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A framework for risk assessment

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Abstract

Risk is a composite concept: it is the product of the probability that an event will take place (usually that something will go wrong) and the (negative) effect it will have if it does take place. In general, risk abatement within engineering is concerned with minimising both components, with the balance of effort being determined by cost-effectiveness. Risk assessment is the action (or inaction) taken to address the risk issues identified and evaluated in the assessment and analysis efforts, generally with a view to containing or reducing the risk. While the private sector may enhance management by controlling risk, it is more difficult for the public sector to do the same with their shareholders (population), as the risks relate to other sectors, mainly infrastructure. This paper presents a risk assessment framework to address the multiple goals of disaster risk reduction in order to be coherent with the planning of social and economic development, providing a design concept for the development of risk management policies. The legal basis for risk reduction policies is critical for transparent decision-making and allocating public funding for disaster mitigation. Risk management actually takes place on three different levels: (1) Before the disaster – planning, drills and communication (2) During the event – communication, operations associated with the operation of existing systems (3) After the disaster – assessment and reconstruction. Lessons learnt for starting all over.

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1. Introduction

Everyday life is always subject to uncontrollable events with negative or unwanted effects, whether in the form of risk to the individual, as in sickness or injury, or to the community, as in natural disasters, climatic changes, etc. Formerly, these risks may have accepted as largely inevitable but, with the advent of advanced technology and our ability to control, influence or isolate ourselves from nature, there is a growing perception in society that one should be able to eliminate risk, and that if something goes wrong, someone must be to blame. It is useful to recall that risk is a composite concept: it is the product of the probability that an event will take place (usually that something will go wrong) and the (negative) effect it will have if it does take place. In general, risk abatement within engineering is concerned with minimising both components, with the balance of effort being determined by cost-effectiveness.

Risk management (UNESCO 2006) is the action (or inaction) taken to address the risk issues identified and evaluated in the assessment and analysis efforts, generally with a view to containing or reducing the risk. A number of approaches are available, including:

Risk avoidance. Selecting a lower risk choice from a set of alternatives represents a risk avoidance approach. This would seem the obvious thing to do, but there are certainly situations where it is not appropriate to select the lowest risk choice, for example, when this would reduce design flexibility or limit future options.

Risk control. This is the most common of the risk handling approaches and is essentially the process of monitoring parameters that have been identified (during the risk analysis) as critical, and applying corrections to the program as required

Risk assumption. This is simply the conscious decision to accept the risk, usually because of the associated benefit, as is the case when activities which should normally be carried out sequentially are carried out (fully or partially) concurrently (fast tracking).

Risk transfer. Transferring or sharing the risk between several contractors or between contractor and purchaser is the idea behind insurance, and is reflected in contingencies. Risk transfer can be beneficial to all parties.

2. Risk and their origins

Adopting the definition of risk as *the probability of an undesirable* event occurring *and of its* having *significant consequences,* one needs to identify both the undesirable event and its possible consequences.

In that sense, risk hazards stem from four main groups:

- Physical
- Technical
- Biological
- Socio-economic

Table 1 gives examples of risk hazards (Dauphiné 2001) falling under each category.

3.Factors influencing risk perception

People perceive risks differently, and psychologists confirm that some risks are overstated while others are underestimated. Table 2 shows the different factors which have an influence of how people perceive risks.

It must be noted, however, that these perceptions also depend on the culture of the country and the background of the people concerned. Some youths will willfully, go out into the sea, when the Meteorological Services have announced bad weather and high sea swells. Cyclones, in Mauritius, may be beneficial when they bring in rain, but are considered dangerous when they are accompanied by very strong winds and sometimes without any significant rainfall.

Table 1: Origins of Risk Hazards

Physical	Technical	Biological	Socio-Economic
Cold wave	Air transport	Aids	Civil violence
Cyclone	Chemical	Emergent disease	Civil war
Drought	Dam	Food hygiene	Drugs
Earthquake	Land transport	GMO(Genetically Modified Organisms)	Famine
Fire	Nuclear	Infectious disease	Genocide
Heat wave	Sea transport		Law and Order
Heavy rain			Terrorism
Landslide			
Rock fall			
Tornado			
Tsunami			
Volcano			

Table 2: Factors influencing the perception of risks/disasters

Factor	Low perception	High Perception
Accident frequency	Rare/unknown	Frequent
Benefits	Perceived benefits	Unknown benefits
Catastrophic potential	Time-space dispersion	Time-space concentration
Comprehension	Comprehensible	Non comprehensible
Date of impacts	Immediate	Extended duration
Effect on children	Small	Big
Equity	Equitable impacts	Inequitable impacts
Exposure	Voluntary	Non voluntary
Familiarity	Familiar	Non familiar
Fear/Terror	Not terrifying	Terrifying
Impact on future generation	None	Forecasted impacts
Institutional efforts	Involved	No involvement
Origin	Uncertain	Specific
Personal control	Controllable	No control
Personal involvement	Low	High
Publicity/media effect	Low	High
Reversibility	Reversible impacts	Irreversible impacts
Uncertainty	Scientific certainty	Scientific Uncertainty
Victim identification	Statistical	Specific victims

4. Risk hazard classification

The risk hazards may be classified according to space and time (Dauphiné 2001), vulnerability and impact, perception, forecasting and prevention (see Table 3). The use of such a classification system (Alexander 2002) may help better describe a risk hazard.

