Development and Implementation of the Southeastern Asia-Oceania Flash Flood Guidance (SAOFFG) Project

Jakarta, Indonesia, 2-4 February 2016

FINAL REPORT OF THE PLANNING WORKSHOP

March 2016

TABLE OF CONTENTS

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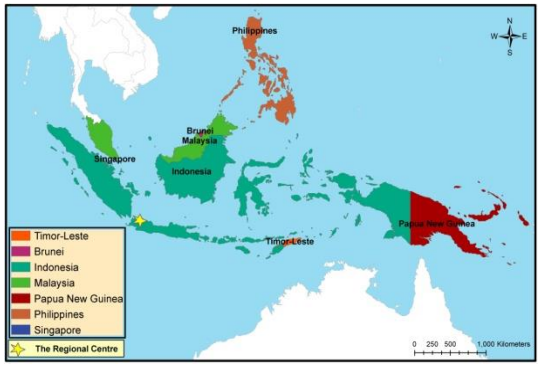
1. Background



In the SoutheasternAsia-Oceania region, flash floods account for a significant portion of the lives lost and property damages that result from flooding. Given that flash floods can occur at any time or place with disastrous results, there is an urgent need to prioritize efforts that aim to improve early warnings capabilities. Improvements help society cope with flash flood threats by enabling the mandated national authorities to undertake appropriate measures, thereby contributing to protecting the population at risk from the disastrous effects of flash floods.

As part of WMO's Flood Forecasting Initiative and on the basis of a 4-party Memorandum of Understanding signed by the World Meteorological Organization (WMO); US NOAA National Weather Service; the Hydrologic Research Center (HRC), San Diego, USA; and U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance (USAID/OFDA), the signatories have established a cooperative initiative for the Flash Flood Guidance System with Global Coverage Project. To attain global coverage, specific projects are planned and carried out on a regional basis with countries that have committed in writing to participate actively in the implementation and operation of the forecast system.

2. Introduction and Opening of the Meeting

Based on correspondence received from the six countries in the region expressing the desirability and need for the establishment of a regional flash flood guidance system for Southeastern Asia-Oceania, the initial planning meeting was organized by the WMO. The workshop was hosted by the Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG) in Jakarta, allowing participants the opportunity of visiting the premises of the BMKG to see operational weather analysis and forecasting capacities, capabilities and infrastructure of the BMKG. This tour provided an excellent opportunity for the participants to receive first-hand information on the Indonesian weather RADAR network, Numerical Weather Prediction (NWP) mesoscale modeling, Nowcasting, Weather Observation Network, and connection to the Global Telecommunication System (GTS). All participants expressed their deep appreciation to the BMKG for its hosting of the initial planning meeting and for providing a valuable visit of the BMKG facilities.

In opening the initial planning meeting, the representatives of BMKG, WMO, and USAID/OFDA highlighted the importance of improving the timely delivery of flash flood information and guidance to the populations at risk and in the importance of fostering stronger partnerships among countries in the region to strengthen national capabilities to forecast and warn populations at risk from flash flooding and other hydrometeorological hazards. Although the core aspects of the project focus on the implementation of technology and scientific approaches undertaken mainly by the countries' National Meteorological and Hydrological Services (NMHSs), it was highlighted that the guiding indicator for the ultimate success of the project is the effectiveness of the outreach to citizens and reducing their risk of being affected by flash floods in a disastrous way.

In his opening remarks, MrA.E.Sakya, Director General of BMKG and Permanent Representative of Indonesia with WMO, highlighted the value of regional cooperation particularly given the impacts of climate variability and change on infrastructure and the need for early warning systems to help reduce the risks from hydrometeorological hazards, to promote sustainable development, and to attain and maintain economic prosperity. He also emphasized the need for the international exchange of data and information for improving forecasting and early warning, stressing that severe weather events do not confine themselves to national borders. He emphasized that floods/flash floods are extremely devastating hydrometeorological hazards in Indonesia, affecting millions of people each year. He continued to explain the impact of the hydrometeorological hazards throughout the world over recent time, indicating a significant decrease in casualties in comparison with significantly increasing trends for economic losses. Mr Brian Dusza (USAID/OFDA) welcomed the planning workshop and iterated that the approach taken by the global flash flood guidance initiative is fully in-line with the objectives of USAID/OFDA. He said that he was pleased to see progresses that were being made for the implementation of SOAFFG project as it would assist capabilities of countries within the region to help cope with flash flood events by enhancing their flash flood early warning capabilities. Mr Paul Pilon (WMO) recalled the objectives of the meeting and its expected results and welcomed the participants to provide their active inputs into shaping this important regional Flash Flood Guidance System project. He also thanked the BMKG for all its efforts including hosting the meeting, thereby helping to make a positive atmosphere for the meeting.

3. Organization of the Initial Planning Meeting

The meeting was attended by representatives of National Meteorological and Hydrological Services (NMHSs) from Indonesia, Malaysia, Papua New Guinea, Philippines, and Singapore. Other participants included representatives from WMO and HRC, the list of participants is provided in Annex 1, while the annotated workshop agenda is given in Annex 2. Invitations had also been extend to Brunei-Darussalam and Timor-Leste, but unfortunately neither was able to attend this meeting.

In depth information was provided by WMO and HRC to participants of the Initial planning meeting on the objectives and deliverables of the Flash Flood Guidance (FFG) system, its conceptual and operational set-up, and products to be delivered. The Project Brief and the Implementation Requirements documents, which had been provided in advance of the workshop to participants, are attached as Annexes 3 and 4, respectively.

4. Proceedings of the Initial Planning Meeting

Country Presentations

Experts from each country provided in-depth presentations on the current situation of their national services related to hydrometeorological forecasting capabilities, practices and development plans. The presentations will be available on the WMO website (www.wmo.int)[1]. The presentations revealed the similarities and differences that exist among the countries regarding their capabilities to deliver weather and flood forecasting and early warnings, especially for those pertaining to flash floods. Countries do not presently have dedicated systems including the use of hydrological modelling to specifically address the provision of flash flood forecasts and warnings.

Mr Adiyasa (Indonesia) provided an overview of hydrometeorological hazards, flood forecasting and early warning systems in Indonesia. He stated that floods, landslides, and drought are the main

[1]The cited material for the Southeastern Asia-Oceania Flash Flood Guidance project can be located by referring to the activities of the Flash Flood Guidance System within Floods/Flood Forecasting heading under the Hydrology and Water Resources Programme:http://www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php.

hydrometeorological hazards, while floods and flash floods are the most dangerous events causing the most human losses and property damages. He showed daily and monthly flood forecasting maps for Jakarta and its vicinity and explained the Jakarta Flood Early Warning System (JFEWS) and its main components. He stated that forecasts and warnings were disseminated to the emergency management agency, various organizations and the general public through web portal and email.

Mr Sazali (Malaysia) gave an extensive overview of the causes of floods that occur along the coasts during the Monsoon Season. He stated that the frequency of the occurrence of the floods has increased considerably in the last fifteen years and showed images of some flood events. He also stated that mudflows, debris flows, and landsides are triggered by the heavy rainfall. He explained how the governmental agencies cooperate during the flood events such that the National Meteorological Service of Malaysia provides radar data and Numerical Weather Prediction data to the National Flood Forecasts Centre that runs flood forecasting models and issues flood forecasts and warnings to the public and respective agencies via web site, email, SMS, TV, Siren, Radio, and phone. He articulated the system architecture for data collection and dissemination of the hydrometeorological observation network that comprises 443 rain gauges and 332 water level measurements. He explained both the evaluation of the flood forecasting models and flash flood forecasting system for Kuala Lumpur and Shah Alam. He concluded his presentation explaining the challenges of flash flood forecasting and warning such as forecasting intense rainfall for a short period of time, very short lead times from rainfall to flooding, 24/7 operations, lack of trained forecasters, and lack of funds to provide continues training and maintain the systems.

Mr Samuel Maiha (Papua New Guinea) showed occurrences of the flood events in Papua New Guinea and explained institutional responsibilities for the provision of flood forecasts and warnings. He provided information about the international projects that are currently under implementation such as the UNDP coastal flood warning system, the Global Framework for Climate Services (GFCS), the national weather service command service, and multi-hazard early warning systems. He concluded his presentation explaining current challenges as being inadequate hydrometeorological observation network density including weather Radars, low internet bandwidth, lack of data and information analysis platforms, lack of human resources, inadequate communication systems, and lack of forecasting and warning tools for flood forecasting.

Mr Maximo F. Peralta (Philippines) provided an overview of extreme flood events, types and causes of flooding, flood mitigation measures, flood forecasting and warning system, and data and information dissemination. He stated that floods and flash floods occur mainly due to the geomorphological and topographical conditions, tropical cyclones, semi-permanent cyclones and anti-cyclones. He depicted that frequency, intensity, and duration relationship for rainfall have changed and gave examples of flood events and their impacts due to tropical storms. He continued to explain the types of floods and their causes such as urbanization, population growth, waste disposal, cultural, and religious attitudes. He articulated some flood mitigation activities as comprising structural measures such as river and channel improvements and non-structural measures such as flood plain management, flood forecasting and early warnings. He then provided an overview of the hydrometeological observation network, giving specific examples of sensors, communications systems, and data dissemination. He explained the current riverine foresting system including the dissemination of the forecasts and warnings to the emergency management agency and the general public.

Mr Wing (Singapore) gave a presentation on the weather and climate of Singapore, the challenges in weather forecasting, the role of agencies, the issuance of heavy precipitation warnings, and the operational tools for forecasting and warnings of heavy precipitation. He stated that weather conditions in Singapore are dominated by Monsoon Seasons, and he showed satellite images of different weather systems such as convection, squall line and Monsoon surge. He explained that weather forecasting is quite difficult in the tropical region due to the rapid development and dissipation of convective systems. He showed the weather observation network components such as weather

Radar, Automatic Weather Stations (AWS), wind profilers, the satellite reception system, and radisonde stations. He concluded his presentation by explaining that the European Centre for Medium-Range Weather Forecasts (ECMWF) and Australian Bureau of Meteorology precipitation products are used in daily forecasting for Singapore.

SWFDP and FFGS Linkages

Mr Harou informed the participants about the Severe Weather Forecasting Demonstration Project (SWFDP) of WMO, its objectives and goals, progress of SWFDP Regional Subprojects in different areas of the world including development of SWFDP for Southeastern Asia-Oceania (SWFDP-SAO). He also briefed participants on the potential expansion of SWFDP to cover many areas of the world within the next 5 years for the benefit of the developing countries including especially the least developed countries (LDCs) and Small Island Developing States (SIDSs). He also highlighted efforts being undertaken to integrate the SWFDP-Southern Africa with Southern Africa Region Flash Flood Guidance (SARFFG) project and prospects of potential linkages and integration of SWFDP-SAO with SAOFFG in due course over time.

