Assessing Natural Hazard Risks Using Probabilistic Catastrophe Loss Models


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Risk managers should consider last year's Cyclone Gonu as a wakeup call to risk in the region, say **Dr Mahmoud Khater**, Senior Vice President of ABSG Consulting and Chief Technology Officer of EQECAT, and **Mr Gary Graham**, Regional General Manager, Middle East, ABSG Consulting, as they use CAT models to assess the likely impact of natural catastrophes on the Middle East.


Mr Gary Graham

By their nature, catastrophic natural events occur infrequently but with high severity. Traditional actuarial loss estimation techniques rely on historical event frequencies and severities to estimate future potential losses. However, this approach cannot fully quantify the wide range of potential future events and losses. This is due to the relatively short recorded history on catastrophic events, and the fact that this history may not repeat itself due to climate changes or changes in the seismological and physical conditions.

Probabilistic Risk Assessment Models

An alternate approach to assess catastrophic risk is via the use of Probabilistic Risk Assessment Models (also referred to as Probabilistic Catastrophe Loss Models, or CAT models). These models integrate knowledge and techniques from many fields such as engineering, seismology, meteorology, geology, hydrology, topography, geography, mathematics, statistics, probabilities, insurance and economics. Such models provide a framework and technology in which these disciplines can be combined to solve these types of complex and inherently spatial problems.

Probabilistic CAT models simulate thousands of physically realistic probabilistic scenarios, also referred to as Stochastic Events, with different severities and frequencies, filling the gaps in the historical data in terms of location, severity and frequency of the events.

These comprehensive probabilistic event sets provide a far more complete statistical picture of the range of potential-loss outcomes than can be obtained by conventional actuarial methods.

During the past decade, enormous progress has been made in understanding the nature and consequences of natural catastrophes. This is a result of the increased sophistication and use of probabilistic catastrophe loss modeling. These models provide guidance in understanding both the frequency and severity of the consequences of natural and man-made catastrophe events. The use of CAT models for the assessment of catastrophe risk is becoming an important tool for underwriters and risk managers to better understand the nature of their exposures and provide the information needed to define the expected cost of the catastrophe exposure, the uncertainties involved and to quantify the insurance premium.

CAT models can quantify the risk exposure from direct losses (typically value of physical property destroyed), and indirect costs (eg business interruption). The more refined this estimate, the more efficiently the risk can be managed.

While the risks from natural hazards cannot be eliminated, they can be assessed using CAT models. Risk drivers can be identified and mitigation measures can be developed to minimise the risk and the hazard to humans, and to reduce direct and indirect economic losses.

CAT models can provide results that can help identify the insurance/reinsurance policy structure that meets the required management objectives. They can be used as planning tools to share/transfer the financial risk from catastrophic events directly to the capital markets.

One of the most useful results produced by CAT models is the loss exceedance probability curves. These curves define the losses expected for different return periods, eg, 1-in-100-year loss, defined as the loss with 1% probability of exceedance in any given year. These estimates are used by risk managers to identify the appropriate loss limits for their organisations. The prevailing benchmark for many global corporations is to buy insurance coverage for a 1-in-250-year loss to a 1-in-500-year loss.

Arabian Gulf Cyclone and Earthquake Risk

The current world production of petroleum is straining to meet demand of approximately 85 million barrels per day (mbbl/day). Any slight shortage in supply or exporting would negatively impact world oil markets. Roughly about one-fifth of world oil supply or 17 million barrels per day is exported through the Strait of Hormuz via oil tankers. A major natural hazard event, eg cyclone or earthquake, affecting the Gulf countries could have a significant impact on the region and the world economy.

The North Indian tropical cyclone season has no bounds as storms tend to form between April and December, with peaks in May and November. Most cyclones that appear in the region form over the Bay of Bengal, east of India. Those that take shape over the Arabian Sea, west of the Indian Peninsula, tend to be small and fizzle out before coming ashore.

Cyclone Gonu

The June 2007 Cyclone Gonu was the strongest tropical cyclone in 60 years in the Arabian Sea, and tied for the strongest tropical cyclone on record in the northern Indian Ocean.

Gonu developed from a persistent area of convection in the eastern Arabian Sea on 1 June 2007. With a favourable upper-level environment and warm sea surface temperatures, it rapidly intensified to attain peak winds of 240 km/h (150 mph) on 3 June.

Gonu weakened after encountering dry air and cooler

waters, and on late 5 June, it made landfall on the eastern-most tip of Oman, becoming the strongest tropical cyclone on record to hit the Arabian Peninsula. Had Gonu remained a powerful cyclone and did not weaken before landfall, the losses would have been much more significant due to severe storm surge, flooding and fierce winds.

