White Paper

The Feasibility of Holding an International Conference on the Socio-Economic Benefits of Hydro-Meteorological Services

Written by the Permanent Representatives of China, Spain and the United States of America with WMO

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Introduction

The purpose of this paper is to provide useful background information for a proposed conference on Socio-Economic benefits (SEB) and the use of risk and benefits analysis by National Meteorological and Hydrological Services (NMHSs)national weather services. This paper is also intended to help the decision of hosting such a conference, as a ten-year follow-up to a conference held in 2007.

The principal message of the paper is that national hydro-meteorological agencies should consider shifting from the practice of simply providing weather information to the practice of describing how a particular extreme weather event will affect life, property, and economies. The paper offers an overview of the use of SEB for Early Warning Systems (EWS), use for warnings that vary by specific user or weather event, and an overview of the value of impact-based forecasting services. This paper also discusses implementation of impact-based forecasting and the importance of customer surveys and other methods for evaluating impact-based forecasts.

Please note that this paper is not intended to provide a full summary of international practice and innovation in this field. Therefore, information and examples contained herein are drawn only from the countries that participated in preparing this paper, namely China, Spain and the United States of America.

I. Progress made on promoting socio-economic benefits of NMHS services

Overview of Early Warning System (EWS) Evaluation

The "WMO Guidelines on Multi-Hazard Impact-Based Forecast and Warning Services" (WMO-No. 1150) highlights the benefits of NMHSs evolving from a paradigm where they simply provide weather information to one where they express how the weather will impact life, property and economies. In other words, the goal is to promote services to focus on socio-economic benefit. An evolutionary path for NMHSs is suggested as follows:

- Provision of basic weather information and forecasts;
- Basic threshold-based warnings;
- Threshold-based warnings which include user needs and/or spatial/temporal variation; and
- Impact-based warnings (to include hazard uncertainty and vulnerability);
- Impact (Risk-based) warnings (which adds exposure to vulnerability and uncertainty).

At each step in the progression, the focus shifts towards "what the weather will be and what it will do"
(i.e., socio- economic impact) and away from just "what the weather will be" (impact not considered). More specific examples follow, along with a citation of how they link to socio-economic benefits.

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1. Weather Warnings Using Relevant Thresholds Agreed With Users / Practitioners

Some NMHSs are now working with other non-weather-related organizations, such as business, security and finance industries, health and safety organizations, to quantify thresholds and provide targeted warnings based on them. Such thresholds are often developed based on a probability of occurrence for a given hazard, and thereby aid organizations' decision-making and management of activities. An example of this is the development of criteria to support warnings for an aerodrome, with pre-set thresholds being agreed with the customer. This focus on the user promotes an associated emphasis on the socio-economic impact of those weather phenomena that relate to their mission and needs.

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2. Weather Warnings with Spatial / Temporal Variation in Thresholds

For these types of warnings, the thresholds are no longer predefined and may vary according to the situation in space and time, to represent changing vulnerabilities (i.e., potential socio-economic effects).

Example: U.S. Flash Flood Guidance System

The aim of the Flash Flood Guidance System is to provide estimates of the amount of rainfall over a given duration within a basin that is required in order to cause flooding within the catchment. The System is designed to update its values and 'remembers' rainfall that has already entered the catchment.

In this way, the System takes account of antecedent catchment conditions and can calculate the amount of extra rainfall that is needed in order to produce flooding. When these values are applied in real-time with nowcasts, or in a forecasting capacity, they can be used to generate a *flash flood warning*. The ability of this system to adjust to antecedent conditions is an excellent example of progress towards providing socio-economic value to users.

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3. Impact-Based Forecast and Warning Services

The fundamental distinction between a general weather warning and an impact-based warning is the inclusion of vulnerability of people, livelihood and property to the hydrometeorological hazard in question. That is, the impact of the weather drives the messaging and associated mitigation activities, rather than then the weather itself. And these activities can directly drive socio-economic benefit.

Example from China

On 11 August 2013, typhoon “Jutte” had reached super typhoon strength and made landfall in Guangzhou on 14 August 2013. As part of their service, the China Meteorological Administration (CMA) forecasted the landfall, the precipitation and the wind speed distribution of “Jutte” using the typhoon model.

Using this information, CMA was able to draw a map of impacts using the typhoon disaster impact assessment model. This model divides impacts into seven grades using a color-coded model. For example, red means “serious impact” and green means “slight impact”. These impact maps were offered to the Disaster Reduction and Civil Protection Agencies (DRCPAs), the transportation department and other Provincial Government Departments. These departments guided the disaster prevention and reduction work according to the impact maps.

