Chapter 2
Natural Disaster and Society

2.1 Major Natural Disasters and Their Socioeconomic Impact

2.1.1 Natural Disaster Triggered Nuclear Accident

On March 11th, 2011 at 2 o'clock in the afternoon local time an earthquake of 9.0 on the Richter scale occurred in the Japan trench almost 200 km away from the coast. The earthquake that is known as Tohoku event triggered a tsunami that piled up waves up to 30 m. Automatically the four nuclear power plants along the east coast were shut down and the systems were switched over to emergency power supply. But the earthquake generated a massive tsunami that ran ashore and with its up to 14-m high waves destroyed most of the technical and emergency infrastructure of the Fukushima-Daiichi nuclear power plant. Due to this impact the emergency cooling system failed and the heat inside the reactor blocks rose continuously, triggering a series of hydrogen explosions destroying four of the five power-generating blocks, although the reactor containments remained stable. Nevertheless it came to a core melting in the aftermath of the destruction. The accident set free massive radioactive fallout and released extremely contaminated fluids into the Pacific Ocean. Only the prevailing northward and seaward winds prevented a nationwide catastrophe. The reactor blocks were destroyed although nuclear engineers worldwide claim that it is possible to construct nuclear power plants that resist every earthquake magnitude. The engineers further claim that the Fukushima disaster was not originated by the earthquake but by the tsunami. Macfarlane (2012), newly appointed head of the US Nuclear Regulatory Commission, stated the difference in understanding between geoscientists and engineers is that thus far it is not an established fact that "Nuclear engineers can and do integrate knowledge of Earth processes adequately." Undoubtedly one of the reasons for the tsunami to hit the area that strongly, was the fact that for constructing the plant, the steep cliff at Daiichi was dug out to place the reactor blocks just at sea level; thus requiring less energy for the cooling system. The natural topography about a 100 m behind the power plant area shows an increase to an

U. Ranke, *Natural Disaster Risk Management*,
DOI 10.1007/978-3-319-20675-2_2

average level of about 30 m whereas the tsunami waves were about 14 m high. A TEPCO manager was cited to have confessed that choosing this particular spot for the power plant was “not a good decision.”

The authorities promptly evacuated an area of 20 km around the power plant, a radius that was later extended to more than 30 km. More than 90 % of the 400,000 people originally living in the area were successfully evacuated within a couple of days and sheltered in provisional camps. The radioactive fallout of locally more than 3000 Bq/m^2, Cesium 134, and Cesium 137 was measured in the topsoil covering a small corridor of 30 km length from the plant site towards the northwest in the direction of the city of Fukushima. In all, 16,000 people lost their lives; 90 % of them drowned in the cold water of the Japan Sea. Still 4500 are missing. It is anticipated that the area will be off-limits for at least the next 20–30 years to let the radiation level decay naturally (it takes 10 years to reduce the radiation by 100 mSv).

Following this, the Japanese government resigned and the new government declared a moratorium in nuclear energy production (that was already watered down in late 2012), a drastic turnaround, as all governments before Fukushima were inclined to double energy production from nuclear energy. Together with the Japanese government the Italian Government declared that it would refrain from starting nuclear energy production, and the United States, Russia, France, India, China, and Brasil reiterated they would not deviate from their original nuclear-based energy path. By law Japan limited the runtime of its 54 nuclear power plants to maximum 40 years and shut down almost all the plants in the months to come. Many critics in the country, mostly from the production sector, raised massive fears of an energy deficiency to come with enormous consequences for economic growth. In fact that did not materialize as it was possible to balance the energy demand by bringing additional coal- and gas-fired plants on the network and by importing much energy from abroad. In 2012 Japan imported 25 % more energy than before. But the direct socioeconomic consequences were even much more dramatic. One of the many outcomes of the accident in the Fukushima district was due to energy failure and, due to the fact that the area had to be evacuated completely, was no longer able to produce. The result was that, for instance, the car manufacturer Toyota was forced to reduce production by 30 %, which in contrast, for a couple of months made the German car maker Volkswagen the biggest car manufacturer in the world.

Furthermore within 48 h in Germany the government declared a radical turnaround in its energy policy, banning nuclear power generation in the country and shutting down 9 of its 27 nuclear power plants immediately. Although it had, months before, decided to extend the runtimes for more than 15 years, toppling a decision of the former German government that decided—in accordance with national and international energy producers—gradually to step out of nuclear energy. The European Commission estimates that power generation costs in Europe will double in the next years. The German government is now prioritizing the use of renewable energy especially wind and solar. But such a supply scenario requires massive investments to improve the power grid capability to transport the power from the North Sea to the consumer in the south. According to a press release by the German Ministry of Environment (BMU) of February 2013 the costs for a higher share of renewable energy in national energy production might amount up to €1 billion.

2.1.2 World Food Price Increase Due to Drought

In 2012 the United States of America was stricken by the largest drought in 25 years. There was no rain for weeks, resulting in a drying up of the maize, wheat, corn, and soybean crops and in the death of thousands of cattle due to a dramatic shortage of fodder. In 32 of the Midwestern states, especially the region called the corn belt (consisting of up to two thirds of the territory of the United States) a state of emergency had been declared. According to information from the US Weather Agency NOAA, the 2012 summer experienced temperatures on average of 25 °C, thus lying 1.2 °C higher than the average of the whole twentieth century, with the month of July showing the highest ever recorded monthly temperature in the history of the United States. The temperatures even overstepped the thus far peak temperatures of the year 1936, when that drought was called the "Dust Bowl Year." The prices for fodder immediately peaked to US$330 per ton and thus doubled the 2011 price level. But the 2012 drought was not the only one in recent US history. In 2000 and 2004 there had been severe droughts in the Midwest, with serious impacts on food and agricultural production. The heat wave that had stricken the country was seen as a reaction of ongoing climate change and was, according to the US National Climatic Data Center, overlain by the La Niña phenomenon that radically changed the wind and precipitation regime over the United States. The 2012 drought resulted in a drop in agricultural production in the United States of about 20 % for maize, and led to an increase in prices for all agricultural commodities; for instance, the price for maize increased by 45 %.

Automatically the US drought food production situation had a deep impact on world food prices. The Global Price Index for food that is yearly assessed by the FAO, showing the high price levels that were reached since 2010 remained at a very high level. And the experts of FAO, WFP, and IFAD see food price volatility and high food prices to continue as a result of the anticipated climate projections that will lead to more extreme weather events in the future. The result will be a drop in crop yield and food supply, especially in the developing countries. Stern (2007, p. 65ff.) reported that a 3 °C increase in world temperature will bring up to 500 million people more to the brink of malnutrition. The FAO (2013) furthermore reiterated that only economic growth will lead to better nutritional status. Today's tense food security scenario is also an outcome of a number of other factors. First: as a reaction of the energy price increase in the last years many industrialized nations (especially Brazil but also Germany) converted large parts of their arable land to produce energy plants for biofuel. Second: the food base of some Asian countries that thus far was dominated by a rice and cereal food basis is steadily changing towards a high energy diet (meat). But an animal-source food base requires the provision of one unit food calorie, eight units of cereals (maize, corn, soybeans, etc.) and thousands of liters of water. Third: the expected increase in world population and even more the changing living standards especially in countries such as China, India, and Brazil will lead to an increase in food demand of 50–80 % (IPCC ibid), a demand that can only be settled if the size of irrigated land is increased by 30 % to 60 million hectares and for rainfed land by 20 % (20 million hectares), provided that the precipitation distribution does not change. The WBGU (2007) instead estimates a drop in crop yield of up to 50 % in areas where the precipitation distribution will alter because of climate change. The volatility of the world food market furthermore brought many international investors to the floor who discovered this macroeconomic sector and began speculating on the rise or fall of food prices. Even Germany's largest bank lately reiterated that it will continue to provide agricultural-investment products after the German Bank concluded that speculation is not the only reason for higher prices for farm commodities (Bloomberg News Agency of 13. Jan. 2913). Fourth: hydrometeorological effects such as saltwater intrusion in coastal waters, mass movements, desertification, soil erosion, hurricanes, and floods will further lead to a deterioration of food production worldwide. The decrease of income from only desertification and salting of soil is according to the World Resources Institute (WRI 2007) estimated to top about US$50 billion.

If food prices increase further this will definitively have serious repercussions for the countries of the world. Those countries with a strong economy will most probably be able to buffer the price increase by higher consumer prices and by diversifying the food base. But even now in upcoming economies the price burden might result in a deformation of the rental economy. Fragile states that are today at the brink of poverty will be thrown back to the 1990s (FAO ibid.).

2.1.3 Sea-Level Rise and the Survival of Small Island States

The ongoing global temperature increase already resulted in a sea-level rise, although this increase is admittedly still small when seen from a worldwide perspective. But there are regions on Earth that are becoming more and more vulnerable even by this increase. The so-called small island states especially those in the Pacific Ocean or other areas in the big river deltas where most of them lie just 2–3 m above sea level. The islands of Tuvalu, Samoa, Kiribati, Carteret Island, the Maldives, and many others came into public focus when it became obvious that many of them would disappear from global maps if climate change continued unaltered. There are already today two examples of islands that have vanished and where the people have had to seek refuge at other places: the Carteret Islands of Papua New Guinea, the small island of South Talpati in the Ganges Delta, and some tiny islands on Tuvalu. But it is not the global temperature increase and with it the melting of the arctic inland ice shield that is the dominant factor of the rising level. It is instead more an effect of a thermosteric increase in water volume due to a temperature-induced decrease in density. And it is believed (IPCC 2007) that this increase will continue for the decades to come. According to IPCC (ibid) the global sea level has risen in the Pacific Islands from 2003–2008 by about 2.5 mm, in comparison to an increase of 0.5 mm in the time span 1961–2003. The total sea-level increase of the last 100 years is estimated at 20 cm and will result in a sea level of about 90 cm in the next 100 years. Together with the rising sea level, significant adverse effects (tropical storm surges, floods, salinization of fresh water ponds) will strike that part of the Pacific region in the future. Already today the number of victims due to weather-related disasters reached 20 % of the total population (1.2 million in 1990).

Life hasn't changed over the last thousand years on these islands; the people still have a subsistence-based living. The economic basis is the sea: fish and raw materials come from there. Small but nevertheless significant developments in medical services and in the economy resulted in relatively high urban growth rates; for instance, that of the Republic of Kiribati led to a current population of 100,000 people, an increase from several thousand after the Second World War. The capital of Kiribati today amounts to more than 60,000 people with a population density of 160 people/km^2, making this place one of the most densely settled places in the whole Pacific region. The lifestyle of the people on the small island states did not change much over the last 2000 years, but the high population growth rates brought along serious environmental degradation. Pollution of the water resulted in lower fish catches and poorer water quality.

It is feared that further global warming will lead to two main changes: one is the average temperature increase will lead to a continuously rising sea level. And second, the change in climate conditions will result in more extreme weather events including tropical cyclones, heavy storms, and flooding. Hotter days and less rainfall will dry up the freshwater reservoirs on the islands. The warming of the sea water will furthermore lead to acidization of the water with serious consequences for the coral reefs, to coastal erosion, and salinization of the freshwater resources. According to IPCC (2001),

> [T]he high exposure to natural hazards (tropical cyclones, storm surge, droughts, tsunamis, and volcanic eruptions), the limited physical sizes of the islands, their relative isolation and simultaneously great distance to major markets, limited natural resources and over exploitation by human activities leading to degradation of natural systems, their thin water lenses and decreasing fresh water reservoirs, a strong import dependence and high sensitivity to external markets, the generally rapid population growth and urbanization together with specific industrial activity and the generally poorly developed infrastructure by on the other hand an extensive tourism dependency.

This makes all the small island states in the Pacific Ocean economically, socially, and physically highly vulnerable.

The problem of the rising sea level is that it is definitively generated by the industrialized countries (the largest CO_2 producers in the world are the United States, China, and India) but those countries face only a minor risk from the sea-level rise, whereas the population of the small island states are threatened with the loss of their countries forever and are responsible for only 0.03 % of the world's CO_2 emissions (IPCC ibid), a fact that is internationally already accepted but that didn't really change the attitude of the international community. The risk of vanishing from international maps has been on the international agenda for many years. There has been a series of international conferences and resolutions, but none of them really brought results. Meanwhile the small island states of the Pacific joined in an organization called Alliance of Small Island States (AOSIS) and founded a regional Secretariat of the Pacific Community (SPC) to better address their matters in international discussions. Their main pleas are that the industrialized nationals should finally start complying with the Kyoto CO_2 emission targets and that the international society should define the legal status of what is called a "climate refugee." The president of Maldives Nasheed stated that "the rising sea level is the fate of the country and over the long term the archipelago would no longer exist as nation" and therefore he announced to start talks with Sri Lanka and India to negotiate to "one day" resettle his people in one of the states. But he also sees chances to resettle in Australia and New Zealand. The favorite countries, however, will be India and Sri Lanka as both share their religious and ethnic origins as well as the social and economic system. But the latter two countries already face big social and economic problems, poverty, overpopulation, and an agriculture-dominated economy. Following his announcement there was a big uproar in the country and his government was toppled soon after. Nevertheless he initiated a huge discussion within the United Nations focusing on two different aspects: why should the small islands states—that were contributing almost nothing of the worldwide CO_2 emissions—have to be the first victims of the sea-level rise, and what kind of an internationally guaranteed legal status such emigrants might be given.

The many different definitions the people were already given in the public debate shows how complex it will be to solve this problem of climate refuges, forced migrants, economic refugees, or climate refugees. Those who are affected by the rising sea level argue that they are forced by nature, whereas those identified as probable destinations have already begun to discuss the multidimensional effects of climate change, but only as it affects their own interests. It is mainly the OECD countries that still refuse to take up the notion on the international agenda of the United Nations. But resettling will most likely not be solved in a way the asylum seekers have in mind. It is highly unlikely that one recipient nation will grant asylum to an entire country. Instead they will most probably be divided up with all the negative consequences; it is strongly feared by asylum seekers that it will lead to the more or less disappearance of their social and cultural identity. To create precedents one country in the region already has clarified its political standpoint: Australia. The country fears to be overrun by refugees from all over Asia. Consequently the government declared all refugees entering the country without an official permit will be detained in special camps and returned to their countries. Recently, an article published in the Australian magazine, Security Solutions, argued that forced migration due to climate change is a security threat for the receiving nations (Soderblom 2008). The article used Tuvalu as a case study to suggest a link between forced migration and terrorism. The article claims that if migrants such as Tuvalu's 10,000 people migrate to Australia, then millions of poor and unskilled regional neighbors will come begging for a new life. The New Zealand government on the other hand will allow 75 Tuvaluans per year to settle in the country in order to support the national labor scheme. Tuvalu is one of five Pacific island states the country selected to be likely candidates for the permanent resettlement of the entire population. Therefore it has been discussed to increase the amount of people to be allowed to enter to up to 500 Tuvaluans per year. It is also expected that some residents may be relocated to the island state of Niue, which is in free association with New Zealand, and was largely abandoned after Cyclone Heta struck its shores in 2004. Such an immigration scheme will not really solve the problem, as Tuvalu will not be emptied for over 100 years.

