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EARTHQUAKE, TSUNAMI AND NUCLEAR DISASTER IN JAPAN: AN ASSESSMENT

Abstract

This paper attempts to assess the impacts of the devastating natural disaster - earthquake followed by tsunami, that shook Japan on 11 March 2011, from socio-economic and development point of view. The intensity of the disaster was reflected through a destructive earthquake measuring 8.9 on Richter scale along with a tsunami at a speed of 500 miles/hour. Though, Japan is technologically and economically developed, it described the disaster as the worst crisis in the 65 years of its history since the end of World War II. Huge humanitarian crisis and massive disruption of industrial supply chains negatively affected the economic growth of Japan and put enormous stress on the psyche of Japanese people. The plight of the people had been compounded further by the threat of radiation exposure from the damaged reactors of nuclear power plants at Fukushima. The mishap at nuclear power plants at Fukushima posed some serious questions to the world: how safe nuclear power plants really are? Should the world look for a safer alternative to power problems? The disaster in Japan and its consequences have some serious impacts on Bangladesh from a development perspective. Japan has long been the principal donor and biggest development partner of Bangladesh. But the ongoing crisis in Japan may pose a threat or create some degree of uncertainty to the long term development planning of Bangladesh. Besides, the catastrophic experience of Japan has made Bangladesh rethink about its readiness to encounter similar disasters. As a climate induced vulnerable country, Bangladesh should strengthen its disaster management system by ensuring early warning system, as well as improving rescuing and relief management mechanism to combat such natural calamities.

1. Introduction

At a time when the pro-democracy protesters in Bahrain and Libya were facing stiff opposition from their governments, the attention of the world suddenly turned towards Japan, which was devastated by a severe earthquake accompanied by tsunami on 11 March, 2011. The ferocity of the disaster was reflected in the wake of the devastating earthquake measuring 8.9 on the Richter

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scale along with the tsunami at a speed of 500 miles/hour.¹ The unprecedented 30 to 50 feet high waves from the sea caused destruction in the north-eastern coastal region of Japan.² The tsunami rippled across the Pacific Ocean, knocking at Hawaii and some parts of California as well. The earthquake was reportedly the fourth largest in the world since 1900. Around 21,000³ people were either dead or missing following the earthquake, which made it Japan's worst ever natural disaster since the great Kanto Hanshin earthquake of 1923. While the country was still reeling from the devastation caused by the earthquake and tsunami, the plight of the people had been compounded further by the threat of radiation exposure from the damaged reactors at the Fukushima Daichi Nuclear Power Station of Fukushima Prefecture - 170 miles north of Tokyo. Analysts speculated that the economy could even tip back into recession. Japanese stocks closed down by more than six per cent, the biggest fall since the height of global financial crisis in 2008. Rescue workers combed the tsunami battered region north of Tokyo for survivors and struggled to care for millions of people without power and water. Many countries from all over the world had joined the humanitarian operations in Japan which is economically and technologically one of the most developed countries of the world. It may be mentioned that the quake was much stronger than the 2010 quake which devastated Haiti in Central America. It could be compared with the quake that devastated Indonesia in 2004, followed by a tsunami and killed 200,000 people in more than a dozen countries around the world. Japanese Prime Minister Naoto Kan described it as the worst crisis in the 65 years of Japan since the end of World War II.

Against this background, the paper examines the degrees of loss caused by Japan's disaster and will assess the disaster from geophysical, socio-economic and sustainable development context with special reference to Bangladesh. It is to be noted that the paper has reviewed the information from various secondary sources up to 15 May 2011. The consequences of this disaster (especially the impact of radioactivity) are still ongoing. The time frame of the paper is up to May since the occurrence of the disaster in Japan.

The paper is divided into four sections excluding the introductory section. Section 2 deals with the general information about the disaster such as affected areas across the Pacific, damages and casualties and the like. The overall assessment of Japan's disaster is analysed in section 3. Section 4 focuses on Bangladesh perspective in this regard. The final section draws a conclusion of the paper.

¹ "Tsunami sweeps across Pacific", *The Daily Star*, Dhaka, 13 March 2011.

² *Ibid.*

³ "Japan tsunami: lessons for us", *The Daily Star*, Dhaka, 21 March 2011.

2. Earthquake, Tsunami and Nuclear Disaster: An Overview

Japan's disaster consisted of a set of three events. They were: i) earthquake ii) tsunami, and iii) nuclear disaster.

Earthquake: The 8.9 magnitude undersea megathrust earthquake occurred in the western Pacific Ocean with its epicenter approximately 72 km east of the Oshika Peninsula of Tōhoku.⁴ The other nearest major cities to the quake were Sendai and Honshu. The main earthquake was preceded by a number of large foreshocks and multiple aftershocks. Marcia McNut, the Director of United States Geological Survey (USGS) explained that aftershocks followed Omori's Law⁵ which might continue for years and would taper off in time.⁶ The earthquake occurred where the Pacific plate was subducting under the plate beneath northern Honshu. The Pacific plate, which moves 8 to 9 cm per year, dips under Honshu's underlying plate releasing large amount of energy.⁷ This motion pulls the upper plate down until the stress builds up enough to cause a seismic event. The break caused the sea floor to rise by several meters. The Japanese Meteorological Agency (JMA) informed that the earthquake might have ruptured the fault zone from Iwate to Ibaraki with a length of 500 km and a width of 200 km.⁸ Japan's National Research Institute for Earth Science and Disaster Prevention (NIED) calculated a peak ground acceleration of 29.33 m/sec². The earthquake released a surface energy of $1.9 \pm 0.5 \times 10^{17}$ joules which dissipated as shaking and tsunamic energy. The total seismic moment was more than 200,000 times of the surface energy and was calculated by the USGS at 3.9×10^{22} joules, slightly less than the 2004 Indian Ocean quake.⁹ This is approximately 600 million times more energy than that of Hiroshima bomb. Soil liquefaction was evident in areas of reclaimed

⁴ "Tsunami sweeps across Pacific", *op.cit.*

⁵ Aftershocks occur with a pattern that follows Omori's law. Omori's law is an empirical relation for the temporal decay of aftershock rates. According to this law, the rate of aftershocks decreases quickly with time. The rate of aftershocks is proportional to the inverse of time since the main shock. Thus whatever the odds of an aftershock are on the first day, the second day will have 1/2 the odds of the first day and the tenth day will have approximately 1/10 the odds of the first day (when p is equal to 1). These patterns describe only the mass behavior of aftershocks; the actual times, numbers and locations of the aftershocks are 'random', while tending to follow these patterns. As this is an empirical law, values of the parameters are obtained by fitting to data after a main shock has occurred, and they imply no specific physical mechanism in any given case.

