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PRESENT STATUS AND FUTURE CHALLENGES IN THE ASSESSMENT AND MITIGATION OF MARINE HAZARDS

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Abstract: In recent years the marine hazards have taken major role among natural hazards. 2004 Indian Ocean tsunami, 2005 Hurricane Katrina, 2010 Chilean Tsunami, 2011 Great East Japan Earthquake and Tsunami are major hazards of last decade. Soon after the 2004 tsunami, extensive efforts were mobilized to identify, characterize and map the devastating losses and impacts by marine hazards. This study evaluates the marine hazard, recent events and summarizes the general characteristics of hazards related to marine and coastal areas. The operational and administrative issues on disaster management are discussed. The new research directions on assessment and mitigiation of the marine hazards are presented. The international protective and preventive measures, hazard perception by the public, awareness through public education, community participation, more international collaboration are emphesized.

Keywords: *Marine Hazards, Disaster Management, Coastal hazards, Simulation, Tsunami, Hurricane, Cyclone, Tornado, coastal communities*

INTRODUCTION

Hazards are unpreventable natural events that, by their nature, may expose our Nation's population to the risk of death or injury and may damage or destroy private property, societal infrastructure, and agricultural or other developed land. Hazards include earthquakes, volcanoes, floods, droughts, hurricanes, volcanic eruptions, tsunamis, storms and storm surge, seiches, short or long term sea level rise.

The general characteristics of marine related hazards are described. The possible effects of these hazards on coastal areas and coastal communities are discussed. The present status and the future challenges in the assessment and mitigationof marine hazards considering the reasons, cause, generation, impact, assessment are presented and discussed.

MARINE AND COASTAL HAZARDS

The major hazard regardless of the location can be listed as, volcanoes, floods, droughts, earthquakes, hurricanes, volcanic eruptions, tsunamis, storms and storm surge, seiches, short or long term sea level rise. Some of the hazards may be destructive at coastal areas are described in the following.

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Floods

Floods are the most common and widespread of all natural disasters--except fire. Floods have been an integral part of the human experience ever since the start of the agricultural revolution when people built the first permanent settlements on the great riverbanks of Asia and Africa. Seasonal floods deliver valuable topsoil and nutrients to farmland and bring life to otherwise infertile regions of the world such as the Nile River Valley. Flash floods and large 100-year floods, on the other hand, are responsible for more deaths than tornadoes or hurricanes. Coastal flooding from catchment area and from the marine area is becoming important.

Volcanic Eruptions

Volcanic eruptions are one of Earth's most dramatic and violent agents of change. Not only can powerful explosive eruptions drastically alter land and water for tens of kilometers around a volcano, but tiny liquid droplets of sulfuric acid erupted into the stratosphere can cause temporary climate change. Eruptions near the coastal areas (such as Karakatau, Santorini or Stromboli) may triger subaerial and submarine landslides or collapse of caldera and abandon the lives nearby.

According to the records, volcanic activities since 1700 A.D. has killed more than 260,000 people, destroyed entire cities and forests, and severely disrupted local economies for months to years. Even with our improved ability to identify hazardous areas and warn of impending eruptions, increasing numbers of people face certain danger. Scientists have estimated that by the year 2000, the population at risk from volcanoes is likely to increase to at least 500 million, which is comparable to the entire world's population at the beginning of the seventeenth century! Clearly, scientists face a formidable challenge in providing reliable and timely warnings of eruptions to so many people at risk.

Hurricane-Cyclone-Tornado-Typhoon

The term hurricane is derived from Huracan, a god of evil recognized by the Tainos, an ancient aborigines Central American tribe. In other parts of the world, hurricanes are known by different names. In the western Pacific and China Sea area, hurricanes are known as typhoons, from the Cantonese tai-fung, meaning great wind. In Bangladesh, Pakistan, India, and Australia, they are known as cyclones, and finally, in the Philippines, they are known as baguios.

Few things in nature can compare to the destructive force of a hurricane. In fact, during its life cycle a hurricane can expend as much energy as 10,000 nuclear bombs. As a hurricane approaches, the skies will begin to darken and winds will grow in strength. As a hurricane nears land, it can bring torrential rains, high winds, and storm surges. August and September is peak months during the hurricane season that lasts from June 1 through November 30.