In 2013 Ioane Teitiota, a Kiribati citizen sought political asylum in New Zealand claiming to be a climate refugee. The island of Kiribati, 4000 km north of New Zealand, is threatened by the sea-level rise. He justified his application on the Human Rights Charter of the United Nations Refugee Convention, although the status of a climate refugee is not incorporated in the convention. The New Zealand authorities have rejected his appeal at the court of first instance, but Ioane Teitiota has appealed to the High Court. If his petition is accepted, it would be the first time that the status of "climate refugee" has been jurisdicially acknowledged, a judgment that would give hundreds of thousands of climate refugees in the Pacific Ocean and Indian Ocean small island states a rationale for asylum seeking.

2.1.4 Respiratory Hazards from Ash Clouds

The vast amount of ashes emitted during the Mt. St. Helens volcanic eruption in 1980 triggered an intense debate on how the ashes are posing a respiratory risk to the population. The ashes were then covering large parts of the densely populated midwestern United States. Similar discussions came up during the Soufriere Hills eruption (Montserrat) in 1995 as well as after the Merapi eruption in 2006 in Indonesia. Since Mt. St. Helens quite a number of investigations have been carried out on this issue (Horwell and Baxter 2006). Although the volcanic event is normally short in time, the ashes may remain in the air for several years like the ashes of Krakatoa that traveled the globe for roughly a decade (Winchester 2003). After the Mt. St. Helens eruption regional hospitals had an up to fivefold increase in visits from normal.

Volcanic ashes are made up of hard, sharp-edged silica grains less than 2 mm diameter. As they are emitted by the hot volcanic air high up into the stratosphere the grains are able to disseminate over large parts of the globe, thus also affecting regions that were not subject to the eruption. The epidemiological science mostly deals with ash particles that are even smaller and occur in the range of 10 microns and less. Although those of about 10 microns preferably affect human airways (thorax, bronchi), ash particles of less than 4 microns pose a hazard to the lungs themselves and may cause silicosis and lung cancer. Freshly erupted ash particles are furthermore often covered with a not yet weathered and not yet oxidized cover of acids, hydrocarbons, and trace metals, but also often have adsorbed sulfur and other noxious elements from the gases. These elements are then breathed in together with the sharp-edged particles leading to asthma-type diseases. Although there is little toxicological and epidemiological evidence that a short duration of one or two days of exposure to ash particles of 10 microns may cause a hazard, it is nevertheless obvious that pre-existing respiratory diseases will be amplified by exposure to these particles. Particles of sizes smaller than 4 microns are believed to definitively cause chronic diseases, especially in children.

2.1.5 Failure of State (Hurricane Katrina, United States)

On August 2005 Hurricane Katrina formed from a "normal" tropical storm (Category 1; Saffir–Simpson Scale) to one of the biggest hurricanes to ever hit United States coasts. Katrina was the twelfth tropical storm of that season having its source in the central Atlantic Ocean. The storm first crossed Florida and then entered the Gulf of Mexico. There it rapidly developed to a category 5 hurricane that headed for the Mississippi Delta. Windspeeds of 280–350 km/h were recorded and accompanied with torrential rains over the coastal region. The hurricane made landfall on August 28th, just south of the city of New Orleans, and led to the flooding of the city. New Orleans is located below sea level and at the time was almost entirely surrounded by flood-protecting levees giving the city a so-called bowl or bathtub morphology. This made New Orleans and the areas surrounding the city highly vulnerable to floods from the Mississippi River and to storm surges from the Gulf of Mexico. One dam protected the town towards the north against Lake Pontchartrain and the other from the Gulf of Mexico. Several times in the past New Orleans was hit by hurricanes; the last time was in 1965 by Hurricane Betsy. That day 13,000 people had to be evacuated; 40 lost their lives. In the years before Katrina there were quite a number of hazard scenarios all indicating the high level of vulnerability. The last one was in the year 2004 and pinpointed that about 1 million inhabitants were at risk of losing their homes, 400,000 from diseases and illness, and 60,000 were thought to lose their lives. There were already computer-aided scenarios at hand that defined how to handle a potential disaster.

The hurricane devastated the shoreline about 300 km along the Gulf Coast. The water reached the deeper parts of the city two hours before (!) the hurricane itself made landfall. The enormous windspeed and the torrential rain damaged the dam north of the lake and one along the Central Industrial Canal passing through the center of the town. The water rose quickly and immediately destroyed the levees on both sides of the canal. The water flooded the central city parts of "Orleans Bowl," "Orleans East Bowl," and "St. Bernhard," where the later famous Ninth Ward was located. But the levees in the north protecting the city against Lake Ponchartrain also failed very soon. So the water entered the city mainly from the north. At the end an area of about 250 km^2 was flooded, mostly by 4 m water. At many places the water levels even reached heights of more than 7 m. After the flood was over, it took about 40 days for the city to dry up again. Eighty percent of the city area was flooded, 1800 people lost their lives, and the economic damages were estimated to have reached US$125 billion, making this catastrophe the biggest economic disaster prior to Fukushima.

Right upon the first alerts that Katrina would make landfall at the mouth of the Mississippi Delta and would strike New Orleans, the first evacuation orders were given by the city‘s mayor, at first only for the coastal regions but shortly after also for the entire city. By the time Katrina hit, almost 1 million inhabitants had left in city in about 430,000 vehicles resulting in huge traffic congestion on the major and suburban roads. It was estimated that only about 10 % (about 80–90,000) of the inhabitants were still in the city. They were directed to several official shelters, among them the famous Sports Arena (Super Dome). There about 15,000 people were sheltered, with very poor service facilities (toilets, etc.) that led to massive protests and a multitude of hardships for the evacuees. A total of 1464 deceased victims were officially reported by the Louisiana state authorities, and 350 victims lost their lives outside New Orleans (Jonkmann et al. 2009). The victims were not equally distributed among the social classes of the local population. Although the white part of the population had jobs, cars, and mobile phones at their disposal and thus were able to follow the evacuation advice by local government, most of the victims were black, poor, and unemployed. To them the warning did not come in time. But even if informed in time, they wouldn't have had the chance to act accordingly. Furthermore as there is no registration of people living in US cities, the New Orleans city government did not know that about 50,000 more people lived in the city than expected. Altogether, this social group had to bear the biggest burden. And after having declared a national state of emergency the National Guard cleared the flooded parts of the city. Large riots and tremendous turmoil followed, showing a thus far unbelievable social disparity within American society, that, as discussed before, is pointed out by many people as an example of the failure of the state, the first one in an industrialized nation for decades (Pirsching 2006). As data were not available for all victims for post-disaster analysis, the published figures on the victims concerned (only) totalled 829. Of these only 1 % were under 1 year, but 60 % were older than 60. The age ratio of New Orleans before Katrina was about 12 % older than 60. The explanation for this given by the emergency managers was that this age group would have especially required help on evacuation that they did not get. Also it is stated that many of the elders strictly rejected the evacuation orders. The male–female ratio did not reveal any gender preference on the casualties. On the race indicator it turned out that about 50 % were black African Americans, 40 % white Caucasian, and the rest were mostly Hispanics or of Asian origin. As the ratio of African Americans in New Orleans before Hurricane Katrina was even higher, this fact is taken by Louisiana state officials that the often-raised accusation that the flood mostly killed "poor blacks" is not the fact. A statistical analysis revealed that the average percentage of victims from Katrina coincides with data from other flood events worldwide (Jonkmann ibid.).

Today, more than eight years later New Orleans is not the city it was in 2005. Immediately after Katrina the city invested US$8 billion to increase the dam heights and to set up a citywide pumping system capable of pumping the water from a (normal) hurricane out of the city bowl. These improvements turned out to be very successful as the next Hurricane Isaac that hit New Orleans in September 2012 (the same day the Republican Party wanted to nominate Mitt Romney for president) "only" resulted in smaller damages, although it has to be stated that Hurricane Isaac was not as strong as Katrina (Saffir Simpson Scale 1–2). Furthermore most of the houses have been reconstructed. Some areas that were at high risk were completely evacuated and the people were resettled in lower-risk areas. The proprietors were compensated for their losses not on the reconstruction cost basis, but for the worth of their property before the hurricane, with the consequence that those who suffered most were compensated least. In fact the population of New Orleans became in the years after "more white"; even the proportion of Hispanics was reduced by about 10 %. Today large areas of the lowlands near Lake Pontchartrain that were formerly settled by many "underprivileged" are no longer living quarters and the houses are becoming ruins. Many of those Katrina evacuated did not came back in the following years as most of them did not have any property to live on, and the number of inhabitants was reduced to about 200,000 in the years after Katrina; meanwhile about 350,000 are living in New Orleans again (Pirsching ibid.).

2.2 Natural Disaster and the Society of Risk

2.2.1 Population Dynamics and Risk

Since 2011 the world's population has exceeded 7 billion people, who are estimated to comprise 6 % of the total population that has ever lived on our planet (110 billion) since about the Stone Age according to information of the US Population Reference Bureau (2011). China is the country that today hosts the largest population (1.38 billion) followed by India (1.25 billion) and the United States of America with 320 million. The population dynamic of the next 40–50 years will continue, but the increases will definitively slow down. The population dynamic will see India in 2050 with an additional 1.4 billion people as the most populated country on Earth, and China will experience no net increase. Another phenomenon in this regard that concerns population development experts is the rapid increase of elderly persons worldwide, reaching ages that are (normally) not attributed to an "effective" production capacity. Today there are already about 900 million people over the age of 60 worldwide and it is expected that by the middle of this century that number will rise to 2.4 billion, most of them in the high-income countries, whereas at the same time in some developing countries the number of people under the age of 25 will increase from 40 to 60 %. But the mere increase in population is no longer seen as the Earth's most striking issue. What population dynamics experts worry is that these people will then make use of much more of the natural resources than today, an effect that can already be seen in some Asian countries where the people changed from a cereal-based food to a more meat-based food. And for each volume of meat about eight volumes of grains must be invested (ecological footprint).

A third factor of concern in population development is the fact that the general increase in population is superimposed by an extreme trend for migration into the larger megaconurbations, like Calcutta, Tokyo, or Lagos. Although only five such megacities with more than 10 million inhabitants existed in 1975, the number will increase to 26 in the year 2015, most of them in Asia and Latin America. The population increase of the megacities will be about 60 million yearly. Today one in two people lives in a city and in only about 35 years, two out of three will. Although 80 % of US Americans today live in cities, it is anticipated that such a population development will also hold true for the densely populated nations in Africa, Asia, and Latin America. So that in the year 2050 more than 50 % (4 billion) of the entire world will be living in megacities. In Asia, Africa, and Latin America we will experience a doubling of the city population in 30 years to about 2.6 billion. Figure 2.1 shows that the majority of the megacities of the world will be mainly located in Asia.

Another striking feature for the population at risk from natural disasters is the changing climate. Scientific evidence presented by the Intergovernmental Panel on Climate Change (IPCC 2001, 2007; UNFCCC 2009) already overwhelmingly indicated that "climate change is, without doubt, occurring and the Earth is warming" (IPCC 2007). Furthermore the IPCC concluded that most probably global warming

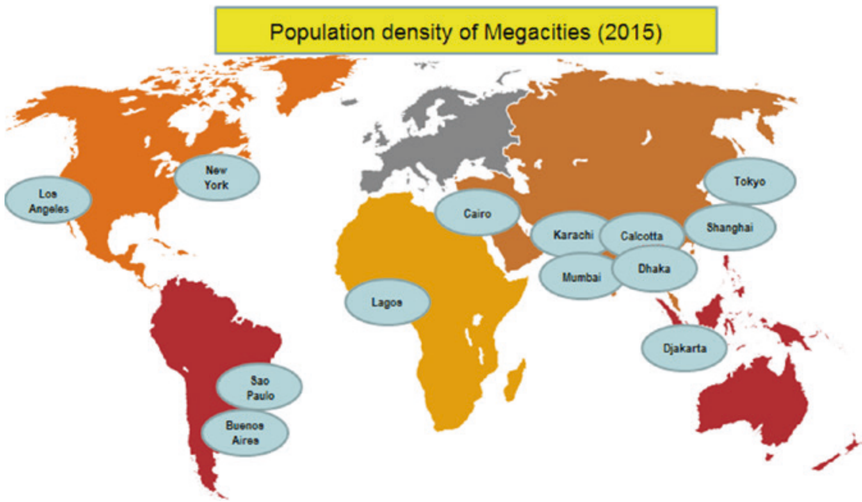

Fig. 2.1 World map of megacities "2015" (Own graph)

is caused by emissions of greenhouse gases from human activity mainly from combustion of carbon and by the clearing of natural vegetation. The Earth's system consists of five major interacting components: the atmosphere, the hydrosphere, the cryosphere, the land surface, and the biosphere. The climate is largely controlled by the flow of heat from the sun, 50 % in the form of the shortwave part of the electromagnetic spectrum and the other half by the near-infrared light spectrum. Radiation is about 30 % reflected by clouds, the atmosphere, or the surface, and 60 % of the radiation enters the Earth's system and is thereafter stored in oceans, land, the atmosphere, or the ice shield, warming the Earth's surface.