⁶ "Japan earthquake: Tsunami hits north-east", *BBC News*, 11 March 2011.

⁷ "Regarding the 2011 off the Pacific coast of Tōhoku Earthquake", available at: <http://www.bosai.go.jp/e/international/110318/110318.html>, accessed on: 25 March 2011.

⁸ "The 2011 off the Pacific coast of Tōhoku Earthquake~fourth report" available at: http://www.jma.go.jp/jma/en/News/2011_Earthquake_04.html, accessed on: 25 March 2011.

⁹ "Regarding the 2011 off the Pacific coast of Tōhoku Earthquake", *op.cit.*

land around Tokyo, particularly in Urayasu, Chiba, nearby Haneda airport and Odaiba. The liquefaction damaged houses in the town and trapped vehicles.

Tsunami: The earthquake caused a major tsunami which wrought destruction along the Pacific coastline of Japan's northern islands. The tsunami propagated across the Pacific and warnings were issued and evacuations carried out in many countries bordering the Pacific (including the entire Pacific coast of North and South America from Alaska to Chile). The tsunami warning issued by the JMA was the most serious on its warning scale. It was rated as a 'major tsunami' being at least three meters high. The tsunami inundated a total area of approximately 470 square km in Japan.¹⁰

Kuji and Ōfunato have been swept away without any trace. Other cities reportedly destroyed or heavily damaged by the tsunami include Rizuentakata, Kamaishi, Miyako, Ōtsuchi, Yamada (in Iwate Prefecture); Namie, Sōma and Minamisōma (in Fukushima Prefecture), Higashimatsushima, Onagawa, Natori, Ishinomaki and Kesenuma (in Miyagi Prefecture); and Asahi (in Chiba Prefecture). The most severe effects of the tsunami were experienced along a 670 km long stretch of coastline from Erimo in the north to Ōarai in the south.¹¹ The following readings were obtained from recording stations maintained by the JMA around the coastline of Japan:

Table 1: Water Level due to the Tsunami at Different Ports of Japan

Time (in JST)	Location	Tsunami height (in m)
15.12	Iwate Kamaishi-oki	6.8
15.15	Ōfunato	3.2 or higher
15.20	Ishinomaki-shi Ayukawa	3.3 or higher
15.21	Miyako	4.0 or higher
15.21	Kamaishi	4.1 or higher
15.44	Erimo-cho Shoya	3.5
15.50	Sōma	7.3
16.52	Ōarai	4.2

Source: Compiled by the author from various sources.

The Pacific Tsunami Warning Center (PTWC) issued widespread tsunami warnings covering the entire Pacific Ocean i.e., Kuril Islands, California, Hawaii, Oregon, western part of Alaska, USA, British Columbia or Vancouver Island of Canada, eastern seaboard of Philippines, Wewak, East Sepik of Papua New Guinea, south Pacific countries Tonga and New Zealand, Mexico, Chile and Galapagos Islands.

¹⁰ Maswood Alam Khan, "Earthquake in Japan: A sign foreboding the apocalypse?", *New Age*, Dhaka, 14 March 2011.

¹¹ *Ibid.*

Nuclear Explosion: The Fukushima I, Fukushima II, Onagawa Nuclear Power Plant, and Tōkai nuclear power stations consisted of a total eleven reactors which were automatically shut down following the earthquake. Higashidōri was already shut down for a periodic inspection. Cooling was needed to remove decay heat for several days after a plant had been shut down. At Fukushima I and II, tsunami waves overtopped seawalls and destroyed diesel back up power systems, leading to severe problems including two large explosions at Fukushima I and leakage of radiation. Over 80,000 people living within 20 km radius of the plant had been evacuated from their residences.¹² It was reported that favourable winds were carrying radioactive particles from the incidents out to sea, mitigating some of the negative impacts. Helicopters were used to dump water on the Fukushima I plant to further attempt to cool the reactor.

Japan declared a state of emergency following the failure of the cooling system at the Fukushima I Nuclear Power Plant. Officials from the Japanese Nuclear and Industrial Safety Agency (NISA) reported that radiation levels outside the plant were up to 1,000 times more than the normal levels and the radiation levels inside the plant were up to 8 times more than the normal levels.¹³ Later, a state of emergency was also declared at the Fukushima II Nuclear Plant about 11 km south. These brought the total number of problematic reactors to six. The local population was advised by the authorities to stay home until the radioactive situation of the environment was totally clarified. Unlike, other five reactor units, reactor 3 runs on mixed Uranium and Plutonium oxide, making it more dangerous due to the neutronic effects of Plutonium on the reactor and the carcinogenic effects in the event of release to the environment. Tokyo Electric Power Company (TEPCO) tried to reduce the pressure within the plants by venting contaminated steam from the reactor vessels into the atmosphere. Residents living within 20 km and 3 km were evacuated from the radius of Fukushima I and II Plants.

It was reported that radioactive Iodine was detected in the tap water in Fukushima, Tshigi, Gunma, Tokyo, Chiba, Saitama, and Nigata. Radioactive Cesium was also found in tap water in Fukushima, Tchigi, and Gunma. Radioactive Iodine and Cesium were also detected in soils in some places in Fukushima. There might be a need to replace the contaminated soil. Food products were also contaminated by radioactive matter in several places in Japan.

A fire occurred in the turbine section of the Onagawa Nuclear Power Plant following the earthquake. On 13 March, the lowest-level state of emergency was declared regarding the Onagawa Plant as radioactivity readings temporarily exceeded the allowed levels in the area of the plant. But, TEPCO stated that it

¹² “Japan to review energy policy over nuclear crisis”, *BBC News*, 10 May, 2011.

¹³ “Japan nuclear: Fukushima seawater radioactivity rises”, *BBC News*, 30 March 2011, available at: <http://www.bbc.co.uk/news/world-asia-pacific-12903072>, accessed on: 30 March 2011.

might have been due to radiation from Fukushima I nuclear accidents but was not from the Onagwa Plant itself.