Mr Pilon stated that satellite precipitation estimations from geostationary and polar orbiting satellites, which were adjusted by using in-situ precipitation observations, were used as a primary precipitation source. Quantitative Precipitation Forecasts (QPFs) from a high resolution numerical weather prediction model (also known as a Limited Area Model) covering specific domains within the project region were needed. Use was being made of Limited Area Models to estimate Forecast Mean Aereal Precipitation (FMAP) for each sub-basin and Forecast Flash Flood Threat (FFFT) to enhance the SAOFGS warning capabilities.

Participants discussed the importance of having high resolution limited area numerical weather prediction model products (1 km or 2 km resolution) over areas where hazards of flash flooding exist and where populations and infrastructure are at risk.

Mr Harou stated that development and implementation of SWFDP-SAO would take five years due to WMO procedures even if funds are available. He continued to explain that the process can be accelerated if the president of Regional Association-V (RA-V) were to send a letter to the regional countries inviting them to indicate their interests in the establishment of SWFDP-SAO; and then based on the responses, he could send an official letter to the Secretary General (SG) of WMO requesting the rapid establishment and implementation of SWFDP-SAO.

Participants discussed in detail the merits and benefits of the linage of SAOFFG and SWFDP-SAO projects and parallel implementations, recommending that actions should be taken to speed up the SAWFDP-SAO implementation.

Local Data Requirements and Outline of Hydrometeorologist Training

Mr Georgakakos(HRC) expressed his gratitude to the experts and senior government officials for participating in the initial planning workshop for the SAOFFG system. He also expressed his appreciation to WMO, USAID/OFDA and BMKG for having organized the meeting. In the following sessions, after explaining the role of Hydrologic Research Center (HRC) as FFG system developer, he presented scientific and technical aspects of the Flash Flood Guidance System (FFGS). These were given at the introductory level and included an overview of the general concept of the FFGS, causes of flash flood events, flash flood guidance definitions, soil moisture model parameterization, snow model, satellite precipitation estimation and bias adjustment, threshold runoff, and data requirements for SAOFFG.

Mr Georgakakos explained the importance of using local data in the FFGS to calibrate model parameters. He also emphasized the importance of participating countries in providing their available historical hydrometeorological data to HRC and in making real-time precipitation data accessible; otherwise, only global data with coarse resolution would be used. The importance of the use of real-time precipitation data to bias-adjust satellite precipitation estimates was also stressed. He reviewed the various data types required for the FFGS, such as: precipitation, soil data, vegetation cover, evaporation, temperature, discharge, stream/river (locations) network, and quality controlled digital elevation data. Data requirements for the project are provided in Appendix B of Annex 4 of this document.

Mr Georgakakos stated that training was an integral part of the project, and extensive training would be provided to the participant countries forecasters. He showed the schematic diagram outlining the FFGS hydrometeorologist training programme, which is contained in Appendix A of Annex 4 of this report. He explained that it consisted of five steps:

- Step 1 introductory regional workshop;
- Step 2 eLearning hydrometeorologist training;
- Step 3 specialized training at HRC;
- Step 4 regional operations training workshop; and
- Step 5 regional operational sustainability workshop.

He further articulated that when the training was completed, forecasters should be confident and competent to use FFGS products for flash flood forecasting and the provision of early warnings.

Overview of FFGS Products and Use

Mr Georgakakos explained the role of HRC and introduced the FFGS concept, products, and their operational use by first explaining their definitions and characteristics. He explained satellite precipitation products, namely:

- Global Hydro Estimator (GHE) precipitation, which is produced by US National Oceanic and Atmospheric Administration (NOAA) using Infrared (IR) channel (10.5 micrometre) of geostationary meteorological satellites;
- Micro Wave adjusted Global Hydro Estimator (MWGHE) precipitation, which is estimated by correcting GHE precipitation with Micro Wave satellite precipitation;
- Gauge Mean Aereal Precipitation (Gauge MAP), which is estimated by using WMO synoptic reports obtained from the WMO GTS network;
- Merged Mean Areal Precipitation (Merged MAP), which is derived from the best available mean aereal precipitation estimates from GHE precipitation or MWGHE precipitation or Gauge MAP or Radar estimated precipitation.

He indicated that the Merged MAP is the bias adjusted precipitation product to be ingested into FFGS models; namely the SNOW 17, Sacramento Soil Moisture Accounting (SAC-SMA) and Flash Flood Threat models. The Forecast Mean Aereal Precipitation (FMAP) is generated from the numerical weather prediction Limited Area Models (LAMs), such as ALADIN and WRF. He continued by explaining other FFGS products, namely:

- Average Soil Moisture (ASM), which indicates upper soil (20-30 cm) water content, including free and tension water;
- Flash Flood Guidance, which is an amount of actual rainfall that may cause bankfull flow conditions at the outlet of a sub-basin for a given duration (e.g., 1, 3, or 6 hours); and

- Three Flash Flood Threat products, which indicate the possibility of flash flood occurrences at the outlet of a particular sub-basin, including Imminent Flash Flood Threat (IFFT), Persistence Flash Flood Threat (PFFT), and Forecast Flash Flood Threat (FFFT).

He concluded by explaining recent FFGS advancements such as Urban Flash Flood Warning, use of satellite inundation mapping to correct soil moisture, and landslide occurrence prediction.

The presentation of Mr Sayin built upon that of Mr Georgakakos by demonstrating the operational capabilities of the Black Sea and Middle East Flash Flood Guidance (BSMEFFG) system and use of the derived products. He also provided an overview of verification results for the BSMEFFG system for 2014.

Facilitated Discussions

Mr Pilon provided an overview of the purposes of the workshop indicating that the main objective of the Flash Flood Guidance System was to build capacity of the NMHSs to help society cope with hydrometeorological hazards particularly those of flash floods. The workshop would also allow an opportunity to present and discuss the needs for flash flood forecasting in the Southeastern Asia-Oceania, including dissemination procedures and coordination between the National Meteorological and Hydrological Services and the Disaster Management Agencies. He provided information about WMO Flood Forecasting Initiative, stating that FFGS was in-line with the WMO Flood Forecasting Initiative objectives, and he also outlined the global FFGS implementation strategy.

Mr Pilon articulated the roles of WMO with respect to the development and implementation of the SAOFFG system, stating that WMO was the primary liaison with the NMHSs for the development and implementation of the project and its associated training programme. Further, the project is designed to provide support for establishing closer collaborations and coordination between NMHSs and Disasters Management Authorities and to enhance regional collaborations and cooperation.

Mr Pilon outlined the roles and responsibilities of NMHSs and Regional Centre in the SAOFFG project. NMHSs had the following responsibilities: to provide historical data to the project developer, HRC; to provide in-situ data to the Regional Centre; to participate in the flash flood hydrometeorological training programme; to issue flash flood warnings and disseminate them to their national Disaster Management Authority; and to cooperate with the Regional Centre on the SAOFFG system issues. Then, he cited roles and responsibilities of the Regional Centre as being: to communicate effectively with WMO, HRC and NMHSs on SAOFFG system activities; to have computer hardware and software capabilities and good computer network connections; to monitor routinely availability of the SAOFFGS products; and to conduct flash flood validation studies. Detailed information about roles and responsibilities of NMHSs and RC are provided in Annex 4 and Appendix A in this document.

Mr Pilon provided a brief overview of the organizational and managerial aspects of the project, reiterating the roles and responsibilities of the NMHSs and the Regional Centre. He then introduced the concept of a Project Steering Committee (PSC) and its composition, indicating that each participating country would be represented on it, as well as HRC, OFDA/USAID and the RC. Details of the PSC are found in Annex 5, while the implementation requirements are provided in Annex 4 of this document.

Interest of the Participating Countries

During the facilitated discussions, participants asked a number of questions about the FFGS products and system operations. After clarifications were made by HRC and WMO, all participants of the five Southeastern Asian-Oceania countries indicated agreement that implementation of the FFGS would be very useful for their countries particularly given the importance and value of issuing flash flood

warnings. As well, such implementation was seen as being an important contribution to enhancing their national capabilities and would also help foster closer regional cooperation on disaster risk reduction. Participants from Indonesia, Philippines, and Singapore indicated that they wanted to participate in the project, while those from Malaysia and Papua New Guinea, although having an interest, indicated the need to seek the approval of their respective governments. To facilitate communication of interest in the project, a sample letter was provided participants. It can be found in Annex 6.

It had been noted that representatives from Brunei-Darussalam and Timor-Leste had not been able to participate in the meeting. The meeting agreed that following this initial planning meeting, it would be important for WMO to follow-up with representatives from both countries to seek their interest in being involved in the project.

Offer of the Regional Centre

Mr Mulyono R. Prabowo, Director of Centre for Public Weather Services of Indonesian NMHS, expressed the willingness of the Indonesian NMHS to host the Regional Centre for the SAOFFG project, saying, as well, that Indonesia may need assistance from WMO and HRC for the implementation and operation of the system. All participants were pleased with the kind offer of Indonesia to host the Regional Centre. Representatives of WMO and HRC ensured him of their organizations support for the successful implementation of the project.

Project Implementation Plan

Mr Georgakakos described the project implementation plan, showing the major tasks, milestones, and schedule. Delegates kindly asked to send their Letter of Commitment to WMO by the 4th of March to start the implementation of the project. Delegates agreed on the project implementation plan, saying that they would do their utmost to comply with the plan. SAOFFGS implementation plan is provided in Annex 7 of this document.

Closing of the Planning Workshop

Closing remarks were made by WMO, HRC, and BMKG representatives. Thanks were also extended to all attendees for their active participation in the workshop and spirited involvement in the discussions, which contributed to the successful conclusion of the workshop.

5. Conclusions from the Initial Planning Meeting

1. There was agreement among participants that **the development and implementation of the SAOFFG system** will significantly improve the capabilities of NMHSs in Southeastern Asia-Oceania to produce timely and accurate warnings of flash flood induced hazards, thereby contributing to disaster risk reduction by saving lives and reducing property damages.

   Participants discussed the concept and expected results of the SAOFFG project and agreed that it was consistent with the global aspect of the Flash Flood Guidance system and its regional implementation projects. The objective of the Southeastern Asia-Oceania Flash Flood Guidance project is to contribute towards reducing the vulnerability of the region to hydrometeorological hazards, specifically flash floods, by developing and implementing a Flash Flood Guidance System to strengthen regional capacity to develop timely and accurate flash flood warnings.

2. Participants agreed that the official name of this initiative will be **Southeastern Asia-Oceania Flash Flood Guidance (SAOFFG)** project. This name will be used in all documents and communications.

3. Workshop participants noted that the FFGS has a global aspect and that it is being implemented as a component of the WMO Flood Forecasting Initiative (WMO-FFI). The intent is that the implemented FFGS will be fully integrated into the day-to-day operational activities of the National Meteorological and Hydrological Services responsible for the provision of flash flood early warnings.

4. Participants agreed in principle on the following core elements of this regional project:

    - General concept and technical approach chosen to provide Flash Flood Guidance;
    - Roles and responsibilities of the dedicated Regional Centre and the National Meteorological and Hydrological Services for project implementation;
    - Project governance including the roles of all partners;
    - Guiding principles for the implementation of the SAOFFG; and
    - Concept of Operations.

