Introduction to the Theory of Human-Induced Disasters

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By

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Cambridge Scholars Publishing

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This book first published 2023

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-5106-7
ISBN (13): 978-1-5275-5106-0

And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth. So God created man in his own image, in the image of God created he him; male and female created he them. And God blessed them, and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it, and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.

—Genesis 1:26-28.

CONTENTS

About the Book

Disasters do not always come in the form of earthquakes, tornados, spewing volcanos, droughts, floods, and snowstorms. These are the known ones, the acts of nature, for which we can prepare. In this book the author opens up a new field in disaster research, namely disasters directly caused by humankind: human-induced disasters. The book covers a broad spectrum of man-made disasters, from hazardous establishments that can explode, burn, or release toxic gases, to political corruption and incompetent leaders, rampant crime, and mass shootings.

The book takes a closer look at risk exposure for humans, animals, vegetation species, and objects such as infrastructural assets and property. They are all vulnerable, in varying degrees, to the negative consequences of human-induced disasters. In addition to disaster vulnerability, related concepts such as resilience and coping capacity are explored. A new concept is also introduced, namely disaster sustainability, particularly applicable to human-induced disasters.

The book has been written in understandable terminology for the general reader, but also for academics and students in the social sciences. Theoretical concepts have been illustrated at length with examples from everyday life.

This book should have been on the shelves many years ago, to sensitise the human race about its ever-increasing responsibility to prevent biological and material devastation.

Preface

Disaster! A scary word that spells danger, chaos, destruction, pain, and loss of life. It's something that everyone fears, because we all have some knowledge or even experience of a disaster, in some or other form. It appears that nobody can escape it and all that we can do is to prepare ourselves as best we can and then wait for it, live with it. Our perception of a disaster is one of serious risk, tragedy, and trauma.

The most known concept of a disaster is a *natural* disaster – the result of earthquakes, hurricanes, flash floods, drought, landslides, hail, snow, volcanic activity, tsunamis, and lightning − what is summarised as "an act of God". There is a school of thought that advocates for the removal of the word *natural* when disasters are discussed. They believe that disasters are not natural; hazards are, and the subsequent disaster can be managed by humans. It could well be. This book will use the term natural disasters, simply for ease of reference, but the reader should note that natural <u>hazards</u> and their consequences are implied.

In 2011 a major earthquake off the coast of Japan caused a tsunami which impacted a nuclear plant. This event led researchers to develop a second disaster theory, namely a *natural-technological* disaster, or Natech disaster for short. It implies a disaster, which originated from a natural hazard (earthquake) leading to a secondary hazard such as a tsunami, which eventually triggers a disaster on a man-made establishment. The resultant tsunami waves and flooding damaged the nuclear plant in Japan, which was created by man. This tragic event in Japan illustrated the interaction between a natural and human-induced disaster.

The purpose of this book is to explore a third form of disaster, caused purely by human beings, so-called human-induced or anthropological disasters. This new concept in disaster theory is presented here in the hope that it will stimulate new thinking into the crucial role that humans play in the creation of life-threatening and asset-damaging disasters.

Natural disasters have historically occurred with an irregular frequency and in mostly unpredictable forms in terms of the severity of their consequences. On the other hand, human-induced disasters are much more prevalent. We have them around us all the time, in varying degrees of severity and involving varying numbers of people, animals, vegetation species, assets or all of the above. Strangely, when human-induced disasters occur, they are usually not referred to as disasters even though they cause loss of lives, destruction of assets and the environment, followed by disruption in society. The connection is seldom made between hazardous human activity and its disastrous outcome. This book endeavours to bridge that gap.

The world around us is becoming more complex by the day because of a multitude of factors, such as economic development, wars, terrorist attacks, technological innovation, societal demands for wealth creation and, ultimately, global nation control. Human populations are rapidly growing to extremes, so the sustainable utilisation of natural and man-made resources is stretched to the limit. As a result, humankind is often responsible for disasters in which nature plays no or little role. Examples are fires, explosions, the release of toxic gases from industrial establishments, wars, political mismanagement of countries and, most controversially, climate change.

Traditionally, disaster theory is based on three pillars: vulnerability, coping capacity, and resilience. This book explores these concepts in detail, but also adds another dimension: *sustainability*, applicable to societal and business survival in the long term.

The book introduces a vital and fast-growing phenomenon in the field of human-induced disasters, namely political governance (PolGov) disasters. This form of disaster has become quite relevant in these times, where we see exponential growth in the incompetence of political leaders, corruption in governments, rigging of elections, and distortion of the principles of democracy. We also hear about a new world order from the World Economic Forum, which holds horrendous societal implications for populations around the globe. The concept of PolGov disasters is introduced in the form of a case study on ongoing state capturing in South Africa, where political powers are abused to loot state coffers.

