflect changing aquatic vegetation conditions (method and procedure of vegetation monitoring), and the effect of stream-bed changes on H-Q rating curves.

4.7 Sediment Disasters and Mass Movements

4.7.1 The main goal of the Sediment Disasters and Mass Movements theme is to develop the Integrated Management Platform that consists of systems, policies and international cooperation. It has three different perspectives on sediment disasters. These include: (1) issuance of landslide/debris flow warning and consistently improving upon them; (2) improvement in capacity for water-related disaster management; and (3) optimization of disseminating sediment disasters related information.

4.7.2 In 2016, as the last year of the activity, this theme tried to make all possible results to complete outcomes which the theme leader suggested in the first meeting. Major results of the Activity 1 can be divided into three ingredients: (1) Identify the mechanism of sediment disasters; (2) Establish the analysing system and data base; and (3) Develop various measures for sediment disasters. Our research found that one single landslide would make catastrophic disasters as it moves along the stream, therefore understanding the nature of sediment disasters is top priority. Evaluation of structures such as dam, levee, and so on also needs to be done. Finally, developing guidelines to reduce the sediment disasters and managing data are also required.

4.7.3 The Activity 2 focuses on increasing our ability to manage sediment disasters through collaboration with experts from other countries. This year the thematic area generated three remarkable achievements in this field: (1) International workshop among Korea, Taiwan, and Japan (July 5 to 7, 2016); (2) Korea-Italy bilateral symposium on landslide prediction and warning technology (Mar. 14 to 15, 2016); and (3) Official Development Assistance (ODA) project in Vietnam and Laos. From these events, we have learned the importance of cooperation in dealing with sediment disasters and have tried to find a better way to help developing countries based on their needs.

4.7.4 In the Activity 3, the main objective is disseminating information on sediment disasters into communities. Two methods are considered: (1) Early Warning System; and (2) Public dissemination. The thematic area suggests advancing the use of “safety map” (www.safemap.go.kr) of MPSS (Ministry of Public Safety and Security, Republic of Korea) for ordinary people. This map is the world’s first portal site on this topic and contains 127 items on safety information from 20 governmental agencies. Sediment disaster is applicable to the category of Disasters in this map.

5. WORKSHOP FOR THE DYNAMIC WATER RESOURCES ASSESSMENT TOOL (DWAT)

5.1 The **D**ynamic **W**ater Resources **A**ssessment **T**ool (DWAT) was developed by HRFCO and KICT. Mr Cheol-Hee Jang provided a presentation explaining the concepts and approaches undertaken, including a description of the hydrological process model used within the tool and how various elements within the hydrological cycle are mathematically modelled.

5.2 The presentation resulted in several questions and comments being provided. It was learned that public domain GIS (GDAL) was used within the model, to help reduce the costs associated with implementing it. The tool has been designed to assist long-term planning and policy assessment and development. Its application can allow

assess of land-use changes within the basin over time, the impacts on water availability under different consumptive use scenarios, and the impact on availability due to climate change through the application of scenarios.

5.4 Mr Cheol-Hee Jang indicated that the model has been tested on basins ranging in size form 23 km^2 to 1,000 km^2. It was noted that the computational time step could vary form 1 minute (for smaller basins) to monthly. The Tool was tested to explore its ability to assist in city planning and development. He also indicated that a draft user guide has been prepared.

5.5 The experts also discussed possible future features that could be advantageous to develop. For example, it was noted that the Tool does not consider snow accumulation and ablation, while this would be needed for application in environments where snow is more common and is a significant contribution to the timing and amount of stream discharge and a source for soil moisture and groundwater recharge. As well, the Tool currently only considers in situ climate stations to estimate various elements (e.g., rainfall, temperature, etc) for sub-basins as input to the model. It was noted that this was due to the large observing network that exists, but that consideration should be given to also allowing use of satellite and radar data to derive the best estimates of Quantitative Precipitation Estimates (QPE) for the sub-basins. It was thought that should a Flash Flood Guidance System be operating covering the basin, its merged QPE could be used within the Tool, rather than replicating the computational process. As well, the use of Numerical Weather Prediction outputs was discussed, particularly if the Tool were to be used for shorter-term planning purposed for planning water use restrictions, etc. It was also noted that a module would be needed to downscale climate scenario input to the sub-basin scale for sue in the longer-term planning applications.