In order to balance the Earth's energy system it would be necessary for the amount of heat entering the system to be in equilibrium with the radiation. The atmosphere contains several trace gases including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), together called "greenhouse gases" (GHG) or "Kyoto-gases," and also contains a considerable volume of water vapor that altogether can absorb a good portion of the infrared radiation. Thus the greenhouse gases hinder the heat leaving the Earth's atmosphere, resulting in the retention of more heat near the Earth's surface, a phenomenon that was already assumed from the famous "Keeling curve" that monitored the CO_2 concentration in the atmosphere at the Mauna Loa volcano in Hawaii. The curve could prove that the CO_2 concentration in the atmosphere increased from 310 ppm in year 1960 to more than 380 ppm in 2010. Schellnhuber et al. (2006) reported that the earliest record on CO_2 was from 1750 indicating a CO_2 level of 280 ppm and points out that today the CO_2 equivalent is already at 430 ppm. Similar increases were reported also from nitrous oxide and methane concentrations over the last 30 years (Stern 2007). The "greenhouse effect" led to a significant increase in surface and air temperature in recent decades. The increase resulted in a rise in the global sea level since 1970 to the present of about up to 3–6 cm, largely due to the loss of ice from Greenland and Antarctica. And if the rise is not stopped by the year 2100 the sea level will increase according to new estimations by a meter or more. It is moreover projected that the global average surface temperature will hardly drop in the first thousand years even if it were possible to cut greenhouse gas emissions to zero. The role of clouds is not fully understood although they definitively play an important part in the Earth's energy balance. Clouds either absorb infrared radiation from the Earth's surface or thus contribute to the warming. On the other hand, most clouds are reflectors of solar radiation that tend to cool the climate system. The net average effect of the Earth's cloud cover at present is a slight cooling. However, this effect is highly variable, depending on the height, type, and optical properties of clouds (IPCC 2001).

If the actual trend in temperature rise continues this would lead an increase in Earth's surface temperature of 2–4 °C. This would result in:

- A rise of the sea level of three to 4 m and will double the number of people (400 million) exposed to coastal flooding and near coastal salt water intrusion.

Thus small islands (e.g., Maldives or Tuvalu) are already about to settle in other countries handing over their national sovereignty into host countries' hands.
- An increase in the number of "extreme" events of disasters with more heat waves and less cold weather is expected.
- A change in water resource availability. Up to 30 % decrease in runoff in lower latitudes is expected, leading to more droughts and more flood events in high latitudes. This would result in an even more disproportional distribution of water resources on the Earth than today. More social and economic conflicts are assumed to develop when an additional one to four billion people suffer from water shortages.
- A deficiency of irrigation water in lower latitudes will lead to a dramatic decline in agricultural yield. Up to 3 million people, most of them in Africa, are assumed to be exposed more to malnutrition than today.
- Melting of inland glaciers will have an extremely severe impact on the Himalayas and the Andes. When the waters are not contained in snow and ice and therefore drained off even during rainy seasons this would lead to flooding and also to droughts in winter.
- An increase in vector-borne deceases (diarrhea, malaria, dengue, and others) and a shift of such epidemics towards higher latitudes. The slum quarters of developing countries especially will be extremely exposed to such diseases due to lack of sanitation and clean water access. A strong increase in heat wave fatalities is expected for the Indian Plain and Africa.
- An additional 40 % extinction of species will occur with a 2 °C increase. The drying up of the Amazon region will reduce the tropical rainforest there, and that again will have a strong influence on the world climate.

All the factors resulting from climate change will exaggerate the discrepancy already existing between the high- and low-income countries. In this regard it should be noted that the main emitters of CO_2 are the high-income countries, but the poorer nations will be "hit earliest and most severely" (Stern 2007, p. 99).

2.2.2 Benefit and Risk—A Cause–Effect Relationship

Modern risk management started in the 1980s when American sociologists began asking how risky life was in the context of an increasing use of nuclear energy for power generation in the United States. The Three Mile Island nuclear accident of 1979, where a core melting was narrowly avoided, triggered a huge debate in those days.

The discussions of how risky life is for all of us can be a summarized as (Kaplan and Garrick 1981): "[R]isks are ubiquitous and there is no life without a risk. The only choice we have is that we can choose between different kinds of risk. Risk is never zero; risk can (in the best case) only be small."

Risk can occur in every sphere of human life as business risk, social risk, political risk, safety risk, investment risk, military risk, and so on. Moreover they pointed out that "risk is (entirely) depending on the standpoint of the affected or an observer and is thus a 'subjective thing'" and pose the question: "Why [do] people expose themselves or are exposed in-voluntarily[sic] to a risk?"

The basics of risk are "that risk is has a component of uncertainty and of a kind of loss and damage that might be received." Societies normally do not enter into a risk where they do not see a benefit. Mountain climbers seek the recognition of the public or personal satisfaction by taking the risk to climb dangerous mountains. Tightrope walkers even earn their living with walking on a high wire. But also quite normal activities are in general based on a benefit orientation. A risk–benefit assessment carried out in the United States at the end of the 1990s on the acceptance of the public to site a hazardous waste disposal landfill site revealed that the public was more inclined to accept the risk when compensated (benefited) for the risk with free garbage collection for the community, although acceptance for the installation of a waste incinerator was higher when compensation for medical costs, financial reimbursements, and property value guarantees were offered by the implementing agency. In general risks are not taken without a rational justification. Generating nuclear energy might serve as an example given by Weinberg (1981). A nuclear power plant is erected because the energy consumer is asking for a cheap and constantly available energy supply. The energy company reacts to this by constructing nuclear power plants. The advantages and risks for the company and for the energy consumer are summarized in Fig. 2.2.

Although the benefit–risk relationship can be calculated by a mathematical algorithm, the result will not lead to general acceptance by society. A decision on

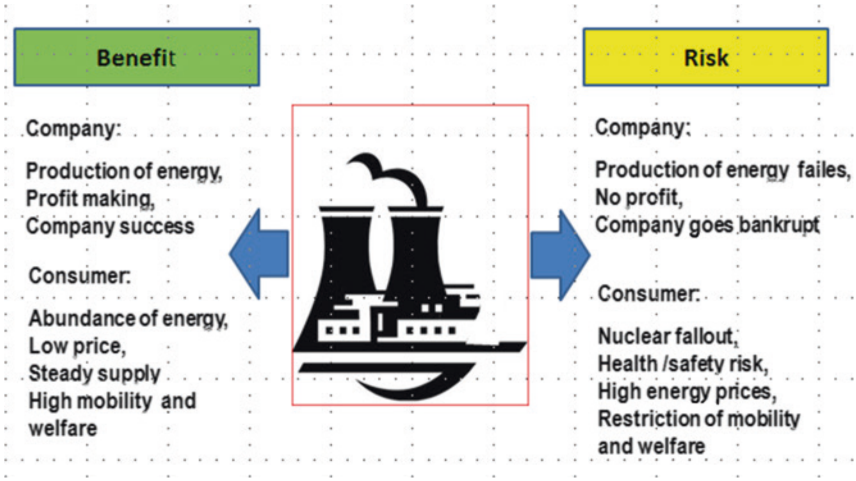

Fig. 2.2 Benefit—risk relationship of power generation from nuclear energy (Based on Weinberg 1981)

what risk we take for what benefit is basically a matter of a societal and common understanding, on how much risk a society is willing to accept in order to gain a profit, for example, of the supply of cheap energy by nuclear power plants. The decision is not a question of “right or wrong,” but rather an outcome of all stakeholders involved in the decision-making process. The moment we deny the use of nuclear energy to generate power, we have to accept that the use of coal-fired power plants is for many countries unavoidable as long as the technology does not provide a cheap and sustainable way to store energy produced from renewable sources. Therefore the benefit–risk relationship is in practice not that simple to understand. There are risks with a quite easily identifiable cause–effect relationship. Natural disasters in general follow such simple linear relationships (see Sect. 5.3). But many risks have a very complex cause–effect relationship, originating in a multitude of potential causal agents resulting in multiple causes and effects that often have no or low identifiable interdependencies. The Fukushima earthquake cum tsunami nuclear accident caused Japanese car production to deteriorate and simultaneously led to high sales quantities for a German car manufacturer and an increase in the employment rate. Such complex relationships are called by the stochastic mathematics “black swan logic.”

Shortly after the debate evolved in the United States a likewise discussion started on the same aspects in Western Europe as a reaction to the Chernobyl nuclear catastrophe when Europe, for the first time since the Second World War, was exposed to never-before experienced threat. In 1986 the German sociologist Beck (1986) published a book on how the individual and societies are nowadays under the paradigm of strong technically oriented economies exposed to risk and created the term “risk society.” Beck pointed out that in our advancing modern economies societies steadily produce wealth and income but simultaneously that increase is systematically combined with an increase in risk exposure. He further pointed out that this increase results in an unequal distribution of risk among the different societal groups, leading to what he describes as a “paradigm of a risk society.” From his point of view the term “risk” is mostly used as “a risk someone take[s] up voluntarily, demonstrating courage and automatically describing this person to be someone that is taking the challenge.” The term is thus derived from the technological paradigm. In this regard it is a quite new phenomenon that man-made risks are different from natural ones in their outcome. Earthquakes can be identified more or less as occurring along fault zones. Volcanic lava, lahars, and ashfall can be located quite precisely, just the same as floods that will definitively occur in the river basins and as landslides that will occur at the foot of steep hills. In contrast, many of the man-made catastrophes can often not be seen, can’t be smelled, or felt. Nuclear fallout will cover large parts of continents and chemical incidents may transport toxic substances into the oceans. Moreover the populations at risk will be totally differently exposed to such impacts, leading to a distinct disparity of risk in the society (Beck ibid), which means that in a society different social groups were “so to speak unavoidably assigned to civil risks.” At the end of the twentieth century, when social ranking was much more dominated by social status, the saying, “Convictions are a result of the social status,” described the situation quite well. In today's risk society however, Beck argues, "[T]he convictions (understanding) are defining actions." With this rationale, he pointed out that in the course of technological progress, modern societies arrived at a comprehensive understanding about the cause–effect relationship between the natural or man-made origin of a catastrophe and its social, economic, or ecological impacts. Only by understanding these dependencies will modern societies be able to define, work out, and implement effective countermeasures to increase their disaster resilience. Beck emphasized that "[K]nowledge, understanding and science is thus getting a political dimension that has to be developed further in natural and political sciences as well as in sociology."

This book wants to go even a step further by broadening the "risk context." In industrialized countries but especially in developing countries, disaster risk management strategies are often set up and brought into being without the participation of those who are affected by catastrophes. It has now become evident that without including the experience of the population at risk, no risk mitigation strategy will be effective. Participation can only be achieved by an early and comprehensive inclusion of the often decades-long experiences of the affected ones. But risk experience is not only the number one topic, but experiences worldwide have clearly shown that any risk mitigation strategy cannot be implemented and will not function against the will of the population. They are the ones who have to take up the recommendations. But often the measures turn out to be too technical and thus contradict their traditional beliefs. The root cause of this problem is that, according to law and administration procedures, those who are mandated with risk mitigation come from national authorities and from the scientific sector, whereas those who are affected have no functioning relationship with the institutions in charge. The main and indispensable task to bridge this social and technical gap is an open discussion forum such as a roundtable has to be established, giving the affected population a fully respected mandate in the decision-making process at the same eye-level sight. Once equal conditions are established it will be possible to reach a much higher state of resilience. Beck indicated that this will only be achieved when the society at risk succeeds in attributing the normally "un-political" natural disaster a "political" dimension (Beck 2011; Rayner 2006) Thus far all respective discussions and elaborations are still highly dominated by scientific and technical categories. This vision is also backed by Hans von Storch of the Max Planck Institute for Meteorology who emphasized (Spiegel Magazin 25/2013) that "[M]ore than generally perceived, natural sciences are a process highly affected by the actual socio-economic environment."

The upcoming awareness of social effects in the changing environment resulted in a new scientific branch: environmental sociology that deals with the "man–nature relationship" in the broadest sense (Diekmann and Preisendörfer 2001). But even in the early 1990s the integration of social elements of risk definition gained more and more acceptance. Up to that time, risk was mainly seen as a technical, scientific, and operational paradigm "to predict physical consequences" for the population of risk and its welfare systems "by extrapolating past experiences to the future," but the physical database for such extrapolations is permanently changing, very often making it impossible to "draw meaningful statistical inferences to predict future effects" (Zwick and Renn 2001). The way people perceive a risk is more a question of their anxiety, their cultural values and traditions, and their status in the societal hierarchy than their physical experience. Therefore only when the social agenda is "internalized" into the risk analysis and made an integral (if not central) part of the risk assessment (Luhmann 1990), will the exposed demand from the risk be covered comprehensively. The different way of perceiving a risk can go so far that a certain risk is seen by an individual or a societal group as absolutely unacceptable. The discussion on the use of nuclear energy in many countries is significant regarding this. The debate amplifies the risk perception that then is called "stigmatization" of certain risk and eclipses the (normally acceptable) impacts thus "determining the perceived seriousness of risk." And the "more stigma relevant elements a person links with a specific risk source, the more likely he will find this risk non-acceptable" (Renn 1989).

In the course of the climate change debate and the increasing world population a discussion arises as to how losses and victims will develop from natural disasters. It seems obvious that the population increase itself will not be the factor that matters, but the trend of poverty migration into the big megacities will be getting stronger. In the search for work and improved living conditions these migrants wear down the already difficult living conditions. Being the last in the chain in the search for living quarters they are forced to settle areas that are from their geological and geomorphological pattern not suitable for living, a behavior that just increases the hazard exposure. A similar outcome is envisaged from the changing climate. Holzer and Savage (2013) in a comprehensive study came to the conclusion on the future risk from earthquakes for people and their living environment that more people will die from earthquakes, even when the statistical occurrence of earthquakes remained more or less constant over the centuries. The study analyzed earthquakes with death tolls of more than 50,000 in the time span since 1500 AD. Comparing those estimates of world population history, they found that the number of catastrophic earthquakes has increased as the population has grown. After statistically correlating the number of catastrophic earthquakes in each century with world population, they predict that total deaths in the century to come could more than double to approximately 3.5 million people if world population grows to 10 billion by 2100 from 6 billion in 2000. The study underscores the need to build residential and commercial structures that will not collapse and kill people during earthquake shaking.