The number 2 reactor at Tōkai Nuclear Power Plant was shut down automatically. On 14 March, it was reported that a cooling system pump for that reactor had stopped working. The Japan Atomic Power Company stated that there was a second operational pump sustaining the cooling systems, but that two out of three diesel generators used to power the cooling system were out of order.

Japan had raised the alert level at its quake-damaged nuclear plant from four to five on a seven point international scale of atomic incidents.¹⁴ The crisis at Fukushima Daichi site, previously termed as a ‘local problem’ is now having ‘wider consequences’. The UN mentioned that the battle to stabilise the plant was ‘a race against time’.

3. Assessment of Japan’s Earthquake, Tsunami and Nuclear Disaster 2011

The overall assessment of Japan’s disaster on 11 March 2011 is as follows:

Worst Crisis in the Japanese History: Following the disaster, fuel shortage, icy rain and power outages have constituted Japan’s worst humanitarian crisis. There were about 21,000 dead or missing, 3,19,000 people evacuated, 2,131 makeshift shelters, 2.4 million people were left without access to water and 2,21,000 households without power.¹⁵ Japan would take at least five years to reconstruct its earthquake and tsunami afflicted regions as it has to balance the need to rebuild houses, roads and power grids, with planning for disaster-proof infrastructure. It has the resources, skills, and social cohesiveness required to rebuild quickly as the world’s third largest construction market, but that the disaster would spur it to think even harder about urban planning and protection.

Unpredictable Radiation Levels and its Health Risks: According to the experts, three things that determine whether a blast of radiation would be harmless, debilitating or lethal are: i) the intensity of exposure, ii) its duration, and iii) access to treatment. They are concerned about two types of radioactive materials (Iodine 131 and Cesium 137) which are generated as byproducts of the nuclear fission process. Radioactive Iodine decayed quickly and would disappear from the environment within weeks or month. Cesium once released into the environment continues to pose a potential risk for many years. Japanese officials have informed that the radiation levels were 30 millisieverts (mSv) between the

¹⁴ “Nuke alert level raised: Japan faces second worst atomic disaster in history”, *The Daily Star*, Dhaka, 18 March 2011.

¹⁵ “Steam rises from stricken Japan nuclear plant”, *The Financial Express*, Dhaka, 23 March 2011.

reactor 2 and 3, 400 mSv near reactor 3 and 100 mSv near reactor 4.¹⁶ The main health danger is cancer, especially leukemia, along with lung, thyroid, and colon cancer. The risk is proportional to the dose received. TEPCO had been accused of a lack of transparency and failure to provide information more promptly. It was also heavily criticised for issuing erroneous radiation readings.

Disruption of Industrial Supply-Chain will hit the World's Biggest Companies:

Some of the world's biggest companies could face severe supply-chain problems after the earthquake and tsunami in Japan due to the disruption of transportation and power supply. The car making industry would be especially hard hit. North eastern Japan had become a key production center, with Toyota, Honda, Nissan, and others operating large plants making vehicle parts. Besides, Japanese companies which had to contend with rolling blackouts imposed to manage electricity supplies account for about 40 per cent of world's technology components. The country made 30 per cent of world's flash memories, used in Smartphone and digital cameras, and 10-15 per cent of D-Ram memory which was a key component in every personal computer.¹⁷ Asahi, NH Techno and Nippon Electric Glass were three of the world's top suppliers of glass for flat panels.

Among the core parts made in Japan that could be at risk of supply disruption were capacitors and transistors components contained in almost every electronic product. The high-end cells for batteries used in notebook computers and cars might face shortage of supply. Many technology companies such as smartphone maker HTC, flat-panel maker AU Optronics, and IT electronics components supplier Flextronics played down the impact on component supplies. According to Foxconn Technology Group, the world's largest contract electronic manufacturers informed that the quake was expected to affect the global technology value chain.

Japan's Economic Growth would be Negatively Affected till Mid 2011:

According to World Bank, the losses caused by the earthquake and tsunami in Japan were estimated at US\$ 235 billion. Japan's economic growth would be affected until mid-2011.¹⁸ However, the reconstruction would encourage further recovery by the end of the year 2011. The massive Japanese earthquake raised the chances of a fiscal crisis in the world's third largest economy and could affect countries around the globe. Japan was burdened by the industrialised world's

¹⁶ "Japan nuclear: Fukushima seawater radioactivity rises", *BBC News*, 30 March 2011, available at: <http://www.bbc.co.uk/news/world-asia-pacific-12903072>, accessed on: 30 March 2011.

¹⁷ "Japan disaster spooks markets", *The Financial Express*, Dhaka, 16 March 2011.

¹⁸ "Rebuilding northeast Japan to take years, billions", *The Financial Express*, Dhaka, 17 March 2011.

biggest debt, which ran close to 200 per cent of Gross Domestic Product (GDP).¹⁹ However, economists stressed that the earthquake was not of the same impact as the devastating quake which ravaged Kobe. The World Bank estimated that exports from the region could slow by 0.75-1.5 per cent if Japan's GDP shrank by 0.25-0.5 per cent. Reinsurance giant Swiss Re estimated that the earthquake and tsunami had cost it US\$ 1.2 billion but the figure could be revised upwards.²⁰ However, the US billionaire and investor, Warren Buffet, told that the disaster would not hamper the Japanese economy and could prompt new stock buying.

The Japanese government planned to dedicate up to ¥ 10 trillion in crisis lending to businesses to help them finance day-to-day operations and repair damage from the disaster.²¹ Additionally, the Bank of Japan would keep monetary policy exceptionally loose to aid reconstruction and minimise the damage to the economy. It injected an extra ¥ 3.0 trillion into the markets in a bid to shore up confidence and ensure liquidity.²² The government could provide special financing in the form of low interest loans or interest payments subsidies backed by the public funds when a natural disaster or other events triggered major economic instability. The government was also discussing for creating a recovery fund that would provide medium to long term lending for firms directly hit by the disaster. However, setting up such a fund would require several changes to the law.

Disaster Crippled the Fishing Industry of Japan: Several weeks after the earthquake and tsunami, the Japanese government authorised the dumping of 10,000 tons of low-level radioactive water into the sea near Tōhoku to increase storage tank capacity at the Fukushima Daichi nuclear plant.²³ Testing confirmed that radioactive Cesium and Iodine levels in sand lance caught off of Ibaraki Prefecture were higher than the allowable standards. As a result, people were refusing to buy fish caught in the Tōhoku region, even in areas where fishing vessels and infrastructure remained unaffected.²⁴ That would further drive

¹⁹ "Nature's fury strikes Japan", *The Economist* cited in *The Daily Star*, Dhaka, 13 March 2011.