    All items listed above are provided in the Project Brief document, which is Annex 3, and in the Implementation Requirements document, which is Annex 4. These are also supplemented through the discussions and conclusions arising from the initial planning meeting held in Jakarta, Indonesia, on 2-4 February 2016.

5. With regard to the governance of the project, participants agreed on the structure and interim terms of reference of a **Project Steering Committee** (PSC) as attached as Annex 5 to this report.

6. To enable the effective functioning of the PSC, the participants agreed that participating countries should designate, through their permanent representative with WMO and after consultation with his/her hydrological advisor, *focal points* and *alternates* in serving on the PSC, with the expectation that these designates would serve throughout the duration of the project.

7. The participants agreed that once government approvals to participate in the SAOFFG project had been obtained, Letters of Commitment (LoC) of the participating countries should be signed by the permanent representatives with WMO and sent to WMO. It is proposed that wherever feasible, the letters should reach WMO not later than by the **4th March, 2016** (see draft Letter of Commitment in Annex 6).

8. Participants noted with appreciation the offer of the NMHS of **Indonesia** to provide services as a **regional centre** for the project within the terms of reference as described in the "Implementation Requirements" document. The offer was discussed in detail and was accepted unanimously by all country representatives. Additional correspondence from the NMHS of Indonesia will be required to confirm its offer of hosting the Regional Centre.

9. WMO and HRC will work with the NMHS of Indonesia to assist it in establishing the functionality of the Regional Centre, to facilitate data transfer for project implementation, and to provide forecast products to participating countries.

10. WMO requested HRC, the Regional Centre, and the participating countries to develop at the earliest direct communication links to facilitate project implementation.

11. Participants recognized that **the incorporation of local data and information** are necessary to enhance system reliability, accuracy and effectiveness in the provision of flash flood early warnings. Further, it was noted that several countries have deployed weather Radar, but may not be using it to its fullest advantage. It was further noted that the FFGS would not incorporate such data in the current phase of the SAOFFG project, but that it would be given serious consideration in a future phase.

12. With a view to a timely implementation of the project, the participants agreed to comply as much as possible with data requirements specified in Appendix B of Annex 4 such that the following data will be transferred to HRC through the regional centre, which is responsible for data exchange between the SAOFFG developer (HRC) and NMHSs:

    - Historical hydrometeorological data since May 2012 to present;
    - Soil data, vegetation cover and stream network;
    - Metadata of hydrometeorological stations; and
    - Quality controlled Digital Elevation Model (DEM) data.

13. Participants noted the data and information requirements of the project at the global, regional and local levels. Based on the presentations and discussions during the workshop, the required data, metadata and related information will be specified and documented in a Requirements Document that will be sent to all focal points by HRC together with data and information questionnaires. The feed-back information from focal points should reach the Hydrologic Research Center (HRC) and the Regional Centre respectively according to the implementation plan (Annex 7), which had been agreed upon at the Planning Workshop.

14. Participants agreed that the establishment of the system is a collaborative endeavour, based on the continuous feedback between development and testing, and between the Regional Centre and the participating countries. Participants recognized also that a successful design and reliable operation of the SAOFFG requires high quality data provided in a timely manner to the Regional Centre. The real time data of selected hydrometerological stations needs to be transferred to the Regional Centre as per the plan of implementation through WMO GTS and/or ftp services and/or other means.

15. To facilitate system implementation, it was agreed that data, metadata and related information needs to be transferred to the Regional Centre as soon as they become available within the timelines to be specified in the updated Requirements Document. The Regional Centre will establish promptly a dedicated and secured ftp server to ensure safe data transfer.

16. Subject to the fulfilment of commitments by the NMHSs, WMO in collaboration with HRC and the Regional Centre will strive to deliver beta-versions of first regional products by October 2016.

17. Participants agreed on the proposed milestones for the **implementation plan** that are attached as Annex 7 to this report.

18. Participants noted that WMO, within the limitations of available resources, will provide overall project coordination and necessary support to activities that lead to the successful implementation of the project. This includes, inter alia, the development and provision of training programmes that will be undertaken by the Regional Centre, HRC and WMO.

19. Participants agreed on the implementation of **landslide susceptibility maps** in the SAOFFG system.

20. Participant noted the development of new additional FFGS capabilities, including Urban **Flash Flood Forecasting and Warnings.** It was felt that the application of such an expanded system capability over some of the major urban areas having high risk from flash flooding would be beneficial. This would be a topic for consideration as the project develops.

21. Participants noted that there is a great benefit for the concurrent implementation of the Severe Weather Forecasting Demonstration Project-Southeastern Asia-Oceania (SWFDP-SAO) and SAOFFG projects in the region such that two projects can be linked to exchange data and products such as Quantitative Precipitation Forecasts (QPFs) of the high resolution numerical weather prediction model to enhance flash flood early warning capabilities. Participants agreed to consult with their respective government authorities to confirm their interests for the rapid implementation of SWFDP-SAO and recommended: 1) president of RA-V send invitation letters to the regional countries to indicate their interests in the establishment of SWFDP-SAO; 2) based on response of Members to his letter, president of RA-V to send an official letter to the Secretary-General of WMO for the rapid establishment and implementation of SWFDP-SAO; 3)strong and close linkages between SAOFFG Project Steering Committee and SWFDP-SAO Regional Subproject Management Team (RSMT).

ANNEX 1

Southeastern Asia-Oceania Flash Flood Guidance (SAOFFG) Project

INITIAL PLANNING MEETING
2-4 February 2016, Jakarta, Indonesia

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ANNEX 2

Development and Implementation of a Southeastern Asia-Oceania Flash Flood Guidance (SAOFFG) System

as part of the

Global Flash Flood Guidance System

INITIAL PANNING MEETING

2 – 4February 2016, Jakarta, Indonesia

FINAL ANNOTATED MEETING AGENDA

Day 1, Tuesday February 2nd (OPENING CEREMONY AT BMKG)

08:00 – 08:30 Transfer participants from Hotel to BMKG
08:30 – 09:00 Registration of participants
09:00 – 09:10 Opening remarks by DG of BMKG
09:10 – 09:20 Welcome speech by WMO
09:20 – 09:30 Welcome speech by USAID/OFDA
09:30 – 09:45 Overview and purpose at the workshop (WMO)
09:45 – 09:50 Photo Session
09:50 – 10:15 Coffee break
10:15 – 10:30 Transfer to hotel (facilitated by BMKG)

10:30 - 10:45 Tea Break

10:45 - 11:30 Role of the HRC and introduction to the FFGS concept(*HRC*)

- Flash flood definitions
- Global Flash Flood Guidance Initiative
- Flash Flood Guidance defined
- Forecaster Interface
- FFG Examples

11:30 - 11:45 Role of WMO *(P. Pilon, WMO*)
11:45–12:00 Role of USAID/OFDA *(USAID/OFDA*)

12:00 – 12:15 Role of NOAA*(HRC)*

12:15 - 13:30 Lunch

13:30 - 14:30 Presentations on flash flood issues –forecasting & warnings and their use in disaster management (*Hydrometeorological representatives* of Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore)

- The nature of the flash flood problem(s) and their impacts
- Roles of various agencies (in forecast, development and dissemination of warnings)
- Linkages to disaster management agencies
- Capability of using current data to forecast and warn (remotely sensed and in-situ data) and capability of Numerical Weather Prediction (NWP) for flash flood forecasting
- Current/existing forecast operations for flash floods
- Discussion of operational needs and constraints for warnings and disaster management

14:30–15:30 Needs of disaster management agencies for forecast and warnings of hydrometeorological hazards (*Disaster Management representatives* of Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore)

- Role of disaster management agencies with respect to flash floods, including urban flash floods, and landslides
- Disaster Management perspectives on requirements for forecast lead times, location, accuracy of forecast, and impacts of forecast
- Need for closer collaboration or increased abilities of forecasting agencies.

15:30 - 16:00 Tea Break

16:00 - 17:00 Example of FFGS Regional Implementation: Black Sea and Middle East Flash Flood Guidance (BSMEFFG) System *(A.Sayin, WMO)*

Day 2, Wednesday February 3rd

09:00 - 09:30 (Summary of Day 1)
09:30 - 10:30 Facilitated discussion on the SAOFFG System and assessment of *current* flash flood management approaches in the region (All)

10:30 - 11:00 Tea Break

11:00 - 11:45 Overview of FFGS Products (*HRC*)

- Soil Moisture Model Parameterization
- Snow Model
- Satellite Precipitation Estimation including Precipitation Bias Adjustment
- Threshold Runoff Estimation

11:45 - 12:15 FFGS Products Interpretation and Use *(HRC)*

- Product interpretation and adjustments

- From FFG products to advisories and warnings
- Quantitative Precipitation Forecast (QPF) Application
- Detailed discussion and examples
- Real-time Data Requirements and Use

12:15 - 13:00 Demonstration of the FFGS in real-time and previous evaluations *(A.Sayin, WMO)*

- Demonstration of BSMEFFG system
- Validation reports using historical forecasts and data

13:00 – 14:00 Lunch

14:00 - 15:00 Severe Weather Forecast Demonstration Project (SWFDP) and FFGS linkages (*WMO*)

- SWFDP, how it works
- Coverage area, model resolution, products and timeline
- Integrating SWFDP capabilities with FFGS

15:00 - 15:30 Discussion on QPF requirements for SAOFFG System application *(HRC)*
15:30-16:00 Data required for FFGS application *(HRC)*

16:00 *Visit to BMKG*

19:00 *Welcome Dinner (BMKG)*

Day 3, Thursday February 4th

09:00-09:30 Availability and access to critical data and information - Roles and Responsibilities of NMHSs in the Region - Discussion *(All)*
09:30-10:00 National and regional professional and technical capacities needed for project operations – Discussion *(All)*
10:00-10:30 Facilitated discussion on interest of countries to participate in the project *(All countries)*

10:30 - 11:00 Tea Break

11:00 - 11:30 Operations Concept of the project, including establishment of a Regional Centre and National Focal Centres, regional cooperation *(HRC)*
11:30 - 12:00 Organizational and management aspects of project planning and implementation *(P. Pilon, WMO*)
12:30 - 13:00 General discussion and expression of intent of countries to participate in the project, continued *(All countries)*

13:00 – 14:00 Lunch

14:30 - 15:00 Next steps and work plan (*HRC*)
15:00 - 16:00 Review of decisions and recommendations (*All*)

16:00 - 16:30 Tea Break

16:30 - 17:00 Review of decisions and recommendations, continued (*All*)
17:30 - 18:00 Final remarks and closing of the workshop

End of the Meeting

Development and Implementation of International and Regional Flash Flood Guidance (FFG) and Early Warning Systems

Project Brief

SOUTHEASTERN ASIA-OCEANIA FLASH FLOOD GUIDANCE (SAOFFG) SYSTEM

SUMMARY

The purpose of this project is the development and implementation of regional flash flood guidance and early warning systems. The approach will entail development of regional technology, training, protocols and procedures to address the issues of mitigating the impacts of flash floods and the application of such a system allowing the provision of critical and timely information by the National Meteorological and Hydrological Services (NMHSs) of the participating countries.