Hurricanes form over tropical waters (between 8° and 20° latitude) in areas of high humidity, light winds, and warm sea surface temperatures (typically 26.5°C [80°F] or greater). These conditions usually prevail in the summer and early fall months of the tropical North Atlantic and North Pacific Oceans and for this reason, hurricane "season" in the northern hemisphere runs from June through November.

Drought

Agricultural disasters may not be as dramatic as a volcanic eruption or a hurricane, but they are by far the most damaging. Worldwide, since 1967, drought alone has been responsible for millions of deaths and has cost hundreds of billions of dollars in damage. Many different climatic events can trigger crop failures including excess rainfall leading to flood damage or crop disease, heat waves, drought, fire, unexpected cold snaps, severe storms, climate-related disease outbreaks, and insect invasions. Drought can be defined according to meteorological, hydrological, or agricultural criteria.

Meteorological drought is usually based on long-term precipitation departures from normal, but there is no consensus regarding the threshold of the deficit or the minimum duration of the lack of precipitation that make a dry spell an official drought.

Hydrological drought refers to deficiencies in surface and subsurface water supplies. It's measured as stream flow, and as lake, reservoir, and ground water levels.

Agricultural drought occurs when there is insufficient soil moisture to meet the needs of a particular crop at a particular time. A deficit of rainfall over cropped areas during critical periods of the growth cycle can result in destroyed or underdeveloped crops with greatly depleted yields. Agricultural drought is typically evident after meteorological drought but before a hydrological drought.

Earthquakes

An earthquake is a sudden movement of the Earth crust, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates. Sometimes the movement is gradual. But sometime, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free. If the earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage. The rupture by the earthquake under the may generate tsunami.

Although we still can't predict when an earthquake will happen, we have learned much about earthquakes as well as the Earth itself from studying them. We have learned how to pinpoint the locations of earthquakes, how to accurately measure their sizes, and how to build flexible structures that can withstand the strong shaking produced by earthquakes and protect communities.

Faults are narrow zones in the Earth, usually extending no more than about 10 kilometers deep, which separate rigid crustal blocks.

A well known fault is the San Andreas Fault which separates the Pacific plate from the North American plate. The Pacific plate is moving to the northwest at a rate of about 10 cm per year. Similarly Sunda Arc at west of Sumatra in Indian Ocean, Java trench at south of Java in Indian Ocean, Tokai and Tonankai trenches at East of Japan in Pacific Ocean, Philipinnes trench in South China sea, Auletian and Cascadia zones are major earthquake zones in the sean and causing tsunami.

Seiches

The term was first promoted by the Swiss hydrologist François-Alphonse Forel in 1890, who had observed the effect in Lake Geneva, Switzerland. The word originates in a Swiss French dialect word that means "to sway back and forth", which had apparently long been used in the region to describe oscillations in alpine lakes.

Seiches are periodic oscillations of water level set in motion by some atmospheric disturbance passing over a Great Lake. The disturbances that cause seiches include the rapid changes in atmospheric pressure with the passage of low or high pressure weather systems, rapidly-moving weather fronts, and major shifts in the directions of strong winds. Seiches exist on the Great Lakes, other large, confined water bodies, and on enclosed or semi enclosed basins.

Freak Waves

Freak, rogue, or giant waves correspond to large-amplitude waves surprisingly appearing on the sea surface ("wave from nowhere"). Such waves can be accompanied by deep troughs (holes), which occur before and/or after the largest crest (Pelinovsky Kharif, (2003). Seafarers speak of "walls of water", or of "holes in the sea", or of several successive high waves ("three sisters"), which appear without warning. Sometimes, the definition of the freak waves includes that such waves are too high, too asymmetric and too steep. More popular now is the amplitude criterion of freak waves: its height should exceed the significant wave height in 2–2.2 times. Twenty-two super-carriers were lost due to collisions with rogue waves for 1969–1994 in the Pacific and Atlantic causing 525 fatalities. At least, the twelve events of the ship collisions with freak waves were recorded after 1952 in the Indian Ocean, near the Agulhas Current, coast off South Africa.

Storm and Storm Surges

A storm surge is a rise of sea level above the normal level along a shore as the result of strong onshore winds, reduced atmospheric pressure, and setup due to strong storm waves. Storm surges accompany a tropical cyclone in the oceans of tropical water. They may also be formed by intense low-pressure systems in non-tropical areas. Storm surge is not common in marginal seas and enclosed seas. Storm due to onshore wind cause the destructive waves near the coastal areas. The combination of storm surge and normal (astronomical) tide is called 'storm tide'. The worst impacts occur when the storm surge arrives on top of a high tide. The storm tide can inundate wider areas than expected.