5. Measuring disasters

Mauritians are well accustomed to hearing the different cyclone warnings (Proag 1995) which is based on a probability estimation and the Richter scale, based on a logarithmic scale, used for measuring the magnitude of earthquakes.

Logarithmic scales are often used or suggested when the range to be measured is very wide. This is precisely the problem with disasters where the extent of damages may vary widely. All depends on what parameters need to be measured, so that different disasters may be compared. Some parameters that may be used for this purpose include number of victims, estimated damages (i.e. cost for repairs), loss of biomass (trees destroyed).

The number of victims, monetary values of losses, measurement of biomass loss can be convenient units of scale. Probably, to enable a better comparison between countries, the actual number of victims, monetary damages or biomass lost should be divided by the country’s population, GDP, total area or total biomass.

Table 3: Risk Hazard Classification

Location	Point	Non-point	Stochastic	
Extent	Local	Regional	National	Worldwide
Occurrence	Cyclical	Seasonal	Complex	Stochastic
Trigger	Slow	Sudden		
Duration	Short	Average	Long	
Reversibility	Low	High		
Human Impacts	Low	Medium	High	
Economic Impacts	Low	Medium	High	
Sociocultural Impacts	Low	Medium	High	
Degree of Individual Control	Low	High		
Degree of Perception	Low	Medium	High	
Evolution of Perception	Underestimated	Overestimated		
Vulnerability	Low	High		
Evolution of Vulnerability	Decreasing	Increasing		
Forecasting	No	Partial	Yes	
Prevention	No	Partial	Yes	

A synthesized could probably regroup all the different scales as, for example, in Table 4.

Table 4: Synthesised Scale of Disasters

Level	Human loss	Financial loss	Biomass lost	Examples
I	1	1 and 2	1 and 2	Accident
II	2	1 to 4	1 to 4	Disaster
III	3 and 4	1 to 6	1 to 6	Catastrophe
IV	5	2 to 6	2 to 7	Major catastrophe
V	6 and 7	4 to 6	2 to 7	Super catastrophe

6. Risk Management Cycle

The risk management framework (Quarantelli 1978; Dauphiné 2001) may be summarized in 3 steps:

- Before the Disaster
- During the Event
- After the Disaster

Table 5 gives the details which are discussed below.

7. Before the Disaster

Before any risk becomes an issue or disaster, several tools are available to foresee their occurrence, namely:

- Forecasting
- Monitoring
- Warning

When it is difficult to forecast the occurrence of catastrophic events, one way to mitigate the possible impacts would be to minimize the eventual risks through an adequate design. Unfortunately, some principles – probably fashionable and attracting funds for research - have been put forward, apparently to reduce risks.

These are:

- Sustainable Development
- Alara principle
- Precautionary principle
- Zero risk principle

In effect, these principles can be good servants if used wisely, but can become bad masters if applied blindly just for application's sake.

Table 5: Risk Management Framework

BEFORE THE DISASTER	Foreseeing Techniques Monitoring Techniques Warning Risk Reduction Strategies Simulation, drills shown on TV
DURING THE EVENT	Reducing the magnitude of the disaster Time Management Crisis Management Tools Geography of the Crisis Management
AFTER THE DISASTER	Assessing the Impacts Compensation/Relief Reconstruction Principles

To reduce risk, it is possible either to:

- act on the risk or hazard,
- act on the vulnerability

such that the disaster does not occur or that the negative impacts are mitigated. It may be useful to anticipate the management of the disaster.

Reduction of the risk depends on the nature of the risk. Technical risks can use this strategy. An airplane will have double or multiple parallel brake and landing gear circuits to make sure that one of them works. On the other hand, when a country abandons nuclear energy, most likely other sources of energy – with probably an increase in global warming – will be used, to meet the energy demand. Vaccination does help to reduce the risk of diseases. Regular servicing certainly reduces the number of engine breakdowns.

Another type of risk reduction advocates containment. Thus, nuclear power stations in France have 3 containment barriers to form a blinding against radioactive propagation. Certainly, this is better than the case of Tchernobyl, where there was no confining wall around the reactor (Dauphiné 2001).