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4. Impact (Risk-Based) Forecast and Warning Services

For impact-based forecast and warning services, the exposure of people or things is explicitly considered along with the hazard and vulnerability. These types of forecasts and warnings are designed to provide detailed information precisely to whom or what is exposed.

In this context, risk may be mathematically expressed as:

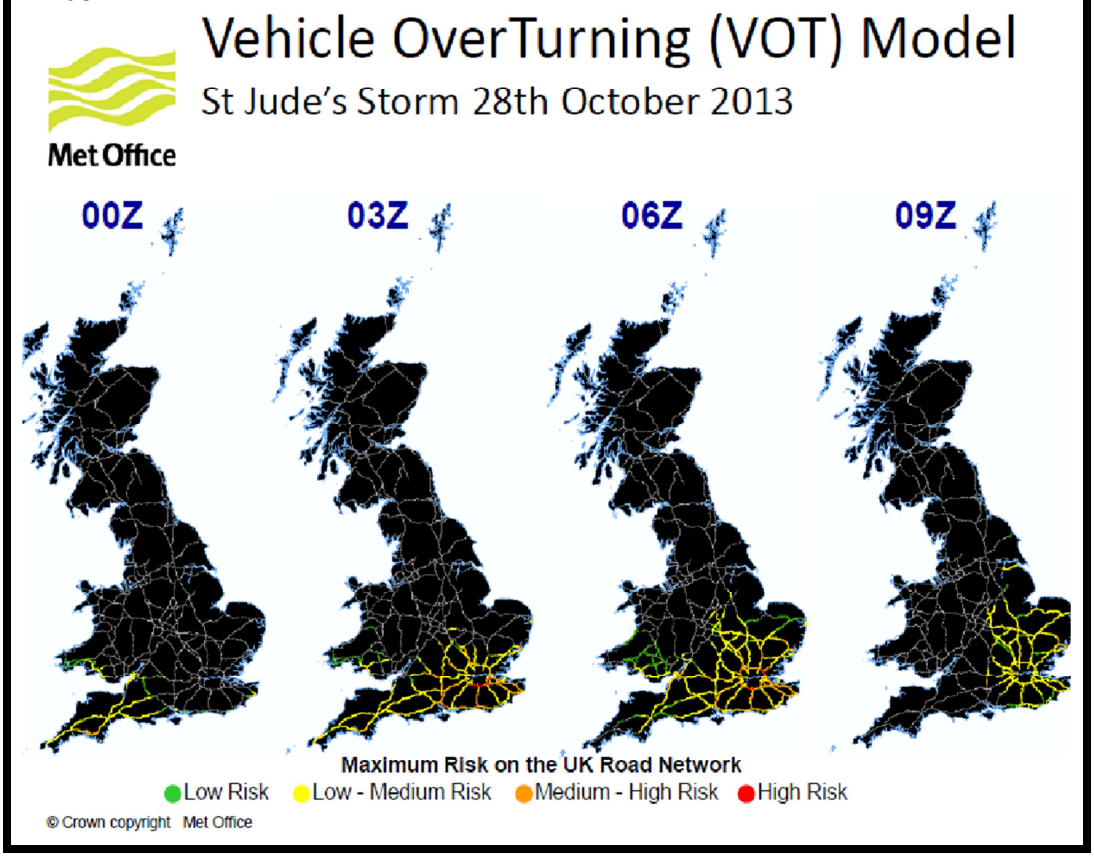
$$|\text{Risk of Impact } (x,t)| = |\text{Hazard } (x,t)| \cup |\text{vulnerability } (x,t)| \cup |\text{exposure } (x,t)|$$

In order to provide these types of warnings, NMHSs (or the responsible government agency) must have available detailed vulnerability and exposure information relevant to the hazard and individual entities for whom (or which) the forecasts are provided. This requires the development of strong relationships between NMHSs and Disaster Management Agencies (DMAs) to ensure these warnings are as relevant and useful as possible in terms of socio-economic benefit. Many NMHSs are recognizing the benefit of developing such relationships for this purpose alone.