To accomplish this, the World Meteorological Organization (WMO) will cooperate with the Hydrologic Research Centre (HRC), San Diego, USA to implement a flash flood guidance and early warning system designed along the lines of similar systems that have been made operational in different parts of the world. In cooperation with a designated Regional Centre, normally located within one of the participating countries, the project will be executed by the participating national hydrometeorological services with the HRC providing technical assistance in cooperation with NOAA/National Weather Service for the system implementation and training; and WMO providing technical backstopping and supervisory services including Monitoring & Evaluation of the project. USAID/OFDA is providing funding support for the project.

Specifically the countries to be included in the project are proposed to be the followings: **Brunei Darussalam, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, and Timor-Leste.**

Based on estimation of rainfall from satellite imagery and available gauges, the system will provide the NMHS of each participating country with an estimate of the precipitation amount and an indication (guidance), based on physically-based hydrological modelling, as whether it would generate a bankfull discharge(e.g., minor flooding) at the outlets of small, flash flood prone basins throughout each country. The NMHSs will integrate local knowledge from other sources (their national networks, observers report, etc.) to validate the guidance and issue as required a warning through channels proper to each country

Technical assistance includes the development and implementation of the flash flood guidance and warning system as well as research and development into system enhancements, including inclusion of infrared and microwave technology for satellite rainfall estimates, as needed for the different implementations, and training and capacity building on system operations and applications to disaster risk reduction (i.e., an end-to-end system approach). The approach will provide a tool for each country within the specified region to access the data and information needed to develop alerts and warnings for flash floods.

The main objective of this project is, therefore, to contribute towards reducing the vulnerability of the region to hydrometeorological hazards, specifically flash floods, by developing and implementing a flash flood guidance system to strengthen regional and national capacity to develop timely and accurate flash flood warnings.

1. Beneficiaries

In many areas of the world, flash floods are a regular phenomenon accounting for loss of human life and significant economic and social damages, adding up to hundreds of millions of Euros for a single event. Flash floods can affect not only mountainous and hilly rural areas with sparse settlements but also major urban areas. In addition, an increase in their frequency and magnitude is anticipated as a consequence of climate change. Implementation of a flash flood

guidance system would provide benefits to all societal and economic stakeholders of each country.

A key benefit of the proposed system is that it is capable to provide early awareness of impending local flash flood threats for all potentially vulnerable communities. A true value of the system will be to provide rapid assessments of the potential of flash floods allowing improvement of the early warnings for the occurrence of a flash flood and therefore allowing for more rapid mobilization of response agencies.

The system implementation also provides capacity building and cooperation for effectively mitigating disasters from flash floods. Training and capacity building will be a strong component of the implementation of this program. There will be opportunities in cross-training of hydrologists and meteorologists from countries within the region and with different backgrounds and skills in hydrometeorology, which forms the basis of flash flood detection and prediction.

The availability of the system guidance products will also help to improve the way flash flood events on trans-boundary Rivers are addressed, encouraging international technical cooperation and regional cooperation in preparing public awareness campaigns and response strategies.

Primarily aiming to improve national service delivery capabilities to deal with flash flood threats, the implementation of the flash flood guidance system will also provide the opportunity for enhancement of regional collaboration of disaster mitigation and response agencies and improvement of community awareness of flash flood hazards threat and mitigation.

Training programs will be designed to include NMHSs to develop strong scientific and technical capabilities to use the FFG system and further to include disaster management agencies where the responsible agencies will be involved in system validation programs which will require determinations of where flooding did or did not occur. The issuing of warnings based on flash flood guidance and flash flood threat products will conform to establish national practices, if existing; alternatively the project could provide support to a national dialogue for their development. The establishment of such criteria requires understanding of the hydrometeorological processes and prediction uncertainties, as well as capabilities of the population to take effective action. Such a process will encourage the national agencies to interact with local communities both in establishing such criteria, and in regular reviews of their effectiveness. The responsible agencies will need to design awareness campaigns for both municipal agencies and the public at large concerning the interpretation of flash flood warnings and effective action strategies (i.e., what to do in when flash flood warnings are received). To be effective, this effort will require input from local community representatives (emergency response agencies and the public at large). Maintaining these public awareness campaigns and information distribution as ongoing efforts required to reduce flash flood casualties will be needed.

The flash flood guidance system functions at one level as a disaster mitigation tool by mitigating loss of life and livelihoods, and by rapidly targeting disaster response agencies to potential problem areas. On another level it can be used to provide maps of flash flood probabilities, threats and decision-aiding for imminent actions. These maps can be used to provide a risk assessment tool and guidance concerning the development of infrastructure – that is, as a guide to where special care should be taken in the design and locations of particular facilities as the population expands to live in flash-flood prone areas.

All these agencies will be involved in system validation programs which will require determinations of where flooding did or did not occur. To be effective, this effort will also require input from local community representatives (emergency response agencies and the public at large).

2. Sector-Level Coordination

Through the project partners representing the technical aspects of the system implementation and operation will be brought together with agencies in disaster risk reduction to develop a detailed work plan that will enable operational engagement of technical and disaster risk reduction agencies for implementation of the system.

The work plan for disaster risk reduction will address activities such as joint training programs and public outreach and awareness programs. This effort will provide the opportunity for enhancement of regional collaboration of disaster risk management agencies and improvement of community awareness of flash flood disaster threat and mitigation. Training programs will be designed to include NMHSs and the disaster management agencies.

3. Technical Design

Flash floods are a hydrometeorological phenomenon that requires integration of meteorology and hydrology in real time and ingestion of local information and expertise for reliable warnings. The system design aims to allow for both. This system will serve as a catalyst to develop protocols in line with regional and country norms pertaining to other event warnings. The system allows that even within a region different countries will develop their own manner of system configuration and use adapted to local requirements as a tool for developing flash flood warnings and watches together with other local timely information.

Important technical elements of the Flash Flood Guidance and Warning System are the development and use of a bias-corrected satellite precipitation estimate field, high-resolution numerical weather prediction model outputs (where available), and physically-based hydrological modelling to determine flash flood guidance and flash flood threat. These system elements can now be applied anywhere in the world. Real-time estimates of high resolution precipitation data from satellite are now routinely available globally (and can be further enhanced with locally available radar estimates of precipitation). Global digital terrain elevation databases and geographic information systems may be used to delineate small basins and their stream network topology anywhere in the world. In addition, there are global soil and land cover spatial databases available to support the development of physically-based soil moisture accounting models (see Flowchart in Figure 1). The real-time satellite precipitation estimates needed to drive the regional systems on a global scale (using global data provided by NOAA and the WMO) will be developed first followed by the development of specialized products.

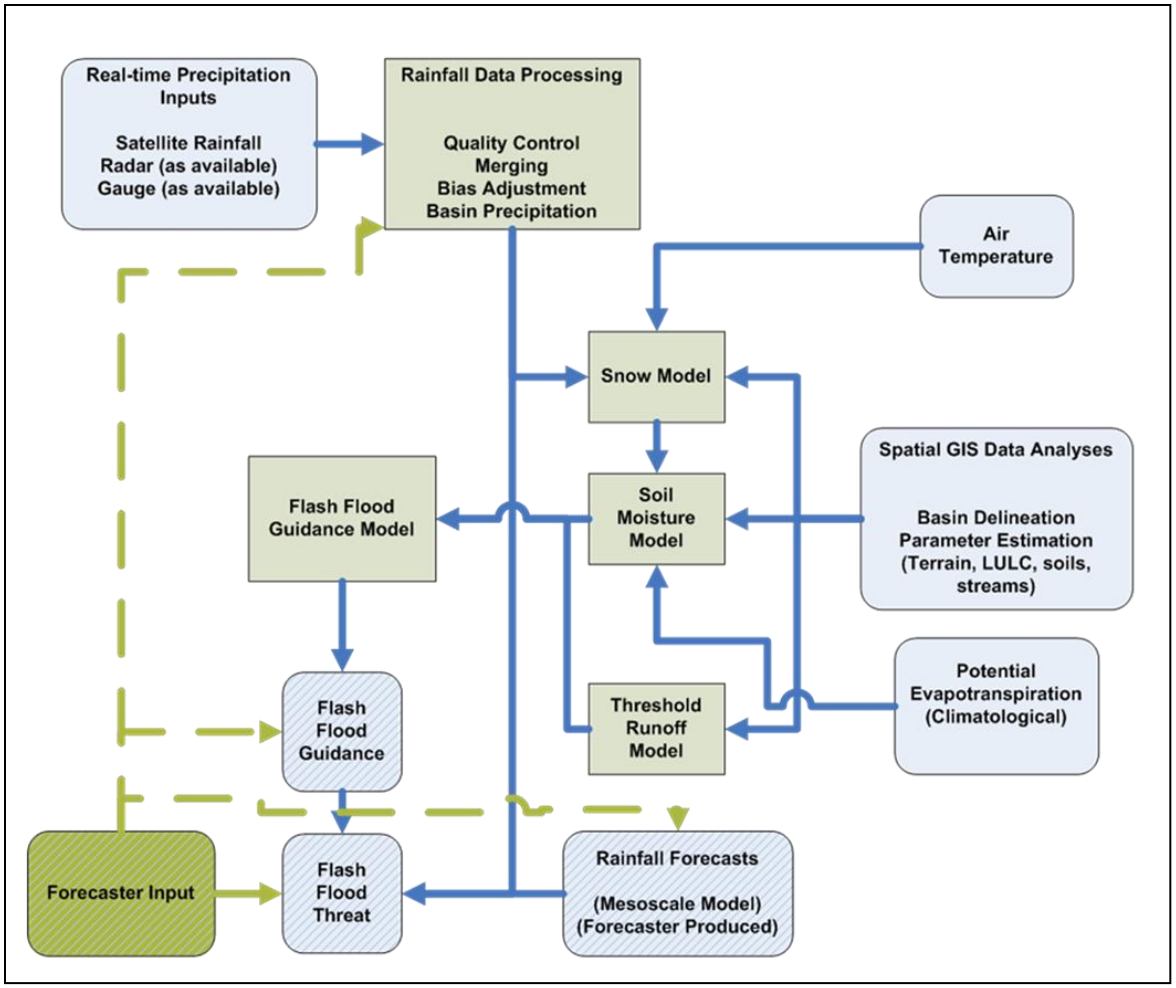

Figure-1 Schematic Flowchart of the Flash Flood Guidance System

The system allows the NMHSs to use local nowcast/short-term-forecast methods they wish to use to issue the warnings, including (and strongly recommended) local forecaster adjustments. The system design allows this coupling with the existing or developing NMHS approaches on a national or even local scale.

System flexibility and system capability to engage local forecasters should help greatly towards the development of regional/local protocols for integration within existing warning dissemination systems.