This example shows how much our daily life is governed by social and economic factors that are superimposed by the natural conditions to which we are exposed. Thus the general increase in disaster impacts that was experienced all over the world made clear that the risks are increasing and in future will be even higher. This finding alerted politicians and scientists and in May 1994 representatives of all nations assembled in Yokohama at the World Conference on Natural Disaster Reduction (UNIDNDR 1994) to adopt the "Yokohama Strategy for a Safer World." The strategy initiated Guidelines for Natural Disaster Prevention, Preparedness and Mitigation, accompanied by the Hyogo Plan of Action to be endorsed by the General Assembly of the United Nations as an internationally binding regulation. The Conference reacted to UN Resolution 44/236 to address the increasing casualties and damages from natural disasters on a global scale. Yokohama called for an integrated approach for disaster management in all its aspects and to initiate a process towards a global culture of prevention. The strategy aims to support efforts of national governments in the implementation of the program although acknowledging that each country bears the primary responsibility for protecting its own people, infrastructure, and other national assets from the impact of all kinds of natural disasters and moreover emphasized that each national government has the responsibility to enforce the law accordingly.

In the aftermath of the Yokohama Conference many states formulated national programs and action plans in order to ensure a higher level of resilience (UNISDR 2004). The great advantage of the conference was that it initiated the inclusion of all sectors of public life: the populations at risk, natural scientists, and engineers to benefit from their experience. The decision making was no longer seen as an exclusive task of the executive. Thus the discussion became broadly based on multiple stakeholders and was opened for implementing polycentric mitigation strategies. Germany already has reacted to the change by founding the German IDNDR-Committee that later developed into the German Committee for Disaster Prevention.

Since Yokohama natural scientists have also been called to take their part in the "formative actions" of the state, especially to initiate and organize a shift in paradigm from a "culture of risk" to a "culture of prevention." The inclusion of scientists and social groups in risk management led to an integration of all stakeholders involved in problem analysis, decision making, and implementation of mitigation efforts as well as in the final evaluation of achievements. By this a "formative state" in the best tradition of liberalism and democracy will increase its legitimation and strengthen public acceptance (WBGU 2011). Also in the sector of natural disaster management a state, when acting accordingly, can demonstrate that increasing disaster resilience is not a rationale to curtail individual freedoms or a call for abstaining from a self-nominated life, but is an opening chance for multistakeholder cooperation to increase the security of society in general. The best experience was made with such an inclusion approach when in Indonesia in 2006 the National Law on Disaster Management was enacted. Since then national disaster management has been nationwide and gives a robust mandate with well-defined responsibilities. With the newly formulated law it became possible to initiate a risk mitigation culture with a socially equal reorganization of decision-making mandates and implementing responsibilities, breaking the monopoly of science in the risk discussion.

2.2.3 Population at Risk

The daily impression of natural disasters makes us believe that disasters in general increase in number and severity and that nobody will be excluded from the impacts. The statistically proven reality on disaster from natural hazards according to information by Guha-Sapir et al. (2011) is that:

- The number of disasters is increasing.
- But the death toll from the disasters is decreasing.
- The economic impact is vastly different between low-, middle-, and high-income countries.

In order to assess how the populations in the different countries are really exposed to natural hazards, a closer look at the global risk distribution pattern is required. Only when the scope is widened to a larger than a local or regional perspective on the frequency and severity of natural disasters can the overall capacities of the people to withstand the risks be assessed and compared. Such a fact-based insight will improve the understanding of the general risk patterns and will lead to the identification of the root causes and their related threats. Based on fact-based findings the necessary technical, social, and financial mitigation measures can be identified and consequently implemented to reduce the risks. Such a generalized insight will moreover offer the chance to transfer knowledge and experience made in one part of the world to another, in order to increase local resilience there. Identifying and communicating global risk patterns proved to be the most appropriate approach to increase resilience, as the geotectonic setting, as well as the world weather situation are global phenomena both defining the risk patterns. In addition, changing climate conditions are posing a further global moment to risk distribution, the same as the exponential urbanization that results from a growing world population. For all areas at risk over the world a most realistic reliable and robust prediction on likely losses, magnitudes, and frequency of disaster events is indispensable. To be able to reduce disaster impacts efficiently, the linkages between the geotectonic, hydrometeorological, and climatic root causes and the social and economic development processes, such as urbanization and environmental change must be understood in addition to "invisible" risk factors such as gender bias, social inequity, sociopolitical conflict, and poor governance (UNISDR 2007). Although investigating the overall risk patterns enables us to understand the general distribution of risk, risk identification for specific social groups or certain regions requires a specific insight to local hazard conditions.

There are several international statistics on natural disaster occurrence, frequency, and severity assembled and regularly assessed mainly by the NATCAT Service, the download center for statistics on natural catastrophes of the Munich ReInsurance Company (Munich), the Sigma of Swiss ReInsurance Company (Zurich), by the UN organizations UNISDR, UNDP, and UNU-EHS, and also by the US Foreign Office of Disaster Assistance (US-OFDA) and many others especially the International Federation of the Red Cross. The most comprehensive database on natural and epidemic disasters has been collected by the Centre for Research on the Epidemiology of Disasters at the Catholic University of Louvain (CRED-EMDAT), Brussels, Belgium. The organization has been mandated by the United Nations as the central organization to collect and assess data on natural

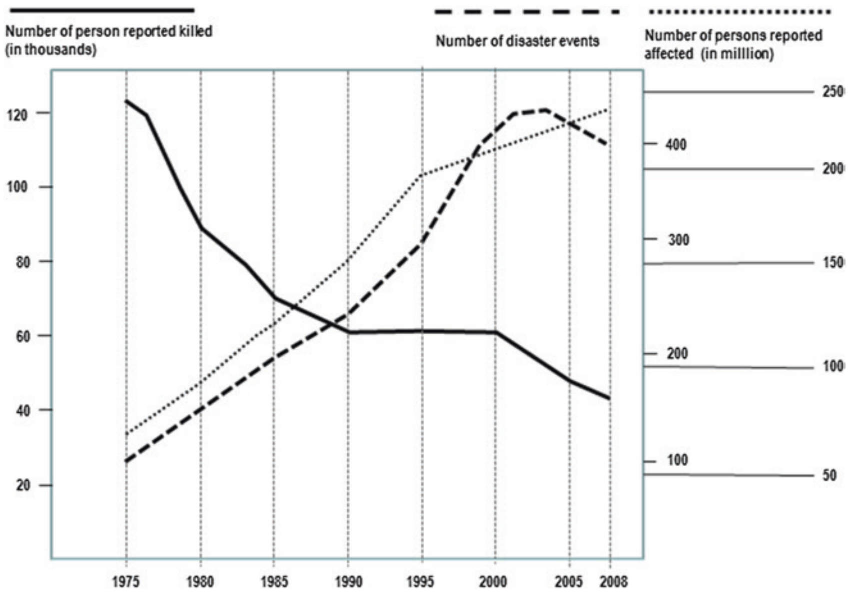

Fig. 2.3 Comparison of the number of disaster events, killed and exposed people (1975–2008) (*Courtesy* Guha-Sapir et al. 2011, 2013)

disasters. CRED is strongly supported by all disaster/emergency management organizations worldwide, especially by the USAID Office for Foreign Disaster Assistance. In total 8900 disaster events have been listed for the time span 1975 until 2008 in the EMDAT-Natural Disaster Database (CRED). The data collection could prove that there have been 600 disaster events yearly, that have killed in total 2.3 million people and have injured and made homeless more than a billion.

Today's ratio of the number of events to the people affected, respectively, killed by natural disasters has changed significantly in the last 35 years (Guha-Sapir et al. 2011, 2013). A clear trend in the ratio has been proven by the CRED-EMDAT database. For the analysis the number of disaster events was juxtaposed to number of persons killed and affected by disasters (Fig. 2.3). In 1975 about 100 events claimed 120,000 lives and affected 70 million people. Since then the number of yearly disaster events has risen to more than 600 disasters globally each year. But at the same time (only) 40,000 people lost their lives. Similar to the number of events the number of persons affected has also risen to more than 200 million. The graph clearly indicates that in the time under investigation although the number of events quadrupled, the number of people killed in disasters has been lowered to 30 %. When in 1975, 100 events claimed 120,000 lives, then—when the trend just would have been extrapolated—this would give a fourfold higher death toll. Instead the death toll in 2008 has been (only) 40,000 persons. This can be interpreted that by a preventive and effective disaster emergency management it is possible to drop the number of people killed

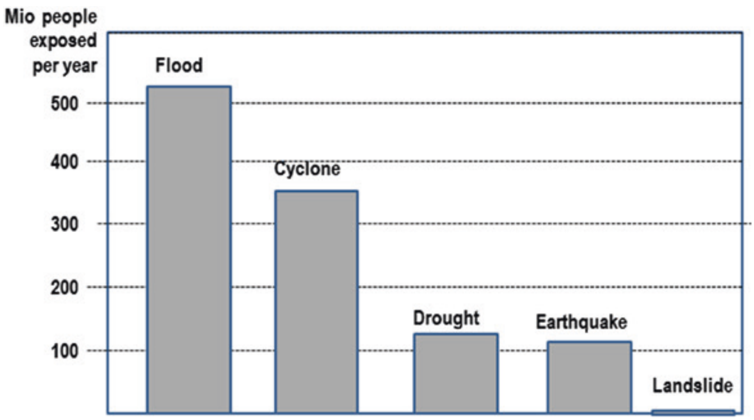

Fig. 2.4 People exposed per year to risk from different natural hazards (*Courtesy* Nadim et al. 2006)

(statistically) to 1/10. This graph reveals a much better insight to the "real" risk impact from natural disasters than when simply based on the number of people killed alone. This graph is furthermore a pledge that societal perception and from media coverage to political decision making on natural disaster severity should no longer solely be linked with the number of killed persons alone, but rather should take the number of those affected into consideration. The suffering of these societal groups has not been addressed properly in the past and the "fortunate" diminishing of the death toll ratio should not be taken as a justification to reduce the efforts in disaster mitigation.

An information CRED-Emdat stated that reliable information on disasters at a global level can (reproducibly) only be given for the times from 1985 onwards. They were able to prove that for the time before 1985 the data delivered to them were often very scarce, overrepresenting certain disaster hotspots, and were mostly lacking well-monitored timelines. When regarding only the time span from 1990 until today, the world disaster risk exposure gives a similar outcome to that previously stated. About 200 disaster events killed 60,000 people and exposed 250 million people. Compared with today's figures on the death toll, number of events, and exposed peoples, this would present the assumption that the impact of the today's disasters is (only) half of that in 1990. International statistics furthermore point out that most of the people worldwide are exposed to floods, followed by cyclones, droughts, and earthquakes and indicate that for everyone killed by a natural disaster about 3000 are exposed to hazards (Fig. 2.4).

Another striking feature from the CRED-EMDAT statistics highlights that the risk from natural disasters on a world scale is not at all distributed ubiquitously. Most disasters occurred in China with 35 events, followed by the United States of America with 26, and Indonesia and the Philippines with 20 each. Next come India (17), Afghanistan and Vietnam (14), Australia, Burundi, and Pakistan

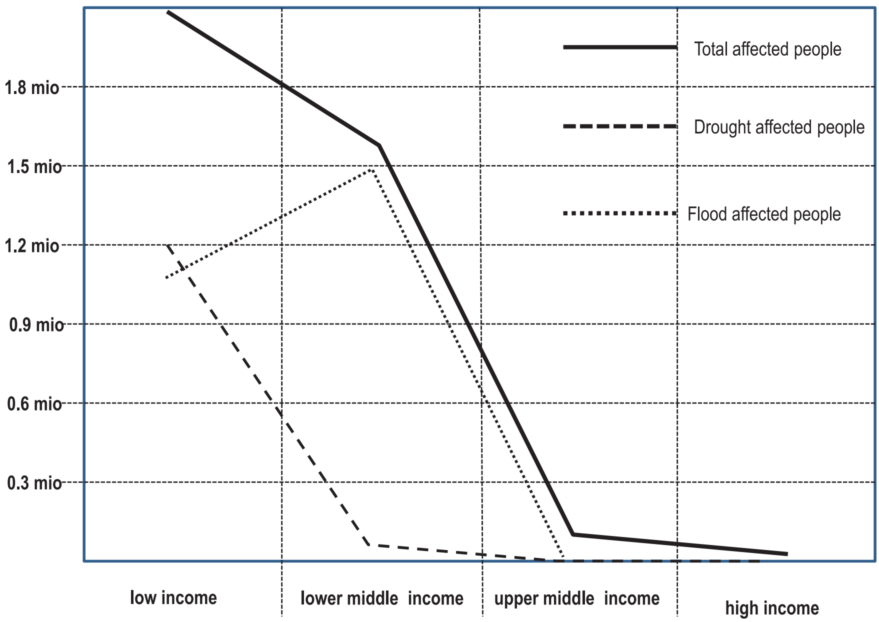

Fig. 2.5 World overview from 1975–2000 of number of people affected, categorized by income classes and disaster type (Compiled from Guha-Sapir et al. 2011, 2013)

(19 each), and Ethiopia, Germany, Mexico, and Romania (7); also Bangladesh, Canada, Japan, Kenya, and Malaysia share one group (6) and Papua New Guinea, Russia, and Somalia (5) another one. This compilation clearly shows that disasters occur in high-income countries at almost the same frequency as in the least-developed countries. But when the number of people affected by natural disasters is regarded for the time span 1975–2000, categorized according to income classes, it becomes obvious that low-income groups of societies worldwide are extremely overrepresented as can be seen from Fig. 2.5, which shows that about 2 million low-income people were hit compared to “only” 200,000 in high-income classes. Of the 13 biggest disasters since 1970, the low- to middle-income countries have claimed high death tolls, whereas disasters in high-income countries in general caused the highest economic losses (Fig. 2.6).

