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**ASSESSING THE
VULNERABILITY OF LOCAL
COMMUNITIES TO DISASTERS:
AN INTERACTIVE GUIDE AND
METHODOLOGY**

Community Risk Profile Tool (CRP)

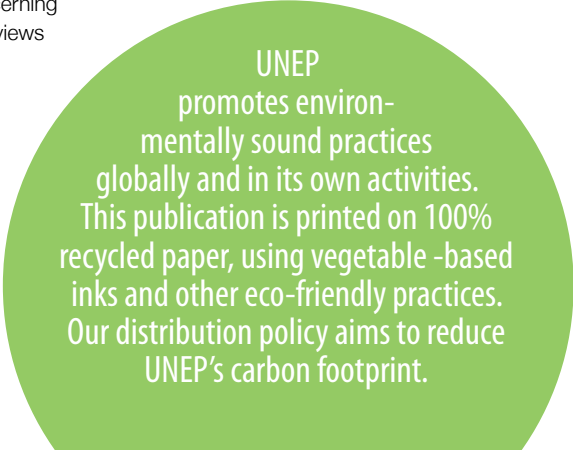
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Community Risk Profile Tool (CRP)



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1. INTRODUCTION

1.1 OVERVIEW

Most communities face risks which they have to assess and manage. Risks may arise from human activities such as industrial accidents, or they may be of natural origin such as floods, earthquakes, etc. Risks need to be taken into account in the decision making process of the overall disaster management policy of such communities. There are, of course, decisions concerning management of risks themselves, but other decisions, such as those relating to land use planning or industrial investment, also require consideration of risk.

Assessing risks is not an easy task. It requires conducting in-depth studies, which will only be justified if the expected level of risk is high. Against this background, UNEP decided to develop this Community Risk Profile (CRP) tool to provide communities with a means of making a rough estimate of various types of risks they are exposed to, supporting the decision making process, especially as to whether or not further assessments are needed. The CRP is not, therefore, a risk assessment tool. It is a tool that will provide users with a qualitative approach to characterise an expected level of risk and thus decide on the necessity for further assessment. It is also a tool that can be used to support awareness raising and capacity building activities. This is a guide where the methodology has not been widely used. Therefore, we strongly recommend that communities using the CRP tool provide UNEP with feedback to facilitate the review and improvement of the tool.

The CRP tool itself is in the form of a set of Excel™ spreadsheets that allow users to characterise the risks facing a given community by responding to a set of questions. Once the spreadsheets are filled out (i.e. the questions are answered) the community's CRP is produced automatically. This process is described in detail in this manual.

1.2 SCOPE OF THE MANUAL

To assist users in their decision making, the manual extends the definition of risk from the classical combination of probability and severity to a broader one that includes the vulnerability of an area and emergency preparedness. The CRP can be used to assess an initial level of risk independently of existing mitigation measures. It can also be used to assess whether existing measures are adequate to cover an initial risk. In all cases, a high risk level should induce in-depth risk assessment.

1.3 WHO SHOULD USE THE COMMUNITY RISK PROFILE TOOL?

The CRP tool is designed for a range of users involved in risk assessment or community management, with a focus on local authorities responsible for disaster related issues and land use planning, as well as on insurers and aid agencies wishing to investigate risk in a given community area. Industry too will find parts of the CRP relevant.

The CRP can be used in support of capacity building activities in both industrialised and developing countries, although some of the questions covered are somewhat technical and may require preliminary training. A training kit has been developed in parallel with the CRP tool for this purpose. However, the CRP can also be a very effective training tool in its own right, as it addresses the main issues of risk assessment in a community. Performing a community risk assessment with the CRP tool will lead local authorities to ask relevant questions about the way risks are managed in their communities, and will raise the whole community's awareness of vital issues.

2. OUTLINE OF THE METHOD AND PROCEDURAL STEPS

2.1 RISK ASSESSMENT CRITERIA

The CRP considers risk as a multi-dimensional characteristic of a given area. Different types of risks are assessed but, for each one, a typical event is identified that is a cause for concern and is assumed possible. Risks are then characterised according to the criteria presented and discussed in the following sections.

2.1.1 PRESENCE

The first question to be asked is whether there is a source of hazard within the community that could cause a given type of accident. Where one or several hazard sources are identified, risk analysis is necessary to estimate all of the dimensions of the risk, as described below.

Although assessing the presence/absence of risk may appear simple, some care needs to be exercised. A hazard source located outside of a community could nevertheless affect the community, and must therefore be taken into account.

The hazard sources to be considered are the following:

- Industrial plants, including SMEs
- Transport infrastructure: roads, railways, waterways, pipelines
- Volcanoes
- Rivers (as potential sources of floods)
- Slopes (landslides can occur)
- Forest and vegetation (which may ignite and cause a wildfire)
- Sea shore (where a tsunami can occur)
- Earthquakes
- Storms, in particular tropical cyclones.

Additional investigations may be necessary to help users identify hazard situations where the presence of a hazard source is not immediately obvious.

2.1.2 KNOWLEDGE

Knowing a risk—i.e. analysing and assessing it—is a first essential step in risk management. If a hazard source is identified it is essential that a true risk analysis be performed to obtain a true estimate of the risk. Obtaining knowledge of the risk is based on analysis and other technical means. When knowledge of a risk is insufficient, and where the CRP indicates that a relatively high risk level is to be expected, further studies should be undertaken to attain a satisfactory level of knowledge.

It should be borne in mind that the CRP is only an indication of actual risk level, based on average assumptions and very general criteria. If more precise results are already available, they should be used to estimate the risk, instead of the very general indications provided by the CRP.

2.1.3 INTENSITY

For an identified hazard source, 'intensity' characterises the scale of a potential event. This manual considers very different types of events but uses a common intensity scale that is applicable to assessment of events of any kind. A direct relationship is assumed between intensity level and the damage sustained by a given type of element that is known to be at risk and to be vulnerable.

Many accidents have a point or linear origin and develop an intensity which is maximum at the origin and diminishes progressively when moving away from the source. Below a certain level of intensity—that is, above a certain distance—no effect is observed. Intensity level can therefore be characterised by a surface area over which a given effect—lethal effect, for instance—can be observed.

This is the approach adopted by the CRP. For industry, it provides an estimate of typical intensity levels for most hazardous activities. For other types of risk that have non-localised effects, the intensity level is usually characterised by a ‘standard’ intensity indicator (e.g. wind speed for cyclones or earthquake intensity for seismic events).

A common intensity scale proposed for point or linear hazard sources is shown below (Table 1). The boundaries between risk categories are somewhat arbitrary and could be discussed further by stakeholders in the future.

Intensity level	Corresponding surface area
1	Effect area <0.2ha
2	Effect area 0.2–3 ha
3	Effect area 3–12 ha
4	Effect area 12–40 ha
5	Effect area >40 ha

Table 1: common intensity scale

2.1.4 PROBABILITY AND FREQUENCY

An accident can be characterised by its intensity, a risk by the combination of the likelihood of an event (expressed in terms of probability or expected frequency) and its consequences. For example, although the intensity of a collision between the Earth and a comet would be very high—as such an event would cause massive devastation and loss of life—the probability of such an event is so low that the risk can be considered as negligible. In practice, it is never taken into account in making risk-based decisions. In the case of very rare events, or of events that can occur only once in a given place (e.g. the collapse of a cliff), probability is assessed using indirect indicators.

For more events that occur more frequently, their frequency can be assessed using a historical approach. If frequency is defined as the return period of a given event, it is possible to extrapolate an expected future frequency from the past frequency, provided the conditions under which the event occurred in the past still pertain in the future.