²⁰ "Disaster could cost Japan US\$ 235b: WB", *The Daily Star*, Dhaka, 21 March 2011.

²¹ "Japan plans up to US\$ 127b in lending to business", *The Financial Express*, Dhaka, 20 March 2011.

²² *Ibid.*

²³ "High Radiation in Japanese Fish Raises Concerns", available at: http://abcnews.go.com/Health/radiation-japans-fish-raise-concerns_world/story?id=13302515, accessed on: 30 March 2011.

²⁴ The radioactive materials in seafood have made the Japanese people nervous. The radiation level of Iodine-131 concentrations remained at 140,000 times the government-set limit. Cesium levels are also a concern. The fear of radioactivity is likely to proliferate because radioactive seafood is a nightmare which comes true for two uniquely reasons to

demand for imported seafood for the foreseeable future. For example, prices for sardines had fallen from US\$ 0.48 per kilogram to US\$ 0.18 per kilogram. Alfonsin (kinmedai) was one of the most delicious types of fish in Japan, and recently prices had fallen regionally from US\$ 26 per kilogram to US\$ 14 per kilogram.²⁵

Many fishermen lost not only their vessels, but also the infrastructures to ensure the quality product for market. The Fisheries Agency in Japan confirmed that 19,000 vessels were damaged or destroyed and they estimated that the economic impact on the fishing industry alone would likely equate US\$ 1 trillion. The fact that over 40 per cent of fishermen in Japan were already at retirement age exacerbates the difficulties in determining the next steps for rebuilding coastal communities and the future of the affected areas. Fishing ports such as Minamisanriku, Miyagi, Rikuzentakata, Iwate, Onagawa, Hachinohe, Aomori - all locally famous for a variety of wild-caught and farmed seafood including Flatfish, Salmon, Scallops, Tunas, Oysters, Sardine, and Pacific Saury, were heavily damaged. The present economic situation in Japan presents significant challenges to rebuilding the fishing industry in the affected areas. The government should think about training new entrants, finding innovative ways to reduce costs, and implementing more stringent regulations that would allow coastal fish stocks to rebuild to levels consistent with the biological maximum sustainable yield in the long-term.

Geophysical Impact of Earthquake on 11 March 2011: The quake that struck northern Japan not only violently shook the ground and generated a devastating tsunami but also moved the coastline and changed the balance of the planet. Italy National Institute of Geophysics and Volcanology informed that the earth axis shifted 25 cm as a result of the earthquake and the U.S. Geological Survey estimated that the main land of Japan had shifted eastward up to 13 feet or 2.4 meters.²⁶ In addition to that, Japan is much wider than it was before. The scientists of National Aeronautics and Space Administration (NASA) calculated

the Japanese people. Japan is the only country that has experienced atomic war and the long-term effects of radiation, leaving the public fearful of nuclear technologies even today, more than 65 years after Hiroshima and Nagasaki. The nation has also the experience of the worst public health disasters of the post-war period, with thousands crippled by mercury poisoning of seafood caused when toxic chemicals were released into the sea in the 1950s and 1960s.

²⁵ "Seafood radiation hits Japan's sushi", available at:

<http://www.theaustralian.com.au/news/breaking-news/seafood-radiation-hits-japans-sushi/story-fn3dxity-1226035582189>, accessed on: 04 April 2011.

²⁶ "10,000 missing in port town: death toll rises to 1,300", *The Daily Star*, Dhaka, 13 March 2011.

that the redistribution of mass by the earthquake might have shortened the day by a couple of millionths of a second and tilted the earth axis.²⁷

Huge Humanitarian Responses from all over the World: Japan received messages of condolences and offers of assistance from a range of international leaders. According to Japan's foreign ministry, 120 countries and 30 international organisations offered assistance to Japan.²⁸ The lists of charitable and humanitarian responses to the disaster from governments and non-governmental organisations, corporate sectors, and private donations are given in annex 2, 3, and 4.

Stress on the Psyche of Common Mass: The current crisis in Japan put the Japanese system and way of life of the people under severe strain. The Japanese were usually reticent about accepting foreign assistance. They were, therefore, overwhelmed by offers of aid from all over world. They did not know exactly how they should handle that. But what had in some ways disappointed the Japanese was that many countries were also withdrawing their citizens from Japan in view of possible spread of nuclear radiation. The order of US government to its navy ships to go far away from the Japanese shores to avoid possible radiation contamination was a psychological setback for Japanese people. The fact that the US was also not depending on Japanese data in assessing the impact of the nuclear tragedy was disturbing to them.²⁹ The Fukushima nuclear plant revealed a series of missteps, bad luck, and last minute improvisations by the Japanese. Another important aspect was that the Japanese always respected the competence and efficiency of their bureaucracy. But this time, the bureaucracy seems unable to cope efficiently with the triple crisis.

Japan is a Land of Active Seismic Zone: Since long, Japan has had a long history of earthquake and seismic activity (see annex 1). The islands of Japan are primarily the result of several large oceanic movements occurring over hundreds of millions of years from the mid-Silurian to Pleistocene as a result of the subduction of the Philippine Sea Plate beneath the continental Amurian Plate and Okinawa Plate to the south, and subduction of the Pacific Plate under the Okhotsk Plate. Japan was originally attached to the eastern coast of the Eurasian continent. The subducting plates have been going deeper than the Eurasian Plate pulling Japan eastward for 15 million years.³⁰ Now a days, the Japanese archipelago is considered as a mature island arc and is the result of several generations of subducting plates. Approximately 15,000 km of oceanic floor had

²⁷ "Japan widened, moved close to America", *The Daily Star*, Dhaka, 16 March 2011.

²⁸ David Cutler, "FACTBOX-Aid and rescue offers for Japan quake", available at: <http://www.trust.org/alertnet/news/factbox-aid-and-rescue-offers-for-japan-quake/>, accessed on: 13 April 2011.

²⁹ Ashfaqur Rahman, "Sunday Pouch: Annus horribilis for Japan", *The Daily Star*, Dhaka, 19 March 2011.