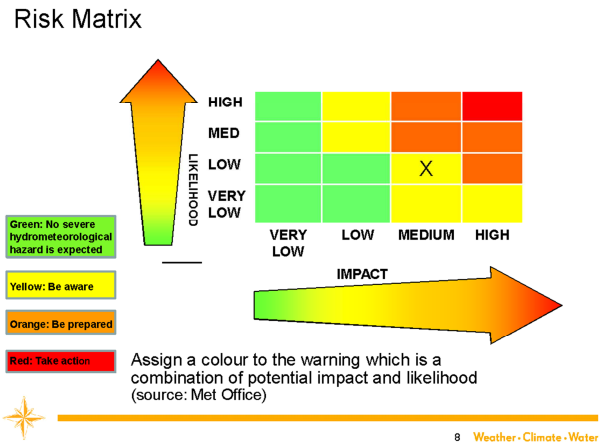
Impact forecasts and warnings utilize weather as input and provide the impact as output. In the following Risk of Vehicle Overturning Model, the output is expressed *purely* in terms of risk. In fact, in this particular case, the highest impact areas do not always coincide with the worst weather, as the weather combines with factors related to vulnerability and exposure to yield the net impact.

Example from United Kingdom (the Met Office)

Forecast of the risk of overturning vehicles due to high winds.
Note that the highest impacts (in red) are not at the locations of the expected highest winds.



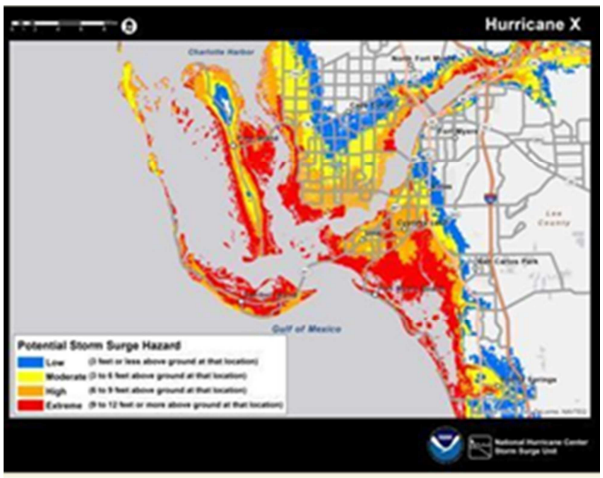
Another example of impact forecasting is via the color-coded "Meteoalarm" system. In this system, expected risk (and, again potential of socio-economic impact) is expressed via the risk matrix below by integrating factors related to hazard uncertainty, vulnerability and exposure:



The U.S. has developed a Potential for Storm Surge Flooding Map as another example of impact-based forecasting. The Map was developed, through social science research techniques, to clearly and concisely depict the risk associated with the storm surge hazard from a tropical cyclone. Developed over the course of several years in consultation with social scientists, emergency managers, broadcast meteorologists, and others, this map shows:

- Geographical areas where inundation from storm surge could occur;
- How high above ground the water could reach in those areas;

Specifically, areas of possible storm surge flooding for a given storm are represented in different colors on the map based on water level:



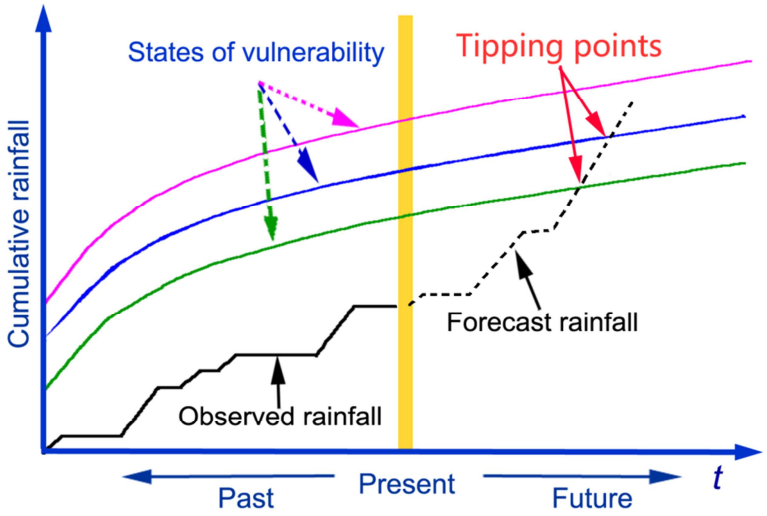
Up to 3 feet above ground
Greater than 3 feet above ground
Greater than 6 feet above ground
Greater than 9 feet above ground

Pathways to implement Impact (Risk-Based) Forecast and Warning Services

Since 2010, CMA has started to promote the implementation of Impact (Risk-based) Forecast and Warning Services by using the following four technical pathways.