In the CRP, the likelihood of accidents which could occur in the future is expressed in terms of frequency, and a common frequency scale is proposed for this purpose (Table 2). When no historical data are available, the same scale is used to express likelihood on the basis of an assessment of risk criteria.

Once again, this scale is open to debate amongst stakeholders.

Frequency level	Frequency (events per time period)
5	1/10 years
4	1/100 years
3	1/1000 years
2	1/10000 years
1	1/100000 years

Table 2: common frequency scale

2.1.5 ELEMENTS AT RISK

Elements at risk are, first of all, people (i.e. the population, workers or users of a transport system) but they can also be economic in nature. It is the number of such vulnerable elements that will be affected by a hazardous phenomenon that determines the damage level of an accident. For example, an accident occurring where no vulnerable element (e.g. population, building, natural environment) is present will cause no damage, whereas one with an intensity beyond the lethal effect limit occurring in a densely populated area would cause a large number of fatalities. An estimate of the elements at risk exposed to the effects of an accident is thus an essential aspect of a risk estimate. The CRP assesses elements at risk by inviting users to make the choices indicated below:

Human beings exposed:

- **Local population:** Select the human density of the area at risk
- **Transport users:** Select the type of transport lines present in the area at risk

Economic assets exposed:

- **Industry:** Select the type of industrial activity in the area at risk
- **Service:** Select the type of economic activity in the area at risk
- **Transport lines** (roads, railways, waterways): select the types of transport lines present in the area at risk.
- **Critical facilities*:** Select the answer that characterises the exposed area
**Critical facilities are the amenities and equipment that are necessary to ensure the smooth functioning of an area and that play a major role in its resilience. They include schools, hospitals, major administrative departments, railway stations, airports, police stations, fire department, etc.*
- **Energy:** Select the types of energy production and transport infrastructure present in the area at risk
- **Communications:** Select the types of communication infrastructure present in the area at risk

Environmental exposure:

- **Natural environment:** Describe the natural environment in the exposed area
- **Water supply system:** Select the type of water resource present in the exposed area

The level of exposure of each of these categories of element is obtained by selecting the most representative characteristics for the area. For example, where the population is concerned, the user is asked to select the description that best fits the potentially exposed area, as shown in Table 3:

Level	Description of the area
1	Very low density (farmland, scattered houses), very few vulnerable elements
2	Low density area (individual dwellings, villages, quiet residential areas), a few vulnerable elements
3	Intermediate density area (residential area), several vulnerable elements
4	High density area (busy residential area), many vulnerable elements
5	Very high density area (urban area, city centre, very active commercial zone), very large number of vulnerable elements

Table 3: scale of elements at risk

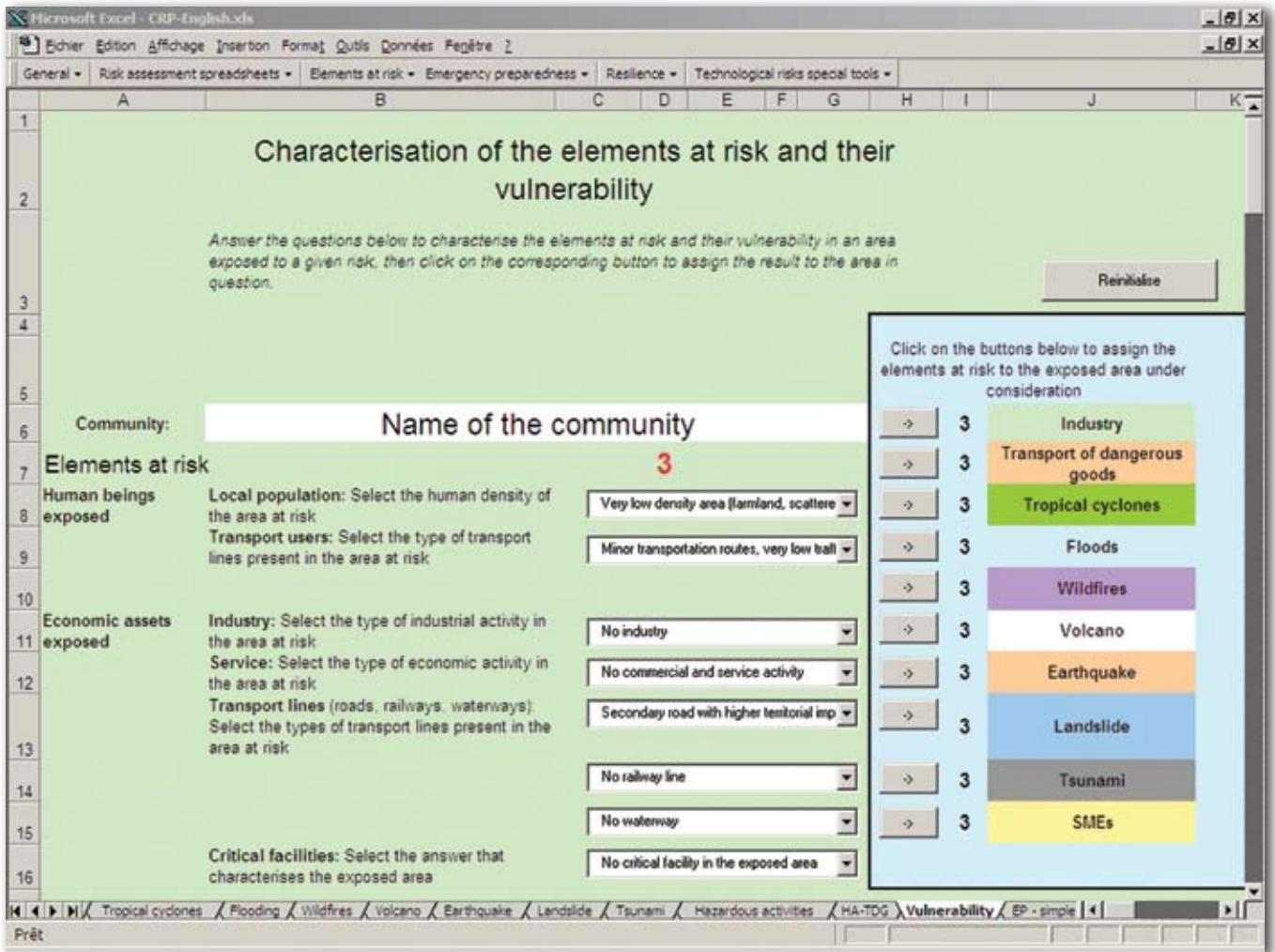


Figure 1: The elements at risk questionnaire
 (the buttons on the right are used to assign the calculated elements at risk to the areas concerned by different types of risk)

Elements at risk may vary from one part of the community to another. The CRP's *elements at risk - vulnerability* questionnaire (Figure 1) allows users to adapt their assessments of elements at risk to different parts of a community, in accordance with different types of risk.

2.1.6 VULNERABILITY

The vulnerability of a group of elements at risk characterises the capacity of the elements to withstand the effects of a hazard or the degree to which damage will be sustained. For example, a house that has been reinforced may withstand a flash flood. Similarly, concrete houses may withstand moderate overpressure better than metallic structures. Vulnerability is thus an aspect of risk that must be assessed, and reducing vulnerability is one of the steps that can be taken to reduce risk.

The CRP considers three types of vulnerability: technical vulnerability, or the capacity of a given set of elements to withstand an accident, and the economic and social vulnerability of a community (see Figure 2, p. 12).