³⁰ "Quake could ignite Tokyo time bomb", *The Daily Star*, 13 March 2011.

passed under the Japanese area in the last 450 million years.³¹ Moreover, Japan is situated in a volcanic zone on the Pacific Ring of Fire. Therefore, frequent low intensity earth tremors and occasional volcanic activity are felt throughout the islands.

Japan's Early Warning System saved many Lives: Japan's early warning system for prediction of earthquake is very strong. JMA is in the charge of sending early warnings. JMA, which includes more than 1,000 seismometers in Japan, sent out warnings of impending strong shaking to millions one minute prior to the effects of earthquake being felt in Tokyo. Television and three major mobile phone carriers had developed the simultaneous broadcast systems to receive the early warning. After receiving a warning, a person might have a few seconds at longest to take action. The earthquake early warning was set up to enable people to mitigate damage from an earthquake so that people may protect themselves at home, at the office, and near cliffs. Railway workers might use that warning to slow down train, and factory worker might use it to stop assembly lines prior to an earthquake. It was also possible before the earthquake on 11 March 2011 because the damaging seismic S-wave travelling at 4 km/second which took about 90 seconds to travel 373 km to Tokyo. The relatively harmless P-waves travelling at twice the speed can be detected earlier.³² JMA believed that the early warning system had saved many lives from the disaster.

Human Beings are Still Helpless to Natural Disaster: Japan is one of the most technologically advanced nations of the world. It has shown its economic prowess on a global scale and is now facing the worst situation caused by the fury of nature that brought destruction of an unimaginable proportion to both men and materials. Japan's woes from the quakes and then the tsunami are too colossal in every sense and its nuclear radiation issue has added a dangerous element as several reactors have been inflicted by the catastrophe. It is somewhat unthinkable for any human being, more particularly in a country like Japan that has achieved so much of development and also has an enormous economic might. The devastation in Japan has once again brought to fore the harsh reality that unfortunately human beings are still helpless before natural disasters. Notwithstanding the fact that science and technology have achieved wonders including spectacular feats like sending men to the moon, the mankind is undoubtedly helpless in facing the unpredictable fury of the nature. This is an axiomatic truth. Therefore, the lesson for human being is to face such calamities with great courage and fortitude.

Is it the End of Use of Nuclear Power in Japan and Rest of the World? There are 442 nuclear reactors that supply about 15 per cent of electricity all over the

³¹ *Ibid.*

³² "Regarding the 2011 off the Pacific coast of Tōhoku Earthquake", *op.cit.*

world. More than 35 nuclear power plants are currently under construction around the world, 24 of them are in Asia. In the modern economy, the energy to turn machines is intertwined with national security, foreign policy and warfare (see annex 6 for the nuclear energy policy by country).

The Fukushima Daichi power plant provides a lesson for the rest of the world regarding the nuclear expansion programme. Nuclear power generation is the only form of energy production that can lead to a catastrophic accident as the reactors are inherently vulnerable. High pressure and temperature are maintained for high energy fission chain reaction inside the reactor. Nuclear reactors are systematically complex. A fault in one subsystem is quickly transmitted to others and gets magnified, plunging the whole system into crisis. Nuclear power involves radiation exposure at all stages, from Uranium mining, fuel fabrication, to reactor operation and maintenance, to routine emission, and spent fuel handling, storage and reprocessing. Nuclear reactors leave a toxic trail of high-level radioactive wastes. These remain hazardous for thousand of years. The half-life of Plutonium-239, which is produced by fission, is 24,400 years. Therefore, handling of radioactive chemicals needs advanced expertise and technology. The crisis has triggered anti-nuclear power protests in Europe. Up to 60,000 protesters formed a 45 km human chain in Germany to denounce the government policy of extending the life of nuclear plants.³³

The Fukushima incident took place when it appeared that the nuclear power industry was on the cusp of a period of growth. Increasingly, states appeared to be turning more to nuclear power in an era of rising fuel prices, concerns about the greenhouse gas effects of fossil fuels, and a slowdown in production of hydrocarbons. Even in our part of the world, crude oil production has declined. The challenge will also lie in reducing the lag between technological breakthroughs and their adoption commercially. In the energy sector, it has taken about 25 years for new technologies to be widely available. For example, natural gas technologies have been widely available since the 1970s but natural gas has only slowly emerged as a competitor for oil-based fuels. High costs of investment and the sunk costs of plant and equipment represented by existing technologies have been a deterrent in the adoption of new technologies. In such circumstances, the question that arises: is the nuclear power safe? This question of nuclear safety had been relegated to back stage over the last ten to fifteen years under the twin barrage of global warming and energy shortage. Nuclear energy is rightly seen as a green energy with little or no green house gas emission. Nuclear energy is envisaged to meet the growing energy demand worldwide when hydrocarbon resources (coal, oil, gases) are being depleted at

³³ “Japan’s Quake hit areas need emergency supplies”, *The Daily Star*, Dhaka, 14 March 2011.

ever increasing rates. So, why not nuclear energy should solve the twin problem in one swoop?

4. Bangladesh Perspectives

Disaster Preparedness for Earthquake and Tsunami: Although earthquake in Bangladesh is yet to be recognised as case of severe natural disaster, a couple of quakes of modest magnitude in recent times created a latent threat. Due to geographical location, Bangladesh is always under a potential threat of earthquake, which might cause catastrophic devastation. A high magnitude tremor has the highest possibility of happening at any time, which might cause the devastations particularly in Dhaka and Chittagong cities. Though Bangladesh has made tremendous improvement to mitigate and manage many of its natural disasters like floods and cyclones, the mitigation strategies regarding earthquake still remains at its infancy. At this stage, the country needs to incorporate the concept of earthquake mitigation and management issues within the existing national disaster management plan/programme. Moreover, motivation programme (regarding Do's and Don'ts during earthquake) and increasing people's awareness can considerably reduce the casualties.