Modeling an event such as Gonu is an ideal application for Probabilistic CAT Modeling. CAT models can take prospective view of the risk, and can estimate the potential losses from catastrophic events that may occur in the future by taking into accounts climate changes, global warming and cyclicality in sea surface temperatures.

Such an event in the Arabian Sea would bring fierce winds, severe rainfall, thunder storms and giant waves as high as 10 metres. Since several coastal cities in the Gulf of Oman are near sea level, hundreds of thousands of people would be forced out of their homes. Communication links would be knocked down and power outages would be widespread. Desalination plants, which are the main drinking water source, would fail due to flooding, switchgear damage and loss of natural gas supplies. Such a scenario would trigger massive drinking water shortages for several weeks.

Coastal oil and gas installations would be severely damaged and shut down and the world's most important crude oil tanker route will be severely affected. Mina Al Fahal Oil Terminal, which ships all of Oman's 650,000 barrels per day of oil exports, would experience severe winds of about 180 km/h and storm surge of about 10 metres. Crude oil and refinery products are loaded on tankers off Mina Al Fahal by subsea pipeline and Single Buoy Mooring (SBM) Systems. The loading facilities and platforms of Mina Al Fahal would sustain significant damage, and it would take four to six weeks for a return to full operational capacity. The refinery and other oil facilities at Mina Al Fahal would also sustain significant damage and loss of functions. Sohar Refinery would also sustain flooding and loss of function.

The main liquefied natural gas (LNG) terminal at Qalhat (known as Sur Terminal), which handles 10 million tons per year of LNG, would be exposed to 200 km/h winds and severe flooding resulting in closure for five to eight weeks.

Giant waves would force large amounts of water to the coast making ports non-operative. The main port of Sohar would sustain significant flooding and loss of function.

Further north, the United Arab Emirates port of Fujairah, one of the world's largest ship refueling centres would be flooded and closed for two to three weeks.

The estimated losses from such an event could be in the range of $25 billion to $35 billion which is much higher than the $4 billion loss caused by Cyclone Gonu itself. Risk managers and officials in the Gulf region should consider Cyclone Gonu as a wakeup call to the risk in the region.

Earthquake Hazards

Cyclones are not the only natural hazard risk that can affect this part of the world. Earthquake hazard could be significant as well. The Arabian Plate is defined by several tectonic features (See Figure 1), with the Zagros and Taurus Mountains in the northeast defining the continental collision between the Arabian, and the Eurasian plates.

In the east, the Arabian Plate subducts beneath the Makran region of Pakistan and Iran, and southeast is the Owen Fracture Zone. The Gulf of Aden spreading centre to the south, the Red Sea spreading centre to the west and the Dead Sea transform fault to the northwest. Saudi Arabia, the world largest oil producer, occupies part of the Arabian tectonic plate. Due to the small size of this plate, the country lies close to plate boundaries in all directions and is, therefore, prone to potentially damaging earthquakes.

Figure 2 shows the 475 year peak ground acceleration (PGA) on firm soil (PGA with 10% exceedance probability in 50 years). This map is consistent with the view of the international working groups that assembled the world map for seismic hazards. Softer local soil conditions could significantly increase ground shaking. The city of Dubai would experience a ground shaking of about 3 m/s^2 to 4 m/s^2 PGA. This is a significant ground shaking that would cause widespread damage to residential, commercial and industrial facilities if not properly designed. Similarly, the United Arab Emirates port of Fujairah would experience about 3 m/s^2 to 4 m/s^2 ground shaking as well. It would sustain significant damage and would be closed for several weeks.

Costal oil and gas installations would be severely damaged and shut down. Mina Al Fahal oil terminal would experience ground shaking of more than 2 m/s^2. The refinery and other oil facilities at Mina Al Fahal would sustain light to moderate damage and loss of function. The Sohar Refinery and port would be subjected to 3 m/s^2 and would also sustain moderate loss of function.