The vulnerability of an area is characterised by answering the following questions:

Vulnerability	Questions to address
Technical vulnerability	Industry: What type of structure is most representative of the exposed area?
	Services: What type of structure is most representative of the commercial and service activity buildings in the exposed area?
	Residential: What type of structure is most representative of the residential buildings in the exposed area?
Economic vulnerability	Industry: What is the weight of industrial activity in the exposed area with respect to the rest of the community?
	Services and commerce: What is the weight of service and commercial activity in the exposed area with respect to the rest of the community?
	Exposed critical facilities: What is the weight of critical facilities in the exposed area?
	Agriculture and natural environment: What is the importance of the exposed area for agriculture and natural environment?
	General economic activity: How would you describe the economic activity of the area?
Social vulnerability	Social vulnerability: How would you describe the population in the exposed area?

Qualitative criteria can be applied to rank vulnerability for each of these themes on a scale of 1 to 5. Initially, the community's vulnerability is assumed to be maximum for each aspect. Other choices could be made: for example, considering the average of vulnerabilities or some type of linear combination.

In the same way as for elements at risk, vulnerability can vary from one part of the community to another and the *elements at risk - vulnerability* questionnaire allows users to adapt their vulnerability assessments to different areas of the community in accordance with different types of risk.

2.1.7 PREVENTION (OF HAZARDOUS PHENOMENA)

It is possible to apply prevention strategies to attempt to reduce the probability of some hazardous phenomena. In industry, for instance, specific safety equipment or organisational measures can prevent failures likely to lead to an accident. In general, the CRP does not extend to assessment of specific preventive measures, but it does allow consideration of whether or not general prevention strategies are applied. These include, for example, the existence of legislation and its degree of enforcement or the existence of local monitoring and alert systems to provide early warning and allow for intervention before a major accident occurs.

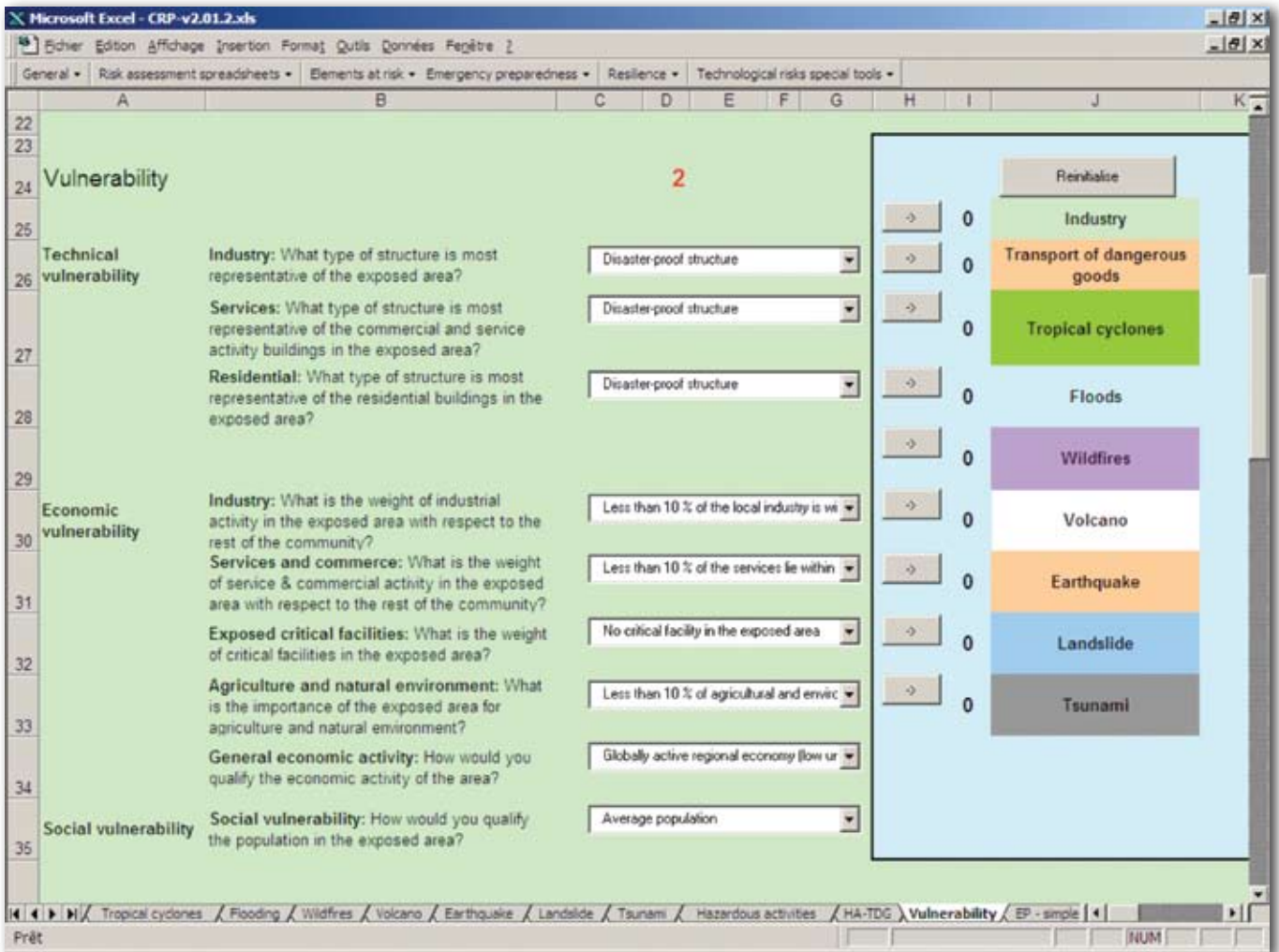


Figure 2: The vulnerability questionnaire
 (the buttons on the right are used to assign the calculated vulnerability to the zones concerned by different types of risk)

In some risk assessment methods, safety barriers (i.e. prevention and protection measures) are assessed in terms of level of confidence and reliability, which has a direct quantitative impact on the probability of the accident scenario. However, such a quantitative link is not possible with the CRP, and the level of prevention is calculated very simply: a score of 1 is given if all prevention measures identified as possible are in place, 5 if there are none. For each prevention measure, CRP users are asked to answer ‘yes’ or ‘no’ for general measures, or to select a percentage of cases where the measure is actually in place. In many cases, the answer will not be obvious, and it is left to the user to decide on the answer that best characterises the community. The strategy employed can vary, depending on the CRP user’s objectives. However, a conservative approach is safer and should be applied in most of the situations, especially when the user is not a risk expert.

2.1.8 PROTECTION, MITIGATION

Protection and mitigation attenuate the effects of hazardous phenomena reaching vulnerable elements. Mitigation devices include dikes protecting against flooding or reinforced walls able to withstand the blast effect of an explosion.

Mitigation also covers specific intervention plans and measures to reduce vulnerability or prevent it increasing. Land use restrictions or building regulations and standards are among the possible mitigation measures.

It is not possible to establish a quantitative scale for protective measures where prevention is concerned. Assessment, in this case, is cumulative, going from 5 when no protection measures are in place, to 1 when all possible measures are present.

2.1.9 EMERGENCY PREPAREDNESS

Emergency preparedness—which is the core of the APELL programme—covers all of the technical and organisational measures that contribute to efficient intervention in the event of an emergency. Several booklets on this subject are available. In the CRP, this aspect is assessed via a questionnaire developed within the framework of the APELL programme .

