

## SIXTH INTERNATIONAL WORKSHOP on TROPICAL CYCLONES

### Topic 5 : **Disaster Mitigation, Warning Systems and Societal Impact**

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Incorporating:

#### **Topic 5.1 Evaluating the Effectiveness of Warning Systems**

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#### **Topic 5.2 Factors Contributing to Human and Economic Losses**

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#### **Topic 5.3 Mitigation Strategies and Community Capacity Building for Disaster Reduction**

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### **5.0 Introduction**

Topic 5 focuses on the application aspects of tropical cyclone forecasting and warnings, and the way such information is conveyed to stakeholders, users and the general public for the mitigation of adverse cyclone impacts. Key findings of the studies carried out by the working groups on the three sub-topics are summarized and progress since IWTC-V is highlighted, along with potential subject areas for discussion in IWTC-VI and recommendations to be made for future development initiatives.

#### **5.0.1 Evaluating the Effectiveness of Warning Systems**

An effective warning system consists of two components: reliable forecasting of tropical cyclones and efficient conveyance of warning information.

##### ***Forecasting of tropical cyclones***

Satellite data, particularly from microwave channels, and EPS (Ensemble Prediction System) guidance or consensus track forecasts are becoming more extensively used by the operational centres with, in some cases, support of nowcasting tools for landfalling tropical cyclones.

Track forecasting based on both statistical and dynamical models has improved steadily for the range up to 72 hours, and position forecasts for tropical depressions are in general less reliable those for more intense cyclones. Statistical and dynamical guidance still need to be improved further, particularly for weak or compact cyclones, for cyclones with unusual track behaviour, mutual interaction in a multi-cyclone situation, and cyclones undergoing extratropical transition.

Intensity forecast remains a challenge, for which NWP (Numerical Weather Prediction) guidance has a limited value and needs to be supplemented by conceptual models and/or statistical models. Rapid

changes in the translation speed, structure, and distribution of precipitation and wind during extratropical transition can substantially reduce the skill of medium range forecast of sensible weather downstream of a tropical cyclone.

EPS is increasingly used in the forecasting of tropical cyclone track and intensity, particularly for the pre-alert of severe weather in the medium-range. EPS products are now increasingly available, and forecasters need to acquire skill and knowledge on how to interpret the EPS products, to assess the uncertainty associated with the EPS guidance, and to utilize the information for optimal operational benefits. Research to make EPS applicable to the forecasting of TC and related weather and hazards (landslide, storm surge, wave and flood forecasting) is being undertaken, and the outcome and experience to be shared with operational forecasters. Methods for calibration of TC intensity, utilization of consensus track forecast or an ensemble of EPS, interpretation techniques of probabilistic forecasts for decision makers, and downscaling techniques need to be developed.

It is recommended that DPP (Disaster Prevention and Preparedness) effort should gear towards the prediction of extreme weather events. Studies on the potential impact of climate variability on the recurrence of extreme weather events should be carried out to enhance disaster preparedness.

There still remains a technological gap among meteorological and hydrological centres, and international cooperation needs to be strengthened further to share information, resources and analysis tools. While various tools are available for use, opportunities for direct communication among scientists working in different disciplines such as meteorology, hydrology, oceanography, and other geosciences are still relatively limited. Large uncertainty exists in the forecasting of flooding, storm surge, and landslides as a tropical cyclone makes landfall.

### ***Conveyance of information***

In the conveyance of information, the uncertain nature of forecasts and potential vulnerability are increasingly reflected in the probabilistic expression of forecasts and warnings. Multimedia channels, including Internet, mobile phones, and digital multimedia broadcasting, are more widely used for dissemination. The intensity scales and advices on protective measures against tropical cyclone impact have been refined further to personalize the risk. Various outreach programmes have been effectively conducted to promote public awareness. Efforts are stepped up to enhance public awareness in cyclone forecasting through extensive funding investment and dedicated efforts of meteorologists and scientists on a worldwide scale.

To improve public understanding of probabilistic prediction, one possible solution is to translate it into a more visual format for different stakeholders. Assistance from social scientists may be necessary in the translation process. Research should be conducted to find out what people understand and do not understand, and the results evaluated through demonstration projects.

