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Climate change and flood hazard

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ABSTRACT

Natural hazards are linked to climate change and they are likely to increase over the years. The vulnerability to certain natural risks such as flooding and coastal erosion can be exacerbated by climate change. The areas susceptible to the greatest increase in flooding are coastal borders which are affected by subsidence and sea-level rise, rather than fluvial flooding. The hydrologic impact of climate change can increase the occurrences of extreme hydrologic events, heavy rainfall, and droughts. There is always a human tendency to intend to control the environment, avoiding the probable natural hazards. The risk management efforts can be helpful for the society to reduce risks, take advantage of the opportunities and cope with the unexpected challenges in an integrated manner, particularly in the context of long-term risk planning and management in the environments with high rates of natural hazards. The flood risk management generally plans for increasing the existing flood protection levels to the major city areas over the next coming years. Exposure of human settlements and long-lived, strategic assets such as transport and utility networks to flood risk is increasing due to climatic changes.

Keywords: climate change, risk, flood, hazard, management

1. INTRODUCTION

Climate is one of several integrated factors of change that must be considered in understanding the vulnerability and related risk management options. The hydrologic impact of climate change can increase occurrences of flood events, and droughts because of a considerable decrease in water availability.

Ecosystems dependent on groundwater at or close to the surface, including rivers and streams, wetlands, flood plains, springs, estuaries, and lagoons, are particularly important because they are crucial contributors for biodiversity and ecologic productivity. They serve for flood control and mitigation; regulate runoff and water supply; improving the quality of surface waters and groundwater; withhold the sediments and reducing the erosion rate. They also stabilize the river banks and shorelines and diminish the risk of landslides; improving water infiltration and support water storage in the soil; facilitating the groundwater recharge through improving drainage conditions and natural irrigation.

Climate change has significant impacts on agricultural water resources such as availability of water supplies, agricultural water management, droughts and floods. The impacts of climate change on water resources should be analyzed considering the various inherent uncertainties associated with the water demand, regulatory requirements, consumer preferences and environmental standards. Besides weather-related hazards, some regions have notable relief features, which are the source of ground instability. The main types of landslides observed in such areas involve superficial landslides with fast speed that can turn into mud flows; landslides with slow kinetics; and finally, falling rocks and boulders [see 36 and 37].

The earth experiences annually death and injuries due to flooding and contamination spread by flood water which can be damaging for food sources by risks of infection [7]. We first consider some of climate change effects in case of extreme weather events such as heat waves, cold waves and floods; which in future, might lead to the hazards to health and social care for people. Health and social care systems are likely to be influenced by climate change, mostly by the increasing frequency and severity of weather-related hazards such as floods and heat waves. The term “hazard” refers to potentially harmful events and therefore we are concerned with weather extremes or anomalies that represent a significant departure from normal weather [9]. Such extreme events can include floods, heat waves, cold waves and storms. This article concentrates on the analysis of a probabilistic approach to quantify and manage the flood risks imposed by climate change.

2. RAINFALL AND HYDROLOGIC PATTERNS

Groundwater provides valuable services for humans and ecosystems. An important threat to groundwater services is the lowering of groundwater levels due to aquifer over-exploitation, drainage for agriculture, and dewatering due to infrastructure development as well as mining. In different regions, changes in rainfall and hydrologic patterns due to climate change can increase the occurrences of reservoir water shortages and affect the future availability of agricultural water resources. It is one of the main concerns for the sustainable development in agricultural water resources management to evaluate the adaptive capability of water supply under future climate conditions [14, 22, 23, 29 and 31].

The water supplied by reservoirs can be severely affected by the climate variability of meteorology and hydrologic phenomena, including the frequency, intensity and location of the extreme events. In addition, due to an increasing shortage of water resources, climate changes could further threaten water availability and management [10, 21 and 27]. The development of a sustainable agricultural water resource management system is necessary in order to evaluate the adaptive capability of water supply under changes in the critical environmental and climate conditions [see 31].

Pulwarty and Sivakumar [17] analyzed some effective factors in drought risk management. The factors include the danger Index and the evaporation related indicators such as relative humidity, temperature departures from normal range, reservoir and lake levels, ground water levels, surface soil moisture rates and snowpack. Some indicators are calculated at point locations and the others are analyzed at regional or climate divisions, drainage-hydrological basins, or other geographical units. Most countries, regions and communities currently manage the drought risk through crisis-driven approaches [17,28 and 35].

The quantity of rainfall infiltrated into soils and available for crop growth with the exception of the loss from surface runoff during irrigation periods is derived from the relationship between the ponding depth and the amount of rainfall. In a recent study [14] the water supply capacity was calculated as the sum of the difference between values associated with the watershed inflow and reservoir overflow during irrigation annual periods.