Many of the discussions in this book rely on a system approach. It was therefore considered sensible to introduce the reader in the beginning to the theory of systems. The interaction of various systems, whether they be open, partly open or closed, is considered fundamental to the study of human-induced disasters.

The book has been written for a diverse range of readers that includes researchers, academics, lecturers, students, disaster responders, and the general public. The concepts that are introduced in the various theories, are generously illustrated through proper examples. The book gives the reader new insights into the mechanisms of human-induced disasters, how they are caused, their consequences, how they can be prevented, and how they can be managed. It explores new concepts in disaster theory in general and provides a platform from which further exploration can be done. Several case studies are included to illustrate the concepts of vulnerability, resilience, coping capacity, and sustainability. The reader is encouraged to use these case studies to further explore the theory of human-induced disasters. In this regard, questions are listed at the end of each case study, to stimulate discussion by the reader or learner groups.

When reference is made to “him”, “his” or “he” as the male gender, it includes the female gender.

The author

ABOUT THE AUTHOR

Alfonso Niemand is a business consultant specialising in the assessment of risks and legal compliance in industries. He spent more than 30 years in the petrochemical industry in various managerial positions. He holds a Bachelor of Science degree from the University of South Africa in chemistry and theoretical physics, and a Master's degree in business leadership from the same university. For his Doctoral degree at the Disaster Management Training and Education Centre of the University of the Free State in South Africa, he developed an optimised model for the regulatory management of human-induced health and safety risks associated with hazardous establishments.

He is married to Carine, and they live in Cape Town, South Africa.

CHAPTER 1

SYSTEMS THEORY

Systems theory is a study that focuses on the interrelationships between individual elements that collectively comprise a system. It means the properties of the whole system are taken into consideration in addition to studying the properties of the individual elements. In this context, a system is considered an entity, which maintains its overall function through the mutual interaction of its individual independent elements or components.

The study of the theory of human-induced disasters starts with an exploration of the theory of systems. The theoretical concept originated in the 1940s and is a powerful instrument that is used widely in everyday life today, for example in the development of algorithms for a variety of processes. It is a study of how phenomena are organised and how they interact, irrespective of their matter, type, spatial position, or chronological scale. It enables us to investigate the control factors and driving forces that are common to all complex things and how they mutually influence one another.

The components of a system are always interacting with their surrounding environments and have the remarkable ability to change other systems. In the process they can acquire new qualitative and quantitative properties through constant development, resulting in continual renewal and natural evolution. The systems concept is illustrated in Figure 1.1.

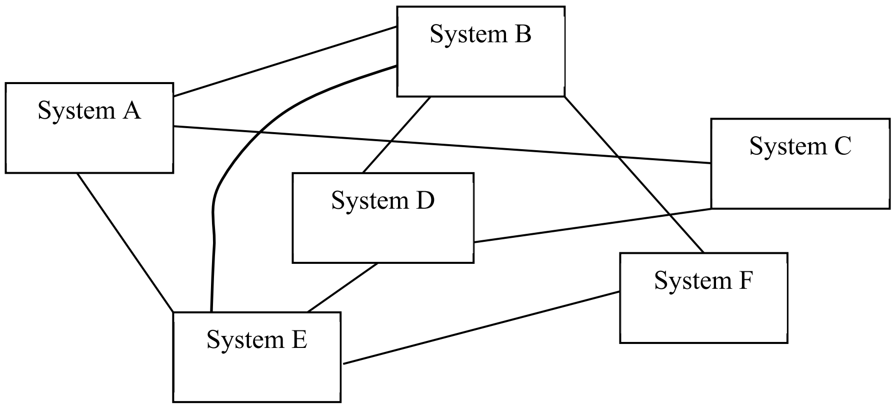

Figure 1.1 The concept of random system interaction

All types of disasters, but in particular human-induced disasters, can be studied effectively by applying the concept of systems. The hazards that create risks are systems. The risks in their varying forms are systems. The consequences of the risks that lead to a disaster, are systems. And finally, the receptors of these consequences are systems. Studying all these systems individually, enables us to unravel intricate detail and identify relationships that will eventually enable us to manage the disaster more effectively.