- **Risk Survey at national level.** Climate risk needs to be assessed and complemented by exposure and vulnerability information. NMHSs need to start national risk survey in order to investigate the climate parameters, geographical information, socio-economic information, and, in particular, the historical losses caused by historical climate extremes.

- **Calculation of the thresholds which induce disasters.** The following figure shows the meaning of the thresholds. This is an example for flood hazard inducing threshold.



- **Risk assessment and mapping.** Identification of areas with high, medium and low risks when being hit by climate extremes.

- **High precise Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecast (QPF)**

A Case of Impact-Based Warning by CMA

Since 2008, CMA has started a general survey of flood disasters for small and medium rivers and for flash flood disasters. According to the survey, CMA calculated and mapped the threshold values of critical rainfall of all third order streams.

For example, on 5 July 2013, the Anhui Provincial Meteorological Service (APMS) forecasts indicated that there would be a strong precipitation event in Tonghe River Basin, a branch of Huihe River. The forecast precipitation amount would be between 180 and 260mm, with more than 350mm in some particular areas. Compared to the threshold values calculated by APMS, this event was expected to induce severe flood disaster in Tonghe Basin.

By using the forecast products, flood and hydrological models, APMS mapped the flood disaster risk distribution of this event in Tonghe Basin and then offered all the information to the disaster management agency of Anhui Province. According to the map, the disaster management agency evacuated the people in high risk areas. This warning was very successful and there were no casualties.

II. Contributions to summarizing the work done on evaluating the benefits of those services

Weather-Ready Nation (WRN) Societal Outcome Performance Measures

The National Oceanic and Atmospheric Administration (NOAA)'s WRN initiative targets building community resilience in the face of increased vulnerability and risk to weather-related events. At the heart of WRN are Impact-Based Decision Support Services (IDSS), which focus on ensuring NOAA disseminates accurate, consistent, and high-quality forecasts that are effectively communicated in ways that allow for that information to be used to make timely and good decisions. One of the key aspects of the WRN initiative is to affect societal outcomes. Such outcomes can include reduced costs

to individuals and businesses, improved public safety, and improved economic efficiency for businesses.

NOAA has a long history of forecast verification and associated metrics that track various attributes of forecast skill using Government Performance and Results Act metrics (e.g., Tornado and Flash Flood Warning lead times) augmented by periodic measures of customer satisfaction in key groups (e.g., emergency and water managers).

To support the goal of evaluating the socio-economic benefits of NMHS services, NOAA is now working to develop success criteria/performance metrics that ultimately relate to societal outcomes. These outcomes depend on both NOAA outputs and effective societal use of (and response to) these outputs. While performance evaluation based on outcomes is more challenging, it is also more meaningful as it seeks to assess how and to what extent NWS products and services create value for society in terms of economic efficiency, economic output, and improved public safety.

NOAA will be focusing on the following areas to develop societal outcome performance measures:

- *Watch, Warning, Advisory system;*
- *Storm-Ready Program;*
- Ambassador *initiative;*
- *IDSS* pilot *projects;*
- *NOAA Awareness weeks.*

CMA Risk Management System

CMA has set up an integrated risk management system. It covers the whole governance process in risk management, including risk assessment, early warning, warning dissemination, emergency response, reconstruction and resilience.

Satellites and SEB

A quick note regarding satellites and SEBs – satellite data can be analyzed to help determine the socio-economic benefits of a particular observing system. For example, an indicative

"impact per cost" ranking can be generated by dividing the impact by the estimated annual cost for an observing system.

III. The results of the work done on the evaluations of the benefits from NMHS services

Customer Satisfaction Surveys using the American Customer Satisfaction Index® (ACSI)

Conducting regularly customer satisfactions surveys has provided a sustained, standardized, and quantitative method for gathering user feedback and assessing the value of services to society. Customer surveys have provided the following benefits:

- Validated existing services and support;
- Helped in understanding more about our users and determined whether they received, correctly interpreted, and responded appropriately to weather messages;
- Helped ensure products and services continually evolved to meet user needs and expectations;
- Helped ensure program resources were used to address highest priority needs;
- Provided ability to baseline and track societal trends in obtaining and using weather information; and
- Provided ability to compare performance with other government and private entities.

The use of the ACSI cause and effect model, with input drivers of perceived quality, perceived value, and customer expectations, has yielded a standardized overall satisfaction score from regular users of weather information, and also those in society who may be only casual users, but benefit from services. Overall satisfaction leads to society's future trust and loyalty in the organization.