The latest seismic zoning map prepared by Bangladesh University of Engineering and Technology (BUET) found that 43 per cent landmass of Bangladesh has been under high risk zone, 41 per cent under moderate zone and 16 per cent under low risk zone.³⁴ In geologic terms, this region is quite young as the mountains are still growing and Bangladesh is very close to the Indian-Eurasian tectonic plates which are potential enough to cause any major earthquake. According to Professor Mehedi Ahmed Ansari, Department of Civil Engineering of BUET, if there was an earthquake measuring 7.00 on the Richter Scale in Dhaka, it would cause death of at least 1,50,000 people due to fragile faulty structure of the residential buildings and commercial centers. He also mentioned that about 70,000 to 80,000 houses out of 3,26,825 houses will be completely destroyed.³⁵ Earthquake vulnerability of any place largely depends on its geology and topography besides population and building density, quality of buildings, etc. Most of the time, it is not the earthquake rather it is the building that kills people. If the collapse of even a single building can be stopped, it could save lives of many inhabitants in that building. It may not be possible to demolish all the old buildings, but all newly constructed buildings can be made earthquake resistant by strictly following the National Building Code (NBC). If an area like old Dhaka with narrow lanes and a huge population is affected, the situation would be beyond comprehension. Moreover, the existing set up of

³⁴ "Lessons from Japan's cataclysmic quake", *The Financial Express*, Dhaka, 19 March 2011.

³⁵ "Natural disaster is devastating tremor imminent in Bangladesh?", *The New Nation*, Dhaka, 07 October 2010.

utilities (gas and water pipes with electric cables) also stands as a hindrance. Rescuing the trapped people is the first job in the event of an earthquake and this needs trained people with appropriate equipments. Even though various departments of the government have contingency plans, they do not have the required equipments. Again equipments entail training to the rescue workers. Side by side, strict application of building codes, enforcement of law and order, and creation of public awareness has no alternatives. A three-year project at one million taka was launched to strengthen disaster preparedness capacity especially earthquakes, but much effort is still needed.³⁶ Moreover, the case of earthquake should be considered as a top priority before going for any construction like bridge, buildings, and expressway. In doing so, the unplanned expansion and growth of cities especially Dhaka should be stopped.

Japan's Predicament Provides a Lesson for the Proposed Nuclear Power Plant: Electricity generation is demand-led priority sector in Bangladesh. The country has a shortage of 1,500 to 2,000 MW electricity at present. It is estimated that there will be an additional demand for 21,000 MW by the year 2025. Under the existing generation capacity, more than 85 per cent of electricity is produced by natural gas. If no natural gas field is discovered, this power need must be met by coal, imported oil, and nuclear power. In parts of additional demand, coal would supply a maximum of 10,000 MW and imported oil 5,000 MW and 500 MW must be supplied by nuclear power.³⁷ Bangladesh is a country of 150 million population, the majority of whom have neither gas nor oil based electricity yet. Therefore, this country has no plan to ditch its nuclear power ambition despite a catastrophic tsunami in Japan. Dhaka has signed an initial accord with Moscow to buy two Russian nuclear reactors, each having the capacity to produce 1000 MW power. The government hopes to set up the plants at a cost of about US\$ 3 billion by 2017. A final agreement is expected when Prime Minister Sheikh Hasina visits Moscow in the middle of this year.³⁸

The horror of Chernobyl or the latest Fukushima explosion might be taken as a wake-up call for Bangladesh. Nuclear energy generation in a densely populated country like Bangladesh is an alarming prospect. In the event of meltdown, there is hardly any space to evacuate people. Even a vast country like former USSR found it extremely difficult to evacuate its people after Chernobyl disaster because the heavy nuclear fallout covered a very broad area. Moreover, the nuclear power cannot be stored without the risk of groundwater contamination or

³⁶ "Earthquake: Preparedness to lessen the casualties is important", *The Financial Express*, Dhaka, 21 March 2011.

³⁷ Dr. Aminul Islam Akanda, "Enthusiasm and realism with nuclear power plant", *The Financial Express*, Dhaka, 17 March 2011.

³⁸ M Abul Kalam Azad, "Dhaka seeks to build two 1,000MW plants", *The Daily Star*, Dhaka, 02 April 2011.

environmental degradation. The waste from the nuclear energy is extremely dangerous and it has to be carefully looked after. Another critical issue is the doubt over the domestic capacity of Bangladesh Atomic Energy Commission (BAEC) to handle the safety, and safeguard control over the implementation of the proposed nuclear plant.

Several studies by different countries and expert groups show that the cost of electricity generation from nuclear power has comparative advantage over gas and coal. Farid Uddin Ahmed, the Chairman of BAEC informed that the plants are being set up at a place where there had been no record of massive tremor at least for the last 100 to 150 years. BAEC needs to ensure safety and adhere to the US Nuclear Regulatory Commission (USNRC) or equivalent standards. Bangladesh has the option to take help from the committed cooperation of the International Atomic Energy Agency (IAEA) on the construction process of Rooppur Nuclear Power Plant.

Japanese Aid and Future Development Projects: Japan is the largest bilateral donor for Bangladesh that makes commitment of US\$ 300-500 million every fiscal year. It has deferred the approval of US\$ 600 million new credit proposals till the next fiscal year owing to the devastations it suffered in the recent earthquake and tsunami. The credit proposals include US\$ 400 million for the construction of Padma Bridge and US\$ 200 million for a water treatment plant in Khulna and other projects. A high official of the Economic Relations Division (ERD) informed that not only for Bangladesh, all new Japanese commitments to other countries have been suspended for the current fiscal year.³⁹ The ERD official mentioned that the credit proposals for Bangladesh were supposed to be approved in Japanese cabinet very soon. Besides these, an agreement on a Japanese grant of ¥ 500 million (around Tk. 42 crore) for primary education sector has been signed on 30 March 2011.⁴⁰

Impact on Exports to Japan: Bangladesh's move to make inroad into the multibillion dollar Japanese clothing market may suffer. The volume of trade between Bangladesh and Japan is worth more than US\$1.4 billion/year and the trade balance is heavily tilted towards Japan.⁴¹ Local traders mainly import vehicles, vessels and transport related equipments, machinery and mechanical appliances, mineral products, textiles and textile articles, optical, photographic measuring, checking, precision, medical and surgical instruments. Local exports make shipments of woven and knit garments, leather and jute goods and raw jute.

Bangladesh Knitwear Manufacturers and Exporters Association (BKMEA) informed that it may postpone an apparel fair scheduled to be held in Tokyo in

³⁹ The Japanese fiscal year starts in April and ends in March.

⁴⁰ "Japan to donate for development project", *The Daily Star*, Dhaka, 31 March 2011.

⁴¹ "Tsunami won't affect trade with Japan", *The Financial Express*, Dhaka, 17 March 2011.