The system will provide evaluations for the threat of flash flooding over time scales of hourly to six hours and for sub-basins on the order of 150 sq. km. on average. Given the computational burden and depending on available computational resources, it is very likely that the most valuable lead times for system use will be up to 6 hours. Efforts might also be undertaken through the application of numerical weather prediction model outputs to extend the range of threat prediction to 24 hours.

4. Implementation Approach

The system design is such that it allows for efficient global data ingest and it supports regional cooperation among NMHSs. The design is characterized by distributed operations and functions. Several centres of computation and product dissemination will support the operational functions of the NMHSs through the timely provision of data, software, hardware and training. The overall organizational structure is shown in Figure-2.

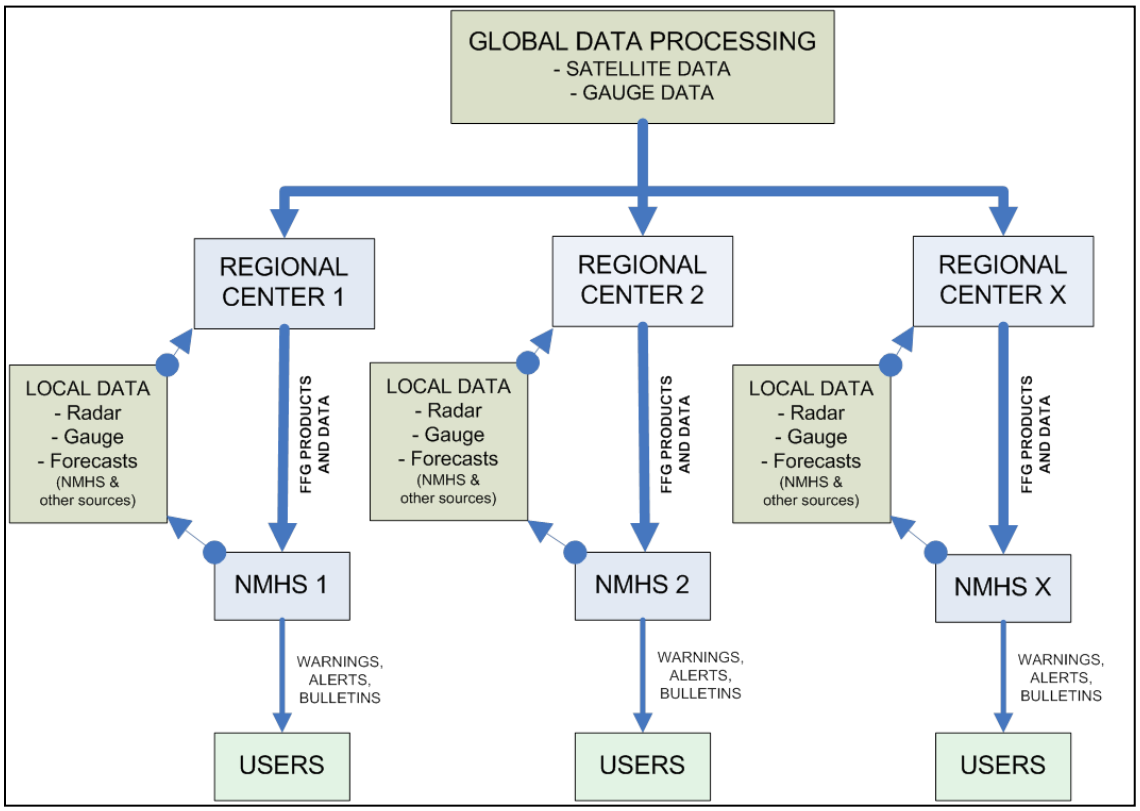

Figure-2:Flash Flood Guidance and Warning System as a distributed system of computer hardware, data and information to support NMHSs worldwide.

The interface with global information is the link to real-time global satellite precipitation estimates and global in situ observations will be through one or more of the World Meteorological Organization (WMO) Global Centres.

All requisite real-time data (global, regional, and local) are ingested at servers located at the Regional Centres where the FFG software is installed. Graphical and text products are then provided to the participating countries through a secure internet connection.

It is necessary to designate a focal institution (most probably an NMHS or an existing Regional Centre with proven scientific and technical capabilities) and with existing communications and infrastructure capabilities to support a Regional FFGS centre.

Key operational Regional Centre responsibilities are:

- Disseminate real-time country graphical products from the FFGS for the NMHSs in the region;
- Collect available real-time local meteorological data for ingest to the FFGS for the development of regional products;
- Support regional flash flood operations by;
    - Provide regional validation of products and formulation of plans for improvements, and
    - Provide communications for system analyses to NMHSs of the region.
- Provide communications of regional system modifications necessary to system developers;
- Develop a historical archive of the system products;
- Support WMO and developers with regional training of NMHS representatives; and,
- Provide routine maintenance and IT support for the FFGS server.

NMHSs functions pertaining to the use of the flash flood guidance and warning system will include: country hydrometeorological analysis using the system products and information and other local products and information; country modifications of the regional-centre flash flood guidance and precipitation nowcasts on the basis of within-country most-recent data and information; development of local flash flood watches and warnings; monitoring of system performance (availability and effectiveness) and feedback to the regional centre; and links to within-country disaster management agencies for effective disaster risk reduction. Resources of country NMHSs will determine the actual configuration and type of software used in each case, given the provision of within-country baseline software and links to regional centre facilities as discussed previously.

It is expected that the products available from the Regional Centre will be adequate to support a range of processing capabilities at the NMHSs, from those that can be performed on a PC with Excel software to those that support interactive graphical generation of products. This provision will allow the NMHSs of all the countries to develop real time flash flood forecasts and watches/warnings using the global-data information and their local data and information. There will also be a provision for countries that are willing to share local real-time data to produce graphical products and updated guidance information for their areas to complement the locally produced products with the baseline configuration mentioned.

One key to sustainability is confidence in a reliable, accurate system. To accomplish this, reliability evaluations will be included in the concept of operations.

5. Transition and Exit Strategy

Upon completion of the project, each country within the region will have access to the flash flood guidance and early warning system data and products via the internet. The required data will be accessed and processed through the regional facilities. At the country level only a PC and internet connectivity will be required to access the data and products required to evaluate potential flash flood threat, making the system very sustainable. The regional centres will be selected based on resource requirements to ensure appropriate access to the required data and maintenance capacity.

Much of the effort to ensure sustainability of the flash flood guidance and early warning system will be through training and cooperative development efforts. This approach is intended to ensure ownership and full operations responsibility. In addition, a concept for the operation of

the system within the existing operations protocols of the countries will be outlined for each country during training. A User Guide will be developed for the Regional Centre for system operations and maintenance.

6. Project Implementation

Project implementation is based on the basis of a Project Implementation Plan (PIP) that will be discussed during the initial regional planning meeting. The Plan will provide information with regard to essential requirements and criteria that need to be met for the successful implementation of the project. These requirements include: Availability and accessibility of critical input data and information including geo-spatial information, historical and near real-time meteorological and hydrological data, basic institutional infrastructure and technical/professional expertise of participating meteorological and hydrological services.

The PIP including a work plan will be discussed during the initial planning meeting with principal stakeholders and beneficiaries of the project.

7. Institutional status

In February 2009, WMO signed a Memorandum of Understanding (MoU) with USAID, HRC, and NOAA on the implementation of the Flash Flood Guidance System with global coverage project. In June 2012, the MoU was renewed until the end of 2017. Funding is available from USAID as the principal donor organization.

As a result of the expression of interest of participating countries in the Southeastern Asia-Oceania Flash Flood Guidance System, an initial planning meeting has been arranged. This meeting will allow:

- Country experts to see first-hand the technical components of the FFG system;
- Country experts to assess the potential utility of adopting such a system within their operations;
- Understanding of the requirements of national centres and the regional centre;
- Understanding of national implementation requirements including professional staff;
- Understanding of the regional and national primary data collection required for the initiation of the project; and
- Countries to consider the overall project and whether each wishes to commit to undertaking and supporting the implementation of the project in the Southeastern Asia-OceaniaRegion.

Should countries wish to commit to the implementation of the project, countries would then decide on their national centres and the regional centre.

WMO in collaboration with financial, technical and regional partners now plans to organize the initial planning meeting where interested countries through the Permanent Representatives of WMO Members and their Hydrological Advisors or designated alternates are expected to discuss all aspects of the proposed project and eventually express whether they commit to participate and cooperate in the project activities and provide technical information that is critical for the successful implementation of the project in the region.

Aside from the commitments made by participating national agencies, it will be essential to have full details available on issues such as in-kind contributions through infrastructure and personnel, areal information specifying the area(s) to be covered by project activities in the region, availability of supporting data and information including geospatial and historical hydrometeorological information. Likewise, the governance of the project and the roles and responsibilities of national participating centres and a Regional Centre will be on the agenda of discussion with expected recommendations and decisions to be made during the meeting. This will be compiled through information received from countries and services on the basis of a Requirements Document to be developed.

The project will be phased over a period of several years that will be determined during the initial planning meeting, with the bulk of the development and implementation activities occurring during the first year to two years. The remaining years of the project will focus on training, system operations/evaluation and validation of system outputs to ensure on-going sustainability.

ANNEX 4

GLOBAL FLASH FLOOD GUIDANCE SYSTEM

Implementation Requirements

Regional Implementation Requirements for Southeastern Asia-Oceania (SAOFFG)

Document Purpose

This document provides guidance to project participants, in particular National Meteorological and Hydrological Services (NMHSs) on minimum requirements with respect to professional capabilities, availability of data and information as well as computational and communication infrastructure to implement a **Flash Flood Guidance System (FFGS)** with global coverage. In addition, the document provides information of the functions of the Regional Centre and NMHSs leading to the delivery of flash flood guidance products on regional and national levels.

These requirements reflect a system that provides timely and useful data and information based on robust communication infrastructure in a form that is consistent with the operations in place in many of the National Meteorological and Hydrological Services (NMHSs) throughout the world. Of primary importance is to establish a system that becomes part of NMHS operations and is used as the primary tool by these services for providing flash flood alerts/warnings to the appropriate agencies and/or the public.

Overview of the FFGS

The primary purpose of the FFGS is to provide real-time informational guidance products pertaining to the threat of potential flash flooding. The system is designed to address the reduction in devastation caused by flash floods in terms of reductions in the loss of life, suffering and property damage. The system provides the necessary products to support the development of warnings for flash floods from rainfall events through the use of remote sensing-based rainfall estimates (primarily satellite).

The system products outputs are made available to forecasters as a diagnostic tool to analyze weather-related events that can initiate flash floods (e.g., heavy rainfall, rainfall on saturated soils) and then to make a rapid evaluation of the potential for a flash flood at a location. The system empowers users with readily accessible observed data and products and other information to produce flash flood warnings over small flash flood prone basins. The system is designed to allow the addition of experience with local conditions, incorporate other data and information (e.g., Numerical Weather Prediction output) and any last minute local observations (e.g., non-traditional gauge data), to assess the threat of a local flash flood. Generally, evaluations of the threat of flash flooding are done over hourly to six-hourly time scales for sub-basins from 100 - 150 km^2 in size.