5.6 Mr Cheol-Hee Jang noted that the beta version of the Tool will be available by end of 2016. This version would be applied within RA II to further test the system. It was thought that about two years would be required to finalize the beta version of the Tool including making some additional modules available. These would include the ability to easily incorporate climate change scenarios including downscaling, as well as a module to reflect snow modelling. The experts commented that the Tool as illustrated in the workshop was excellent, and they were excited with the possibility of receiving the Tool for testing and use within their countries.

6. FUTURE WORK PLAN

6.1 Participants discussed the development of work plans for the next intersessional period and the future structure of the RA II Working Group on Hydrological Services. The future structure agreed upon for the consideration of the 16th Session of RA II was:

Working Group on Hydrological Services (WGHS)

Expert Group on Coordination and Capacity Building (EG-CCB)
- Theme I Water Related Disaster Management
- Theme II Provision of Hydrological Services

Expert Group on Measurements, Monitoring and Infosystems (EG-MMI)
- Theme I Hydrometric Measurements

- Theme II Sediment Disasters and Debris Flows

Expert Group on Hydrological Applications (EG-HA)
- Theme I Water Resources Assessment
- Theme II Flood Forecasting
-Theme III Hydrological Aspects of Drought
-Theme IV Hydrological Adaptation to Climate Change

6.2 Participants reviewed the aspects of the RA II Operating Plan 2016-2019 pertaining to the Working Group on Hydrological Services (WGHS). The above working group structure was added to the Operating Plan for the WGHS for ease of future reference.

DEPT	BRANCH	ER	KEY OUTCOME	KEY PERFORMANCE INDICATOR	DELIVERABLE	PRORGAMME	TC	REGION	ACTIVITY	Y2016	Y2017	Y2018	Y2019
DRA	RAP	2	2.2	2.2.1 [EG-HA Theme II]	Improvement in hydrological warnings capability through enhanced and effective cooperation with other NMHSs	WWW, HWRP, DRR	CBS, CHy	RA II	(a) Prepare recommendations on the use of NWP outputs in flood forecasts; (b) Document approaches to ascertain the deterministic error of each ensemble element of NWP products; (c) Use WMO Flood Forecasting Initiative as platform		x	x	x
DRA	RAP	3	3.3	3.3.1 [EG-HA Themes 1 & IV]	Improvement in adaptation capacity of water resources systems in a changing climate [using Water Resources Assessment methodologies]	WWW, HWRP, WCP	CBS, CHy, CCl	RA II	(a) Assess changes in climate extremes - Data and method of climate extreme study: data inventory, climate index - Trend of some climate extremes: temperature, rainfall and others (b) Translate climate and climate change information into actions in water resources development and management	x	x	x	x
DRA	RAP	3	2.1	2.1.1 [EG-CCB Theme I]	Improvement in capacity for water-related disaster management (Hydrological extremes)	WWW, HWRP, DRR	CBS, CHy	RA II	(a) Organize a workshop on the provision of input and support to disaster management (b) Attend seminars on sediment disasters in order to communicate and cooperate among member countries		x	x	x
DRA	RAP	3	3.3	3.3.1 [EG-MMI Theme I]	Improvement in hydrometric measurements with quality and accuracy	WWW, HWRP	CBS, CHy, CIMO	RA II	Provide guidance on the use of appropriate instrumentation and methods of observation in diverse conditions		**x**	x	**x**
DRA	RAP	2	2.2	2.2.1 [EG-HA Theme II]	Issuance of flood, flash and urban flood warnings and constantly improving upon them	WWW, HWRP, DRR	CBS, CHy	RA II	(a) Document experiences in the use of the Central Asia Region Flash Flood Guidance System (FFGS) in participating countries by reviewing its use (b) Facilitate FFGS understanding by operational hydrologists in the Region (c) Develop recommendations on the use of hydrological forecasts in flood management	x	x	x	x
DRA	RAP	2	2.1	2.1.1 [EG-MMI Theme II]	Issuance of landslide/debris flow warnings and constantly improving on them	WWW, HWRP, DRR	CBS, CHy	RA II	Collect and disseminate guidance materials and manuals on the assessment of rainfall/flood induced mass movement hazards and potential forecast methodologies		x	x	x
DRA	RAP	3	3.3	3.3.1 [EG- CCB Theme II]	Development of national and regional capacity building programmes and related training activities for hydrological services	HWRP	CHy	RA II	Synthesize report from individual reports from participating countries in RA II on national and regional capacity development activities in hydrology and make recommendations on their enhancement		x	x	x