Public Weather Service satisfaction survey and assessment on the socio-economic benefits of early warning service for major national economy sectors in China

CMA and the National Bureau of Statistics co-conduct the annual public weather service satisfaction survey in order to take an objective and quantitative measurement of people's opinions on public weather services. The results have helped improve the service quality of CMA, particularly in terms of the accuracy, timeliness, convenience and practicability.

Since 2008, CMA has also made assessment on the socio-economic benefits of early warning services for major national economy sectors, including transportation, wind energy, electric power, etc. Those assessments have demonstrated that the meteorological disaster prevention and mitigation have achieved remarkable socio-economic benefits and minimized the loss of lives.

IV. Overall evaluation of the benefits from the Madrid 2007 Conference

When trying to assess the benefits from the Madrid 2007Conference, a good starting point would be to review the objectives and outcomes that were defined in advance of the Conference, as well as the results of the implementation of the Action Plan.

The Madrid 2007 Conference was organized in the wake of two earlier WMO conferences held in 1990 and 1994, respectively, both of which were themed “Economic and Social Benefits of Meteorological and Hydrological Services

The focus of the 2007Conference was not strictly to present methodologies or studies on the evaluation of economic benefits, but also to overcome the “insufficient involvement of user communities and weak participation of developing countries” witnessed in previous Conferences. To this end, the overall goal of the 2007 Conference was to ensure a fruitful dialogue among providers and users to improve the understanding and application of the NMHSs products and services. ”. This goal was largely achieved and the Madrid Conference had a high political profile and gathered 450 participants, from 115 countries, among them a significant representation of user communities who had the chance to listen, to speak and to discuss in seven plenary sessions and seven focus events.

The main outcomes that were sought and the main qualitative benefits that followed the Conference were as follows:

- *Information gathering and dissemination* for Governments and stakeholders on the social benefits of the investments in global and national meteorological infrastructures. A number of publications were produced, including the Conference book “Elements for life” as well as all the previous inventories of SEB studies prepared for the Conference and as a result of preparatory regional events.

- *Increased awareness* in the user communities of the availability and value of current and potential services. The Conference provided a vital forum for dialogue among producers and end-users and for matching needs and capabilities. This concept was developed in a series of Users Fora and Learning Through Doing (LTD) projects that took place in subsequent years all over the world, and inspired the current “WMO Strategy for Service Delivery and Its Implementation Plan”, underpinning also the Global Framework for Climate Services (GFCS).

- Promote *new approaches for SEB assessment*, engaging the research and academic communities. After the Conference, a renewed interest of those groups was witnessed and several initiatives such as new publications (Conference book, Economic Primer for NMHSs, etc.), workshops (Chile, Panama and Peru) and Regional Conference (RA VI (Europe)) took place.

- Provide the basis for *national and international partnerships*. Again, the post-conference environment has seen an increased focus in national partnerships (such as those exemplified by LTD projects) and international partnerships (such as the GFCS).

- *Guide the priorities of NMHSs* for infrastructure investment, service provision and service delivery. The concept behind this outcome was to ensure that enough emphasis was given not only to infrastructure investments but also to the user-provider interfaces in service provision and delivery, highlighting the user requirement definition and the delivery and communication phases of the value chain. The WMO Strategy for Service Delivery was inspired by this concept and might be seen as a guiding document to establish NMHSs priorities.

- The Conference also agreed on the Madrid Action Plan (MAP), implemented through 15 actions to be undertaken or shared by Governments, NMHSs, WMO Secretariat and other stakeholders. No evaluation of the benefits of Madrid

Conference could be considered as complete without the evaluation of the subsequent Action Plan.