Systems can be either open or closed. Open systems can interact freely with one another, without any restrictions on actions or dynamics, although each system element has a clearly defined boundary within which its influence on other systems is generated and maintained. The meteorological conditions in a particular geographical area such as wind speed, wind direction, ambient temperature, cloud cover, incidence of lightning, among others, typically form open systems. They have various effects on elements in the geographical area such as different human and animal population groups, agricultural land, river systems, wetlands, and industrial developments.

Closed systems cannot interact freely with one another. There are one or more restrictions in one or all elements of the system, which inhibits their influence on other elements. A typical example of a closed system is the application of ammonia liquid in refrigeration rooms, private residences where privacy rules apply, a chemical reactor, a high-security prison, or a room in which a confidential discussion takes place, hopefully without bugging devices.

Another example of a closed system is the US Pentagon, headquarters of the US Department of Defense. As can be imagined, information in various formats (paper; electronic; inside people's brains) is gathered, stored, and handled in this huge reinforced concrete structure. Various complicated protocols are in place to ensure that what is inside, stays inside without a possibility of leaking. And yet, one small breach of the security arrangements could lead to the leaking of highly sensitive and strategic information into another system in the world. The Pentagon would then immediately forfeit its status as closed system to that of an open system – interaction took place with its surrounding world with potentially disastrous consequences.

Systems can also be partly closed (partly open) for example the storage of high-flashpoint flammable liquids such as fuel oils in aboveground storage tanks mounted in containment bunds. The liquid or its vapour cannot escape into the surrounding open environment, but in case of a fire inside the bund, smoke and hydrocarbon particulates will be released uncontrollably into the air. What used to be a stable, closed fuel storage system will suddenly be changed into an undesirable open system.

It should become clear that fully closed systems exist only in an ideal world.

Systems have some peculiar characteristics. They are dynamic. They can change the way in which they accept signals from other systems or emit signals to other systems. They can change from open systems to closed or semi-closed systems, and *vice versa*. The complexity of a system is determined by the interaction mechanisms between the individual system elements. Complex open systems have their own memories, invisible embedded records. No single element of the system is able to know, understand or forecast accurately the input impetuses, reactions, and outputs within the system. Complex open systems always have feedback loops, which can be beneficial and invigorating (positive) or weakening and limiting (negative). Both types of feedback are essential for the system to function effectively. This is the most important feature of any system. See Figure 1.2. An initiating signal is generated in System X and sent to System Y. System Y processes the information or impetus and sends feedback to System X, but also to any other random and unforeseen system that may be affected.

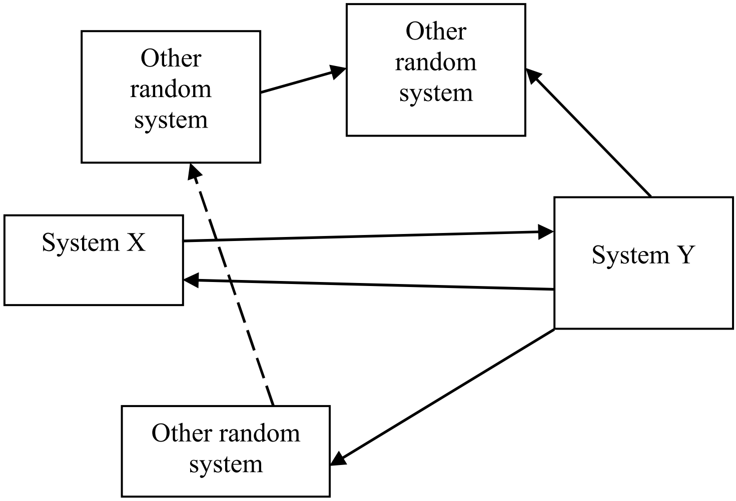

Figure 1.2 System feedback

Elements of a system interact continuously in a dynamic, interactive way that is accompanied by large and varying exchanges of information. These system interactions are always arbitrary, mostly uncontrollable, nonlinear and have a limited reach due to the absence of a controlling mechanism that regulates the flow of information. In biology, living cells can be seen, studied, and manipulated. System behaviour cannot be predicted in any way.

Complex systems perform their functions under conditions of chaos, far from stability. It means there are continual variations and responses to the stimuli that have an impact on the system. These stimuli provide energy to the system. As soon as evenness and stability are attained, the system changes to a perfectly closed one and no further interaction with its surroundings will occur. Systems can be controlled by humans, but only to a certain degree, depending on what the system equilibrium allows. It requires an in-depth study of the system and the formulation of best practice forecasts, which in themselves are complex tasks. In many cases people have no control over system behaviour.