The LNG terminal at Qalhat would be subject to ground shaking of more than 2 m/s^2. The main port of Sohar will sustain moderate loss of functions. The port facility at Mina Al Fahal would sustain light to moderate

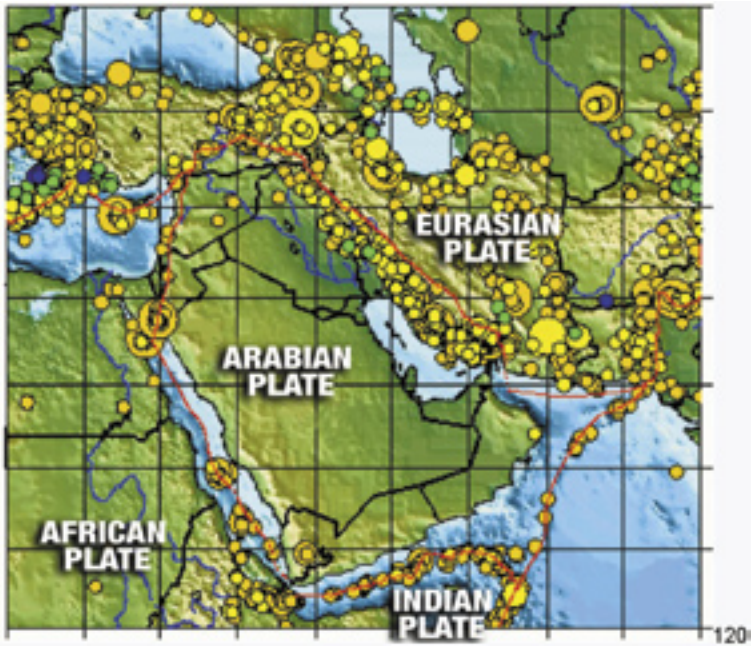

Figure 1: Earthquakes of Magnitude 5.0 and greater since 1965 and Tectonic Setting of the Arabian Gulf

damage and loss of function.

A repeat of the 1945 magnitude-8.0 event on the Makran subduction zone in a location closer to the Arabian Gulf or a similar event on the Zagros seismic belt would produce long duration and long period ground motion that would severely damage oil and gas installations, ports, terminals, utilities, infrastructures, and other industrial and commercial structures. Oil refineries throughout the affected area would sustain up to 20% damage and could experience business interruption for up to eight weeks. Bulk storage tanks would be damaged and tank ruptures might lead to loss of contents resulting in environmental damage and fires. The direct and indirect economic losses for the gulf region of such an event could be in the order of $75 billion to $100 billion.

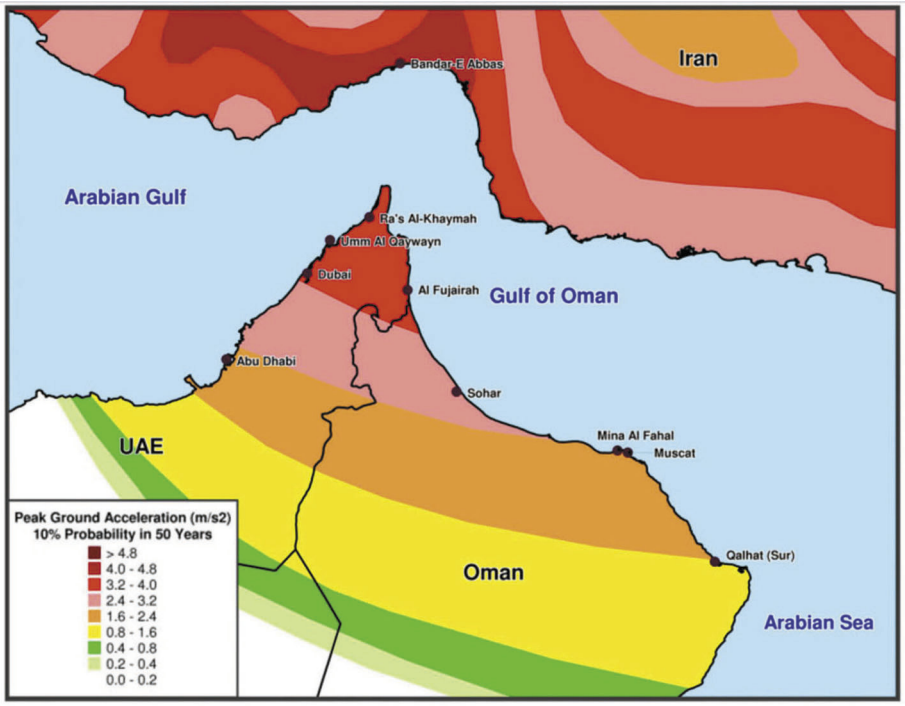

Figure 2: Peak Ground Acceleration (m/s^2) with 10% Probability of Exceedance in 50 Years

Summary

In summary, we can state that catastrophic natural hazard events can have significant effect on the Gulf region and the world economy. Probabilistic CAT models can be used to assess and quantify the risk and support managing it. These models can promote business stability by reducing the uncertainty in prospective finance losses resulting from natural and man-made catastrophe risk.