Flooding:
The possible changes under global warming

Flooding is one of the worst weather-related disasters because it generally affects a large area, destroying not only properties, but potentially causing fatalities. **Mr Johnny Chan**, Dean, School of Energy and Environment, and Director, Guy Carpenter Asia-Pacific Climate Impact Centre and City University of Hong Kong, presents the possible causes of floods, the possible changes of the frequency of occurrence of flood events under global warming and also addresses the question of how such information might be useful to the insurance industry.

Flood events often occur rather suddenly and so that there may not be enough time to implement disaster mitigation measures. A good understanding of the causes of individual floods is therefore crucial in increasing the lead time for issuing warnings. From the insurance perspective, such an understanding could provide a better estimate of the possible losses. With global warming being a reality, it would also be of importance to estimate how the frequency of occurrence of flood events may change.

Causes of flooding

In simple terms, flooding occurs when a large volume of water suddenly appears in an area and mechanisms are not present or not efficient enough to remove the increase in the volume of water. So what are the causes of such large volumes of water?

In the Asia-Pacific region, the most common causes include thunderstorms and typhoons. A severe thunderstorm can dump over 300 mm of water within an hour. The drainage systems in many cities are simply not designed to cope with the presence of such large volumes of water within a short period of time. Even if they are, city trash often blocks the drains and hence flooding occurs. Rural areas and cultivated land are more susceptible to flooding because of the general lack of wide enough drainage channels. If the soil is already fully soaked from previous rain events, flooding can occur much easier.

Raised lake and river beds increased flooding possibilities

Lakes are supposed to serve as a buffer for draining the water. However, if the lake beds are raised by waste or sediments from rivers flowing into the lakes, their function as a buffer can become ineffective so that lake shores or nearby river banks can be flooded in the event of a heavy rain. Along a river, if excessive logging takes place in the upper reaches of the river, topsoil can be washed down to the river, raising the river bed so that even a thunderstorm that does not produce very heavy rain could lead to flooding because the river no longer has the ability to accommodate the same volume of water compared with the case when the river bed is much lower.

In hilly terrain, heavy rain associated with severe thunderstorms can lead to a flash flood in which a large volume of water goes downstream along the river at an accelerated pace (due to the sloping terrain) so that flooding can occur within a much shorter period for the same rainfall rate. Again, it is even easier to have a flash flood if the soil in the upper reaches of the river is already saturated with water from previous rain events.

Typhoons and snow

When a typhoon hits, flooding occurs not only because of the heavy rain associated with the typhoon but also because of storm surge, which is the sudden onshore movement of water from the sea due to the low pressure of the typhoon and the strong winds. The effect of storm surge can be exacerbated if it occurs at the time of the astronomical tide. For example, during the passage of Typhoon Hope in 1979 in Hong Kong, the high tide reached 4.3 m, which brought severe flooding to the territory.

In colder areas where snow is accumulated, water from melted snow, sometimes accompanied by rain, can also cause flooding. This can be severe as such melting often occurs up in the mountains so that the water from the melted snow will accelerate down the slopes to cause flash flooding.

Possible effects of global warming

Under global warming, more water vapour will be available in the atmosphere so that more water is available to be "squeezed" out of the atmosphere when the conditions are right for rain development. In other words, rain can be more intense (in terms of mm per unit time).

Increase in water vapour

In fact, studies in Hong Kong and India have shown that the frequency of occurrence of heavy rain has increased in recent years, presumably because of this increase in water vapour. If this is a general phenomenon, heavy rain can be expected to occur more frequently. And as most of the flooding is associated with heavy rain, therefore, if other conditions remain the same, the frequency of occurrence of flooding can be expected to increase under global warming.

Rise in sea level

Furthermore, global warming will lead to a rise in sea level. As a result, for a typhoon of the same intensity, the water level associated with storm surge when a typhoon makes landfall will likely be higher and hence the chance of flooding will also increase. Although some studies have claimed that tropical cyclone intensity may increase under global warming, more recent modeling results suggest that any possible increase in intensity will only be of the order of a few percent. Further, studies of intense typhoons in the western North Pacific show no statistically significant trend in the intensity. Thus, the possible increase in flooding frequency associated with typhoon landfall is mostly due to heavier rain and higher level of storm surge.

Implications for the insurance industry

Statistical modeling based on past data has been the primary tool for estimating possible loss due to weather hazards. However, with the changes in the land surface conditions and the effects of global warming, frequency of occurrence of historical events may not be a good indicator of what is likely to come. More in-depth studies will need to be made as to how recent modifications in land surface conditions (e.g. from agricultural to urban, extensive logging, etc) may be related to changes in the frequency of occurrence of flood events, and whether these changes are related to changes in the frequency of occurrence of heavy rain. It is also necessary to investigate, for each location, whether the frequency of occurrence of heavy rain has increased based on in situ rainfall rate measurements. A similar analysis needs to be made with regard to sea level rise for coastal areas likely to be hit by tropical cyclones.

For future conditions under global warming scenarios, we will need to rely on computer model projections. However, most of these models have rather coarse spatial resolution so that some kind of "downscaling" (either statistical, dynamical or a combination of both) will need to be made to project possible changes in the frequency of occurrence of heavy rain at a particular location, and hence that of flooding. Projections on the frequency of typhoon landfall could also be made using similar approaches.

Conclusion

Disasters caused by flooding will likely be on the increase under global warming. As a result, the insurance industry must develop new strategies and methodologies in estimating possible losses due to flooding instead of relying on traditional approaches. This requires the collaboration between the industry and climate scientists so that more appropriate estimates can be made. One of the reasons of establishing the Guy Carpenter Asia-Pacific Climate Impact Centre at City University of Hong Kong is exactly for developing such collaboration, not only in the study of floods, but of other weather-related disasters as well.