The complex interaction between elements of the world can be understood in a holistic manner by following two different approaches: a *descriptive* and a *prescriptive* approach. The descriptive approach uses cognitive theories, perceptions, and logical reasoning to describe how humans organise and understand external stimuli. The prescriptive approach makes use of two paradigms to facilitate the understanding of complex phenomena, namely *reductionism* and *systems analysis*.

Reductionism claims that the best way to understand a new phenomenon is to study the functioning or properties of its individual parts. Let us take the human body as an example. The best way to understand its most complex functioning is to analyse its individual organs, muscles, tissues, bones, and cells. Systems theory focuses on the interrelationship between the individual parts. Instead of reducing an entity such as the human body to its multiple individual elements, systems theory focuses on the arrangement of, and relations between, the individual elements and how they interact mutually to achieve a particular function. The way in which the elements are organised and how they interact with one another determine the properties of the system.

System analysis allows decision makers to apply the fundamental dynamics of open systems as a useful management instrument to identify, reconstruct, optimise, and control behaviour in a particular system. Consideration must be given to the multiple objectives that need to be achieved, potential constraints on system interaction and the resources required to enable all systems to interact synergistically toward achieving a desirable outcome.

Organised entities do not exist in a vacuum but depend on their surrounding external environment. The external environment, in turn, forms part of a larger system that includes elements such as the economy, politics, technology, nature, society and a legal framework. Organisations comprise groups of people that are organised systematically to achieve a common goal. It also applies to societies, administrations, and governments. An organisation receives inputs from its external environment, transforms them and exports the outputs back to the environment in a continuous process of interactive functioning. This feedback characteristic of any system, which can partially be controlled by human interaction, is critically important in our understanding of disaster behaviour.

An organisation has requirements that include human resources, technology, financial resources, and structure. When we break down human resources, human needs must be considered, bringing into play complex psychological and social aspects. The total organisation must be considered, together with the interrelationships of structure and, most importantly, human behaviour. The systems approach allows an organisation to be viewed both as a whole and as part of the larger environment within which it functions, so that any part of an organisation affects all other parts in varying degrees of peculiarity and intensity. The organisation is an open system within a broad surrounding environment in which multiple channels of interaction may exist. Change in one part of the organisation will inevitably affect other organisational parts and consequently, in time, the entire system.

The concept of feedback is important for any organisational system. Feedback refers to information or an activity that reflects the outcomes of an act or series of acts by an individual, group, or organisation. The organisation is a subsystem, a domain, that is always in continuing interaction with larger systems. It therefore depends on its external environment not only for its inputs, but for the acceptance of its outputs. Consequently, the organisation must develop means for adjusting to environmental demands.

System interaction can sometimes be mind-boggling as shown by the butterfly effect, the principle on which chaos theory is based. A butterfly in New York flaps its wings. A few days later a typhoon is experienced in Tokyo. The butterfly forms the initiating system; the weather in Tokyo, the receptor system. If it were not for the action of the butterfly in New York, a typhoon would not have occurred in Tokyo.

A man drinks coffee in the morning on an ordinary day. Later that week the man decides to buy a new car. It can be argued that drinking coffee was the cause of the man's decision to buy a new car. It's not about the coffee. It's about the action that the man took.

A study was done on the impact of changing only a few decimals in weather modelling data on the overall weather forecast result. The researchers found that such small changes had significant effects on the overall forecast outcome. This conclusion illustrates that small changes in the initial characteristics of the elements of an open system can have a major effect on the long-term behaviour of other systems.

A more real example: a man (first system) stands next to an open container with gasoline in it (second system). He lights a cigarette and inadvertently throws the burning match into the container, which immediately starts a fire with black, billowing smoke. The gasoline system sends strong feedback to the man system in the form of heat, light, and smoke. In addition, the gasoline system sends a response signal to the surrounding atmosphere in the form of soot, odours, and unburnt hydrocarbons.

For all the above examples statistical inference models can be developed, including frequencies of occurrence. The value of chaos theory lies in its application to systems theory where it acts as a useful instrument to identify causal factors, such as human behaviour, and to predict the type of consequential disaster.

System analysis tools can be applied successfully in environmental and health risk management. Risk assessment provides a systematic approach for identifying the nature and severity of the risks associated with environmental and health hazards. Risk can be managed through the formulation and implementation of risk control measures, following the identification and characterisation of the risks. All human activities and processes bring with them a degree of risk with varying impact severity. The aim of risk assessment and management is to provide scientific, social, and practical information about the risks, so that the best possible decisions can be taken to mitigate them. To manage the risks, however, one first needs to measure and quantify them. Many institutions fail to do a good job of measuring the risk and controlling the external factors that may have an impact on human health and safety. By understanding the actual risk and applying a comprehensive and repeatable methodology that measures projected risk levels, we can significantly improve both the assessment of, and control, over health and safety risks in our complex world.