Figure 2.7 from Cred-EMDAT in which the economic damages are plotted according to the level of country income, further underline the above-given findings. The earthquake of Kobe, Japan in 1995 with an economic loss of about US$100 billion and Hurricane Katrina (United States) in 2005 with a loss of US$130 billion, have been the world’s most costly disasters ever. Both disasters occurred in high-income countries, and middle-income countries face a much lower risk of economic damage. The maximum was reached in 1999 from the earthquakes in Turkey (Kocaeli) and Taiwan and floods in China. The risk of economic losses in low-income countries is comparably low with a ratio that

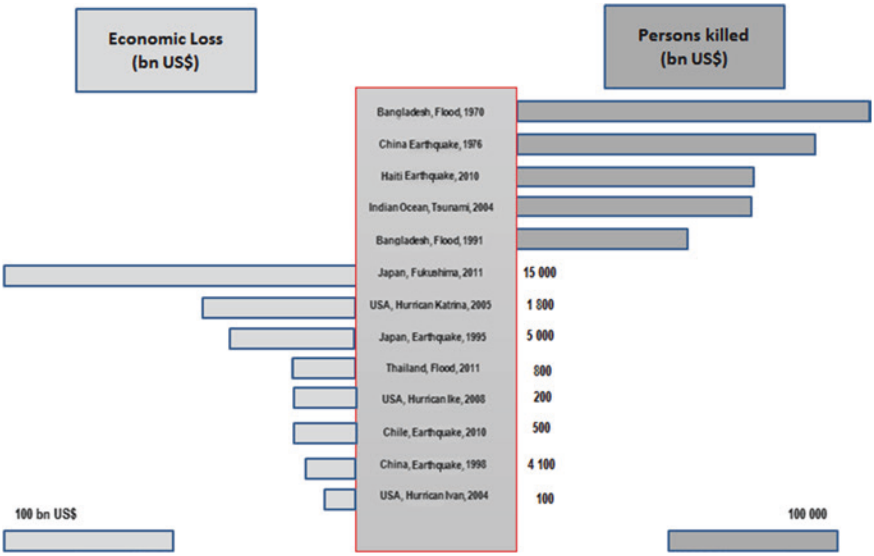

Fig. 2.6 Economic losses versus persons killed from natural disasters 1970–2010 (Compiled from UNISDR 2007, Guha-Sapir et al. 2011, 2013; Munich Re 2013)

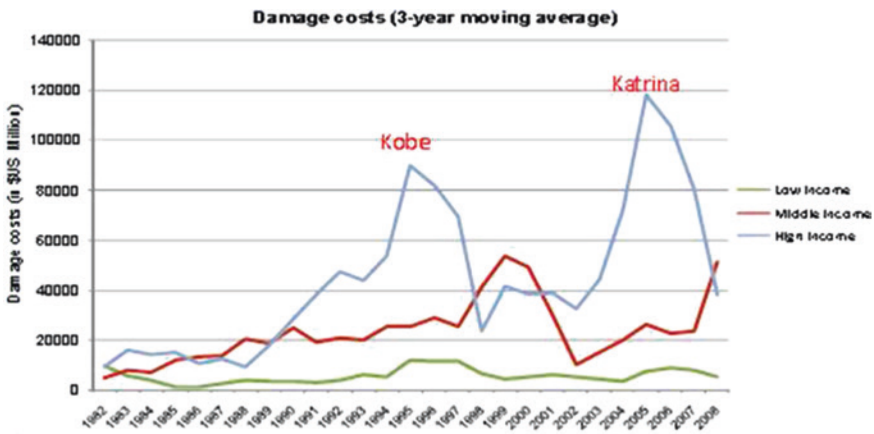

Fig. 2.7 Disaster losses according to country income levels (*Courtesy* Guha-Sapir et al. 2013)

has not changed in the last decades, a fact indicating that the amount of valuable assets accumulated is still very small. Nevertheless the biggest economic loss thus far ever was caused by the earthquake/tsunami/nuclear power plant accident of Fukushima (US$300 billion), but it is not possible to distinguish between the losses from the natural disaster and the losses caused by the power plant failure (Fig. 2.8).

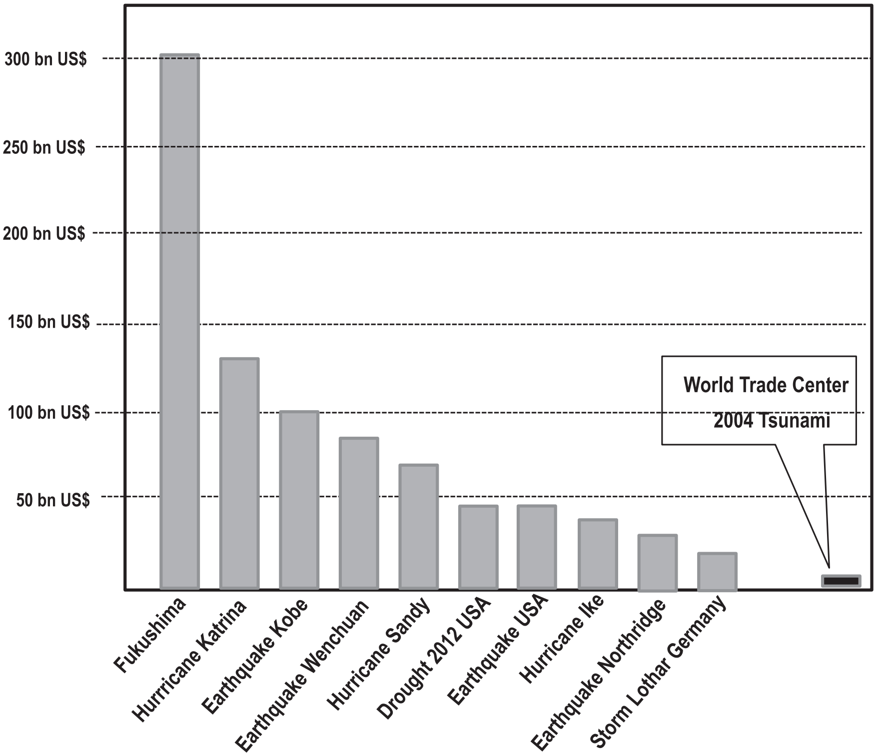

Fig. 2.8 The 10 biggest losses from natural disaster events compared to the losses from internationally best known disasters (tsunami, World Trade Center)

Regarding the economic losses from disasters since 1975, it seems that the losses have increased significantly from about 1990. There are at least two reasons for this impression: one is according to CRED information that the loss figures are "somehow" distorted owing to scarce and unproven data reported for the times before 1980, and second that because in the last 20 years, even in the least-developed countries, the accumulation of valuable assets (factories, office buildings, etc.) has increased significantly, a fact that is also indicated in the Munich Re World Map of Insured Losses (MunichRe 2013).

Moreover the impact of the different types of disaster is quite different (Fig. 2.9; redrawn from MunichRe 2012). Although geotectonic disasters make up more than 50 % of all fatalities, their share of loss is ("only") about 30 %, whereas weather-related events make up 70 % of all loss events; their fatality ratio is much lower (about 50 %). That means the lesser occurring geotectonic disasters claim comparably higher casualties whereas the many weather-related disasters claim significantly few lives. The ratio of economic losses due to these two disaster types shows another remarkable picture. The economic losses from weather-related disasters make up 70 % compared to geotectonic disasters (30 %),

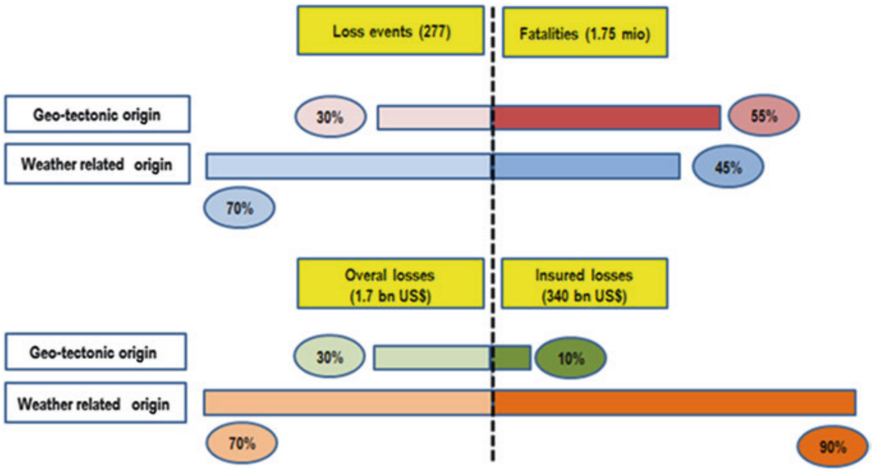

Fig. 2.9 Casualties versus economic losses of the 40 biggest disaster events since 1980 (Compiled from MunichRe 2012, 2013)

however, they are also responsible for more than 70 % of all economic losses (geotectonic 30 %). Regarding the insured losses, the picture is even more different. Although 90 % of all assets were insured against floods and wet mass movements, only 10 % of the assets were insured against geotectonic disasters. That means floods and wet mass movements occur mostly in regions where large volumes of economic assets have been accumulated, and geotectonic disasters occur mainly in regions with limited aggregated economic values, of which only some assets were insured.

This picture at a first impression contradicts the findings of Munich Re (2012, 2013) according to which 60 % of the casualties were victims of disasters of climate and weather origin, and 40 % of geotectonic. This is because there is no correlation between the number of events and the casualty ratio. Statistics revealed that annually there are about 50 geotectonic events (earthquakes, volcano eruptions, tsunami, mass movements, etc.) that claim 0.8 million people (40 %), and there are 300 hydrometeorological events that claim 1.2 million people (60 %). From the analysis it becomes clear that it is inadvisable to draw the simple assumption that the higher the frequency of a disaster type is, the higher will be the number of victims. If just a one-to one equation were rational, the amount of weather-derived disasters would claim about 5 million people.

The social dimension of natural disasters becomes even clearer when we compare the fatality ratio of developing countries with that of industrialized countries. According to data from SwissRe (2010) 95 % of the 1.8 million people killed by the 40 biggest natural disasters occurred in developing countries, whereas “only” 5 % in industrialized countries. The ratio of economic losses (here given as the amount of insured losses), however, show the opposite: of the more than US$300 billion losses, more than 90 % occur in industrialized countries, and

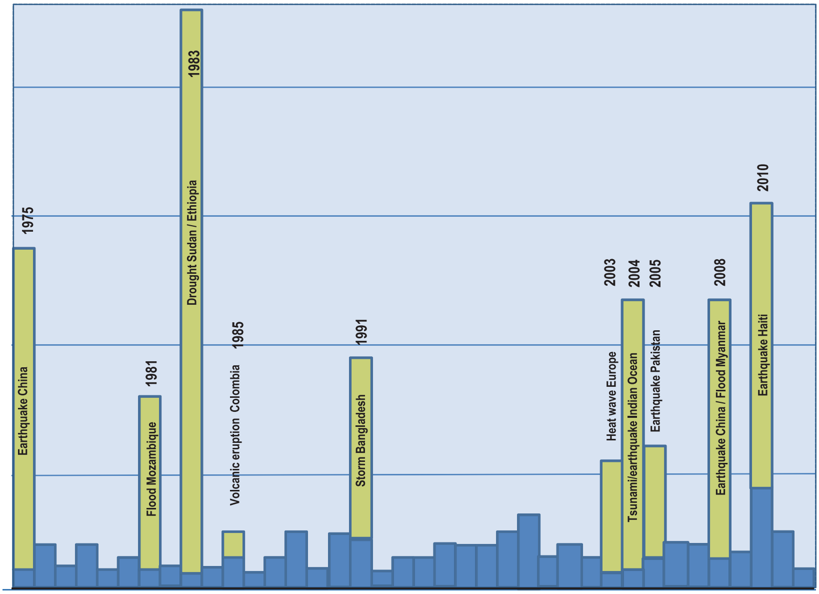

Fig. 2.10 World natural disaster events attributed to specific events, 1975–2000 (Compiled from Guha-Sapir et al. 2011, 2013)

"only" 5 % occurred in developing countries. When adapting the findings of SwissRe to the two biggest disasters of the last decade, Hurricane Katrina and the Indian Ocean tsunami, exactly the same relationship appears.

Another remarkable fact becomes obvious from Fig. 2.10. Most of the death toll in the time span from the years 1975 to 2000 derived from about 20 major disasters.

The figure clearly proves that most of the victims are attributed to the many severe droughts in the early 1980s that, for example, in the Sahel region killed about 400,000 just in the year 1983. In this context it should be noted that the statistical evidence on drought victims is not without ambiguity. Therefore the data should be treated with some caution. A similar death toll resulted from the large earthquake that hit China in 1975 (>200,000) or by the 2004 tsunami in the Indian Ocean that also killed more than 200,000 people in one event alone. In recent years one of the most disastrous events was the earthquake in Haiti that also claimed more than 200,000 lives. On all of these megadisasters as they were called by UNISDR (ibid; see also: Sect. 3.2.3) about 1.8 million people were killed. When taking out the megaevents from the statistics, a baseline of death toll risk of about 40,000 people per year seems to be the actual yearly fatal risk from natural disasters worldwide.

When a natural disaster strikes the most vulnerable groups are the poor, disabled, elderly, and the young. According to information from the World Health Organization (WHO) older adults are that fraction of a vulnerable society who are especially more likely to experience greater risks and adversity than others in any disaster. Most elderly (>65 years of age), children under 15, women, and the disabled experience the negative impacts of natural disasters the most, partly because of age-related disabilities but also because of social circumstances, such as social isolation. And WHO pointed out that worldwide the demographics are developing so that the population all over the world is aging. The projections suggest that there will be an almost threefold increase in the global population over 65 within the next half century (Tuohy 2011). But not only are the elderly disproportionally affected, the younger ones below 15 years of age are also. This group of society is mainly not able to get realistic insight to the problems and (especially in developing countries) moreover are often lacking technical and operational capacities to cope with accordingly. For instance, investigations on age and gender impact of Hurricane Katrina revealed the older adults were the fraction of the New Orleans population that faced disproportionately high adverse impacts compared to other population groups. The Indonesian tsunami of 2004 saw the highest death rates among the over-60 s and the deaths during the 2003 Paris heat wave killed more people over 70 years of age than any other group; and more than half of all casualties in the 1995 Kobe earthquake were older adults, with 90 % of deaths in this group. The same holds true for the mortality from the Tamil Nadu flood in India in 2006, where the under-10 years and the over-50 s had a five to ten times higher death toll ratio than the group between 10 and 30, or the occurrence of leptospirosis epidemics that increased 20 times in the days after the 2008 flood in Jakarta and that mostly affected the population directly dwelling near the rivers and canals in the city (Guha-Sapir et al. 2006). A disaster will amplify both personal and social challenges the older adults are facing already and as a result, older adults become more vulnerable to negative outcomes during disasters. Emergency preparedness planning must therefore take more care than before on the special age-related needs of older adults.

The above-given data on how different societies react to natural disasters clearly reveal that coping capacities differ highly: high-income countries have, due to their financial, technical, and managerial capabilities, better chances to withstand a catastrophe than many of the developing countries that are often lacking such ability. Their personal and social vulnerability hinders at all levels from national political decision making down to the individual to prepare, respond to, and recover from such events effectively.