Tsunamis

A tsunami is a series of ocean waves of extremely long wave length and long period generated in a body of water by an impulsive disturbance that displaces the water. These impulses can be originated from undersea landslides, volcanoes and impacts of objects from outer space (such as meteorites, asteroids, and comets), but mostly, submarine earthquakes.

Compared with wind-driven waves, tsunamis have periods, wavelengths, and velocities ten or a hundred times larger. So they have different propagation characteristics and shoreline consequences. The similar height wind waves and tsunamis cause very different destruction at shallow zones. Because tsunamis are shallow water waves and they propagate by translation of water particles which cause extremely high water velocities and amplification of the water at shallow areas.

The major phases of tsunami from source the target are

i) Initiation: Energy transferred water body by abrupt deformation and displacement of ocean bottom (due to some reasons) displaces the overlying water from its equilibrium position and cause the wave formation.

ii) Split: Within several minutes of the initiation, the initial tsunami wave is split into the waves and propagates in the direction perpendicular to crest line (rupture axis). A part travels out to the deep ocean (distant tsunami) and another part travels towards the nearby coast (local tsunami).

iii) Propagation: The tsunami wave propagates towards the target coast with a speed proportional to the square root of the water depth. Therefore the deep-ocean tsunami travels faster than the local tsunami. But the arrival time of local tsunami is shorter because of short distance between the source and target coast.

iii) Amplification: When tsunami approaches shallow region, the continuity (conservation of mass) cause shorter wave length and provides stronger velocities and higher amplitudes. This character of tsunami cause major damage, loss of property and lives.

iv) Runup: As the tsunami wave travels from the deep-water, continental slope region to the near-shore region, tsunami run-up occurs at land. Run-up is the vertical distance from mean sea level and highest level of tsunami reached at land. The current velocities, flow depth, arrival time, are other hydrodynamic parameters of tsunamis at shallow and inundation zones (Ozer and Yalciner, (2011). Much of the damage inflicted by tsunamis is caused by strong currents and floating debris. The small number of tsunamis that do break often form vertical walls of turbulent water called bores. Tsunamis always travel much farther inland than normal waves.

There are numerous destructive tsunamis in history since Storegga slide (7000-8000 Before Present), Santorini eruption in 16th BC. But tsunami became the major destructive hazard in the last decade after 2004 Indian Ocean and 2011 Great East Japan events. The total loss of lives are more than 250 000 in 2004 event and 20 000 in 2011 event (Yalciner et al, 2006, Koyuncu, 2011, Ozer et al., 2012, Zaytsev et al. 2012)

Some of the marine hazards are predictable. But earthquakes and related tsunamis are still unpredictable. The major research and assessment efforts still could not forecast the time of occurrence and level of the earthquake and tsunami events. Even the hazards are predictable or unpredictable; the more successful assessment and mitigation strategies have to be achieved. To do this, new research directions for better assessment and mitigation is necessary

PRESENT STATUS AND DIRECTIONS IN ASSESSMENT AND MITIGATION OF MARINE HAZARDS

Four concepts for mitigation of coastal hazards are presented by Dennis et al. (2011). They are i) Overlapping multi-hazard zones, ii) division the development process in stages iii) Light-handed flexible iv) Government purpose for regulating land. All mitigation techniques are not interchangeable. The success of any technique is dependent on a number of independent factors including the type of hazard, resources available, legal requirements and amount of public support. Community's potential loss due to natural hazards can be reduced by a balanced approach that applies mitigation measures to both new construction and the existing built and natural environment. Improved decision-making in coastal planning and development will decrease the vulnerability of the built and natural environment to damage and reduce the financial cost of disaster relief. Retrofitting existing structures and infrastructure will likewise reduce the risk of future damage (Harrington, 2011).

Hazard Mitigation can be implemented through education, planning and practice. Mitigation measures can be applied to strengthen homes and public buildings, so that people and property are better protected against natural hazards. Mitigation technologies can be used to strengthen critical facilities such as hospitals, fire and police stations, and other public service facilities so that they can remain operational or reopen more quickly after a natural disaster(Harrington, 2011).