The natural environment, and human wellbeing in particular, have to be considered as complex systems that are constantly adapting to their environment. The state of our biophysical environment and human health and safety are influenced by a variety of independent factors and, because the system is socially dependent, societal impacts are different for every community. The environmental safety and health system thus needs to be considered together with its interactions with humans, organisations, and impact processes. A multistakeholder risk assessment approach is required.

A comprehensive definition of a disaster is given in Chapter 3. For now, consider a disaster as an event that can harm humans, animals, vegetation species, and physical infrastructure. Disasters can be understood by taking six interacting subsystems or domains into consideration. The domains are illustrated in Figure 1.3.

- The *social* domain, comprising interaction between individuals and groups of people and human behaviour in general. It includes people trauma and disruption of order in communities.
- The *political* domain, representing the influence that the decisions of politicians may have on the degree to which humans may be exposed to risks regarding their wellbeing. The political domain refers to stresses on governance, exploitation of the disaster for political gain and the unexpected demand for political leader intervention.
- The *legal* domain as a description of the regulatory processes that govern the livelihood risks to which individuals and communities

are exposed. It includes the enforcement of legislation, contracts, and the initiation of litigation.

- The *technological* domain that describes the influence of processes that can have a detrimental impact on the safety and health of individuals and communities. It covers aspects such as manufacturing processes, communication instruments and mechanisms, information processing, the development of weaponry, banking systems, transportation, and disaster reduction technology.
- The *economic* domain as a description of micro- and macro-economic factors and how they influence people in a particular society. It includes damaging of assets, loss of infrastructure, business interruption, loss of income, unplanned capital cost and loss of an employed workforce.
- The *environmental* domain that includes the biophysical and socioeconomic areas of nature. It includes pollution of the air, soil and water, loss of biodiversity, threatening of protected species, and loss of cultural heritage.

Through a systems approach, risk and consequence factors can be identified and their interrelationships can be explored. In other words, the risk factors are assessed as elements of a dynamic and complex system, characterised as nonlinear, changing, self-organising and chaotic components. This approach is quite valuable for the analysis of human-induced hazards, risks, and consequential disasters, where cause and effect are fundamental study requirements, underpinned by human behaviour.

If, for example, a factory operator caused a fire in the manufacturing plant, the circumstances surrounding the operator at the time of the incident will be investigated. This includes aspects such as his emotional state, incident prevention training, awareness training, emergency response training, operational procedures, and the legal aspects required of him in his job.

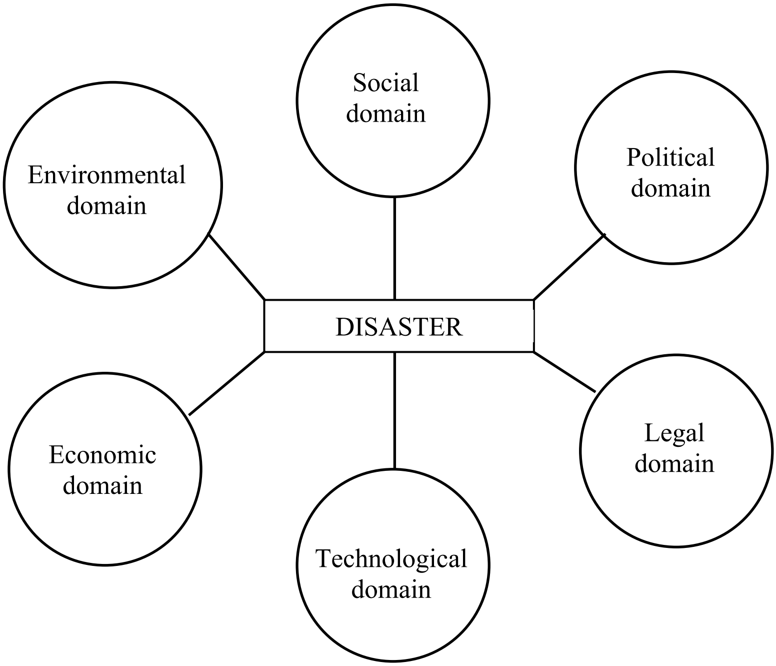

Figure 1.3 The six domains that interact with disaster phenomena

CHAPTER 2

RISK THEORY

Risk arises from the existence of a threat, a *hazard*. This threat poses a danger to one or more *receptors* of the negative consequence of the risk. The stepwise progression from a human action up to its impact or effect on a receptor is illustrated in Figure 2.1.