Important technical elements of the FFGS are the development and use of a precipitation gauge-based bias-corrected satellite precipitation estimate field and the use of hydrologicalmodelling. The system then provides information on rainfall and hydrological response, the two important factors in determining the potential for a flash flood. The system is based on the concept of **Flash Flood Guidance** and **Flash Flood Threat.** Both indices provide the user with the information needed to evaluate the potential for a flash flood, including assessing the uncertainty associated with the data.

The flash flood guidance approach to developing flash flood warnings rests on the comparison in real time of observed or forecast rainfall volume of a given duration and over a given catchment to a characteristic volume of rainfall for that duration and catchment that generates bank full flow conditions at the catchment outlet. **Flash Flood Guidance** (FFG) is that characteristic rainfall volume for the given duration over the small catchment that generates bank full flow conditions at the catchment outlet. FFG is updated in time based on current soil water deficit (as determined by antecedent soil moisture conditions), rainfall, evaporation, and

groundwater losses. If the observed or forecast rainfall volume exceeds the FFG of the same duration, this excess is termed the **Flash Flood Threat (FFT)** and flooding at or near the catchment outlet may be likely.

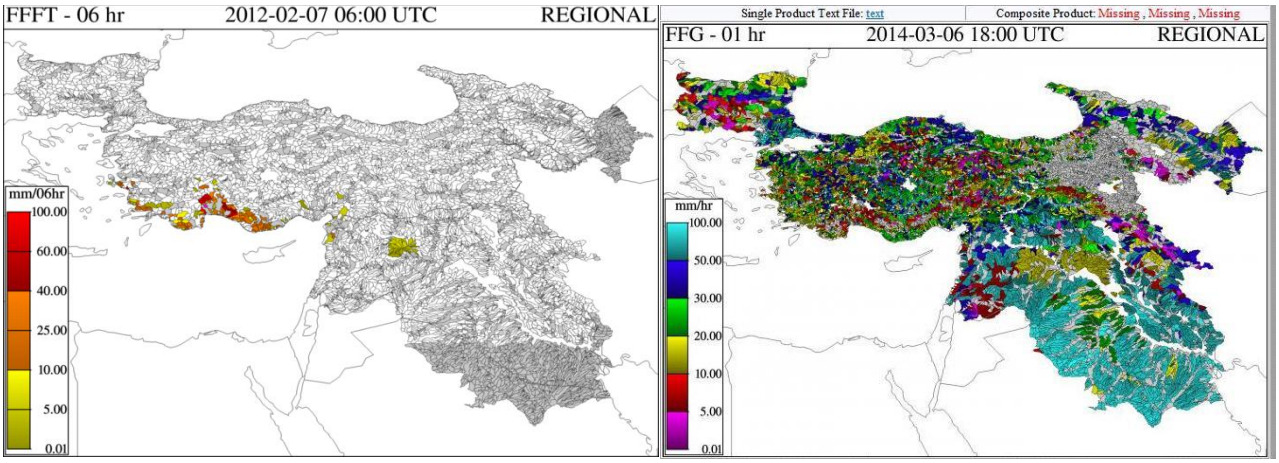

Figure-1:6hr-Flash Flood Threat and 1-hr Flash Flood Guidance for BSMEFFG

Global Flash Flood Guidance System Program Background

The purpose of the Global FFGS (GFFGS) program is the development and implementation of regional flash flood guidance and early warning systems. The approach entails development of infrastructure on a global scale to then support the development and implementation of regional flash flood guidance projects comprising of technology, training, protocols and procedures components to address the issues of mitigating the impacts of flash floods.

Regional flash flood guidance and early warning systems are designed based on programs in Central America, Southeast Asia, Black Sea Middle East and Southern Africa. The project approach is to provide a tool for each country within a specified region to access the data and information needed to develop alerts and warnings for flash floods. The main objective of this project is, therefore, to contribute towards reducing the vulnerability of people around the world to hydrometeorological hazards, specifically flash floods, by developing and implementing flash flood guidance systems to strengthen regional capacity to develop timely and accurate flash flood warnings.

The data and information part of the requirements also provides guidance with respect to the selection of areas/basins on national level that can be covered with a flash flood guidance system based on the availability of critical data and information.

Implementation of this program is in concert with the World Meteorological Organization's Flood Forecasting initiative guided by the Hydrology and Water Resources Branch of the Climate and Water Department of WMO. In the context of this initiative, the World Meteorological Congress has endorsed the implementation of a Flood Forecasting Initiative. A goal of this initiative is to develop and implement programs that encourage hydrologists and meteorologists to work together towards the improvement of operational flood forecasting services.

The GFFGS program is being accomplished under the Memorandum of Understanding (MoU) noted below[2] through funding by the U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance (USAID/OFDA).

The system design is such that it allows for efficient global data ingest and support of regional cooperation among NMHSs. The system design is characterized by distributed operations and functions on global, regional and national levels. Centres of computation and product dissemination will support the operational functions of the NMHSs through the timely provision of data, ancillary information, software, hardware and training. A schematic of the global-regional-national system is shown in Figure-1.

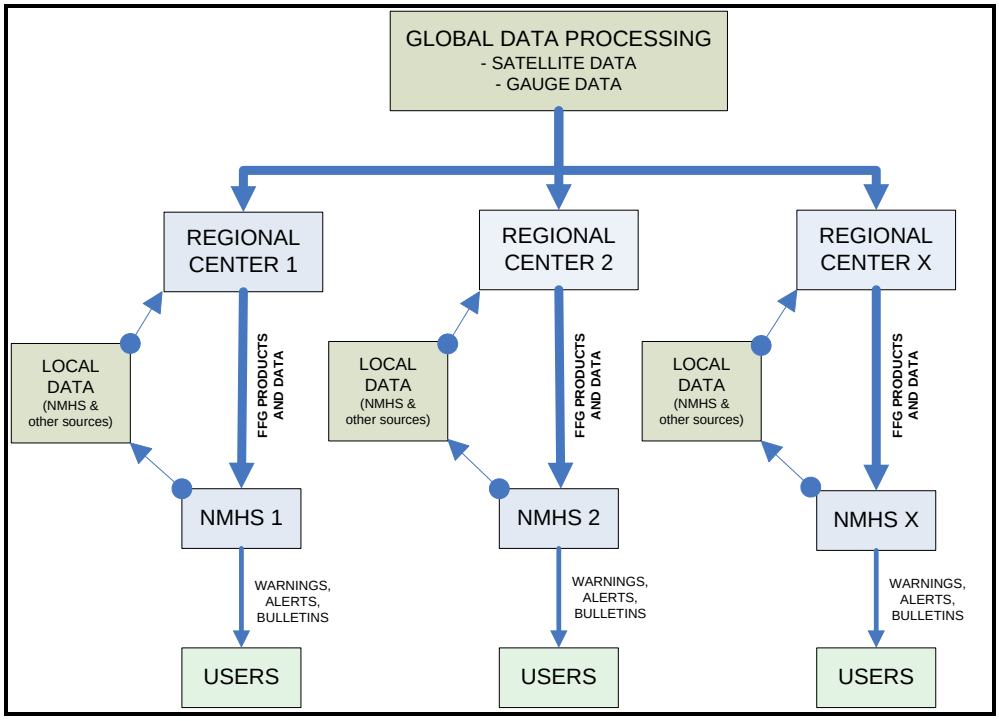

Figure-2: GFFG System Schematic – Global Implementation

Implementations of regional projects are achieved through the development of an interface with the global core and with the RegionalCentres. The global data core link to real-time global satellite precipitation estimates will be through the U.S. National Oceanic and Atmospheric Administration/National Environmental Satellite, Data and Information Service (NOAA/NESDIS). If required, global in situ observations will be provided through one or more of the World Meteorological Organization (WMO) GlobalCentres (Washington, DC; Moscow; and Melbourne) and Regional Telecommunication Hubs including Bangkok, Beijing, New Delhi and Tokyo. The primary functions of the global data ingest and processing core are to:

[2]MoU "Establishing a Cooperative Initiative among the World Meteorological Organization, Hydrologic Research Centres, U.S. National Oceanic and Atmospheric Administration/National Weather Service and the U.S. Agency for International Development/ Office of U.S. Foreign Disaster Assistance for the Flash Flood Guidance System with Global Coverage Project"

- Provide global data ingest and quality control;
- Access global meteorological information to supplement data collected at the regional level as needed;
- Maintain correspondence with the Regional Centres; and
- Implement computational system changes.

The Regional Centres will require ***appropriate communications*** and ***infrastructure facilities*** to support operations. The proposed responsibilities of the Regional Centres are outlined in Appendix A.

In summary, the Regional Centres responsibilities are to:

- Disseminate real-time detailed country graphical products and/or data for the NMHSs in the region;
- Provide routine regional hydrometeorological analysis;
- Provide communications for system analyses to NMHSs of region;
- Provide communications of regional system modifications necessary to developers;
- Provide regional flash flood hazard information;
- Provide regional *validation of products* and formulation of plans for improvements;
- Provide daily *guidance discussion* to NMHSs from a regional perspective;
- Collect available *real-time meteorological data* for the development of regional products;
- Provide *regional training* of NMHSs representatives;
- Provide, if necessary, a *computational platform* for country scale real-time computations and modifications of flash flood guidance products for those NMHSs that lack adequate computational capabilities;
- Provide routine *maintenance and IT support*; and
- Develop *a historical archive* of the system products.

NMHS functions pertaining to the use of the flash flood guidance and warning system include:

- Develop country *hydrometeorological analysis* using the system products and information and other local products and information;
- Develop country adaptations of the flash flood guidance and precipitation nowcasts on the basis of within-country most-recent data and information;
- Develop local *flash flood watches and warnings* as required;
- Provide *data and information* to the Regional Centres (based on regional agreements);
- Monitor system (products) performance (availability and effectiveness), conduct country *verification studies* and feedback to the Regional Centres; and
- Communicate with user agencies for effective disaster risk reduction.

Resources of country NMHSs will determine the actual configuration and type of software used in each case, given the provision of within-country basic software and communication links to Regional Centres facilities.

It is expected that the products available from the Regional Centres will be adequate to support a range of desk top computer-based processing capabilities at the NMHSs, from using simple spreadsheet software to those computational facilities that support interactive graphical generation of products (much like the capability of the Regional Centres). This provision will

allow the NMHSs of participating countries to develop near real-time flash flood guidance and warnings.

Data and Information Requirements

To ensure that the FFGS provides the highest quality data and information to forecasters, various historical and real-time hydrometeorological data and other information are required in order to develop, implement and operate the flash flood guidance systems. Historical data and information are needed for the development of the system and calibration of the models. Real-time data are needed for system operations. Terrain and other spatial-database information are used to delineate the small catchments for which flash flood guidance will be computed, to calibrate the models and to operationalize the flash flood guidance information.