The communication channels for the dissemination of warnings continue to expand to DMB (Digital Multimedia Broadcasting), Internet portal sites, mobile phones, satellite broadcasting. Conventional media such as radio and TV remain an extremely effective and widely adopted means of disseminating weather information for both developed and developing countries, while door-to-door notification in local communities is considered an effective way of communication to personalize the risk. While NMHSs (National Meteorological and Hydrological Services) should take advantage of the advances in communication technology such as wireless broadband access, GPS(Global Positioning System), and GIS(Geographical Information System) to enhance the relevance and effectiveness of warnings, options and backup capabilities to disseminate warnings through multiple and diverse channels with a variety of high and low technology should be retained. Different forms of presentation of tropical cyclone messages should be developed, tailor-designed according to the strength of the dissemination channels and the level of the intended audience to enable effective communication of messages to different sectors of the community.

It is found that warnings conveyed and interpreted in terms of action words are more likely to trigger prompt responses from users. Warning messages should therefore contain specific information on what is to be done by individuals and by the community as a whole to minimize loss of life and property. To enhance response effectiveness through personal interaction, attempts should be made to engage volunteers at the community level under appropriate organizational arrangement as messengers for tropical cyclone warning dissemination on a door-to-door basis. Such initiatives undertaken in a cost-effective manner and with a high degree of community involvement can contribute positively to disaster mitigation efforts.

Despite advances in tropical cyclone forecasting and communication technology, a problem persists with the public not responding adequately to the threat of tropical cyclones, even when the warning itself is accurate and disseminated in time. Numerous factors influence the behaviour of users, including previous experience of false alarms, rare occurrence, the belief that “it won’t happen here”, and so on. Various activities are ongoing to enhance public awareness on the risk of tropical cyclones through outreach programmes, primary and secondary school education, as well as cooperation among decision makers, emergency managers, media, and stakeholders down to the community level. NMHSs are encouraged to collaborate with social scientists, researchers and other stakeholders to develop TC disaster scenarios and visualize hazards in the form of hazard map, risk map or disaster management map, designating evacuation sites and displaying warning/evacuation signs etc. to maximize the effectiveness of public education initiatives.

Social impact study of tropical cyclones should be conducted on a periodic basis by a joint team of meteorologists, hydrologists and social scientists in cyclone prone communities in line with the recommendation of IWTC-V. In societies with dense population, the pressure on land use plus the attraction of coastal land for agricultural or recreational purposes attracts people to settle in vulnerable areas or exposed islands along the coast. Regulatory framework on land use in the coastal region should be developed and enforced to reduce vulnerability.

### **5.0.2 Factors Contributing to Human and Economic Losses**

To evaluate losses through the years, an indexation (normalization) methodology incorporating factors to account for changes in population, inflation, and wealth is desirable. Indexed tropical cyclone losses are further adjusted, where appropriate, to account for the greatly improved building standards that may have been put into place in cyclone-prone areas. Given the significance of societal changes in trends of cyclone damage, another way to present a more accurate perspective on such trends is to consider how past events would affect present society.

After the damage is normalized using changes in inflation, increases in population and economic activity in the region, no consistent trend is found in the normalized damage values according to cyclone impact studies in India, U.S., the Caribbean, and Latin America, implying that the key factors contributing to increased losses are largely attributable to societal factors.

Increased attention to the need for rigorous cost-benefit analyses of disaster mitigation policy alternatives and practices is recommended. Irrespective of how such studies turn out (in terms of relative costs and benefits), there is a substantial benefit to decision making related to disasters to be gained from a more comprehensive and rigorous understanding of the value of disaster mitigation.

More fundamentally, there is also a pressing need for more thorough information on the broad human and economic impacts of disasters, as well as indicators of relative vulnerability in order to help prioritize disaster mitigation investments. Re-insurance companies have begun discussions about the creation of an open-source database. The tropical cyclone community is recommended to collaborate on such efforts to create a centralized, comprehensive, peer-reviewed reference database. In

particular, significant by their absence, data on the non-economic human losses related to tropical cyclones are not always readily available.