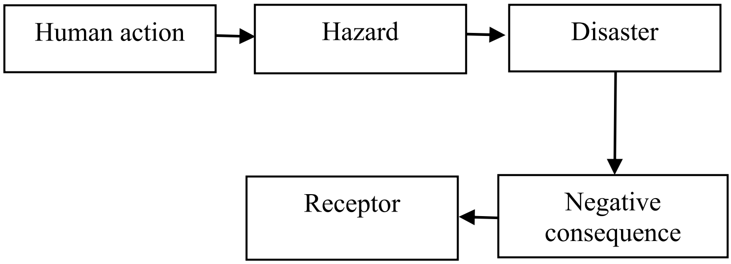

Figure 2.1 Progression of risk from a human action to effect on the receptor

It is important at this stage to further explain the concept of risk *receptors*. They will frequently be referred to in the rest of the book. Human-induced risks are always present around us in everyday life and they are always accompanied by hazards that only need a trigger to bring about a disaster with negative consequences. Who or what will be affected by these consequences? We call them risk *receptors*. Risk focuses on receptors. These receptors include all biological life (human beings, animals, vegetation species, or flora) as well as material objects such as physical assets or property. These receptors will suffer from the effects of the risk consequences, individually or collectively. They are targets. Animals, flora, soil, air, and water are conventionally referred to as the ecological environment. The same notion is used in this book.

Note how the concept of systems is applied here. Take human actions for example. It comprises a multitude of individual interacting system elements that may include biographical information about a person, the physical state of a person, the mental state of a person, and a person's knowledge, skills, and attitude about a particular situation. In addition, the role and responsibilities of a person as well as the way in which the person interacts with a broader establishment play an important part.

Similarly, a receptor my refer to one or all human beings, animals, vegetation species and objects, such as assets or other physical property.

Risk is a combination of the *probability* that a threatening event could happen, and the negative *consequences* that the event could have on the biosphere where human, animal, and vegetation life exists, including assets. Probability refers to how likely it is that the event will occur. The frequency with which such an event happened in the past, for example once in 10 000 years, is usually a good indicator, but not a precise signifier, of its probability of occurrence. The negative consequences refer to the bad outcome of the event and how it could adversely have an impact on lives and assets. So, risk has inherently a bad or negative connotation. It is something that we all want to avoid, or if we cannot avoid it, soften, or mitigate its impacting consequences.

Let's look at some examples of everyday risk in our lives to illustrate the concept. A person uses a car to take the children to school or to buy groceries. There is a chance (probability) that he may get involved in a collision, whether it will be his fault or that of another driver. He or his passengers may get injured or even killed and his car may be damaged beyond repair (consequences). He may be held legally liable for fatalities or injuries of innocent parties, damage to their asset and hence he may face criminal charges. These are risks that he cannot avoid – they are real, and they are there. It's part of life. But there are actions that he can take beforehand, options that are under his own control, to avoid the risks or to mitigate their consequences: make sure his car is roadworthy, have a valid driver's licence, use safety belts, avoid busy roads and dense traffic, drive cautiously and defensively, or use public transport.

You fly in an aircraft as a passenger. There is a chance that the aircraft may fall from the sky or collide with other aircraft. It is a risk that you willingly take, knowing that the consequence for you may be severe. If the aircraft crashes, you will probably lose your life and you have no control over it. You can try to prevent a crash by using a reputable and reliable airline. You can try to mitigate the negative consequences by taking out life insurance so that your dependents are at least taken care of financially when you are gone. You can take out medical insurance in case you are lucky to survive the crash with injuries only. But when you are up there high in the sky with your fellow passengers, you must accept your fate. Of course, you can avoid the risk altogether by not flying and rather drive, but then other, different risks, come into play. One tool that can help you in this decision is to compare the historical number of injuries or deaths per kilometre per passenger travelled.

You select a financial advisor to invest your savings in a growth fund. You realise that markets are affected daily by a multitude of factors, some good, some bad, some very bad. There is a chance that your money will grow, but there is also a chance that your money may disappear. You try to minimise the risk by selecting a reputable, reliable financial advisor and insists that he invests your money in a low-risk portfolio. However, a strange thing about financial markets is that you will also get low returns on your investment. It is called the risk-return balance.