Table 2.1 and Fig. 2.11 on the World Risk Index (WRI) compiled by the United Nations University, Bonn (UNU-EHS 2012), highlight that risk exposure is strongly dependent on the developing status of a country, In Fig. 2.11 the WRI has been correlated with the Human Development Index (HDI) to give statistical evidence of the correlation of social and economic living conditions and disaster exposure (UNDP 2013) for a selected group of countries. The boundaries of low to very high were set arbitrarily in order to make the indices comparable. The World Risk Index is based on indices reflecting exposure to natural hazards (earthquakes, floods, volcanic eruptions, etc.) as well as the vulnerability of a society by indicators describing the frequency of disaster occurrence and the deficiencies in coping with the impact and how a society has developed effective mitigation strategies.

Table 2.1 World Risk Index (WRI) of selected countries

Country	Abbreviation	WRI	HDI	Country	Abbreviation	WRI	HDI
Afghanistan	AFG	1	175	Congo	CNG	23	142
Ethiopia	ETH	2	173	Laos	LAO	24	139
Australia	AUS	3	2	Lesotho	LES	25	158
Bangladesh	BAN	4	146	Nepal	NEP	26	157
Benin	BEN	5	166	New Zealand	NWZ	27	6
Bolivia	BOL	6	108	Nicaragua	NIC	28	129
Brazil	BRA	7	85	Niger	NIG	29	187
Burkina Faso	BFA	8	183	Norway	NOR	30	1
Chile	CHI	9	40	Pakistan	PAK	31	147
China	CHN	10	101	Papua New Guinea	PNG	32	156
Germany	GER	11	5	Peru	PER	33	77
Dominican Republic	DOM	12	97	Philippines	PHI	34	114
Finland	FIN	13	21	Russia	RUS	35	55
Haiti	HAI	14	161	Samoa	SAM	36	99
India	IND	15	137	Switzerland	SWI	37	9
Indonesia	INO	16	121	Turkey	TUR	38	90
Iran	IRA	17	76	Hungary	HUN	39	37
Island	ISL	18	14	Vanuatu	VAN	40	124
Italy	ITA	19	25	Venezuela	VEN	41	71
Japan	JAP	20	10	United States	USA	42	3
Cameroon	CAM	21	150	United Kingdom	UK	43	27
Columbia	COL	22	91				

Courtesy UNU-EHS (2012)

Figure 2.11 shows that countries with a low risk exposure and a high HDI are almost all located in Western Europe, but even countries such as the United Kingdom (UK) and Germany both face regular floods. Although the flood events are often perceived by the affected population as “extreme events” (see Sect. 3.2.3) their death toll is normally very small and the impacts from the disasters do not greatly affect the national economies. On the opposite side of the graph countries such as Bangladesh, Afghanistan, Niger, and Haiti are located, all facing frequent and strong disasters and are low developed in status. Although having achieved partly significant improvements in their disaster resilience the large populations of these countries outnumber the achievements every time thus resulting in the very high risk figures. Nevertheless there are exemptions to this finding. One is Japan that on one hand has one of the highest HDI while its risk exposure due to its geotectonical exposure is also very high. And another is the Pacific island of Vanuatu that is according to UNU-EHS the most risk-prone country of the world. There a comparatively small number of earthquakes and cyclones affect a country that has due to its geographical situation almost no chance to develop effective

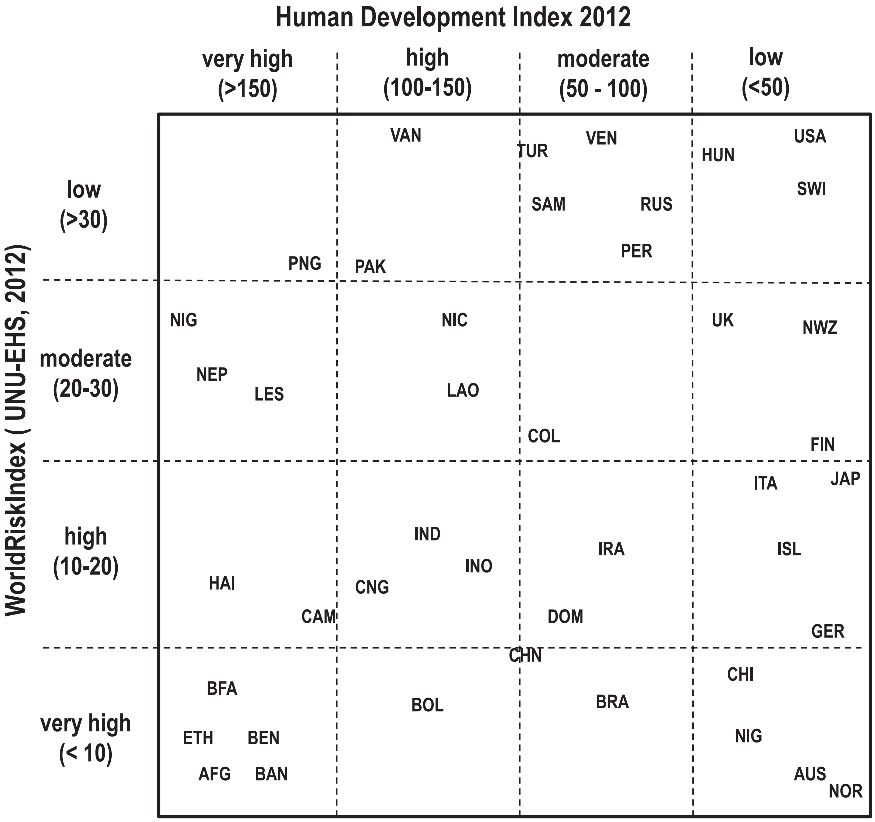

Fig. 2.11 Country risk exposure for the year 2013 (Based on UNU-EHS World Risk Index 2012 and Human Development Index, 2013)

countermeasures. This situation also holds true for many other small island states including Tonga, Kiribati, Fiji, and Maldives, among others. Summarizing the findings, it can be stated that there is a clear dependency between risk exposure and social and economic development.

Both indicators follow an opposite trend. This emphasizes the often-discussed finding that disaster risk management is more a matter of poverty alleviation than technically oriented emergency management. Such an analysis on reported death tolls and economic losses are of great importance to political decision making. In order to make societies more resilient in general against any kind of disaster, a political decision-making process has to answer the questions regarding the level of security that should be achieved and for what kind of hazard, social group, where, and to what extent it should be prepared. Or will society be safeguarded against each and every risk and at the highest level possible and is a society then willing to pay for such prevention.

2.2.4 Gender Relation to Natural Disasters

The tsunami of December 26th, 2004 killed about 230,000 people all around the Indian Ocean and claimed the lives of more than 170,000 alone in the Indonesian city of Banda Aceh at the northern tip of the island of Sumatra. However, it was not possible to count the death toll from the earthquake that triggered the tsunami. According to information of the Indonesian Ministry for Rehabilitation and Reconstruction (BRR 2007) six times more people were killed than injured in the province, a ratio that was, for instance, in Sri Lanka less than 1.5:1 and that dropped further towards the East African coast. And the tsunami killed more men than women in Indonesia. The ratio of killed men to women was between 1.2:1.0 in the entire Aceh province, whereas in the city of Meulaboh (West Aceh district) just opposite the earthquake epicenter the ratio was 2.1:1.0. Such a ratio is typical for tsunami and storm surges as men have a higher physical ability to use rescue opportunities, whereas on other hand the tsunami hit at eight o'clock on a Sunday morning when many men had already left their houses for market business. And the chance to survive the tsunami has been higher in the cities than in the rural areas. The death toll was also higher for children under 15 years and adults over 50, resulting in a death ratio of about double the amount of children and elderly than of adults.

This short description clearly shows the typical outcome of a natural disaster in developing countries. The victims are different according to their age, sex, and social status. It is the gender bias that creates the vulnerability. In general women are poorer than men, and disproportionately employed. And if employed they are mainly working in the informal sector, often unpaid or at least underpaid. Inherited laws and social patterns such as arranged marriages or the male- dominated banking system, superimpose women's dependence on fathers, husbands, and sons, thus limiting their access to resources and increasing their inability to change things (Anderson 1994). Moreover, health dangers as a result of multiple births also contribute to their low social status. Traditionally assigned responsibilities to home-based duties limit women's mobility and also hinder their chances for education and access to information as well as participation in political decision making. These factors push them deeper into the cycle of vulnerability. As women in developing countries work mainly at subsistence farming, the global shift to export-oriented agriculture undermines their economic base. This forces many of them to migrate into the big conurbations thus exposing them to rather unsafe living conditions on the fringes of the cities, moreover to urban environmental pollution but also to disasters such as flooding or landslides. As long as males dominate traditionally organized societies and as long as ideological constraints still prevail in many industrialized countries, women will still be more vulnerable to disasters. Moreover demographic trends put women increasingly at risk.

According to many studies and investigations on the social dimension of risk mainly by the United Nations (2000), IPCC (2001, 2007), UNIASC (2006), Birkmann (2006), and others, the World Bank Group and international donor agencies such as OXFAM (2000) have proved that gender vulnerability in general is a matter of poverty, or as stated before, "a lack of opportunities and capacities." Therefore the Millennium Development Goals (MDG3) underline the necessity to increase gender equality especially of the people at risk. Gender inequality is seen as an archetype that again produces further inequalities with negative consequences for women, their families, and their communities. MDG3 emphasizes that addressing gender disparities and empowering women is an important development objective. But the demand for gender equality does not necessarily mean equal outcomes for males and females. Gender inequality occurs significantly in three domains: the household, where it defines the distribution of household tasks, often limiting women's ability to work outside the home, as well as women's control over fertility decisions; in the market issue it reflects the unequal access to land, credit, and labor markets; and concerning society, it expresses restrictions on women's participation in civic and political life. Using the definition in the World Development Report, "Equity and Development" (World Bank 2006),

> [G]ender equality means equal access to the opportunities that allow people to pursue a life of their own choosing and to avoid extreme deprivations in outcomes that is, gender equality in rights, resources, and voice, as it appears that economic growth and social stability is positively correlated with gender equality of a society.

2.2.5 Traumatization

Natural disasters and other catastrophic events, such as traffic accidents, plane crashes, or a terrorist attack are extraordinarily stressful to the survivors. Although such traumatization occurs with many disaster events such kind of psychological impact is often not considered in emergency risk management practice. Stressful situations can harm a human population in a way in which the adverse psychological exposure exceeds the coping capacity of the affected population especially that of children, the disabled, or other socially deprived groups. Through the 2004 tsunami almost 10,000 children lost both parents according to information given by the National Indonesian Planning Commission (BAPPENAS 2005). Such disasters shatter one's sense of security, making one feel helpless and vulnerable in a dangerous emotional state and unable to rebuild a stable life. And such traumatization can last many years, if it can be cured at all. There is a clear difference between developing and industrialized countries in dealing with traumatization. In industrialized countries curing such impact is generally seen as the task of institutionalized medical services, whereas in traditional societies, for instance, Islamic societies, numerous kinds of social networks exist, helping the victim to a cure. There are also a number of programs that deal especially with orphans. Also in these countries the International Red Cross and the International Crescent Moon run specific programs that are oriented towards helping traumatized persons. Another problem of many societies in developing countries originates from the role of women in the society. According to tradition the men lead the household and represent the family. All legal contracts (house rent, plot documents, etc.) are signed by the males. In the case where a disaster has killed the husband, the surviving wife has few opportunities to claim her interest, as women still often do not hold their own passports or ID cards, depriving them from appealing a law case.

A lack of coping capacity for such incidents is especially symptomatic in poor countries and led to fact that more than 90 % of deaths due to natural disasters occur in such countries. The poor residents of New Orleans had to bear the heaviest loss of life, health, and property due to Hurricane Katrina. But such an event would have most likely caused a much higher death toll in a developing country. The "disparity in disaster outcomes between rich and poor can be understood as a function of both pre-event vulnerability and post-event response" (McCarroll et al. 2013). Socioeconomic factors such as individual technical and financial resources, the social and communal infrastructure, and overall political stability all affect the risk and consequences of natural disasters. Moreover, poverty is a well-known determinant of poor physical health, and the poor may therefore be more vulnerable to adverse physical health outcomes in the wake of a disaster. Malnourished, nonimmunized, and chronically ill persons are from experience less able to withstand the physical and emotional stress of a disaster. The impact of such disasters or traumatic events often goes far beyond physical damage. Injury is a leading cause of post-traumatic stress disorder (PTSD).

People react in different ways to disasters and traumatic events called PTSD. Most people who go through a trauma have some symptoms at the beginning, whereas others develop them over time. They may also come and go over many years. From medical experience it isn't clear why some people develop PTSD and others don't. Whether a victim develops PTSD depends mainly on how intense the trauma was, how long it lasted, and whether he or she received professional help and support after the event. The emotional distress in the aftermath of a traumatic event can result in a wide range of confusing and sometimes frightening emotions, with shock and disbelief in accepting the reality of what has happened and in fear that the same thing will happen again. Many people show symptoms of anxiety, that one might lose control and break down or helplessness on the unpredictable nature of a disaster. The symptoms usually start soon after the traumatic event, and can cause great distress; PSTD symptoms generally concern the emotional sphere, the cognitive situation of the patient, and his or her physical abilities. US-VA (2014) identified four major types of stress symptoms:

- Reliving the event (also called re-experiencing symptoms, or flashback). This becomes manifest in bad memories or nightmares that can come back at any time. Other examples are feeling on alert and on the lookout for danger, having trouble concentrating or sleeping, having a pounding heart, cold sweat, rapid breathing, or stomach tightening.
- Avoiding situations that remind one of the event. This becomes manifest in escaping stress-forming situations or crowds of people that can trigger memories and that can lead even to avoid talking or thinking about the event (e.g., avoiding driving after a car accident).

- Negative changes in beliefs and feelings. People may feel fear, sad, and depressive. They show grief and anger, and feel guilty that they were not able to prevent the situation. Moreover many are ashamed because they cannot control their feelings.
- Feeling keyed up (also called hyperarousal). This becomes manifest in always being on the alert and on the lookout for danger. Even harmless situations may arouse anger and irritation, like a sudden loud noise next door.