July 2011 as it would not be able to draw much attention from the Japanese retailers.⁴² The association which represents the country's 1,300 knitwear manufacturers had hoped that the exposition would catapult Bangladesh as a leading apparel exporter to one of the world's biggest clothing markets. Knitwear market in Japan is alone worth over US\$ 25 billion. The market for woven and synthetic garment is believed to be more than the size of knitwear. According to BKMEA, Bangladesh in 2010 exported knitwear items worth US\$ 70 million to Japan, posting a 60 per cent growth over the previous year. On the contrary, Bangladesh imports more than 30,000 reconditioned cars from Japan worth nearly US\$ 600 million/year.⁴³

5. Conclusion

Historically, Japan is a global strategy master in disaster management. In retrospect, this is the nation, which has survived world wars, atomic bombings, defeats, and many unprecedented calamities. Each time, it got hit, it has bounced with a greater collective resilience. The past tells that the sense of a foreboding danger and combating it with an unparalleled calmness is in the temperament traits of the Japanese. A Japanese citizen takes every possible precaution to the wrath of faith. The issues raised by the Fukushima disaster are likely to result in a slowdown in current plans for the expansion of nuclear power generation all over the world. The current generation of nuclear power reactors has lowered the costs of power generation, vastly improved safety features and state of the art waste and proliferation management capabilities. With rising electricity prices, these nuclear power plants are economically competitive. Even land scarce Singapore is studying the long term feasibility of nuclear energy. In this context, Bangladesh does not have any options other than establishing nuclear power plant for meeting the growing demand of electricity. The contribution of Japan to develop the infrastructure of Bangladesh is tremendous. Therefore, Japan's quick economic stability, as the biggest development partner, is another major concern for the people of Bangladesh. The environmental changes all over the world are a reminder for all of us regarding the ferocity of the nature and vulnerability of human being. Bangladesh is widely known for its climate induced vulnerabilities. Therefore, it should strengthen its disaster management bureau/system in the context of early warning, rescuing and relief management to combat such natural calamities. One believes that cohesiveness, resilience, compassion, technological expertise, and the extra ordinary competence of the Japanese will help them to overcome the present crisis.

⁴² "Exports to Japan may suffer", *The Financial Express*, Dhaka, 21 March 2011.

⁴³ *Ibid.*

ANNEXES

Annex 1

The following is a list of earthquake in Japan with a magnitude of 7.0 or above which caused significant damages and casualties since 1900:

Year	Magnitude of Earthquake	Location	Death toll
01 September 1923	8.3	Great Kanto	1,00,000 to 1,42000
27 March 1927	7.6	Tango	3,020
02 March 1933	8.4	Sanirku	3,000 or more
10 September 1943	7.2	Tottori	1,083
13 January 1945	6.8	Mikawa	2,306
20 December 1946	8.1	Nankaidō	1,362
28 June 1948	7.1	Fukui	3,769
16 June 1964	7.6	Nigata	26
16 May 1968	8.2	Aomori	52
12 June 1978	7.7	Miyagi	28
17 January 1995	6.8	Great Hanshin	6,434
04 May 1998	7.5	Ryukyu Islands	-
23 October 2004	6.9	Chūetsu	40
20 March 2005	7.0	Fukuoka	-
16 August 2005	7.2	Miyagi	-
15 November 2006	8.3	Kuril	-
13 January 2006	8.1	Kuril	-
25 March 2007	6.9	Noto Peninsula	-
16 July 2007	6.6	Chūetsu offshore	-
14 June 2008	6.9	Iwate-Miyagi Nairku	-
09 August 2009	7.1	Izu Islands	-
11 August 2009	6.6	Tokai	-
26 February 2010	7.0	Ryūkyū Islands	-
21 December 2010	7.4	Bonin Islands	-
09 March 2011	7.2	Tōhoku	-
11 March 2011	8.9	Tōhoku	21,000 (appr.)

Source: Compiled by the author from various sources.

Annex 2

The following is a list of responses from all over the world for Japan's disaster on 11 March 2011:

Country	Aid (in dollar)	Materials	Search, Rescue, technical & Medical teams
Afghanistan	50,000		
Albania	100,000		
Armenia			Rescue team of 25
Australia		Food and equipments	Rescue team of 76
Azerbaijan	100,000		
Bangladesh		Blankets, rubber boot & gloves	Rescue and medical team
Bulgaria		Blankets, food, housing materials	
Cambodia	100,000		
Canada	600,000	Thermal wool blankets and masks	Rescue and medical team of 17
China	700,000	Fuel, food and medicine	Rescue and medical team of 15
East Timor			Rescue team of 100
Estonia	200,000		
France		Equipments	Nuclear expert team of 134
Georgia	100,000		
Germany		Equipments	Search and rescue teams
Hungary			Technical rescue team
India		Blankets and cloths	
Indonesia	200,000		Rescue & medical team
Israel		Cloths, blankets, chemicals	Medical and rescue team of 53
Korea	100,000	Boron, power sources	Rescue team of 1047
Laos	10,000		
Macedonian	€ 100,000		
Malaysia			Search, rescue and medical teams
Maldives		Food	
Mexico			Rescue team
Mongolia	100,000		Rescue teams of 12
Netherlands	1000,000		
New Zealand		Rescue equipments	
North Korea	600,000		
Pakistan		Food	Medical team
Philippines	250,000	Rescue equipments	Rescue team of 41
Russia		-do-	Rescue team of 50

Serbia	860,000		
Singapore	600,000	Food, mattress, blankets	
South Africa			Rescue team
Sri Lanka	100,000		Medical and rescue team
Taiwan	4300,000	Food, blankets, cloths	Rescue & Medical team of 24
Thailand	660,000	Food, medicine	
England		Rescue equipments	Rescue team of 70
United States		Rescue equipments	Rescue teams
Vietnam	250,000		

Source: Compiled by the author from various sources.