A company builds a new factory to produce a highly toxic chemical substance. The product has the potential to kill thousands of people if it gets released into the open atmosphere. The driving force for the decision of the company is that this chemical is very scarce and is in high demand in the market, with the prospect of high profitability and a high yield on shareholders' investment. So, the company knows the serious risks in advance, but they nevertheless decide to proceed with the production of this chemical. They could have avoided the risk by abandoning the decision. All that is left for them now is to accept and manage the risks, which they can do by getting adequate public liability insurance, using the best state-of-the-art production technology, employ highly skilled plant engineers and operators, and maintain the plant in a good working condition to avoid breakdowns.

Citizens vote for a particular political party in the hope that it will lead and protect them to enjoy a prosperous and peaceful life. The decisions of the voters are guided by election campaigning promises that the party makes as well as its possible governance track record. Voters use this information to avoid, or minimise, the risk. There is, however, always a chance, a risk, that the political party may let its voters down, for various reasons. Once the political party gains leadership of the country, the hands of the voters are tied. They must wait until the next election to show their resentment if they are dissatisfied and unhappy. In the meanwhile, all they can do is protest and show their dissatisfaction publicly.

A property developer decides to invest in the building of a new shopping centre. He identifies the risks beforehand and feels comfortable that the investment will yield good returns. He develops a plan to manage the risks. His decision is based on the gathering of as much market information as reasonably practicable and by obtaining the opinion of experts. The developer accepts that there are risks involved but avoids the most salient ones upfront and is prepared to manage the residual risks as they show up. It may happen that the developer discovers at a late stage of the project that the consumer market has changed substantially and that a shopping centre is not viable anymore in that area. The decision may then be taken to adapt the construction to provide office or living space instead.

The above examples illustrate that risks are always present around us. It is a common phenomenon of our imperfect world. Fortunately, we have the ability to identify the risks, decide on how we can avoid them or decide on how we can manage them.

The attentive reader will at once ask: Can risk have a positive outcome or consequence? The answer is no. If the consequence is positive, then it was not a risk at all – it was an *opportunity,* which is a completely different topic. Risk and opportunity are opposites. They may, however, manifest simultaneously. A gambler visits a casino to spend money on the slot machines. He may lose money, which is the risk. But he may also win money, which is the opportunity. When he starts gambling, both outcomes exist and the gambler is well aware of them. In management science people are taught to develop an inclination to convert risk into opportunity. The gambler believes that he can eliminate the risk by using clever gambling skills or through "feeling lucky". He wants to convert risk into opportunity. Give him full marks for his optimism!

Similarly, opportunities present themselves in many forms in life. A woman makes an outside fire from logs. The fire burns with strong, high flames and makes a red-hot bed of coals. She looks at it, thinking about her choices. She can deliberately stick her hand or foot into the flames and get terrible burn wounds (the risk) or she may use the coals to cook, roast a lovely meal, or boil water for a bath (the opportunities). She could also use the heat from the flames to warm her body if it's cold outside. Any doubts about which choice she will make? The lady is able to turn a serious risk into quite useful opportunities. In addition, she transferred the risk from her hand and foot to the meal, the roast, or the bath water.

Human-induced risk is a function of five determinants. Firstly, the probability (Pr) that a consequence may occur, which would be detrimental to the receptor. Next follows the vulnerability (V) of the receptor, resilience (R) of the receptor, the coping capacity (C) of the receptor, and the sustainability (S) of the receptor.

In mathematical notation we express this relationship as follows:

$$\text{Risk} = f\,(\text{Pr};\ \text{V};\ \text{R};\ \text{C};\ \text{S})$$

This concept will be developed further in Chapter 8 where the quantitative estimation of human-induced risks will be developed.

We are surrounded by risks every day, some small and some large enough to be a threat to human and animal lives, and vegetation species. Risks also threaten physical objects such as infrastructure or assets that are necessary for the wellbeing of people and animals. They are negative influences from our surrounding living space, bringing with them omnipresent threats. They are something that we cannot escape or avoid – we can only manage them as far as humanly possible. Risk is part of daily life as shown in Table 2.1.