The full questionnaire is, however, relatively long and complex and the CRP provides a simplified version, in the form of a subset of the complete questionnaire which, nonetheless, includes all of the essential questions (see Figures 3 & 4). The user is given the choice of: either filling in the complete questionnaire, which provides much useful information; or filling in the simplified one. Use of the full questionnaire is justified if emergency preparedness is the community's main concern.

Microsoft Excel - CRP-English.xls

General Risk assessment spreadsheets Elements at risk Emergency preparedness Resilience Technological risks special tools

A B C D E F G H I

1

2

3

4

5

6 Name of the community

7

8 Emergency preparedness 5

9

10 To assess emergency preparedness, you can either answer this simplified questionnaire or use a

11 full length questionnaire (check the box below) for a more complete assessment. The second

12 option is recommended if the aim of the risk assessment process is to define an emergency

13 preparedness programme, especially in the framework of the APELL process. The simple

14 questionnaire is a subset of the full questionnaire. It covers the essential aspects and principles of

15 emergency preparedness. The complete questionnaire examines actual implementation of these

16 principles in greater detail.

17 Simple questionnaire Full questionnaire

18

19 Is there an emergency plan covering all the identified hazards? Yes

Is the emergency plan based on a hazard analysis? Yes

Does the hazard analysis include a precise description of the potential scenarios (especially, for industrial hazard, the types and quantities of hazardous materials, the process involved, etc.)? Yes

Prêt

Figure 3: the simplified emergency preparedness questionnaire

Emergency preparedness is assessed globally for the entire community and for all hazards, the assumption being that a single organisation will be involved in response to any of the hazards, and that good overall organisation will be beneficial in all situations. The ‘protection’ sections of each of the specific risk assessment sheets nevertheless ask questions to assess the specifics of emergency response in relation to a given type of hazard.

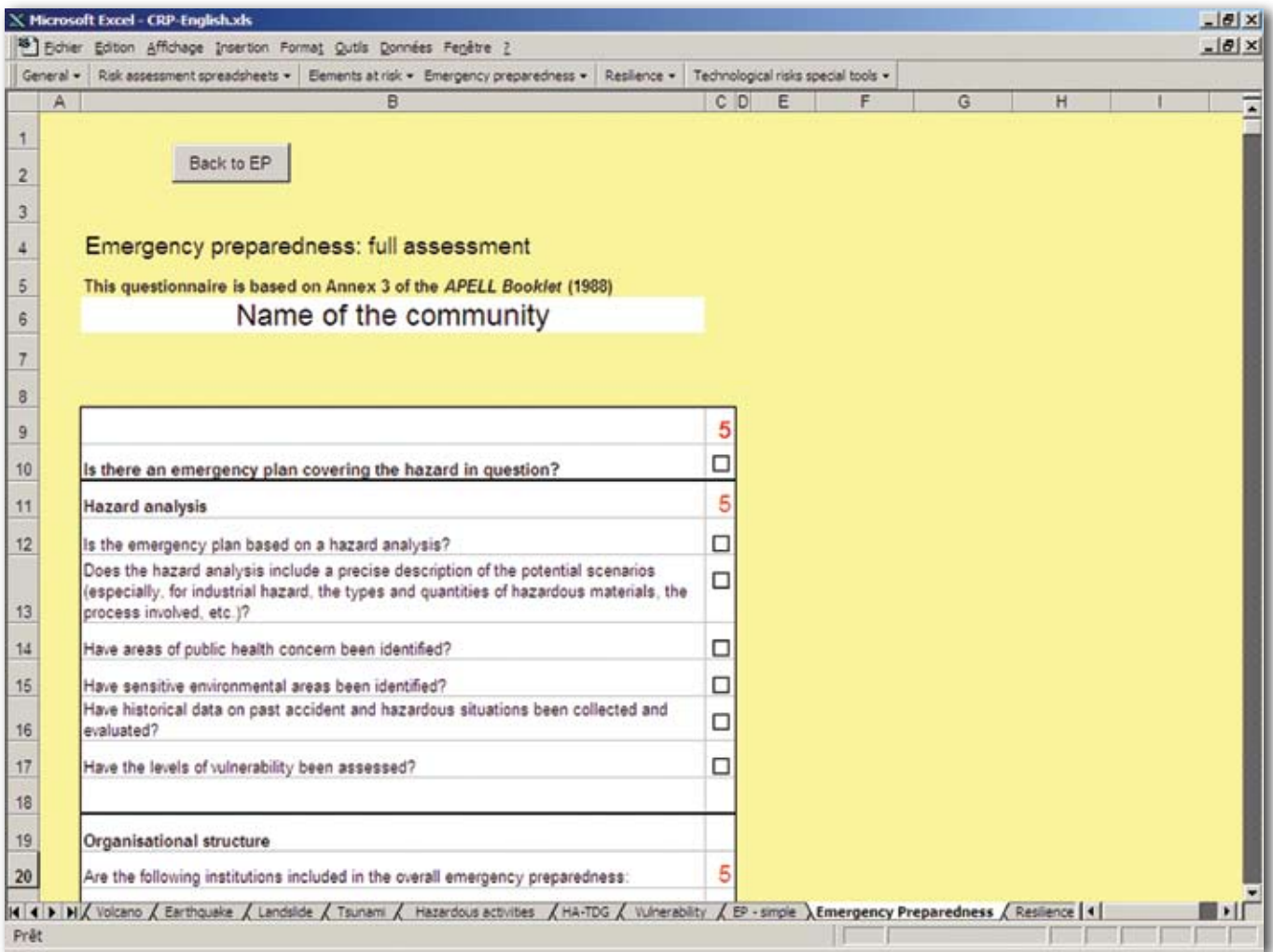


Figure 4: the full emergency preparedness questionnaire

2.1.10 RESILIENCE

Resilience characterises the capacity of a community (or of a person) to recover after an accident. Several aspects of a community’s make-up contribute to its resilience, including: the existence of disaster recovery planning, access to knowledge, the community’s economic capacity and its health system, as well as the system’s learning capacity, local cohesion and the community’s technical capacity.

The CRP presents users with a set of questions on each of these themes (see Figure 5), to help them assess the community’s resilience. The overall score is a weighted sum of all of the answers, with the initial weighting being equal to 1. The weighting distribution is likely to change over time, as feedback is obtained from community users.

Resilience

Resilience is a global characteristic of a community or even of the region to which a community belongs. Resilience is relatively independent of the type of hazard facing the community. To answer the resilience questionnaire, select the answer in the scroll down menu that best describes the community. Most of the choices are between 'True' or 'False'. Some questions, however, require a more detailed answer. For these you are asked to select the percentage of population or situations for which the sentence on the left is true.

Name of the community

In case of an accident: **5**

Disaster recovery planning

A local disaster recovery plan exists.

The disaster recovery plan is considered appropriate.

Access to knowledge

The initial average educational level is good.

The population has fair knowledge of the hazard and of its mid- and long-term consequences. Give percentage.

The population has access to knowledge and information about the possible accident and about its consequences. Give percentage.

Special training on recovery activities (including health, environmental protection, cleaning and remediation, rebuilding, alternative economic activity) is included in the disaster recovery plan.

Figure 5: the resilience questionnaire

To fill in the resilience questionnaire, users are asked to select the answer from a scroll down menu that best describes the community. Most of the choices are between 'True' or 'False'. Some questions, however, require a more detailed answer and, for these, users select a percentage of the population or of situations for which the sentence on the left is true.