Annex 3

The following is a list of corporate donations for Japan's disaster on 11 March 2011:

Company	Country	Cash Donations	Goods Donations
Evergreen group	Taiwan	12,350,000	
Samsung group	South Korea	7,700,000	Cloths and communications equipments
NCSOFT	South Korea	6,300,000	
Mitsubishi Electric	Japan	6,170,000	Company products and goods
Goldman Sachs	United States	6,100,000	
JP Morgan	United States	5,000,000	
Panasonic	Japan	3,700,000	Radios, flashlights, solar LED lanterns, batteries
Sony	Japan	3,600,000	
Daimler	Germany	2,840,000	
Walt Disney Company	United States	2,500,000	
Barclays	United Kingdom	2,400,000	
Bank of America	United States	1,200,000	
Nomura	Japan	1,200,000	
Square Enix	Japan	1,200,000	
Jefferies & Company	United States	1,000,000	
Nike	United States	1,000,000	US\$ 250,000 worth of footwear and apparels
Air Liquide	France	1,000,000	
HSBC	United Kingdom	500,000	
Russell Investments	United States	125,000	
Spin Master	Canada	100,000	
Fedex	United States	81,000	
Lloyd	United Kingdom	300,000	
Valve Software	United States	3,600,000	
Nintendo	Japan	2,400,000	
Sega	Japan	1,200,000	
Namco	Japan	122,000	
Tecmo Koei	Japan	122,000	
Nexon	South Korea	1,200,000	

Source: Compiled by the author from various sources.

Annex 4

The following is a list of responses from non-governmental organisations and private sectors for Japan:

Responses	Organisations/Private	Amount of Donations (in millions)
Non-government Organization	300 Taiwanese singers, United Methodist of Christ, Unitarian Universalist Service Committee, Disciples of Christ, NC Baptist, Samaritan's Purse, Canadian Red Cross, Philippines National Red Cross, Korean Community Chest, UNICEF, Korean Disaster Relief Association, Hong Kong Red Cross, The Salvation Army, Tzu Chi Foundation, JP Morgan Chase, AT&T, Bangkok hospitals, Shelter Box, World Vision, Delta Airlines, Singapore Soka Association, Four largest music companies (EMI, Sony, Universal and Warner) collaborated to make songs for Japan.	
Private	Lady Gaga	US\$ 1.5
	Shakira	Unknown
	Sandra Bullock	US\$ 01
	Clint Eastwood	Donate the film 'Hereafter'
	Queen Elizabeth	Undisclosed
	Hideki Matsui	¥50
	Ichiro Suzuki	¥100
	The Eyed Peas	Newly released song 'Just can't get enough'
	Gwen Stefani	US\$ 01
	Daisuke Matsuzaka	US\$ 01

Source: Compiled by the author from various sources.

Annex 5

The following shows a list of damages and casualties in Japan due to the disaster on 11 March 2011:

Infrastructures and Services	Locations/Names	Description
Ports	Hachinoh, Sendai, Ishinomaki, Onahama, Hitachinka, Hitachi, Chiba, Soma, Shiogama, Kesenunuma, Ofunato, Kamashi and Miyako, port of Tokyo, port at Kashima	All ports were briefly closed after the earthquake as they were located in the disaster zone and re-opened to limited ship traffic by 29 March 2011.
Dams	Fujinuma Irrigation Dam	Ruptured and caused severe flooding
	Six were affected out of 252	Found shallow crack in their crests and gravity dams suffered a non-serious slope failure.
	Four dams within the quake area	Remained unreachable
Water		The number fell to 1.04 by 21 March 2011
Electricity	TEPCO, TEP, KEPCO	Rolling blackouts of three hours are expected to last until the end of April and will affect the Tokyo, Kanagawa, Eastern Shizuoka, Yamanashi, Chiba, Ibaraki, Saitama, Tochigi and Gunma prefectures.
Oil, Gas and Coal	Cosmo Oil Company	Set on fire by the quake and halted production due to safety check
	JX Nippon Oil and Energy	Set ablaze by the quake. An analyst estimated that consumption of various types of oil might increase by as much as 300,000 barrels per day, as back-up power plants burning fossil fuels try to compensate for the loss of 11 GW of Japan's nuclear power capacity. The city owned plant for

		importing liquefied natural gas in Sendai was severely damaged and supplies were halted for at least a month.
Transport	Tōhoku Expressway	The expressway did not re-open to general public use until 24 March 2011.
	Sendai Airport	Severely damaged by tsunami
	Narita and Haneda Airport	Re-opened within 24 hours
	JR East Train service	Canceled all the services for the rest of day
	Tōkaido Shinkansen, Jōetsu and Nagano shinkansen, Tōhoku shinkansen, Tokyo and Nasu-shibora, Akita Shinkansen, Yamagata Shinkansen	There were no derailments of Shinkansen bullet train services in out of Tokyo but their services were also suspended.
Telecommunications	Cellular and landline phones, internet services	Suffered major disruptions in the affected areas.

Sources: Compiled by the authors from various sources.

Annex 6

The following is a list of nuclear energy policy by country:

Country	Installation	Under Construction	Plans to Build	Plans to Phase Out	Nuclear restriction policy
Australia	no	no	no	no	yes
Albania	no	no	yes	no	no
Algeria	research only		yes		
Argentina	yes				
Armenia	yes				
Austria	no	no	no	no	1978, prolonged in 1997
Bangladesh	no				no
Belarus	no	no	yes	no	no
Belgium	yes			yes	no
Brazil	yes				
Bulgaria	yes	yes			no
Burma	no				
Chile	no	no	research is done	no	no
Croatia	no, but shared plant in Slovenia				
Denmark	no	no	no	no	1985 law prohibits production
Egypt	no	no			
Ghana	research reactor		yes		
Germany	yes	no	no	yes	no
Greece	no	no	no	no	yes
Hong Kong	no, but shared plant	no	no, but usage is planned to increase	n/a	Hong Kong has planned to increase the share of nuclear power in electricity consumption from 23 per cent in 2009 progressively to 50 per cent.
Hungary	yes			no	no
Ireland	no	no	yes		yes
Israel	no				
Italy	no (old plants are inactive)	no	yes	no	
Libya					
Lithuania	yes	no	yes	no	no
Luxembourg	no	no	no	no	no
Malta	no	no	no	no	no

Morocco	no	research	yes	no	no
Netherlands	yes	no		no	no
Nigeria	research	no	no	no	no
New Zealand	no	no	no	no	yes
Norway	no	no	no	no	yes
Portugal	no, research only	no	no	no	yes
Poland	yes	no	yes	no	no
Slovakia	yes				no
Slovenia	yes	no			no
South Africa	yes		yes		
Spain	yes				no
Syria	no				
Tunisia	no	no	yes, but not very specific		
Turkey	no	no	yes	no	no
Uruguay	no				
Venezuela	no	no	stopped after 2011 Fukushima	no	no
Vietnam			yes	no	no

Source: Compiled by the author from various sources.