7. CONSIDERATION OF INPUT TO CHy-15 AND 16th SESSION OF RA II

7.1 The meeting considered the major accomplishments achieved by the WGHS and developed a short list of those where decisions from either or both the next Session of CHy or the 16th Session of RA II would be desirable. These major accomplishments included:

Major Accomplishments	Session	Decision
Dynamic Water Resources Assessment Tool (DWAT)	CHy, RA II	CHy: urges CHy to assess the Tool testing its ability and to provide guidance on its further development for global utility RA II: requests RA II Members to assess the Tool, testing its ability and to provide guidance to the RA II WGHS Chairperson on its further development for the benefit of Members
Guidelines for Verification of Hydrological Forecasts	CHy, RA II	CHy: urges CHy to review and assess the global utility of the Guidelines as a potential contribution to the WMO Flood Forecasting Initiative RA II: requests RA II Members to review and apply the verification procedures, reporting their results and views on the procedures to the RA II WGHS Chairperson
Software tool for index velocity method	CHy, RA II	CHy: urges CHy to assess the utility and applicability of the software tool and methods therein for measuring discharge under backwater and tidal influence RA II: requests RA II Members to test the Software Tool, reporting their results and views on the procedures to the RA II WGHS Chairperson

8. ADOPTION OF THE REPORT AND CLOSURE OF THE MEETING

8.1 Participants agreed that the final draft report would be circulated to participants allowing a period for Mr Sung Kim to update the work plan with members who were not in attendance and to include their description of progress made during the intersessional period. Once their views have been incorporated, the draft report will be circulated to participants with a two week period for provision of revisions. It was agreed that the final endorsement of the report should be sought from the Chair of the Working Group before finalizing it and seeking approval of the President of RA II for its publication.

8.2 The Chairperson, Mr Sung KIM, thanked the participants and the WMO Secretariat for their contributions and professionalism that made the meeting a success. He also thanked experts for their hard work over the last four year period, and he indicated with pleasure that he has seen the experts accomplish many of their tasks in their work plan.

8.4 Mr P. Pilon expressed his gratitude on behalf of WMO to the Government of Korea for their having provided financial assistance, as without this funding the second and third meetings of the RA II WGHS would not have been held. He also thanked Mr Sung Kim, Mr Cheol-hee Jang and all staff in supporting the effective organization of the meeting and for their efforts and assistance. He also thanked Mr Kim specifically for his demonstrated leadership and persistence in directing the work of the working group and in reporting their successes. In closing, he underscored the importance of fulfilling the work plans as outlined prior to the next session of RA II to be held in February 2017, not only for the benefit of National Hydrological Services in RA II, but for all Regions.

8.5 Participants thanked everyone for the excellent, productive meeting at 16:45.

8.5 The meeting closed on the 27th of October 2016.

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ANNEX 1

List of Participants - RA II (Asia) Working Group on Hydrological Services (WGHS)

(Seoul, Republic of Korea, 25-27 October 2016)

Working Group on Hydrological Services (WGHS):

Chairperson **(HOST)**	Dr Sung KIM Senior Research Fellow Korea Institute of Civil Engineering and Building Technology (KICT) 283 Goyangdae-ro, Iisanseo-gu, Goyang-si, Gyeonggi-do 10223 Republic of Korea Telephone: +82 31 910 0602 Telefax: +82 31 910 0251 E-Mail: skim@kict.re.kr
Vice-Chairperson WGHS (absent)	Mr Muhammad RIAZ Pakistan Meteorological Department Flood Forecasting Division 46 Jail Road LAHORE Pakistan Phone: +92 42 99 200 208 fax: +92 42 99 200 209 E-Mail: riaz1962@hotmail.com
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Theme Leader in Hydrological Responses to Climate Variability and Change and Promotion of the Use of Climate Information by Water Managers (absent)	Dr Guoqing WANG Nanjing Hydraulic Research Institute 225 Guangzhou Road Nanjing 210029 China Tel: +8625 85828531 Fax +8625 85828555 E-Mail: gqwang@nhri.cn E-Mail: guoqing_wang@163.com
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Theme Leader in Sediment Disasters and Mass Movements	Dr Tai-Hoon KIM Senior Analyst National of Public Safety and Security Ministry of Security and Public Administration 365, Jongga-ro, Jung-gu

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Theme Leader in Improved Accuracy of Hydrometric and Sediment Observations including Space-based Technologies	Dr Youngsin ROH Hydrological Survey Center Office building, KINTEX, 407 Hallyuworld-ro, Ilsanseo-gu, Goyang-si, Gyeonggi-do Goyang Republic of Korea Telephone: +82 31 929 0823 Telefax: +82 31 929 0890 E-Mail: rohys@hsc.re.kr