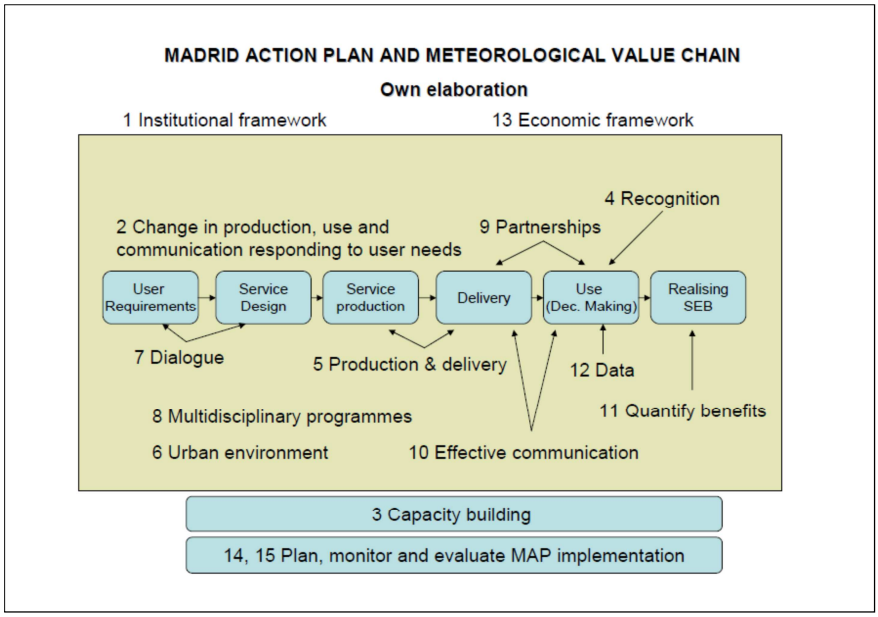
Therefore, in the figures shown below it is possible:

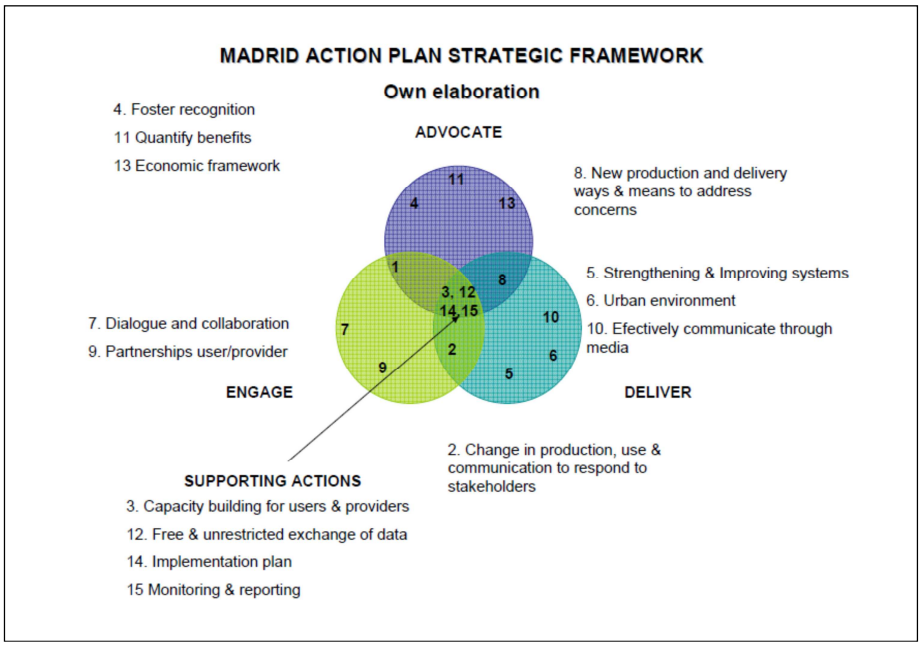
(1) to map the contribution of the individual Actions of MAP to the meteorological information value chain in order to finally make the SEB a reality;

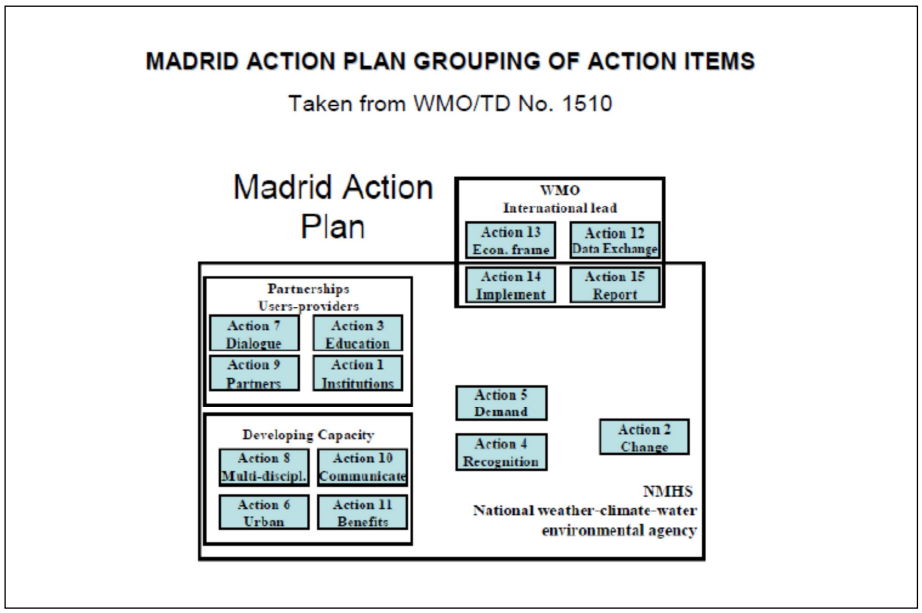
(2) to visualize the strategic framework of the Actions integrated into three main action areas (advocacy, engagement and delivery) and one supporting area;