3. FLOOD HAZARDS

It is necessary to identify and quantify the main risks that long-term climate change poses for predicting flood hazards. However, some areas might be of major importance in predicting range shifts and critical risks, as well as planning conservation actions. The areas susceptible to the greatest increase in flooding are coastal borders which are affected by subsidence and sea-level rise, rather than fluvial flooding. This indicator of relative change should be interpreted appropriately. While some areas are projected to experience a significant increase in the annual probability (frequency) of flooding, this does not necessarily imply the occurrence high magnitude events.

We should consider that the pattern of risk is deeply dependent on the definitions of hazard and vulnerability used as a range of local contextual variables to influence the significance of the risks and the reactions to them. The risk assessment of a region requires the identification of the specification and scenario uncertainties. After identification of the uncertainties that might impact the future annual raining rates, the next step in risk assessment is the identification of potential areas of flood hazards. This estimate needs to be studied at high levels of spatial resolution which require analysis of the individual factors affect the climate change. It is practical to analyze the cross hazards data and sensitive areas, achieved under a GIS mapping. However, the study area can be simply identified by a number of vulnerabilities to natural hazards risk. Information can be analyzed as a specific type of risk quantification that can be achieved using probabilistic temperature and raining performance simulation.

The process of risk analysis involves the hazard analysis based on the interpretation of climatologic records and projections. It is possible to predict a climate risk event's geographic impact in terms of its future probability and intensity [26 and 33]. Over the last fifty years there has been rapid build-up of urban settlements and assets in low lying flood plains and exposed coastal areas [5, 19, 21 and 41], which increase the risks of damage due to extreme climate events.

Foresight [4] concentrates on the extended average characteristics of floods at the national scale rather than extreme flood events. Flooding thresholds for built infrastructure are more difficult to assess than heat or cold wave thresholds, though the potential for damage to infrastructure due to flooding is greater than that associated with extreme temperature. The thresholds for flooding of built infrastructure are based mostly on the location of buildings and facilities in relation to flood extents and depths considering the return periods [2]. That is why the flood hazard is assessed basically on the micro-scale position of critical buildings such as hospitals and emergency services [see 16].

The risk of extreme temperatures or flood events requires to be defined relative to the changes in overcoming the average conditions considering the likely population and infrastructure adaptation to climate change [20, 38 and 39]. Therefore, it should be taken into account that the existing planning criteria defining conditions to trigger emergency responses may not be appropriate in future. A key constraint on analyzing the future changes in flood risk and the uncertainty under climate change is the point that global climate models, mainly where they need to be downscaled to reflect highly orographic rainfall regimes, do not capture local changes in the frequency and intensity of high intensity rainfall events.

Future changes in upstream land-use, stream management and sea level rise at the river mouth could also significantly change the flood characteristics, implying a large but unquantified uncertainty on future flood frequencies. In addition, some resources such as coastal desalination plants become more at risk of flooding due to sea level rise. It should be noted that rising sea levels may remove land from production elsewhere [31].

4. RISK MANAGEMENT

Climate is one of several integrated factors of change that must be considered in understanding the vulnerability and related risk management options. World Meteorological Organization (WMO) defines exposure as "the total value of elements at risk". It is recommended to quantify it using "the number of human lives and the value of the properties or assets which can potentially be affected by hazards". Exposure assessment may be used to determine the expected spatial distribution of potential damage to the assets associated with climate-related hazards [34].

Risk is generally defined as the product of two contributing factors; the probability of an occurrence and the consequences of the occurrence. Typical risk management studies generally involve a study of probabilities called risk assessment. Researchers generally analyze the different aspects of strategic planning, district planning, hazard management, emergency management, flood engineering, storm water management and climate change functions. All that we need to have a fair risk management is the access to the special relevance in a changing climate where change, uncertainty and complexity are generally increasing.

Apart from the typical uncertainties, maintenance and system degradation are the key issues in the risk assessment. We can hint various maintenance strategies existing such as reactive, preventive, predictive, and reliability-centered maintenance; which of course have a direct relation with system deterioration [3]. These issues are closely related to financial planning, combining a full control of thermal risks[33] with financial risks. Indeed, given the relative ease of obtaining distribution data for large numbers of regions is the major part of most estimates for extinction risk associated with the climate change.

Climate change has significant impacts on agricultural water resources such as availability of water supplies, agricultural water management, droughts and floods. Flood risk management and consideration of the effects of climate change is important. A crucial constraint on exploring future changes in flood risk and the uncertainty under climate change is that global climate models do not indicate local changes in the frequency and intensity of high intensity rainfall events. It is necessary to improve the probabilistic approach for the potential risk and vulnerability assessment of the water supply capacity of reservoirs to achieve higher management. The irrigation vulnerability can identify reservoirs with a water supply risk condition under climate change.

5. SOCIAL TRAINING

We should consider that there is always a human tendency to intend to control nature. The policies and practices should promote the delivery of accurate and useful information that is simple enough to be understood by the general public, thereby sharing the information about risk. A greater focus on managing the uncertainties is involved in the engaging communities on disaster risk and openly negotiating exposure and vulnerability reduction priorities which is mainly dependent on the social learning. Information and education are cross-cutting issues that intertwine with a multiplicity of aspects such as preparedness, warning, training, awareness and being proactivity.