It cannot be emphasized enough that quality data and information are needed to provide the optimum system for use by forecasters for the development of flash flood warnings.

Data and information needs are detailed in Appendix B. Appendix C is a survey of automatic rain gauges and weather stations. This information is important to fully understand the current status of these systems.

Resource Requirements

Personnel

The system is designed to be used operationally and jointly by meteorologists and hydrologists. The following expertise is recommended at the Regional Centres and country levels for the primary users, mainly the system operators. Recommended minimal available expertizes are given in Table-1.

Table-1: Minimal personnel Equipment for Regional Centre and NMHSs

Area of Expertise	Regional Centres	NMHSs
Have a meteorological and/or hydrological technical background.	Both meteorological and hydrological forecast expertise.	Either meteorological and/or hydrological forecast expertise.
Have experience in operational weather and/or hydrological forecasting specific to the region or country.	Priority	Priority
Have experience in weather-related hazard emergency management operations	Priority	Priority
Have experience in or knowledge of quantitative analysis of satellite-based rainfall estimates.	Priority	Preferred

Area of Expertise	Regional Centres	NMHSs
IT capability for server system administration, network connectivity, and product availability.	Priority	Preferred

Both the Regional Centre and the country NMHS should operate on a round-the-clock basis either continuously year-round or at the minimum during seasons with significant flash flood risk.

Computers and Communications

High performance servers with the LINUX operating system will be run at the Regional Centres through the project. The country NMHSs are required to have current-generation PCs and an internet connection with periphery devices in order to access products from the internet. On the other hand, the Regional Centre will need hi-speed internet service and, potentially, access to GTS/WIS.

Appendix A

Regional Centres Roles and Responsibilities

Operations Overview – Regional Centres

The Regional Centres (Centres) play a critical role for the sustained operations of the Flash Flood Guidance System with global coverage (FFGS) within the region. The Centres will be the focal point for access by the countries (including their own) to data, information and products required to make rapid decisions with regards to flash flood threats. The Centres will also play a role in training (or providing guidance) and with hydrometeorological analyses within the region. The Centres will also be responsible for maintaining the server nodes of the FFGS. The Centres is essentially the organization at which all regional data and knowledge exist for the successful operation of the FFGS in the region. Accordingly, the Centres role in the FFGS process requires a higher standard of computational infrastructure and professional expertise than that of the NMHSs of participating countries within the region. As with the NMHSs, the schedule for performing their specific operations is based on specific operational requirements as well as the current or anticipated flash flood hazard.

Responsibility for global data ingest and for regional information and communications (e.g., highlighting particularly vulnerable areas within the region, regional hydrometeorological analyses), training and regional coordination of flash flood guidance and warning operations, as well as regional FFGS validation lies with the Centres. NMHSs will work with the Centres in developing flash flood guidance/warning protocols that are appropriate at national level and consistent for the region and mode of FFGS operation, as well as by their particular links to within-country users (e.g., disaster management agencies). Responsibility for flash flood guidance and warnings as well as disaster preparedness and coordination with disaster management/response agencies lies with the country.
The Regional Centres will play a key role in the development of regional protocols and operational requirements and in defining any design requirements specific for that region. To do this the Centres will need to coordinate inputs from the countries during all phases of implementation.

Regional Centres Operational Roles and Responsibilities

The Centres will maintain and operate the Regional Linux server which computes and disseminates regional and country FFGS products (text and/or images). In meeting its responsibility to maintain the base node of the FFGS system, the Centres will have the following roles, responsibilities, and operations to the extent possible:

- As needed, the Centres will develop and maintain a local database of contributed, real-time input products from participating NMHS agencies and make available those products to the automated acquisition processes of the FFGS Computational Server. This will require that the Centres work with the countries to develop a set format of the data to be transferred to the Centres for use developing this real-time database that feeds the FFGS;
- Centres forecasters will work directly with the country forecasters in evaluating and applying the FFGS products and will provide critical hydrometeorological expertise where required;

- Where appropriate, the Centres will be available for the briefings and discussions needed to properly evaluate flash flood potential using the FFGS tool. The Centres forecasters will work with the country forecasters to ensure that they understand the weather forecasts and to provide consistency, including evaluating and interpreting the applicability of current and forecast precipitation events;
- The Centres will evaluate the FFGS products from a regional perspective and will communicate this perspective to the countries as appropriate. The Centres will ensure consistency of FFGS products throughout the region;
- The Centres will provide regional and national validation of system results and will advise the countries of the presence of noted biases in system outputs;
- Where appropriate, the Centres will coordinate the issuance of consistent flash flood watches and warnings (as applicable) using the FFGS tool as well as other information and tools available;
- The Centres will provide routine training/workshops on system operations, product interpretation and development, product verification, etc. to country forecasters; and
- The Centres will coordinate with the global data processing Centres in matters of data flow and communications or for conveying information regarding potential improvements that will affect the region products.

Centres System Management/Maintenance Roles and Responsibilities

Even though the FFGS servers are designed to be fully automated, there will always remain a critical need for ongoing observation and quality control of its processing tasks and data products. This requires expertise from two basic categories: systems administration and operational quality control of the data products. Skills in both areas of expertise are needed to properly monitor and confirm the overall performance of the system. This can be fully achieved only through the cooperative efforts of both IT Staff and Forecasters. In fulfilling its system maintenance responsibilities, the Centres need to perform the following activities:

- Maintain Network Connectivity and Data Availability – This relates primarily to the systems administration efforts of IT staff. Of concern are potential problems related to internet and/or GTS service availability, network cabling, switches, or any one of numerous hardware and security issues related to the servers themselves. The assessment and correction of potential problems relating to any of these areas requires specific technical skill and an understanding of the systems and technologies involved;
- Product Quality Control – This relates to the function of the forecasters at the Centres. Their expertise in hydrology and meteorology is required to properly understand the relative quality of the FFGS input and output products at any given time. Accordingly, Centres forecasters must perform quality control procedures on the data and outputs and determine whether or not any perceived problems are the result of a parametric shortcoming, a failure in one of the FFGS models, or if it might relate to the quality or availability of the real-time input data that drives the system; and
- Operational Process Monitoring – In order to successfully fulfill the specific responsibilities of IT staff and forecasters identified above, both groups must engage in a necessarily cooperative effort of routine and systematic review of system processing activity. This involves regular inspection of system image products, data products, status indicators and log files as a means to confirm the proper operation and health of the system while maintaining a keen familiarity with the status quo in order to immediately recognize any deviation from it.

Training Responsibilities

The Centres will be directly involved in the various training programs during implementation and operations. Training programs can involve both Centres staff and country staff. Regional representatives will be equipped to play a fundamental part in the training of country staff, especially during system operations. The primary purpose of training is for Centres representatives to familiarize themselves and develop a level of competency in the FFGS basics (physical principle, components, operation, and validations), product interpretation and use, and collaboration for prediction and warning. Particular emphasis for the Centres will be placed on validation, operations, trouble shooting and maintenance, data management, communications, realistic scenarios, and preparedness for unusual circumstances or errors. Usual training programs involving Centres (and country) personnel are noted below.

Regional Workshops

An initial and final (operations) workshops are held in the region to introduce hydrologists and meteorologists to a variety of topics including the hydrometeorology of flash floods, basic system design including products, overview of the required data and information needed for system development and operations, system validation, and concept of system operations.

The operations workshop will be held after system implementation and other training programs have been completed. This workshop will be conducted at the Centres and will provide additional training for NMHS representatives from all countries within each region. The system overview and hands-on demonstrations will include presentations by the trained Centres representatives. The focus of this workshop is too identify and plan for country specific flash flood scenarios using the FFGS in addition to synthesizing coordination protocols for operations and communications between the Centres and NMHS staff. An interactive component during the operations workshop allows for a demonstration of the system. Collaboration will involve an accounting of regional and national considerations depending on geography, climate, and communications or other hardware/structural capability.

Hydrometeorologist Training Program

The main focus of this training program is to familiarize meteorologists and hydrologists with the complex interrelationships between atmospheric moisture, low level features, and geomorphology that can result in storm-specific enhancement of precipitation efficiency and increase a given precipitation event's chances to produce a flash flood. The online Hydrometeorologist courses for meteorologists and hydrologists focus specifically on supporting the Flash Flood Guidance systems by providing the necessary tools to assist in the forecast of flash floods. This training is available online to all FFG users.

Online Interactive Training Program

This program provides virtual simulations of the FFGS software functions in interactive and demonstration modes. A collection of flash flood case studies from around the globe will be developed using FFGS software and archives from implemented flash flood guidance systems. Learners will be required to forecast flash flood events using the available information. Centres staff will work together with country staff to accomplish the simulator training.

Hands-on Training

This training will be conducted when the FFGS computational and communications components are in place and operational. Centres and country representatives from the region will receive hands on training simulating daily operations and developing validation programs for each region through close contact with their colleagues in the NMHSs in their region. It is expected that this type of training, perhaps more than any other, will develop a core of professional Hydrometeorologists with flash flood forecasting specialization that will be key for the sustainability and increase effectiveness of the FFGS system both regionally and within each country. In addition these professional Hydrometeorologists will utilize their hands-on experience to train regional and in-country forecasters. This will further increase the sustainability and effectiveness of the FFGS systems into the future.

Regional Training – System Installation and Maintenance

Training will be scheduled during system installation for Centres representatives and prepare them to guide NMHS representatives in operational use of the FFGS system. This training will include the assurance for ingesting required real time inputs (e.g., radar, gauge and satellite rainfall estimates), testing system performance during operation, data archival and restoring functions, and communication components. This training will be accomplished in system administration training program during system installation and implementation at the Centres.

Ongoing Training

An ongoing regional training program involving the Centres will be developed to maintain proficiency with system operations, ensure continued system validation, and ensure continued system use and ownership. This will involve continual engagement with the community of users. Tools will be developed to build capacity to improve the system and handle more complex contingency scenarios (e.g. key data missing, failure in “normal” operations, communications, or other such events).