(3) and to allocate the different MAP Actions to various stakeholders tasked with MAP implementation (see **"**National Meteorological and Hydrological Services, Their Partners and User Communities: (Follow-up to the Madrid Action Plan - for Improved Social and Economic Benefits of Weather, Climate and Water Services)" (WMO-TD 1510).This document (available in English, French and Spanish, can be accessed freely using the WMO library link at: http://library.wmo.int/opac/index.php?lvl=more_results&autolevel1=1#.VNm-R_nF_yE .

From these graphics it is easy to identify that many of the objectives did not directly relate to the preparation of SEB studies of meteorological and hydrological information. In fact, from a total of 15 Actions only one (Action 11) dealt with encouraging to develop this knowledge, and another one (Action 13) dealt with the development of a comprehensive economic framework for service provision. Most of the Actions focused in the interfaces between users and providers at the beginning and at the end of the value chain, trying also to foster mutual understanding and partnerships.







As a consequence, when evaluating the benefits of the Madrid Conference, sufficient credit should be given to the initiatives already mentioned such as the LTD projects, the WMO Strategy for Service Delivery, the GFCS and others, that go beyond the quantification of SEB. In other words, to increase the benefits of meteorological information it is very relevant to make that information aligned with user needs through dialogue. The availability of SEB studies is one additional tool that helps advocacy and awareness raising but does not ensure that benefits are fully obtained (see also WMO RA VI document “Socio-economic benefits of hydro-meteorological services: The benefits of showing the benefits”

It should be noted that no formal and detailed implementation, monitoring and evaluation mechanisms were put in place as a follow up to the Madrid Conference and no evaluation of MAP achievements took place. Therefore, it is difficult to track and attribute all the

benefits obtained from the Conference and MAP in parallel to other international or national initiatives.

V. The evaluation of benefits of holding the proposed Madrid+10 Conference

When trying to analyze the benefits of holding a Conference, as opposed to alternative ways of moving forward, such as capacity building efforts through focalized workshops on SEB evaluation, a holistic approach is suggested.

Once more, the existence of SEB studies is a required and welcome tool to increase the awareness of the benefits of using meteorological and hydrological information, and to advocate for investments in NMHSs.

But SEB studies can also be the basis for product and services improvement. Quoting a paper produced in 2013 by WMO RA VI Task Team on socio-economic benefits (http://www.wmo.int/pages/prog/dra/eur/documents/WG-SDP/TT_SEB_2013_Final_report.pdf): “By understanding how economic benefits are generated for user groups and the economy at large and how a larger share of the potential (maximum) benefits can be realized, the NMHS can embark on a systematic process of product and service improvement with higher pay-backs to the NMHS and society at large”.

There is a relevant capacity gap, though, between some NHMSs with experience in developing sound SEB studies and those without that experience.

There is a relevant need of research activities addressing the development of a multi-hazards forecast system considering how the weather information is used by decision-makers and perceived by citizens. The High Impact Weather project, under the World Weather Research Programme, is working on the needs of users for better forecast and warning information to enhance the resilience of communities and countries in responding to a carefully selected set of hazards. The selection has been guided by their importance as a cause of disasters, by relevance to developing countries, by vulnerability of those living in megacities, and to span the complete range of climate regimes. The results of these activities will support the development of a new global conference.

A new global conference might *reinforce the value of dialogue and partnerships* and the need to promote the implementation of the new WMO Strategy for Service Delivery, connecting them to the SEB studies.

As a first benefit, *a 10 year formal comprehensive assessment and presentation of results of the Madrid* Conference *and Action Plan* is in our view required, taking into consideration the absence of such actions and the mid-term evaluation foreseen in MAP. Many initiatives might have happened without the “MAP label”, though they could be perfectly aligned with the Madrid Conference concepts, and there is value in identifying, summarizing and disseminating this information.