The resilience questionnaire presents the following statements which are to be designated 'True' or 'False':

Disaster recovery planning

- A local disaster recovery plan exists
- The disaster recovery plan is considered appropriate

Access to knowledge

- The initial average education level is good
- The population has a fair knowledge of the hazard and of its medium and long term consequences
- The population has access to knowledge and information about the accident and its consequences
- Special training on recovery activities (including health, environmental protection, cleaning and remediation, rebuilding, alternative economic activity) is included in the disaster recovery plan

Economic capacity

- The initial economic level of the population is good
- What percentage of the population has access to credit?
- The population's level of debt is low
- What percentage of the population has insurance cover?
- The insurance system allows for rapid reimbursement of populations affected
- The general regional economy is good
- Public subsidies are available for reconstruction and economic recovery
- Unemployment and welfare insurance are available to jobless people
- The regional level of unemployment is low
- The regional economy is growing

Health

- The initial health of the population is good
- A good health system is available in a nearby preserved area
- The population has access to the health system (even after having lost home and/or job)
- Temporary shelters are available in case of an accident

Learning capacity of the system

- A learning-from-experience system exists

Local cohesion

- Local participation in decisions is effective
- NGOs and associations are involved in the local social and economic life
- The region is affected by conflict

Technical capacity

- Local construction and remediation companies exist
- Materials for reconstruction are available at local level
- Technologies for reconstruction and remediation are known
- Technologies for reconstruction and remediation are available

3. THE COMMUNITY RISK PROFILE

The CRP is produced automatically once the answers have been provided to the questions in the various spreadsheets. The CRP is in two parts: the CRP matrix (Figure 6), where all of the scores are summarised, and the CRP graphs (Figure 7), which provide a graphic representation of the different dimensions of each specific risk.

		Industry	Transport of dangerous goods	Tropical cyclones	Flooding	Wildfires	Volcano	Earthquake	Landslide	Tsunami
Name of the corresponding area										
Presence	0-5	0	5	0	5	5	0	5	5	0
Intensity	1-5	0	4	0	5	1	0	2	1	0
Frequency	1-5	0	4	0	2	1	0	4	5	0
Elements at risk	1-5	0	3	0	3	3	0	3	3	0
Vulnerability	1-5	0	2	0	0	0	0	0	0	0
Knowledge of risk	1-5	0	5	0	5	5	0	5	5	0
Prevention	1-5	0	5	0	1	5	0	5	4	0
Protection	1-5	0	1	0	1	1	0	5	1	0
Emergency preparedness	1-5	0	5	0	5	5	0	5	5	0
Resilience	1-5	0	5	0	5	5	0	5	5	0

Figure 6: the CRP matrix

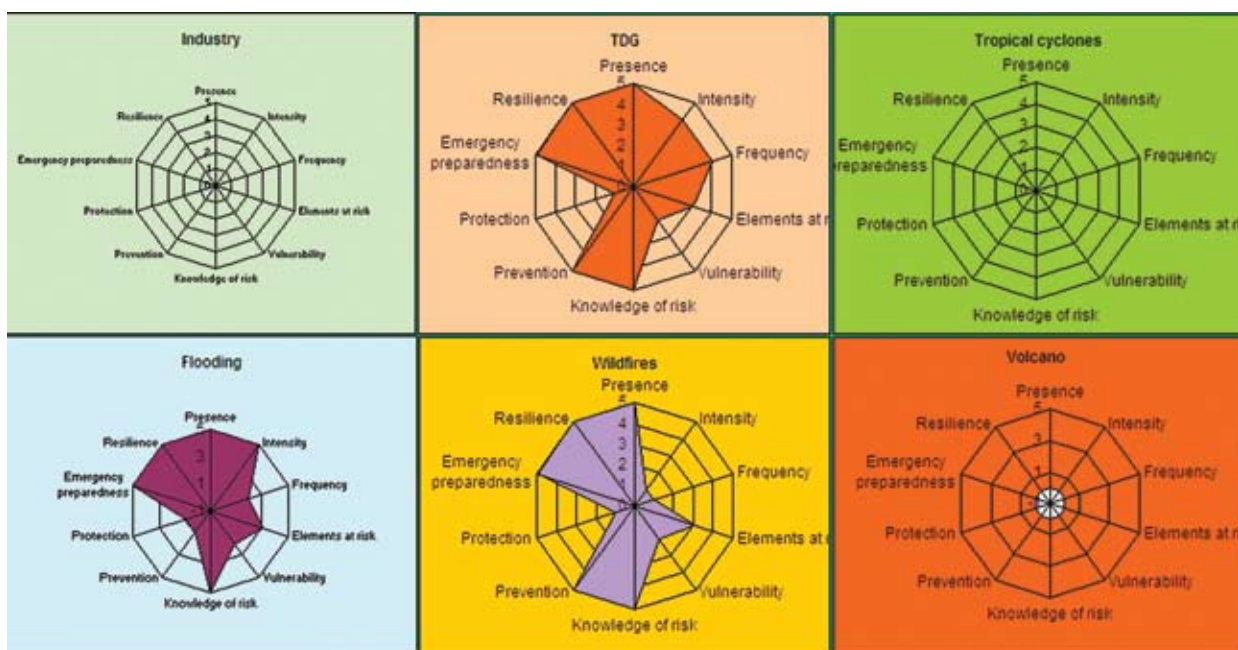


Figure 7: a selection of CRP graphs

Figure 7 shows the CRP graphs for industry, transport of dangerous goods (TDG), tropical cyclones, floods, wildfires and volcanoes. For each type of risk, the greater the surface area of the CRP, the higher the risk and the greater the necessity for prevention and mitigation measures.

The CRP graphs can be divided into three main areas:

- The upper right portion, indicating the characteristics of the hazard in terms of the presence, intensity and frequency of a dangerous phenomenon.
- The lower right portion, giving an indication of the vulnerability of the community to the hazardous phenomenon.
- The remaining portion, the entire left half of the CRP, covering risk control activities.

3.1 INTERPRETING THE CRP GRAPH

All of the criteria are measured on a scale of 0 to 5, and **always with the same orientation**. If there is no hazard source present in the study area, the user will set the presence criterion to zero (0), indicating 'absence' of any hazard source. In this case, all of the other criteria are set to zero automatically, indicating that the study is not relevant.

When a hazard source is present, the presence criterion is set to 5 and all of the other criteria are then assessed on a scale of 1 to 5. For criteria in the 'Hazard' and 'Vulnerability' categories (see Figure 8) a setting of 1 corresponds to low hazard, low level of elements at risk and low vulnerability. Conversely, 5 indicates a high hazard score, a high level of elements at risk and great vulnerability.