When mass casualties occur in a disaster, not only adults are affected. Children are disproportionately put at risk of being injured and traumatized. When children are exposed early to the death of parents, brothers, sisters, or close friends they discover that even parents and close relatives are susceptible to harm. The loss of important, care-giving relationships in their daily lives can generate long-standing traumatic experiences. Children suffer not only from the premature loss of a family member, but also from exposure to the cruel and violent nature of the death which may create feelings of on-going insecurity and exposure to danger or threat. Although children are generally exposed to the same spectrum of hazards as adults, they are still maturing physically, emotionally, cognitively, and socially. Thus, the "impact of perceived threat or physical harm must be put in relation to the child's developmental level and also within social context the child lives" (Shaw et al. 2007). For children, individual factors such as age, gender, race, educational level, medical and psychiatric history, and the child's level of functioning before and during the disaster are the main factors defining the trauma history. Family cohesiveness, the parent–child communication patterns, how the parents respond to the disaster impact, or post-disaster family functioning are powerful factors helping the child to rehabilitate. Moreover, some definable groups of children will require additional, specifically customized assistance for their protection and to facilitate their recovery from the event. Children with special needs include those who are developmentally disabled, children who are medically or psychiatrically ill, children living in poverty, foster care children, and children who have suffered from repetitive exposure to violence or maltreatment. After a disaster has occurred victims experience different kinds of stress reactions that may continue for a significant period of time, for instance, grieving and mourning. After all disasters, the experience of the loss of safety, security, and lack of predictability as to how life will go on, makes a sense of uncertainty become a part of life.

Observations specialists (FEMA 2013) who assist survivors in the aftermath of a disaster had successful and encouraging experiences with the following steps to reduce stress symptoms and to promote post-disaster readjustment and to rebuild emotional well-being and regain a sense of control following a disaster:

- Provide a "safe haven" that gives shelter, food and water, sanitation, allows privacy, and open opportunities to mourn the losses and adjust to the adverse situation.
- Immediately establish direct personal and family contacts to regain a sense of hope, purpose, and self-esteem.
- Establish a self-help group of victims under the guidance of medical assistance in order to talk about the experiences ("tell the story") and to share grief with others.

- Identify key resources such as national or international organizations for debris management, health services, shelter, and basic emergency assistance.
- Identify local cultural or community supports to help maintain or re-establish normal activities such as attending religious services.
- Understand the root causes and consequences of disaster occurrences.
- Change social and health behaviors to enhance ability to cope with excessive stress.
- Establish daily living routines.

2.2.6 Social Connotation of Disaster Impact

There is no better indicator for the social connotation of natural disasters than the fact that 90 % of all death casualties occur in developing countries, and 90 % of all economic losses (most of them insured) occur in industrialized countries. Even more it is anticipated that 90 % of all rescue operations are carried out by the affected people themselves. Figure 2.12 delineates this distinct difference between income and poverty, where 95 % of the death toll of the 40 biggest natural disasters found 95 % of the deaths in developing countries, and 90 % of the economic losses occurred in industrialized countries, 75 % in the United States of America alone. This is a ratio that can be transferred directly to the situation of the catastrophes of Hurricane Katrina and the 2004 tsunami in Indonesia, where the tsunami claimed 90 % of the victims, and the hurricane was responsible for 90 % of the economic losses.

The international disaster statistics mainly from Guha-Sapir et al. (2011, 2013) and UNISDR (2007) confirm this significant difference between developing

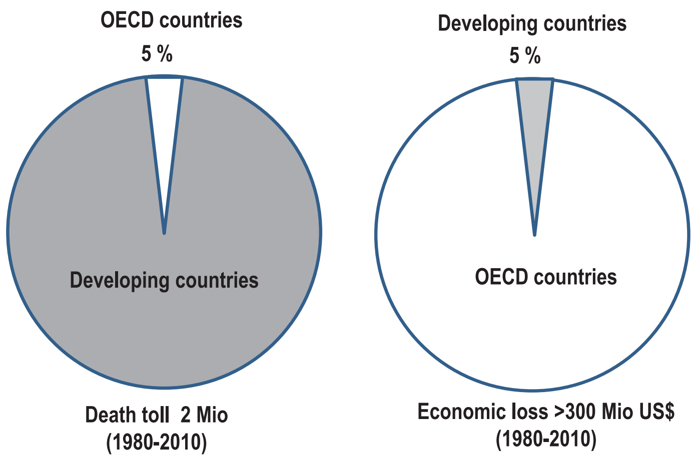

Fig. 2.12 Death toll and economic losses distinguished between industrialized and developing countries (Compiled from Guha-Sapir et al. 2011; MunichRe 2012, 2013; UNU-EHS 2012; UNISDR 2009)

countries and industrialized countries. Although the numbers of casualties are still regarded as unacceptably high, great strides were made in the last decades on the "survival ratio" from natural disasters in developing countries. However, the differences are still dramatic. To give an example: in 1980 there was a series of drought events striking the Sahel Zone, claiming a death toll of more than 400,000. Although the exact death toll figure is not confirmed, casualties were by far the largest in history. Furthermore it should be noted that 1980 was not the only year when Northern Africa was that badly hit by a drought. But the disaster initiated a multitude of national and international help and assistance initiatives. In the aftermath considerable achievements have been made by many developing countries and so-called "threshold countries" in order to safeguard their populations from disasters. These initiatives are highly subsidized by international donor agencies, resulting in a drop of the death toll figure especially from drought disasters from about 30,000 per year to less than 5,000 today. But the achieved reduction should not camouflage two other distinctive aspects in disaster exposure. The death toll itself fortunately dropped considerably, however, the number of the people exposed to a drought hazard has more than doubled, the same as the values of assets prone to damage. This is mostly attributed to the fact that high birth rates and poverty have driven migration into the large conurbations bringing more people to the brink of disasters, thus undermining many of the mitigation achievements.

2.3 Risk to Economy

2.3.1 Eyjafjallajökull, Iceland

In April 2010 the Eyjafjallajökull, one of Iceland‘s mountain glacier volcanoes erupted explosively. Although the impact from the eruption was quite a local phenomenon and did not have a serious impact on Iceland itself (about US$3 million in damage), the economic impact on international and European air traffic was enormous. The volcano erupted twice after more than 100 years of rest before the April 2010 eruption. But this time the eruption was 10–20 times more powerful and caused the cancellation of thousands of flights across Europe and to Iceland. At the time of the eruption the prevailing winds transported the ash clouds first over the North Sea towards England and then turned east to Central Russia and days later shifted south until it reached the Alps. Immediately upon the eruption and as a consequence of the large amount of ashes that were ejected into the atmosphere the International Civil Aviation Organization (ICAO) and the European Air Control Agency ordered a complete stop of all flights over northern and central European airspace for more than five days. Sixty percent of the daily flight connections were cancelled and hundreds of thousands of passengers were forced to stay on the ground. Even the German Chancellor Angela Merkel on her way from the United States had to land in Italy and was forced to take a car back to Germany. The Eyjafjallajökull eruption caused the biggest international air traffic disruption since the World Trade Center attack in 2001. The event affected 10 million passengers and claimed economic losses of about US$2.0 billion according to information from the European Commission. The airline companies complained that the disruption order was overexaggerated as the order was based on recommendations of the Volcanic Ash Advisory Center (see Annex B) but not on aircraft producers given a threshold value of ash concentrations. But the European Commission reiterated putting the safety of passengers first and insisted on the flight moratorium.

2.3.2 International Impact of Local Events (Fukushima Nuclear Power Plant Failure)

The devastating magnitude 9.1 earthquake of March 11th, 2011 along the northeastern Japanese coast was not anticipated to be of such great magnitude. From seismic records, seismologists (Geller 2011) were of the opinion that such a strong earthquake could not occur on this subduction zone. Earthquakes with a magnitude of 8 were expected and accordingly planned for, either for the nuclear power plant of Fukushima at Sandai–Daiichi or for the tsunami protection facilities along the east coast of Japan. The giant magnitude 9 earthquake, which released 30 times more energy than an 8 magnitude earthquake overtopped the 10-m seawalls, causing enormous damage to the coastline and destroying the four power plants of Fukushima–Daiichi. Thus Fukushima is an example of a technically intrinsic and well carried out natural disaster assessment that was toppled by reality. The reason that the seismologists formerly, "did not see the possibility of an earthquake of such a magnitude, was that the historic record on earthquakes along plates boundaries was very scarce," as pointed by Stein and Okal (2011). Instead the record fostered the opinion that "[E]arthquakes with a magnitude of nine and greater will only occur where the lithosphere is younger than 80 million years old and that is moving with a speed of faster than 50 mm per year." This assumption made intuitive sense, as it seemed understandable that both, "[T]he young age of the plate and its high speed favor strong mechanical coupling at the interface between the two plates." At the interface "The strong coupling was therefore assumed, to give rise to larger earthquakes when the interface eventually slipped in a great thrust fault earthquake." Furthermore it was anticipated by Stein and Okal (ibid) that the "rupture-process is performed in segments" as could be demonstrated for the 2004 tsunami (over a length of 1100 km) and thus "the more segments are generated the more energy is released."

The Fukushima–Daiichi nuclear accident was a major catastrophe that had a serious impact on the Japanese and world economy. It turned out that the earthquake itself and the damage from the tsunami could to be rated "quite" low, although with undoubtedly serious impact on the people living in the area and on the national economy. In Japan private houses are insured by a national insurance pool that covers most of the losses against such kinds of disasters. The losses due to evacuation, resettling in other regions, and medical costs are also borne by the government. No private insurance is liable for events like this. If only these two disaster aspects are considered, than Fukushima can be classified a “medium class” catastrophe, which would have resulted only in a small impact on the world economy. It is a fact that highly industrialized nations such as Japan or the United States generally quickly recover from such disasters. Moreover very often the money invested to recover from a catastrophe leads to modernizing the social and economic infrastructure at a higher reliance level. In industrialized countries the losses from disasters normally lower the gross domestic product (GDP) by only about 1–2 %, allowing for a recovery within a year or two (Hurricane Katrina, New Orleans), whereas such disasters in developing countries can have impacts on the GDP of more than 15 %, according to information given by the World Bank in 2004. The Fukushima catastrophe, however, had a great impact on international economies as well as on global ecology. The release of much radioactive contaminated cooling water will result in an increased radionuclide exposition of the offshore regions. Moreover the failure of the power plant led the Japanese government to shut down all nuclear power plants temporarily, resulting in power supply restrictions for the private and industrial sectors. This again resulted in a dramatic drop in industrial productivity especially of the world’s leading car manufacturers. For the first time in decades Japanese carmakers suffered high losses, while on the other hand, the car manufacturers in Europe and America gained much profit.

Natural disasters such as the Eyjafjallajökull eruption not only strike people at the location of the disaster, but can also severely affect the living conditions of people far away. In this example the volcanic eruption affected the international air traffic sector and hindered many people from running their businesses or to connecting with others. The eruption thus has an impact on conditions essential for private as well as public sector life. Although the private sector (houses, household, family organization) is a matter of personal disposal, there are quite a number of technical, administrational, and managerial, physical, or virtual systems that are indispensable to provide essential services to maintain the functioning of a society, called critical infrastructure. Critical infrastructure refers to technical assets as well as to organizational systems that can be especially at risk from natural hazards, the consequences of climate change, or nowadays from terrorism that are essential to sustain societal functioning during a catastrophic emergency.

Critical infrastructure disruptions thus can have direct impacts on social welfare and business. Whereas in many societies, critical infrastructure comprises all kinds of technical and social assets and their operational setups that can be at risk, Norway distinguishes particularly between the challenges to enterprises that are responsible for critical infrastructure and critical societal functions. They define “critical infrastructure” as power generation and supply, electronic and satellite-based communication, water supply and sewage, and the road/rail/air and waterway traffic system; and critical societal functions are the banking and finance sector, food supply, health services, social services and social security system, law enforcement including the police and military services, as well as emergency and rescue services and crisis management (NOU 2006). The critical infrastructure is diverse and complex. It includes distribution networks, highly varying organizational structures and operating models, and interdependent functions and systems in both the physical space as well as in the recently increasing cyberspace. It comprises governance constructs that involve authorities, responsibilities, and regulations from the local up to the national and international levels. Critical infrastructure can be at risk from various natural, man-made, and technological hazards that can result in human casualties, property destruction, adverse economic stability, and public health and safety, and that can consequently damage public morale and confidence in the national problem-solving capability. The risks are heightened by the complex system of interdependencies, which can produce cascading effects far beyond the initially affected sector and physical location of the incident. Securing critical infrastructure-related functioning is a national task whereas the specific mandates, roles, and responsibilities at the national and the local levels and among the public and private owners and operators must be clarified. In Europe the national governments are responsible for the development of a situational awareness and mitigation capability during incidents, whereas in the United States the Secretary of Homeland Security provides strategic guidance assigned in the USDHS (2002).

2.3.3 The Great Flood of 1993 (United States)

Every year the United States sees an extraordinary impact from natural disasters and atypical weather situations. The economic losses from these events have been considerable. In only half a century (from 1989 to the mid-1990s) insurance companies have paid out more than US$45 billion in damage claims stemming from blizzards, hurricanes, earthquakes, tornadoes, floods, droughts, mudslides, wildfires, and other calamities. Altogether, these disasters have affected the economy deeply in terms of property damage, lost wages, utility disruptions, industrial and agricultural production failure, in addition to claiming hundreds of lives. The effect on the economy varies considerably. Some natural disasters, such as tornadoes, hurricanes, and earthquakes are more or less short-term events, lasting several or a few hours, but causing substantial destruction in a concentrated area, whereas others, such as droughts or floods, tend to be of a longer duration, spreading their damaging effects over a relatively larger expanse for days or weeks. Any type of disaster, however, can leave an economic imprint that may persist for years. A major flood has the capacity to affect numerous sectors of the economy from agriculture to manufacturing to transportation. In addition to the obvious damage to public and private structures, other damages are not so obvious, for instance, a reduced fertility of farmland, weakened structural foundations of buildings, or waterlogged roads. There are other factors, such as transportation delays and adversely affected crop and livestock markets.