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World Meteorological Organization

REGIONAL ASSOCIATION II
WORKING GROUP ON
HYDROLOGICAL SERVICES

SEOUL, REPUBLIC OF KOREA
25 TO 27 OCTOBER 2016

Submitted by: Secretariat
Date: 25.10.2016
Original Language: English
Status: **FINAL**

FINAL MEETING AGENDA

3rd Meeting for WMO Regional Association II Working Group on Hydrological Services (WGHS)

and

Workshop on the Dynamic Water resources Assessment Tool

Venue: Han River Flood Control Office / Western Coop Residence Hotel
Seoul
Republic of Korea

25 October to 27 October, 2016

<u>Tuesday 25 October</u> (Han River Flood Control Office)

3rd WGHS Morning Session (09:00 – 10:00) Session Chairman: Dr. Hwirin Kim

- Opening of the meeting and welcome by representatives of the hosting organization and WMO (Han River Flood Control Office Director: Mr Hajoon Park)
- Introduction of participants and adoption of the agenda (Sung Kim)
- Report on activities of the Commission for Hydrology (CHy) as a result of the 3rd AWG Meeting, February 2016 (Paul Pilon)
- Report on decisions and recommendations of RA-II, including the RA-II Strategy as a result of the Working Group and Chairs' Meeting in RA-II, December 2015 (Paul Pilon)
- The RA II Operating Plan 2016-2019 as approved by the RA II Management Group on 15 June 2016 (Paul Pilon)

3rd WGHS Morning Session (10:00 – 12:00)
Session Chairman: Dr. Sung Kim

Report of activities (actions, outputs, milestones and progress) as per the work plans in the following theme areas, focusing on main achievements:

- Water Resources Assessment (Dr. Hwirin Kim, Ms GAO Ge)
- Hydrological Aspect of Drought (Ms. Irina Dergacheva)

Lunch break (12:00 – 14:00) (Lunch will be provided by HRFCO.)

3rd WGHS Afternoon Session (14:00 – 17:30)
Session Chairman: Dr. Sung Kim

Report of activities (actions, outputs, milestones and progress)as per the work plans in the following theme areas, focusing on main achievements:

- Hydrological Responses to Climate Variability and Change and Promotion of the Use of Climate Information by Water Managers for adaptation of climate change in the context of climate variability in hydrological cycle in each country (Dr. Nguyen Xuan Hien) (Substitute)

- Improved Accuracy of Hydrometric and Sediment Observations including Space-Based Technologies (Mr Youngsin Roh)

- Sediment Disasters and Mass Movements (Dr Tai-Hoon Kim)

- Water Resources Assessment in Russia (Dr Mikhail GEORGIEVSKIY) (observer)

Welcoming Dinner (18:00 – 20:00) hosted by the Director of Han River Flood Control Office, Ministry of Land, Infrastructure and Transport (Venue: Korea House 18:00)

Wednesday 26 October

Workshop for the Dynamic Water resources Assessment Tool (DWAT) developed by HRFCO and KICT (09:00 – 10:00): Dr. Cheol-Hee Jang

- Presentation for the development of the Dynamic Water resources Assessment Tool (DWAT)
- Demonstration of the Dynamic Water resources Assessment Tool (DWAT)
- Discussion on application of the DWAT and identification of possible future improvements

Discussion on follow-up and future implementation for the upcoming CHy and RA-II sessions (Sung Kim and Paul Pilon)

- 15th Session of the Commission for Hydrology, Rome, Italy, 7-13 December 2016; and
- 16th Session of RAII, Abu Dhabi, UAE, 12-16 February 2017 and Regional Conference on Management of Meteorological and Hydrological Services (RECO-7) 10-11 February 2017 **(10:00 – 11:00)**

Lunch break (12:00 – 14:00) (Lunch will be provided by HRFCO)

Afternoon session (14:00 – 17:30)

FIELD TRIP

Welcoming Dinner (18:00 – 20:00) hosted by the Director of KICT Hydro Science and Engineering

Thursday 27 October

3rd WGHS Morning Session (09:00 – 12:00)
(Sung Kim and Paul Pilon)

- Discussion on the approved RA II Operating Plan 2016-2019 and development of activities for the RA-II WGHS for the following period (2016-2019)

3rd WGHS Afternoon Session (14:00 – 16:00)
(Sung Kim and Paul Pilon)

- Reviewing and adoption of meeting report
- Closing session