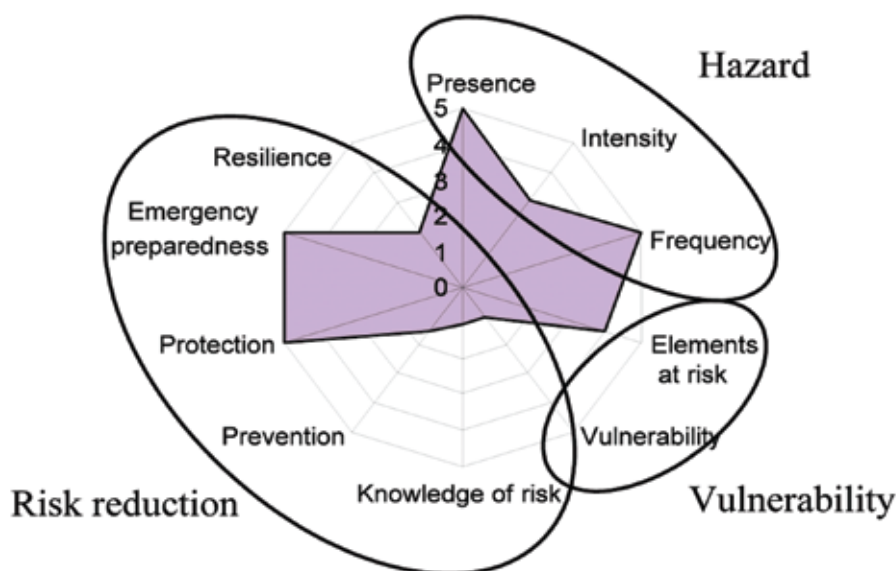


Figure 8: interpretation of the CRP graph

For the 'Risk reduction' criteria, a score of 1 indicates efficient prevention, protection and emergency preparedness, as well as high resilience and good risk knowledge. The situation for all of the criteria, illustrated by Figure 9, can be summarised as:

1 indicates a favourable situation, 5 an unfavourable one

1		2		3		4		5	
Absent hazard					Present hazard				
Low intensity					High intensity				
Low likelihood					High likelihood				
Few elements at risk					Many elements at risk				
Low vulnerability					High vulnerability				
Efficient prevention					Insufficient prevention				
Efficient protection					Insufficient protection				
Efficient emergency preparedness					Insufficient emergency preparedness				
High resilience					Low resilience				
Good knowledge of risk					Insufficient knowledge of risk				

Figure 9: interpretation of the scales

When interpreting the CRP graphs it is also important to bear in mind the definition of risk established at the start of Section 2.1.4. If the surface area of the upper right portion of the graph is large, then the hazard score is high. However, according to the definition, this does not necessarily mean that risk is high. If the area of the lower right portion is small there are few elements at risk and vulnerability is low. Risk is therefore low and, if an accident were to occur, it would cause only limited damage. In addition, if preventive measures are considered to be adequate, the probability of an accident occurring is also low.

3.2 RISK ASSESSMENT PROCEDURE

Risk assessment for a community is carried out by following the steps described below.

3.2.1 DEFINING THE DECISION CONTEXT FOR THE RISK ASSESSMENT

The purpose of risk assessment is to provide useful information to decision makers so that they can make sound decisions. Decision makers are, however, of different kinds, e.g. local authorities, NGOs, industry, etc., and the decisions they make based on risk assessment relate to a range of aspects: for example, to investment in a given community or to implementation of a new local safety regulation, etc. Risk assessment always therefore takes place within a given decision context.

It is essential that this context be known, so that the risk assessment results can be presented in terms that will be relevant and useful to the decision maker. However, the decision criteria should not influence the risk assessment outcome. Definition of the decision context has a direct influence on the next step: definition of the community area.

3.2.2 DEFINING THE COMMUNITY AREA

The second step in risk assessment is to define the system to be assessed. This will, usually, be described in terms of an area in which hazard sources and elements at risk are present. It may be a municipality or a larger or smaller area. The difficulty is in taking account of side effects. Hazard sources located outside of the area can nonetheless have an impact on elements at risk within the community. The community area must, therefore, be considered primarily in terms of a potential impact zone, and hazard sources must be sought both within and outside the community.

Users must be aware that the way in which they define the community will affect the risk estimate. The definition of the community should be in line with the decision context that initiated use of the CRP tool.

Figure 10 illustrates the concept of community. The largest contour will usually correspond to an administrative subset of a larger area, such as a municipality or a region. The community is the area within which risk has to be assessed. It can be an entire region or a municipality, but will be often a subset, e.g. a neighbourhood.

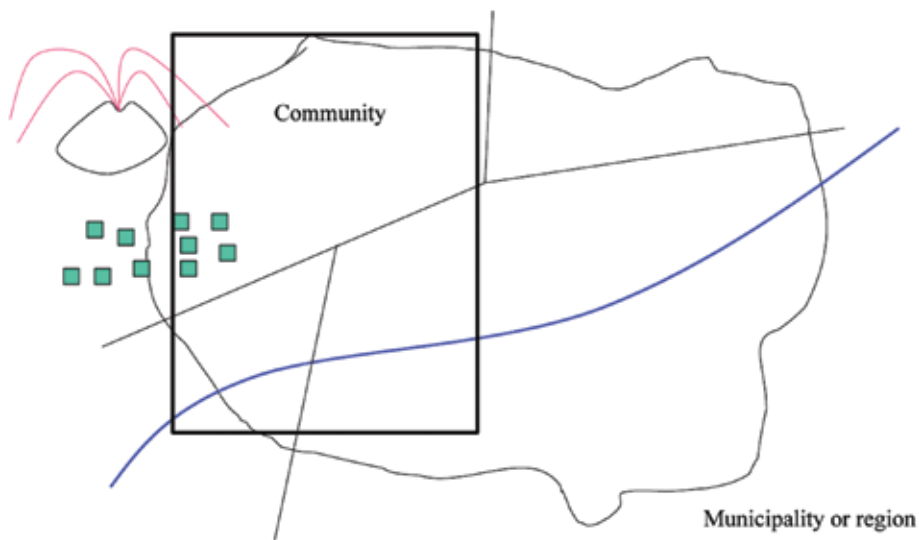


Figure 10: example of a community area within a larger administrative region

3.2.3 IDENTIFYING HAZARD SOURCES

In the example developed below (see Figure 11) there are a number of hazard sources within a community: a river (potential source of flooding); a road (potential source of transport accident involving hazardous substances); and an industrial zone (source of industrial accidents). The community is also close to a volcano and to other industrial plants, and these may also cause hazardous phenomena affecting the community.

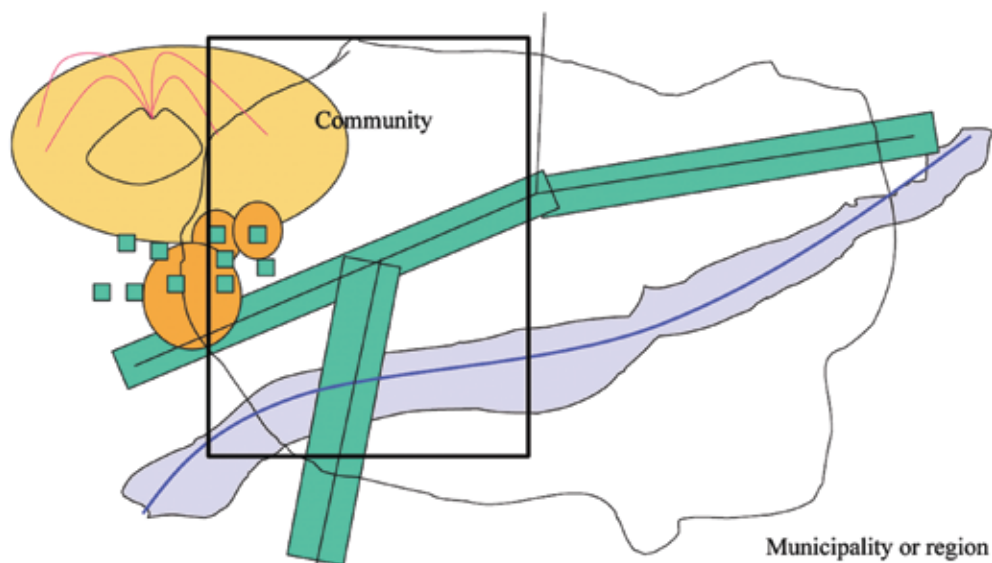


Figure 11: hazard sources that should be considered for risk assessment

The hazard sources to be considered are the following:

- Industrial plants, including SMEs
- Transport infrastructure: roads, railways, waterways, pipelines
- Volcanoes
- Rivers (potential sources of floods)
- Slopes (landslides may occur)
- Forest and vegetation (may ignite and cause a wildfire)
- Sea shore (a tsunami could occur)
- Earthquakes
- Storms (in particular tropical cyclones).