The damage from the "Great Flood of 1993" in the United States, which primarily hit the states along the upper and middle Mississippi River basin, were so widespread that for more than 500 counties in nine states, including the entire state of Iowa, a "state of emergency" was declared. In the St. Louis area, the 1993 flood topped the previous record flood of 1973. The flood was in those days ranked one of the costliest natural disasters of all time, just behind Hurricane Andrew in 1992. The overall costs were estimated to be up to US$20 billion, with a large percentage of uninsured losses (Kliesen 1994). According to the Insurance Information Institute, insured nonagricultural losses were about US$800 million, and insured crop losses were put at US$250 million. Although the flood affected several important sectors of the economy, the disruptions to transportation were the greatest, especially on railroad connections in the Midwest. Numerous disruptions forced many railroads to lay emergency tracks to reach a sustained delivery of the production, especially of the car manufacturers upstream. The Association of American Railroads (AAR) at that time calculated direct losses of US$130 million primarily on physical destruction of rail lines, bridges, and signalling equipment, and another US$50 million as indirect losses from rerouting of trains. The AAR believes that other indirect losses, for example, from business interruptions and lost revenue could reach another US$100 million. As the Upper Mississippi River is an important transportation lifeline, moving a significant percentage of the nation's grain, coal, chemicals, fertilizers, and other goods, the Maritime Administration estimates that indirect flood losses totaled nearly US$280 million. Agriculture also incurred significant losses, with US$530 million in disaster assistance disbursed to nearly 150,000 farmers and another US$500 million in crop insurance. Of this nearly US$1 billion disbursement, 50 % was received by the farmers in Iowa and Minnesota alone. In total the US federal government spent over US$2.5 billion, a financial injection that was intended to support the economic recovery of the region.

As with flood impact everywhere, the largest effects from the great flood were on physical damage, production, employment, wages, and the capital stock at the local or regional level. The flood, moreover, resulted in multifold impacts across the country especially as it came in addition to the big Northridge earthquake and the winter storms in the South, Midwest, and East. Altogether, these events in 1993 affected about one half of the entire US population, disrupted construction in the housing industry, and caused significant reductions in the output of automotive, steel, and appliances, yet on the other hand the adverse weather conditions boosted output of nation's coal mines (Kliesen ibid). But economically the overall effect of these temporary disruptions did not really put the American economy under serious pressure, an assessment that also was anticipated for the US east coast that suffered from a series of blizzards and storms.

At the beginning of 1993, most economists were expecting the US economy to grow at about 3 %. But the first quarter 1993 GDP was only at 0.8 %. This significant drop was attributed by many economists to the adverse weather conditions. But when the second-quarter real GDP growth rate was also below expectations this made it apparent that the first quarter's weakness was not entirely weather-related. As the economic effects of a disaster on a national economy are often superimposed by other than natural factors, calculating the impact often may result in misleading pictures of the economy's overall performance. The many experiences in the disaster–economy relationship tend to assume that a disaster has often a less serious rather than a challenging impact on the economy than the overall national or international economic situation itself. This is due mainly to the fact that the disaster impact influences a multitude of economic sectors that are highly intertwined in innumerable and unseen ways, making a calculation of the real economic effect of a natural disaster a difficult task (Kliesen ibid). In a paper on economic effects from natural disasters Chang (1984) confirms a finding of Dacy and Kunreuther (1969) that "Although a society as a whole suffers from a net economic loss, the recovery efforts in a disaster area may be more than sufficient to replace old roads, bridges and other community assets. If so, disaster areas may be said to benefit from disasters even if the benefit, if any, is a transfer benefit from other areas."

References

Anderson,M. (1994) : Understanding the disaster-development continuum. - Focus on Gender, Vol. 2, Part 1, Oxfam Publications, Oxford.

BAPPENAS (2005): Indonesia: Preliminary damage and loss assessment - The December 2004 Natural Disaster. – Technical Report prepared for BAPPENAS and the International Donor Community, The World Bank, Jakarta.

Beck, U. (1986): Risikogesellschaft - Auf dem Weg in eine andere Moderne. – Suhrkamp, Berlin.

Beck, S. (2011): Zwischen Entpolitisierung von Politik und Politisierung von Wissenschaft: die wissenschaftliche Stellvertreterdebatte um Klimapolitik; in: Schüttemeyer, S.S., (Hrsg.): Politik im Klimawandel: keine Macht für gerechte Lösungen? Nomos, Baden-Baden, p. 239 – 258.

Birkmann, J.(ed) (2006): Measuring vulnerability to natural hazards – Towards disaster resilient societies. United Nations University Press, Tokyo.

BRR (2007): Tsunami recovery indicators package (TRIP) for Aceh and Nias.-National Indonesian Agency for Rehabilitation and Reconstruction of Aceh and Nias, Government of Indonesia.

Chang. S. (1984): Do Disaster Areas Benefit from Disasters? - Growth and Change, Vol, 15, Issue 4, Wiley Online Library (online: DOI: 10.1111/j.1468-2257.1984.tb00748.x).

Dacy, D.C, & Kunreuther, H. (1969): The Economics of Natural Disasters: Implications for Federal Policy. - The Free Press, New York NY.

Diekmann, A. &Preisendörfer, P. (2001): Umweltsoziologie - Eine Einführung. – Rowohlt, Reinbeck.

FAO (2013): Resilient Livelihoods – Disaster Risk Reduction for Food and Nutrition Security Framework Program, Food and Agriculture Organization of the United Nations, Committee on Agriculture, Rome (online: www.fao.org/publications).

FEMA (2013): Coping with disasters. - Federal Emergency Management Agency (FEMA), Disaster Survivor Assistance, Washington DC (online: www.fema.gov/coping-disaster).

Geller, R. J. (2011): Shake-up Time for Japanese Seismology. – Nature, Vol. 472, p. 407-409, Macmillan Publishers Limited.(online: www.nature.com/nature/journal/v472/n7343).

Guha-Sapir D., Parry L., Degomme O., Joshi P.C., Saulina Arnold J.P. (2006): Risks factors for Mortality and injury : Post-tsunami epidemiological findings from Tamil Nadu, CRED Working Paper. - The OFDA/CRED International Disaster Database, Brussels.

Guha-Sapir. D., Vos, F., Below, R. with Ponserre, S. (2011): Annual Disaster Statistical Review 2011: The Numbers and Trends.- The OFDA/CRED International Disaster Database, Brussels.

Guha-Sapir, D., Below, R. & Hoyois, Ph. (2013): EM-DAT: International Disaster Database (2013). - The OFDA/CRED International Disaster Database, Brussels.

Haub, C., & Yanagishita, M. (2011): World population data sheet, Population Reference Bureau, Washington DC (www.prb.org/2011world-population-data-sheet).

Holzer, T. & Savage, J. (2013): Global earthquake fatalities and population.- Earthquake Spectra, Vol. 29, Issue S1, Oakland CA.

Horwell, C.J. & Baxter, P.J. (2006): The respiratory health hazards from of volcanic ashes: a review for volcanic risk mitigations.- Bulletin Volcanology, Vol. 69, p.1-24, Springer-online.

IPCC (2001): Third Assessment Report - Climate Change 2001 - The Scientific Basis, Section 2. - Special Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge MD.

IPCC (2007): Fourth Assessment Report - Climate Change 2007 - The Physical Science Basis, Contribution of Working Group I. - Special Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge MD.

Jonkmann, S.N., Maaskant, B., Boyd, E. & Levitan, M.L. (2009): Loss of life caused by the flooding of New Orleans after Hurrican Katrina: Analysis of the relationship between flood characteristics and mortality. – Risk Analysis, Vol. 9, No. 5, Wiley Online Library.

Kaplan, S. & Garrick, B.J. (1981): Risk Analysis, Vol. 1, No. 1, Wiley Online Library.

Kliesen, K.L. (1994): The Economics of Natural Disasters. - A Quarterly Review of Business and Economic Conditions, The Regional Economist, The Federal Reserve Bank of St. Louis, MS.

Luhmann, N. (1990): Technology, Environment and Social risk – A Systems Perspective. - Industrial Crisis Quarterly, Vol. 4, p.223-231, Sage Publisher, New York NY.

Macfarlane, A.(2012): Fukushima lessons: The disconnect between geology and nuclear engineering.- Elements, International Magazine of Mineralogy, Geochemistry, and Petrology, Vol. 8, No. 3, p.165 (online: www.elementsmagazine.org*)*.

McCarroll, J. E., Vineburgh, N.T. & Ursano, R.J. (2013): Disaster, disease and distress – Resources to Promote Psychological Health and Resilience in Military and Civilian Communities. - Center for the Study of Traumatic Stress, Department of Psychiatry, University of the Health Sciences, Bethesda, USA (www.CSTonline.org).

MunichRe (2012): Topics Geo online – 2012. - Munich Reinsurance Company, Munich.

MunichRe (2013): Topics Geo online - 2013. - Munich Reinsurance Company, Munich.

Nadim, F., Kjekstad, O, Peduzzi,P., Herold,C. & Jaedicke, C. (2006): Global landslide and avalanches hotspots. - Landslides, Vol. 3, No 2, p. 159-173, Springer Link.

NOU (2006): Protection of critical infrastructures and critical societal functions in Norway. - Report NOU 2006:6 submitted to the Ministry of Justice and The Police by the government appointed Commission for the Protection of Critical Infrastructure on 5th April 2006, Oslo.

OXFAM (2000): The Oxfam Poverty Report. – Oxfam, London.

Pirsching, M. (2006): Good Bye New Orleans - Der Hurrikan Katrina und die amerikanische Gesellschaft.- Leykam, Graz.

Rayner (2006): What drives environmental policy ? - Global Environment Change, Vol. 16, Elsevier (online: www.sciencedirect.com).

Renn, O. (1989): Risikowahrnehmung und Risikobewertung in der Gesellschaft – in: Hosemann, G. (ed): Risiko in der Industriegesellschaft, Analyse, Vorsorge und Akzeptanz. - Erlanger Forschungen, Vol. 19, p. 176-192, Erlangen.

Schellnhuber, H.J., Cramer, W., Nakicenovic,N., Wigley, T. & Yohe., G. (eds) (2006) *Avoiding Dangerous Climate Change.* - Cambridge University Press, Cambridge MD, ISBN 9780521864718.

Shaw, J.A., Zelde Espinel, & Shultz, J.M (2007): Children: Stress, Trauma and Disasters. - Center for Disaster & Extreme Event Preparedness, Department of Epidemiology & Public Health Clinical Research Building (DEEP), Disaster Life Support Publishing, Tampa, Florida (online: www.umdeepcenter.org).

Soderblom, J. (2008): Climate change: is it the greatest security threat of the 21st century?. - *Security Solutions, No. 52, March/April, Canberra.*

Stein, S. & Okal, E. (2011): The size of the 2011 Tohoku earthquake need not have been a surprise. – EOS, Transactions American Geophysical Union, Vol. 92, No. 27, Wiley Online Library.

Stern, N. (2007): The economy of climate change - The Stern Review.- Cambridge University Press, Cambridge MD.

Swiss Re (2010): Natur und Man-made Katastrophen 2010. - Sigma, Nr. 1/2011, Swiss Reinsurance Company, Zurich.

Tuohy, R. (2011): Exploring older adults' personal and social vulnerability in a disaster. – International Journal of Emergency Management, Vol.8, p.60-73, Geneva.

USDHS (2002): Homeland Security Act of 2002. The Department of Homeland Security, (online: http:// www.whitehouse.gov/deptofhomeland/sect1.html).

UN (2000): Millennium Development Goal. – United Nations General Assembly, United Nations Millennium Declaration, New York NY.

UNDP (2013): Human Development Report 2013 - The Rise of the South: Human Progress in a diverse World. - United Nations Development Programme (UNDP), United Nations, Geneva.

UNFCCC (2009): Climate Change- Global risks, challenges & decisions. United Nations Framework Convention on Climate Change (UNFCCC), Synthesis Report Copenhagen 2009, 10-12 March, 2nd edition, University of Copenhagen (online: www.climatecongress.ku.dk).

UNIASC (2006): Women, Girls, Boys and Men: Different Needs – Equal Opportunities. – The UN-IASC Gender Handbook. - Inter-Agency Standing Committee Inter-Agency Standing Committee (IASC) United Nations General Assembly Resolution 46/182 (online: www.humanitarianinfo.org/iasc/gender).

UNIDNDR (1994): Yokohama Strategy and Plan of Action for a Safer World - Guidelines for Natural Disaster Prevention, Preparedness and Mitigation.- World Conference on Natural Disaster Reduction, 23-27 May, Yokohama, International Decade of Natural Disaster Reduction (IDNDR), United Nations, Geneva.

UNISDR (2004): Living with Risk - A Global Review of Disaster Reduction Initiatives". – United Nation International Strategy of Disaster Reduction (UNISDR), Geneva.

UNISDR (2007): Global risk reduction: 2007 Global Review. - United Nations International Strategy for Disaster Risk Reduction (ISDR), ISDR/GP/2007/3, United Nations, Geneva.

UNISDR (2009): Global assessment report on disaster risk reduction – Risk and poverty in a changing climate.- United Nations International Strategy for Disaster Risk Reduction (ISDR), United Nations, Geneva.

UNU-EHS (2012): WeltRisikoBericht 2012. – United Nations University (UNU-EHS).

USVA (2014): Effects of Disasters: Risk and Resilience Factors. – United States Veteran Affairs (USVA), Washington DC (online: www.va.gov).

WBGU (2007): Welt im Wandel: Sicherheitsrisiko Klimawandel.- Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, Hauptgutachten 2007, Springer Heidelberg.

WBGU (2011): Welt im Wandel, Gesellschaftsvertrag für eine grosse Transformation. -Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, Hauptgutachten 2011, Springer Heidelberg.

Weinberg, A., (1981): Reflection on risk assessment. - Risk Analysis, Vol. 1, No 1, Wiley Online Library.

Winchester, S. (2003): Krakatao – The day the World exploded, August 27, 1883. – Harper & Collins Publishers.

World Bank (2006): Global Facility for Disaster Reduction and Recovery – Reducing Vulnerability to Natural Hazards. – The World Bank, Washington DC (online: www.gfdrr.org).

WRI (2007): Annual report 20076-2007. - World Resources Institute, Washington, DC.

Zwick, M.M. & Renn, O. (2001): Perception of risk – Findings in of the Baden-Württemberg Risk Survey 2001.- Joint Research Report, Center of Technology Assessment, University of Stuttgart.

http://www.springer.com/978-3-319-20674-5

Natural Disaster Risk Management
Geosciences and Social Responsibility
Ranke, U.
2016, XX, 514 p. 132 illus., 117 illus. in color.,
Hardcover
ISBN: 978-3-319-20674-5