There are improvements on the research on marine hazards. Monitoring, observation, watch and warning systems help further assessment of the cause of the hazards, better description on their coastal effects and further development in mitigation strategies for the safety of coastal communities. The main subjects for the more success in the mitigation of marine hazards are given in the following.

International Protective and Preventive Measures

Present protective measures involve primarily the use of monitoring watch and warning systems employing advanced technological instrumentation for data collection and for warning communications. Worldwide monitoring and observations of volcanoes, cyclones, waves, tsunamis, swell, meteorological parameters are remarkable developments.

In 1965, UNESCO's Intergovernmental Oceanographic Commission (UNESCO/IOC) accepted the United States' offer to expand its existing tsunami center in Honolulu to become the Pacific Tsunami

Warning Center (PTWC). Also established was an International Co-ordination Group (ICG/ITSU) and the International Tsunami Information Center (ITIC) to review the activities of the International Tsunami Warning System for the Pacific (ITWS). ITIC functions include: a) Insuring the dissemination of tsunami watches and warnings and the collection of tsunami information on a real-time basis; b) Giving technical advice on the equipment required for an effective warning system and providing assistance in the establishment of national warning systems; c) Making periodic studies and assessment visits to developing countries in order to evaluate their instrumentation requirements, assess their performance, offer advice as appropriate, and suggest avenues for assistance; d) Evaluating the performance of the Tsunami Warning System with regard to communications, data networks, and the dissemination of warnings; e) Coordinating the development of the observing system which provides the information necessary for the issuance of effective tsunami warnings to those nations wishing to receive such messages.

In the last decade after 2005, UNESCO IOC has established Indian Ocean Tsunami Warning System, North East Atlantic and Mediterranean Tsunami Warning System and Caribbean Tsunami Warning Systems.

ITIC also maintains a complete library of publications and data related to tsunamis. To accomplish this task, ITIC maintains close contact with IUGG (International Union Of Geodesy and Geophysics) and many other national and international scientific organizations. ITIC continuously monitors the results of current tsunami research in order to find applications which may result in the improvement of the International Tsunami Warning System.

Hazard Perception by the Public

Tsunami hazard perception by the people of a coastal area and community participation are the major parts of mitigation. Adequate knowledge of the hazard phenomenon and adequate data on which to base the prediction is essential. The capacity building by education of responsible officers at local and national level also provide much more success. Even if a hazard prediction is based on valid information and data, warning and evacuation may not be sufficient to minimize the impact. Hazard perception by the public is based on a technical understanding of the phenomenon and confidence of the public in the authorities. Fortunately, forecasting of several hazards in recent years has been quite good and the image of the warning systems and their credibility has improved considerably. Forecasting is always difficult since there are uncertainties in the data to be used. This is valid especially for earthquake and tsunamis.

Awareness through Public Education

A heightened community awareness of the potential threat of hazard can be achieved through a public education program. Since the high level transportation activities provide huge amount of touristic and business travels, the travelers must be aware of hazards even if it is not common in their own country.

The public education program consisting of seminars and workshops for responsible government officials, publishing informational booklets on the hazards of hazards are other examples for public awareness. The local and government agencies should take action to mitigate future losses from the hazards. As an example, authorities can develop coastal management policies, and management plans including zoning and planning of hazard potential vulnerable areas. The research and engineering studies in developing evacuation zones or engineering guidelines for building coastal structures must be followed. Procedures related to warnings of different hazards must be reviewed frequently to define and determine better respective responsibilities between the different governments agencies at all levels.

CONCLUSION

In spite of our technological improvements of the last decades, we are still unable to provide timely warnings to many areas of the world. Improvements are necessary in communications actions to ensure that warning information is prompt and accurate. An increased degree of automation is necessary in handling and interpreting the basic data. Research is needed for the development of instrumentation such as deep-ocean sensors, atmospheric detection systems, the real-time interpretation of seismic source parameters, improving our understanding of a hazard and the communities. Research can also lead to improvement of assessment, evaluation and warning systems, to better land-use management of coastal areas and to development of important engineering guidelines of critical coastal structures and plants.

As summary, the long-term objective should be developed susceptible to all types of marine hazards. The immediate objectives at national and international levels should be assessed. Preparedness requires several capabilities, such as rapid identification of hazard, effective national and regional warning systems to alert coastal population and industries, and civil defense and community preparedness to respond to warnings.

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