If it is impossible or difficult to reduce the risk, it is essential to think of **reducing the vulnerability**. Thus, in 1960, the cyclone Carol (Chelin 1989) left Mauritius with many damaged buildings and houses, at a time when construction was of wood and corrugated iron sheets, while the very few concrete houses stood intact. (It may be noted that the Cavendish bridge, at Mahebourg, was built in concrete in 1912, so concrete was not unknown in Mauritius). As a result, afterwards, all houses adopted a concrete structure, even if some finishes could be different, and presently, there are very few buildings not built in or with concrete.

Drivers may have or cause accidents. Having seat belts, protective helmets, etc., are ways to reduce vulnerability. An extension of this follows in the health and safety rules which are advocated on construction sites, but which could or should begin in the kitchen. There are so many ways of having or creating accidents that could be avoided by some simple precautions. If, effectively these precautions may be taken, why not implement them?

At another extreme, if a tsunami is announced on the coast, an evacuation is probably the only solution/precaution. In certain cases, it is possible to try reducing both the risk hazard and the vulnerability. On all construction sites, the use of protective equipment reduces the vulnerability of the workers, but the use of safety nets and shoring is aimed at reducing the risk.

Anticipating the disaster is another aim of risk reduction. By focusing on all components of the risk, the intensity and occurrence of the hazard, and on vulnerable behaviour, this can become quite effective. Concentrating on efficient communication is important to avoid panic and the possibility of bystanders to hamper the progress of ambulances, etc. This often happens when drivers slow down to watch the results of an accident or people coming to watch the progress of a fire, etc.

In Martinique, etc, there is a cyclone day (Dauphiné 2001) aimed at educating/informing people about the pecautions to be taken for cyclones, while in Japan, similarly one day is devoted to earthquakes. Unfortunately, no elaborate precautions were taken or in place when the Mount Pelée (in Martinique) erupted in 1902 (Scarth 2002).

In Mauritius, videos could be shown for fire drills, cyclones, tsunamis, etc, followed by simulation exercises locally. One sequel of the flood disaster in Port Louis on 30th March 2013 would be to prepare an evacuation plan from the town should there heavy rains in the future: what roads (towards north or south) to take if there are sudden heavy rains to go, and which area to avoid, for example. On 29th and 30th June 2013, simulation exercises have been carried out (Le Mauricien 2013) at Canal Dayot/Sable Noir and at Champ de Mars respectively with respect to flooding and a landslide. It would be, again more effective, if videos of these are shown on TV at regular intervals, particularly before the cyclonic and rainy seasons.

8. Management of disasters

8.1 Reducing the magnitude of the disaster

The impact of a disaster could be reduced by working on the hazard or on the vulnerability. **Reducing the immediate vulnerability** is practised in Mauritius when cyclones are announced. Soon after the class 1, 2 or 3 warnings are announced on the radio, people are advised to take precautions, and informed about refugee centres, etc.

8.2 Time Management

Some disasters are imminent, but not immediate and give time to react or take necessary protective/precautionary action. Cyclones are one such case. The flood disaster (Moonien 2013; Wright 2013) in Port Louis on 30th March 2013 did not give much time for warning. So, it is judicious to ask when is the right time to take proper action?

How much time is necessary for responding to a call for action: A few seconds in a plane, a few minutes for a fire or a few months in the case of a drought. Food cannot be brought overnight, except locally. One classical way to reduce response time is to reduce distance - security companies have several braches offices all over the island, just as fire engines are on standby mode in towns and main villages, either to help locally or to reinforce action in other nearby locations.

8.3 Crisis Management Tools

During the last decade, the media network has developed considerably which should enable communication by the concerned institutions to be effective.

- Emergency Plans
- Media management of disasters
- Risk perception by decision makers during the crisis

There exists a National Disaster Committee which usually meets before the cyclonic season or for other emergencies. This committee has general guidelines (**Emergency Plan**) for its stakeholders and goes through them for each concerned institution or stakeholder group.

In turn, each stakeholder may have its own cyclone or disaster committee with its own set of guidelines. For example, the Central Water Authority will ensure that all its standby generators, (near boreholes and pumping stations) are in working order, with filled fuel tanks.

All emergency plans (Alexander 2002) should probably be under constant review, and will work better if they have been established with all stakeholders – and this means the population, not only institutions. This is precisely what airplanes propose to their passengers before/while taking off !! Simulation exercises (such as fire drills) – even just shown on TV – will help the population to understand the risks, the precautions to be taken and the other guidelines to follow during the crisis.

In this context, it is also important (UNESCO 2006) to train people what to do when the UNexpected happens, how to use their imagination and their creativity, because this is what they would need in case of a disaster. All possibilities cannot be considered, because by definition, a disaster always brings the UNEXPECTED.