It should not be forgotten that some of the benefits of Madrid Conference were obtained in advance of the Conference, during the preparatory phase, such as the regional conferences on SEB, the inventory of SEB studies and the awareness-raising materials that advertised the Conference. These benefits could be replicated in an eventual preparatory phase to Madrid+10 Conference.

It is relevant to emphasize the high political advocacy value of organizing a high-level event versus a series of low-level events or actions. Bringing together decision-makers and

potential financial donors, providers and users of meteorological information can provide a forum for exchanging views and experiences and to catalyze the required partnerships.

A global Conference, especially if there are preparatory regional events, might also be an excellent capacity *building forum*, in particular if due consideration is given to practical “hands on” parallel events to exchange, teach or disseminate tools and techniques on SEB evaluation.

VI. Contributions to objectives for the next conference, Madrid+10, and expected outcomes

Most of the objectives of the Madrid 2007 Conference (information, awareness, dialogue, SEB studies, partnership, setting priorities, etc.) are still valid. Nevertheless, following the global developments in an interconnected world and the increasingly complex environment in which NMHSs operate, one of the main objectives, if not the most important, of a future Conference could be to highlight the value of partnerships. Global initiatives such as the GFCS, the Group on Earth Observations (GEO), Future Earth, show the value of synergies and NMHSs are at the core of many of them.

NMHSs cannot work in isolation: on the one hand, there is an increasing need of impact- based forecasting services, on the other partnerships are required to enable sound SEB studies. These partnerships may happen at any point of the meteorological information value chain and may take different shapes: user-provider, Governments-providers, public-private, national-international, etc., as the information and the agents involved in them are multiple. In particular, customer-provider partnerships are essential to implement the evaluation of impact-based forecasts.

Therefore, the new Conference could be organized around a title encapsulating these two main goals: the need to quantify benefits to show to different stakeholders the NMHSs value and, at the same time, the need of partnerships, both to enable sound SEB studies and to make those expected benefits a reality: “Partnerships for a better life: assessing and realizing (drawing) the social and economic benefits of meteorological and hydrological information.”

In addition, the enhancement of the social benefits of climate, weather and water-related information (issues such as the contribution of the information to health and well-being, food security, environmental protection, poverty alleviation or to the Sustainable Development Goals (SDG) as a whole) shouldn’t also be overlooked in this new conference vis à vis the economic benefits.

Low-level objectives could also be identified later to develop the two main goals and to satisfy the need of actually developing a post-conference implementation plan and a monitoring and evaluation mechanism to avoid the current difficulties to assess the progress and the benefits of former conference and MAP.

VII. Conclusions and Recommendations

The benefits of an impact-based forecasting system include improved planning for different scenarios based on different thresholds, impacts or combinations of impacts occurring; better contingency planning (best, reasonable worst-case and most likely outcomes), information about level of confidence in the forecast which would convey additional information for better decision-making (a more informed risk assessment); new information to facilitate wider social benefits; the basis for post-event analysis of natural hazard impacts to assist in planning response and mitigation of impacts, and; a comprehensive and coordinated process to address disaster response and preparedness. All of the aforementioned factors are critical for enhancing and promoting the value of NMHS weather forecasts towards socio-economic benefit.

The paper also describes the value of a “Weather Ready Nation” program, China’s Risk Management System, and the value of customer surveys.

The conclusion to be drawn from the paper is that, at least in a number of Members (for example, China and the United States), new SEB and risk-based analyses are leading to dramatic changes and improvements in how hydro-meteorological services deliver more useful information to their publics.

Noting the importance of impact-based forecasting and the success of the Madrid Conference in 2007, it may be useful to organize a new conference. This new conference would review the advances in SEB studies in the last decade, stressing again the need for customer-provider communications and partnerships. The new conference would also advocate for new investments in meteorology and hydrology, showing the benefits of an improved, and impact-based information for decision-making.

Case studies showing the way in which SEB are computed for different sectors, using different methodologies, will have a capacity-building effect for those countries where these case studies are not currently being undertaken. Likewise, these case studies will allow for an improvement in NMHSs understanding of user needs, allowing NMHSs to present a sound orientation of their service production and delivery that aligns well with their users’ decision-making processes.

In addition, a pre and post-conference series of regional and national events and projects is suggested. The pre-conference events could include regional workshops, to share the results of impact based forecast experiences and SEB studies and to identify and select relevant case studies for the Conference materials. The post-conference events could include national workshops to allow for increased interaction customer-provider and to foster national partnerships and projects.

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