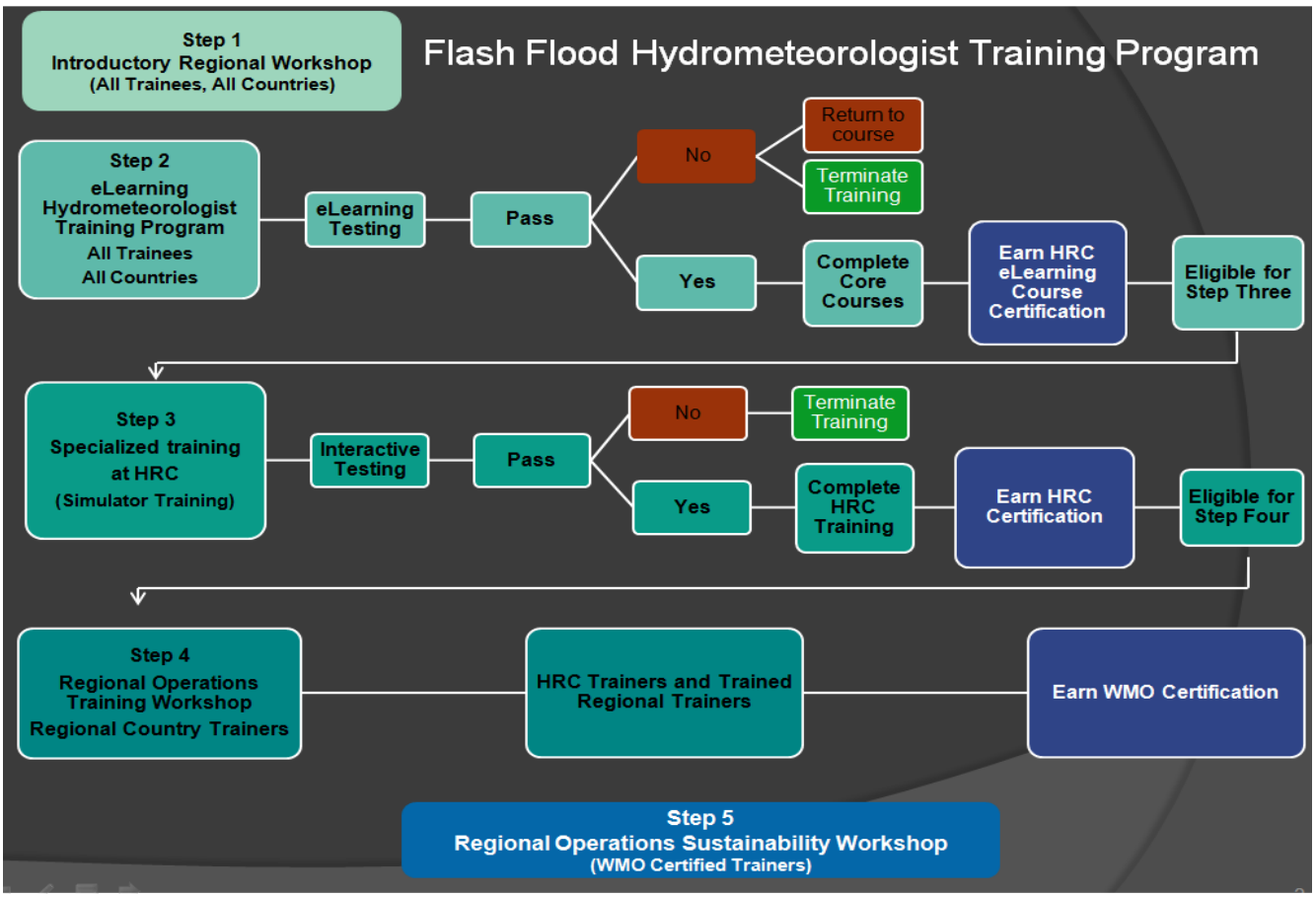

Figure-1: Flash Flood Guidance System Hydrometeorologist Training Programme

Appendix B

Data Requirements

For the development and operation of Flash Flood Guidance System, local historical and/or climatological hydrometeorological and geomorphologic, and real-time data are required. They are used for, among others, model parameterizations, calibrations, bias adjustments. Use of the higher resolution spatial and temporal local data in the FFG models is critical for the system performances. At the absence of local data, they will be obtained from international organizations like soil data from FAO (Food and Agricultural Organization). Therefore, participant countries are advised to collect, arrange and provide the following data types in required formats, depending on the availability of them.

A. NMHS Capacity Information

Institutional capacities, responsibilities:

- Hydrometeorological observation network, data processing and visualization tools;
- River and flash flood forecasting and early warning tools;
- Nowcasting tools;
- QPE/QPF tools and models;
- IT capabilities; and
- Organization structure (forecasting department, regional offices etc.,).

B. Spatial GIS Data, Maps

- Digital terrain elevation data (quality controlled);
- Stream network;
- Lakes/reservoirs/wetlands;
- Soil type, texture and depth;
- Vegetation cover, and land usage; and
- Monthly climatological maps of precipitation, temperature and potential evapotranspiration.

C. Spatial GIS Data, Maps

Channel cross-sectional Information for natural channels with drainage areas less than 2,000 km^2. The following hydrometeorological data, 5-20 years in record length, preferable in digital format:

- Precipitation (hourly, daily, monthly), covering at least past 5 years as much as available;
- Surface air temperature (hourly, daily, monthly);
- Top soil moisture (daily, weekly, monthly);
- Stream flow discharge for local streams with drainage areas less than 2000 km^2 (hourly, daily, monthly);If stream flow discharge data are unavailable, stream stage data (hourly, daily, monthly) and associated stage-discharge curves (rating curves), also for local streams;

- Snow depth, snow water equivalent (SWE) and snow coverage (hourly, daily monthly);
- Flood frequency analysis (regional and local);
- Flash flood occurrences (regional and local);
- Stream geometry studies for small streams;
- Climatological precipitation and flood studies; and
- Karst flow measurement studies.

If above data are unavailable, such hydro-meteorological and climatological data as monthly precipitation; surface air temperature; pan-evaporation/evapotranspiration; soil moisture; streamflow; radiation; wind and humidity; snow depth and coverage and SWE should be provided.

D. Real-Time Data Requirements

FFGsystem uses real-time meteorological observations in WMO synop format that are disseminated through WMO GTS, including the following parameters, among others:

- Precipitation;
- Surface temperature, humidity, wind speed/direction, pressure, solar radiation;
- Snow depth and SWE; and
- Soil moisture.

Besides the synoptic reports, if additional hydrometeorological observations are available, that would be transferred to the regional centre through ftp services, may improve the system performances.

Appendix C

NMHS Observation Network Metadata Requirements

The following metadata for the rain gauges, weather stations, and stream gauges are to be provided:

- Geographical locations (latitude and longitude in decimal degrees);
- Elevation in meters;
- Type of stations and WMO station numbers(synoptic, climate);
- Current operational status (Automatic, Manuel);
- Observation interval (hourly, 3-hourly, 6-hourly etc);
- Available sensors (Precipitation, Temperature, Humidity, Soil Moisture, Dew Point, Snow, SWE etc.);
- Total number of stations and number of synoptic stations that reports to GTS;
- Data transmission type (HF/VHF radio, wide area network, GPRS, satellite etc.);
- Data quality control applied (y or n); and
- Existing database (Oracle, Informix etc.).

ANNEX 5

Project Steering Committee (PSC)

Preamble: The Project Steering Committee (PSC) provides overall governance of the project and its related activities throughout the duration of the project. Its membership and the terms of reference would be confirmed and amended as deemed necessary during the first constituting session of the PSC.

1. Standing Core Members of the PSC

PSC consists of the following NMHSs focal points or their alternates of the Southeastern Asia-Oceania Flash Flood Guidance (SAOFFG) project and partner organizations.

Table-1 Composition of Steering committee

Organization	No of Representatives
Regional Centre	1
Brunei Darussalam	1
Indonesia	1
Malaysia	1
Papua New Guinea	1
Philippines,	1
Singapore	1
Timor-Leste	1
Development Partner (HRC)	1
Donor (USAID/OFDA)	1
WMO	1

Additional experts/representatives are to be invited by the PSC as needed on an ad-hoc basis, and observers may also be invited by the PSC to participate in meetings.

2. Terms of Reference

The (intermediate) principle terms of reference of the PSC are as follows:

- Ensure smooth and timely implementation of project activities and achievement of the project purpose and its expected outcomes based on regular summary reports from national centres and the regional centre;
- Provide technical and administrative guidance to the implementation of the project;
- Establish an adequate *monitoring and evaluation* (M&E) system for the project and implement findings from the M&E process;
- Review and update the *project implementation plan* (PIP);
- Promote benefits of the project on national and regional levels;
- Facilitate links with other regional and national relevant projects, including Severe Weather Forecast Demonstration Project (SWFDP), regional World Bank

hydrometeorological early warning projects, Southeastern Asia-Oceania Flash Flood Guidance (SAOFFG) project;
- Ensure cross-sector linkages with relevant national and international organizations; and
- Seek additional expertise and financial support to supplement project activities.

3. Communication

Meetings of the Project Steering Committee will be initially organized annually. In addition, tele-conferences may be organized on a tri-semester basis or as needed to monitor project progress and solve upcoming issues. Other communication means of the PSC will include a dedicated e-mail list and/or a web-based e-forum. Operational communication will be established between the Regional Centre and country focal points (NMHSs) and the technical development partner (HRC).

4. Guiding Principles for the SAOFFG Implementation

The guiding principles listed below provide an overall framework for the implementation of the SAOFFG and may be specified in more detail by the first session of the Project Steering Committee (PSC):

- Data providers remain owners of data. Data provided to the Technical Development Partner (Hydrologic Research Center, HRC), will be used solely for the purpose of building up the regional FFG components and such data will not be re-distributed other than to the national centres that provided the data and the dedicated Regional Centre that will provide regional services;
- Equal, non-hierarchical access to data and information generated by the project for project partners and beyond are consistent with Resolution 40 (WMO CG-XII) WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities (https://www.wmo.int/pages/about/Resolution40_en.html) and Resolution 25 (WMO CG-XIII) Exchange of hydrological data and products (https://www.wmo.int/pages/about/Resolution25_en.html);
- Services provided by the technical development partner (HRC) and the Regional Centre are of an advisory nature; and
- Full responsibility for provision of national flash flood guidance and warnings remains with the participating NMHS.

ANNEX 6

Letter of Commitment
(SAMPLE – DRAFT)

To be addressed to the Secretary-General of WMO

Subject: **Letter of Commitment regarding the Southeastern-Asia Oceania Flash Flood Guidance (SAOFFG) project**

Dear Mr Taalas,

Reference is made to the planning workshop on the SAOFFG project in Jakarta, Indonesia from 2 to 4 February 2016, which was organized by World Meteorological Organization (WMO) in cooperation with Hydrologic Research Center (HRC) and co-organized and hosted by the Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG) with funding from USAID/OFDA.

I am pleased to learn about the successful outcomes of this workshop and its conclusions which constitute a milestone in the implementation of this important project.

In this regard I would like to reconfirm the commitment of (country) participation in all project activities aiming towards the achievement of the project objectives to the benefit of (country) and the Southeastern Asia-Oceania region as a whole.

I would also like to inform you that (name) has been designated as the focal point and (name) as alternate in all project related activities. The designated officer will represent the country in the Project Steering Committee. Their coordinates are given below.

Focal Point

Name:
Function/Role
Address
Phone
E-mail

Alternate

Name:
Function/Role
Address
Phone
E-mail

It is my pleasure to inform you that we have designated (institution) to act as a National Centre that will be responsible for the implementation of the project at the national level.

I would like to express our appreciation for the efforts so far undertaken by WMO, NOAA National Weather Service, and the HRC, as well as the generous financial support of USAID/OFDA.

Let me assure you of our full support and cooperation with the WMO Secretariat and the project partners in the successful implementation of this project.

Yours sincerely,
Name of PR

ANNEX 7

Milestones for the Draft Implementation Plan