The media (Covello 1992) is very helpful in communicating cyclone Class warnings, in Mauritius. The news is relayed regularly on the press and radio channels. This is good **management by the media** (Dauphiné 2001).

Just as drivers who slow down to watch the scene of an accident may hamper the progess of other traffic and medical attention, journalists who announce in advance that the police has set a trap to catch a criminal or terrorist are in fact **undermining** the operation itself. Should a driver who is exceeding the speed limit be warned by the radio or otherwise that there is speed trap – when he is a potential danger to ALL other road users, not only at this location, but everywhere else where he drives!!

On the other hand, if the authorities do not communicate in due time, then all sorts of rumours will start filtering in, duly amplified with passing time, every hour or day.

8.4 Geography of the Crisis Management

When we look at the possible risks of Table 1, we realize that the risks are not limited to Port Louis or to certain places. While some obvious mitigation measures (health centres, fire stations) have been taken for the whole of Mauritius, for other risks, we should probably identify all the areas which need to be addressed in terms of disaster plans, etc.

9. After the disaster

Broadly speaking, it is necessary, after the disaster – we are familiar with these steps after a cyclone – to assess the impacts/damage, help those affected and rehabilitate the damage

9.1 Assessing the Impacts

Assessing the impacts which comprise the

- difficulties of post disaster assessment,
- benefits of post disaster assessment,

help in obtaining experience in the preparation of a plan for the future.

Assessing the **impacts of a disaster** is not always easy because there are so many people, who believe – rightly or wrongly – that they are to blame. The 30th March flooding in Port Louis is a good example.

Getting data, after the data, may be problematic: different people will give different stories, different highest levels of flood waters which they have observed.

Once the disaster impacts – why, how, what, where, who and when have been assessed, this does provide the **benefits of the assessment**: the lessons learnt could be applied to other locations where similar risks exist. Whether these lessons are applied or not is another story – lack of funds, political unwillingness, risk perception, etc… Those people who have gone through cyclones Gervaise (1975), Hyacinthe/Jacinthe (1980) Hollanda (1994) will have different perceptions than those who have not. Recently, three persons were nearly drowned while surfing when the Meteorological Services had announced a swelling sea with 4 metre high waves !

9.2 Unequal compensation

One protection against risks is the use of insurance, as usually taken by individuals and some organisations to counter loss of human life or material damages. Notable examples include different life insurance policies, the car insurance schemes, and the contactor's insurance against damages on a site.

Here again, perceptions might differ. While the head of a household might take a life insurance, young unmarried professionals wonder why it is at all necessary.

9.3 Reconstruction principles

Only in extreme cases, would a relocation be envisaged. What must be borne in mind, however, is if the previous conditions (same type of construction, same place, with the possibility of similar hazard risks, etc) are repeated, history will just repeat itself.

On a general note, there is a priority list for reconstruction after a disaster. The rehabilitation of networks: roads, water, electricity, telephones should be in working order as soon as possible, although this may imply that some provisional repair must be re-done again, some time, in the future.

10. Conclusion

After a general presentation of risk hazards as they apply to infrastructure, a risk management framework has been presented and discussed.

Experts can plan for emergency situations which arise after disasters. However, unless the relief community and the general public have been well drilled, this planning might not give the expected performance. It is therefore recommended that simulation exercises, drills are not only carried out, but also shown on TV for a wider coverage at judicious, regular intervals.

References

Alexander D., 2002. Principle of emergency planning and management. Terra Publishing, England.
Chelin A., 1989. Maurice : Une île et son passé. Editions du CRI, Ile de la Réunion.
Covello V., 1992. "*Risk comparison and risk communication*", in Kasperson R. and Stallen P, Communicating risk to the public. Kluwer, Amsterdam.
Dauphiné A., 2001. Risques et catastrophes. Arman Collin, Paris
Le Mauricien., 2013. "*Catastrophe Naturelle : deux exercices de simulation ce weekend*" . Le Mauricien, 29th June 2013.
Moonien V., 2013. "*Inondations: Port Louis déjà sous l'eau 2003*". L'Express, 11th August 2013, p. 20.
Proag V., 1995. The Geology and Water Resources of Mauritius. Mahatma Gandhi Institute, Mauritius.
Quarantelli H. (ed)., 1978. Disasters : theory and research. Sage, London.
Scarth A. 2002., La Catastrophe: Mount Pelée and the destruction of Saint-Pierre, Martinique. Terra Publishing, England.
UNESCO., 2006. Water – a shared responsibility. Berghahn Books, New York.
Wright A ., 2013. "*Rien n'a changé pour les autorités* ". L'Express, 10th August 2013, p. 9.