3.2.4 ESTIMATING THE RISK LEVEL ASSOCIATED WITH EACH TYPE OF RISK

The user is asked to respond to a set of questions for each type of risk in order to assess the risk level by assessing the risk criteria presented in Section 2: presence, knowledge, intensity, frequency, prevention, protection, elements at risk, vulnerability, emergency preparedness, resilience.

Risk generated by industry

This spreadsheet covers major industrial risks in the community. It addresses only risks that can have an impact on the community beyond the industrial plants. In other words, occupational health and safety issues within plants are not addressed here. The potential accident events are fire, explosion, leaks of toxic gases or liquids, or loss of containment.

Name of the community

Presence 0

Industrial risk only exists if industries are present in the community. If industrial plants are present, whether large or small and thought to be hazardous or not, answer 'yes' to the question below. If the answer is 'no', there is no need to fill out the rest of the spreadsheet.

Are there plants in the community or in its vicinity?

Knowledge 1

This section will help you to characterize the quality of knowledge of risk in the community, mainly by assessing whether risk analyses exist and whether they are of good quality. Choose the percentage of plants to which the sentence on the left applies. If you don't know the answer, it is recommended to choose the lowest percentage.

There are industrial safety studies or risk assessments available for these plants.

The safety studies provide geographical representation of risk (risk

Microsoft Excel - CRP-English.xls
 General | Risk assessment spreadsheets | Elements at risk | Emergency preparedness | Resilience | Technological risks special tools
 A B C D E F G H I
 1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12
 13
 Prêt

Figure 12: spreadsheet for industrial risk assessment

4. THE RISK ASSESSMENT SPREADSHEETS

This section presents and comments on the following risk assessment spreadsheets:

- Industry
- Transport of dangerous goods
- Tropical Cyclones
- Flooding
- Wildfires
- Volcano
- Earthquake
- Landslide
- Tsunami

Use of the 'Industry' spreadsheet is described in detail and will serve as an example for the other CRP tool spreadsheets.

4.1 INDUSTRY

The 'Industry' spreadsheet (Figure 12, previous page) covers major industrial risks in the community. It addresses only risks that can have an impact on the community beyond the industrial plants themselves. In other words, occupational health and safety issues within plants are not addressed here. The potential accident events are fire, explosion, leaks of toxic gases or liquids, or loss of containment.

PRESENCE

An Industrial risk is considered to be present if there are industrial plants within the community or in its immediate vicinity. (Remember, an industrial accident occurring in a plant in a nearby community can also have an impact on the community being assessed).

All types of plants are to be considered at this stage. The hazards associated with the industries are identified using the 'Hazardous activities' spreadsheet.

KNOWLEDGE

This section indicates how to characterise the quality of knowledge of a risk in a community, mainly by assessing whether risk analyses exist and whether or not they are of good quality. The answer is obtained by choosing the percentage of plants which have safety studies. The spreadsheet invites users to answer the following questions:

- ▶ Are there industrial safety studies or risk assessments available for these plants?

National legislation in most industrialised countries requires safety studies with two objectives: assessment of the intensity and probability of potential accidents and a demonstration of the reduction in risk brought about by prevention and mitigation measures. If such safety reports exist and are available to the community representatives, knowledge of the risk is considered as sufficient.

An additional set of questions then allows the quality of the safety studies to be characterised:

- ▶ Do the safety studies provide geographical representation of risk (risk maps)?

If they do, this can be used as a basis for the community to introduce additional risk reduction measures such as land use planning or emergency planning.

- ▶ Do the safety studies provide information on safety control by the company (safety measures, safety management system)?

This is essential from two points of view. Risk level is linked directly to prevention and protection measures (also referred to as safety barriers). Taking account of these helps to ensure that the risk assessment is truly representative. It also provides useful information for inspection authorities and for emergency planning.

- ▶ Do the safety studies provide information about emergency response?

Risk analysis is the basis for emergency planning. Emergency response is generally described in separate documents that include risk maps produced during risk analysis.

- ▶ Do the safety studies take into account possible interactions with other sources of hazard (natural or industrial)?

Industrial accidents can have a variety of causes, including natural events such as earthquakes, flooding or cyclones. The safety studies should include these scenarios.

INTENSITY

For industrial accidents, intensity is characterised by the area that would experience lethal effects in case of accident. The area can be estimated directly from safety studies or be obtained by using the relevant CRP spreadsheet. A scroll-down menu invites users to select how they want to proceed. If 'guided risk assessment' is selected, the user is redirected automatically to the 'hazardous activities' spreadsheet.

This sheet (Figure 13, next page) was derived from the *Manual for the Classification and Prioritisation of Risks due to Major Accidents in Process and Related Industries* (IAEA, 1996). It provides the user with typical effect distances for specific industrial activities.

The underlying principle is that each industrial activity is associated with typical substances. Users select the activities and substances present in their communities and provide the quantity stored at one single storage unit in a plant. For example, for an LPG transfer unit with three propane spheres each of 500 m³, the user is asked to enter the weight of one of the spheres, i.e. approximately 250 tonnes. In this case, the typical effect distance and surface area are 500 m and 80 ha, which correspond to an effect level of 5. The principle is to convert surface areas into intensity levels, in line with the following scale:

Surface Area	Intensity Level
Between 0.02 and 0.2 ha	Level 1
Between 0.2 and 3 ha	Level 2
Between 3 and 12 ha	Level 3
Between 12 and 40 ha	Level 4
Above 40 ha	Level 5

The same scale of intensity levels and impacted surface areas has been used for all of the localised effects.

The spreadsheet also gives information about maximum effect distance, which should be used as a reference for the estimation of elements at risk and of vulnerability.

Potential for domino effect

If other hazardous plants are present in the effect zone subject to thermal or overpressure effects, a domino effect is possible and intensity is accordingly raised by one level.

FREQUENCY

Assessing the frequency of major industrial accidents is not easy, for a variety of reasons. To begin with, such accidents are not frequent and the situations of the plants involved may differ widely from one accident to another. Technology also develops with time, making risk reduction easier; conversely, technological developments also bring new risks. And the economic situation of industrial plants changes, inducing organisational changes that may affect risk control positively or negatively. For all these reasons, assessing the frequency of future accidents on the basis of historical data is not an obvious choice.

In fact, the best solution is to perform a true risk analysis. This involves identifying potential accident scenarios and safety barriers and using them to estimate the frequency or the probability of an accident over a given period. If such studies already exist for the industrial plants in a community, or if some other estimate of the future frequency of accidents exists, users can enter the results into the CRP tool directly. Otherwise, they can proceed with a 'guided risk assessment'. This approach consists in estimating the risk reduction factor induced by the prevention measures and in calculating a new frequency index by subtracting the risk reduction factor from an initial frequency level fixed arbitrarily at the maximum level of 5.

The approach assumes that probability is linked directly to the preventive measures introduced.

Identification and characterisation of industrial hazard sources

With this spreadsheet you can identify the types of industry present in a community and select specific activities, substances and operations by clicking in the check boxes. For each activity selected, indicate the maximum storage capacity of individual tanks. If you do not know the actual amounts present in a plant, you should indicate the maximum upper value of the range suggested. If you are not able to determine precisely the activities performed by plants for a given industry, select all of the activities corresponding to the selected type of industry.