Table 2.1 Risk as part of daily life

Action	Risk	Risk creator	Risk receptor
Switching on an electric appliance	Unforeseen power failure	Workers at the local authority or the power utility or thieves who stole the cables	Appliance user
Starting a car to drive to work	A traffic collision may await him	Car driver or another motorist	Driver
Embarking an aircraft to go on holiday	The plane may fall	Pilot, aircraft engineers or maintenance team	People on board The aircraft itself
Voting for a particular political party in a democratic dispensation	The elected party may practise large-scale corruption and self-enrichment	Elected politicians	Citizens
Pointing a firearm at a person or animal	Firearm may be loaded and lethal	Handler of the firearm	Person or animal standing in front of the firearm
Playing poker in a casino	Money may be lost	Gambler	Gambler
Ordering an advertised article via mail	The article may get lost Money may be lost	Mail order worker	Purchaser
A deer grazing in the bush	A hunter may kill it	Hunter	Deer
Using a computer database	Data may get lost	Computer user or data administrator	Owner of database

All the above examples have several important aspects in common. The risks originate from something that human beings have done in the past or will do in future. They are *human-induced* risks. The outcome of the risks, the *consequences*, are all negative. It is not desirable to the risk receptor. The consequences all have their own *probability* or likelihood of coming true and these probabilities vary largely from one risk to the other. The risks cannot be avoided or prevented, but they can be *mitigated* i.e., the consequences can be made less severe. Finally, all risks have *receptors*, people, animals, vegetation species or objects that are subject to the impacts of the consequences of the risks.

Risk affects people in different ways. There are *risk takers* or risk acceptors, who are those persons that are willing to accept the negative consequences of a particular risk and face the consequences as they are. These people usually make a trade-off between the negative consequences and positive outcomes from which they can benefit. Daredevil stunt actors are a typical example. They risk their lives at a price – usually a high one.

We also get *risk avoiders*, who are those persons that rather walk away from a situation in an attempt to completely avoid the risk and its negative consequences. Such people are risk averse and choose to minimise their vulnerability by preventing the negative consequences of the risk from affecting their lives. People who prefer to invest their money in a conventional bank savings account, with a guaranteed interest yield, are a typical example. They avoid the option of share investments, where the yield varies, but could be substantially more lucrative.

Is it possible to manage risk? Certainly, it is. Risk can be managed through *risk reduction*, which means a person accepts the risk and makes plans to manage it though planned mitigation. A typical example is the establishment of water sprayers in a warehouse where combustible products are stored. The risk of a fire cannot be eliminated completely, but the negative consequences of a complete loss of the merchandise are reduced. A similar example is the establishment of fire alarms in the product storage area, which will alert people about a potential fire so that they can extinguish it.

Risk can also be managed through *risk transfer,* which is a principle that is most often applied in business transactions where money is involved. In contract law one party may insist on a clause in the contract that stipulates that they would be indemnified against a certain occurrence. A typical example is when a person takes his car for a wash and the carwash has a sign saying “Use at own risk. We are not responsible for damage or theft”. Another example is the application of insurance policies. A homeowner takes out a policy against break-ins and theft of his belongings.

His risk is transferred to the insurer, of course at a price – the monthly premiums that he has to pay. A similar example is a father of a household who takes out a life insurance policy against death or disability. If he dies, the insurance company will pay out money to his family for their continued care. Again, the father pays monthly premiums for that peace of mind.

A consumer who cares much for the environment and who was told about climate change, decided to replace her petrol-driven motor vehicle with one that has an electric engine. By so doing, she would do her part to limit the quantity of carbon dioxide emitted through the vehicle's exhaust. She does not want to be responsible for such a risk anymore. Unknowingly, the lady transfers the risk of carbon dioxide emissions to the power station that generates electricity from coal. Although minute, the extra electricity that the batteries of her new car need to charge, comes from extra coal burning at the power station. On an individual scale it is small, but cumulatively, when everyone has an electric vehicle, the transferred risk becomes indeed significant.

Risk cannot exist in isolation. It is inextricably linked to something that creates it, a trigger. We call this trigger a *hazard*. A hazard is a dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage in the biosphere.

Let us take a closer look at the concept of hazards, the driving force of risks. A hazard indicates vulnerability and is regarded as a dangerous human activity. Hazards exist everywhere around us. It is the trigger of a negative or bad event, which eventually leads to a human-induced disaster. In short, a hazard is a threat, something that we want to avoid. However, we know that life is not that simple and the best we can do is to manage hazards.

The question that comes to mind, is: what are typical hazards and in what form do they manifest themselves? The answer lies in the causal effect(s) of the hazard. For one person an establishment, substance, activity, or situation may not seem dangerous at all, while another person may have the opposite view. It clearly depends on what the perception of a person is about the expected effect or outcome of the hazard. Some people are risk takers, others are risk averse.

Person A does not consider an earthquake to be a threat to his livelihood, because he made sure that his house was located far from a geological fault line, in an area with a known history of no earthquakes. For Person A the possibility of an earthquake at or near his house is negligible. At his home, Person A is not vulnerable to earthquakes. On the other hand, Person B lives in an area known to be prone to earthquakes. He lives there