New and innovative policy options have been proposed for disaster mitigation that will likely stimulate demand for greater attention to costs and benefits. Among these are the securitization of risk through financial products such as catastrophe bonds and derivatives and the provision of micro-finance in developing countries as a tool for disaster recovery in ways that reduce long-term vulnerabilities. Such policies are not widespread, however, and they have not been subject to rigorous evaluation of costs and benefits, but nonetheless have strong support among many disaster experts.

Besides the strong impact of increasing exposures and vulnerabilities on increasing losses due to societal changes over time, the possibility cannot be ruled out that an increase in SST (sea surface temperature) due to anthropogenic climate change would in the long term also lead to more tropical cyclone damage and losses. However, depending on the statistical approaches adopted, scientific evidences are so far inconclusive owing to the complex sequence of relationships linking SST, TC occurrence, TC behaviour, TC landfall impact and social-economic damage.

### 5.0.3 Mitigation Strategies and Community Capacity Building for Disaster Reduction

Despite ever-improving technological solutions for forecasting tropical cyclones and communicating warning messages, human suffering and social, economic and environmental loss as a result of landfalling tropical cyclones continues to increase. Additionally, in the face of changing global climate regimes and the likelihood of more frequent, and possibly more intense, tropical cyclones, coupled with growing populations in tropical coastal regions, it is likely that more people in cyclone prone regions will be in harm's way and the level of loss and suffering will continue to escalate.

In view of such an undesirable trend, warnings systems have been developed throughout the WMO community in the context of a *total warning system*. More than just a matter of simple delivery of a message about impending severe weather conditions, this extends the concept of warnings to a complete end-to-end process that begins with using the best science available to predict and monitor the development and progress of cyclones all the way to the production and delivery of timely and accurate messages to a receptive, prepared and resourceful community in a format that is well understood.

As such, identifying, understanding and reducing community vulnerabilities are just as important as disaster mitigation solutions gradually shift towards the development of social policies as well as engineering of defences. This direction was reflected in presentations at IWTC-V and a strategy has since evolved into the development and implementation of the Hyogo Framework for Action 2005-2015 – *Building the Resilience of Nations and Communities to Disasters* and the Platform for the Promotion of Early Warnings (PPEW).

'Community capacity' is increasingly being recognized as a reliable indicator of how human populations are likely to respond to and recover from the impact of disastrous events. Weather services, community and emergency managers, academics and hazard research centres are all increasingly investing in research and activities aimed at investigating community capacity, and ultimately applying strategies to build community capacity in support of disaster mitigation. The goal is to support a 'bottom-up' approach to strengthen and build resilient communities with the capacity to prepare for, mitigate, respond to and recover from natural disasters. Mitigation strategies in the context of community capacity building are illustrated using examples from Australia, Hong Kong, Fiji and the RANET (Radio & InterNET for the Communication of Hydro-Meteorological and Climate Related Information) project.

One of the outcomes of the IWTC-V was to cooperatively and collectively evaluate the effectiveness of tropical cyclone warning systems and the impact of landfalling tropical cyclones on coastal

communities. It was agreed that this should ideally be achieved through international and multi-disciplinary post-impact case studies. Results of case studies for Tropical Cyclones Zoe (Solomon Islands in December 2002) and Larry (north Queensland coast of Australia in March 2006) will be presented in IWTC-VI.

#### 5.0.4 Conclusion

Based on the above, it is recommended that the following key issues be further discussed in IWTC-VI with a view for future action:

- (a) the need to enhance knowledge and skills in TC intensity forecasting;
- (b) more research and development work on the applications of EPS, particularly for probabilistic assessment of extreme events;
- (c) international effort to collate and compile a library of case studies on the effectiveness of TC warning systems;
- (d) facilitation of more interaction and direct communication amongst meteorologists, hydrologists and DPP experts;
- (e) promulgation of “early warnings” as an “end-to-end” process, all the way through to the last mile to get the messages to the “man-on-the-street” through enhanced community involvement;
- (f) adoption of the Hyogo Framework for Action (HFA) in the formulation of mitigation strategies;
- (g) establishment of a comprehensive reliable international “reference database” on the economic and non-economic losses due to TC and related disasters; and
- (h) coordination of multi-disciplinary studies on the social impacts of TC and related disasters.