There is a feedback mechanism intended to ensure each of the three stages, in particular the preparation stage, 'learning' from experience in ways that will make the society more resilient in the face of the next crisis than it otherwise would have been. Moreover, the increasing social resilience produced by this approach also means that the demands and the risks faced by emergency service personnel should decrease over time. Individuals can learn through experience about how to conduct themselves during a catastrophe, and in turn this will be helpful by raising consciousness and awareness of risk [2, 6, 17, 24 and 25].

Repeated exposure to extreme events and the other manifestations of climate change further exacerbate vulnerability via the decline the resilience of the asset base and the eroding adaptive capacity of high risk groups. Disaster risk management imposes considerable challenges to numerous communities around the world [8 and 40].

There is a fundamental mismatch between public understanding of disaster risk and disaster risk management provision, and the true nature of that risk. The management of disaster mitigation assets should be backed by political prioritization of risks and their communication to the public [11]. It is suggested that larger cities are less vulnerable since the coping capacity is enhanced to meet up with the geographical aggregation of people and values. Older people especially those already in poor health, are particularly vulnerable to weather-related hazards.

There are lots of pro-environmental actions intended to adapt to and/or mitigate climate change which can limit the human effect on the local environment, thus resulting in directly influencing the global climate change cycle. One of the key factors in formulating successful climate change policies is to manage to change the existing damaging individual behavioral patterns [e.g. 18]. The management strategy involves people, the effects of climate change on human behavior, overall health, and globalization of agriculture and therefore all these points need to be incorporated into risk analyses from a public health perspective. Existing standards or protocols for risk management lack any considerations to encounter the climate change.

A considerable present-day challenge lies in finding successful and resilient adaptation strategies to respond suitably to current and future climate change [12, 13, 32and 40]. The most effective risk management and adaptation efforts will continue to be those that are informed by well-founded science and grounded in social, cultural and economic contexts. Adaptive management strategies would help society to reduce risks, take advantage of opportunities and cope with changes in an integrated manner. These considerations can be used to inform risk management programs undertaken at the regional scale. By joining forces in an integrated approach to adaptation, the agriculture, water management and conservation communities can make scarce funds go farther, avoid conflict, and sustain ecological and economic health.

Climate change can play a key role in the civilization's development, and eventually can support the civilization evolution. Climate change may also interact with existing stresses such as habitat fragmentation and isolation. Public recognition of the existence of climate change and importance of its impacts on the economics and environment is an issue with significant societal and political implications.

6. DISCUSSION AND CONCLUSION

The hydrologic impact of climate change can increase the occurrences of extreme hydrologic events, heavy rainfall, and droughts because of an extensive decrease in water availability caused by an insufficiency in precipitation during a significant period [see 26, 29, 30 and 37].

Different advanced techniques can be applied to extend our knowledge about the environmental water requirements of groundwater dependent ecosystems in response to interactive changes in groundwater attributes, and human-induced disturbances. It should be noted that both water quantity and quality are important to maintain habitat and biodiversity for groundwater management.

Our study is concentrated on the exploration of climate-related impacts on precipitation and hydrology changes leading to flood hazards. Some decisions are generally taken about the appropriate use of the dams during extreme events necessarily involved. Therefore, practical decisions are crucial about which hazard presents a greater threat, particularly in the absence of the data needed to reliably forecast the risk of flooding versus drought. The possible reduction of volumes in dams and volumes of available groundwater would create new challenges while predicting the climate change impacts. Therefore a stronger management of these resources will be needed.

People have faced climate change and adapted to it since our species evolved. Adaptive actions are adjustments in assets, livelihoods, behaviors, technologies that address ongoing and future climates variability and change [17]. It is suggested to adapt to the problems we are encountered by now and to factor in a margin for them becoming worse in order to reconcile political conflict and make some policy response possible. However, prevarication against the current and future unknowns in this way is an inherently political process. One will certainly need to openly negotiate different perceptions within the society on what costs and levels of risk could be acceptable. We should consider which risks are realistically avoidable, and how much people are willing to invest in order to try and limit these risks.

Decision making processes needs prioritizing and enhancing the long-term sustained capacity building efforts through developing human resources. It can be practical to establish the systems for educating and training the researchers, professionals, practitioners and people to achieve effective solutions for global and local climate change risks. The risk management system is complex and needs to include several aspects such as compiled historical and technical information, to be practical for experts and urban planners [41]. However, the most effective risk management and adaptation efforts will be the ones that are informed by science and engaged in social, cultural and economic frameworks.

The existing urban planning documents at different levels of government generally do not include detailed catastrophe risk management considerations despite the fact that it could significantly prevent or avoid the risk exposure of populations in areas of future urbanization, with considerably lower costs involved.

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