Community:

Intensity Index: 4 Typical surface area: 30 Typical distance: 1000

Main industry	Main activity	Substance involved	Operations	Quantity range	select	Quantity (t)
Fuel processing and storage	Storage	Oil (crude oil)	Storage with bund	200-20000 tons	<input type="checkbox"/>	
			Other type of overground storage or process	10-5000 tons	<input type="checkbox"/>	
		Petrol (gasoline)	Storage with bund	200-20000 tons	<input type="checkbox"/>	
			Other type of overground storage or process	10-5000 tons	<input type="checkbox"/>	
		LPG	Pressure liquefied	1-1000 tons	<input type="checkbox"/>	
			Cooling liquefied	200-20000 tons	<input type="checkbox"/>	
	LNG	Cooling liquefied	200-20000 tons	<input type="checkbox"/>		
		Gas cylinder storage	Various flammable gases	Maximum cylinder size	5 - 1,000 tons	<input type="checkbox"/>
	Refinery	LPG propane	Overground storage	200-20000 tons	<input type="checkbox"/>	
		Alkylolation				

Navigation: Transport of hazardous goods / Tropical cyclones / Flooding / Wildfires / Volcano / Earthquake / Landslide / Tsunami / Hazardous activities / Hi

Figure 13: spreadsheet for the assessment of intensity of an industrial accident

PREVENTION

The preventive and protective measures taken into account in the CRP can only be general in nature. The sentences listed below allow users to assess the preventive measures. They characterise good practice in terms of risk prevention by industry. For recommendations applying to individual plants, users are invited to select the percentage of situations where they believe a recommendation has been applied. When the entire community or country is concerned, the choice is between 'Yes' or 'No'.

- The industrial plants base their risk prevention on risk analysis
- The industrial plants were designed according to state of the art codes
- The industrial plants use state of the art safety devices
- The industrial plants apply state of the art maintenance procedures
- The industrial plants apply state of the art safety management systems
- Does legislation impose strict safety rules
- Is industrial safety enforced by the authorities?
- The industrial plants inform the authorities and the population about their safety policy and practice
- The industrial plants make improvements after accidents or incidents

PROTECTION

The protective measures envisaged for industrial plants are described below. For all these recommendations, users are asked to specify the percentage of industrial plants where they actually apply.

- Collective protection works are in place (protection walls, shields)
- Local vulnerability reduction measures are applied (reinforced windows, fire resistant material used, etc)
- Land use restrictions prevent additional elements of the surroundings from being exposed to potential hazardous phenomena
- There is a monitoring and alert system
- Emergency plans are defined at the plant level
- Emergency plans are defined at community level (see emergency preparedness, below)

4.2 TRANSPORT OF DANGEROUS GOODS

The Transport of Dangerous Goods (TDG) spreadsheet covers the risks arising from the transport of dangerous goods in the community by different modes of transport: road, rail, waterways, pipelines. The events considered are those that are specific to the dangerous substances transported: fire, explosion, toxic release. Other consequences of traffic accidents (fatalities, injuries or material damage due only to vehicle impact) are not considered here.

PRESENCE

The presence of a hazard arising from the transport of dangerous goods is linked directly to the existence in the community of transport infrastructure likely to carry dangerous goods. Presence of this hazard can be characterised by answering the following questions:

- ▶ Are there roads in the community likely to carry dangerous goods?
- ▶ Are there one or several railways in the community likely to carry dangerous goods?
- ▶ Are there waterways in the community likely to carry dangerous goods?
- ▶ Are there pipelines in the community carrying dangerous gases or liquids?
- ▶ Are there parking areas or marshalling yards where hazardous substances are stored temporarily?
- ▶ Are there port areas where loading/unloading of dangerous goods takes place?
- ▶ Are there intermodal or multimodal platforms or zones?

KNOWLEDGE

The identification and assessment of the risks related to transport of dangerous goods is essential if the community is to manage the risk. More than for any other type of risk, the geographical dimension is essential here and the risk analysis should produce risk maps on which the transport routes are clearly identified. The following questions are used to develop knowledge of the TDG hazard.

- ▶ Has a TDG risk analysis been done for the community?
- ▶ Does the study consider all the possible sources of hazard?
- ▶ Does the study provide geographical representation of risk (risk maps)?
- ▶ Does the study provide information on local vulnerabilities?
- ▶ Does the study provide information on emergency response?
- ▶ Are there specific safety studies on infrastructure (tunnels, bridges)?

INTENSITY

The intensity level for TDG is calculated in exactly the same way as for industry.

Available safety studies can be used to characterise the intensity of potential accident scenarios. Intensity can be expressed in terms of:

- Maximum surface affected by an accident
- Maximum effect distance from the source

As in the case of industrial risk, if such safety studies are not available, a specific spreadsheet—based on the Manual for the Classification and Prioritisation of Risks due to Major Accidents in Process and Related Industries (IAEA, 1996)—allows the identification and characterisation of hazardous activities which could be the source of a major accident. For vehicle transport (rail, road, waterway), calculation involves the quantities of hazardous substances. The figure used should be the average tonnage for a carrier of dangerous goods. Calculation for pipelines uses the pipeline diameter.

FREQUENCY

In line with its aims—i.e. to provide a qualitative estimate of risk on the basis of which further studies should be undertaken and to be usable in very diverse regions of the world where general statistical data on transport accident frequencies may not be available—the CRP proposes two ways of assessing frequency:

- a) Direct use of the results of available TDG hazard studies.
- b) Assessment of probability by means of a qualitative questionnaire, assuming that frequency is higher if overall traffic levels are higher, the number of transport routes is higher, traffic on these routes is intense and if the routes connect with hazardous plants or storage installations. The questions below reflect this approach. They are treated cumulatively as, in general, it is possible to answer ‘yes’ to several of them.

With the second approach (b), CRP users are invited to select the answers that best characterise the transport of dangerous goods in their communities by identifying whether a transport route (road, train, waterway or pipeline) or other transport related infrastructure exists and, if so, what type of dangerous goods traffic it represents (heavy, low, medium). Note: the result will remain zero if no hazard source is identified in the ‘Presence’ section.

Road

- ▶ Is there one road carrying DG in the community?
- ▶ Are there several roads carrying DG in the community?

- ▶ Is there one terminal (fixed chemical plant or container terminal) in the community?
- ▶ Are there several terminals (fixed chemical plant or container terminal) in the community?
- ▶ Are there risk spots in the community (e.g. road crossings, bridges, tunnels, road shrinkage, slopes)?

Rail

- ▶ There is one railway carrying DG in the community. (Users select traffic level)
- ▶ There are several railways carrying DG in the community. (Users select traffic level)
- ▶ Are these rails connected to industries in the community?
- ▶ Are these rails connected to marshalling yards in the community?
- ▶ Are there risk spots in the community (e.g. turnouts (switches), level crossings, tunnels, unstable ground areas)?

Waterways

- ▶ A major navigable waterway crosses the community. (Users select traffic level)
- ▶ There is a sea channel near the community's coast. (Users select traffic level)
- ▶ Is there is a port terminal in the community?
- ▶ Are there risk spots in the community (e.g. crossings, locks, mooring areas)?

Pipeline

- ▶ Are there pipelines for local use (natural gas) in the community?
- ▶ Do major pipelines cross the community?
- ▶ Are pipelines connected to fixed chemical, petrochemical and oil plants in the community?
- ▶ Are pipelines above ground?
- ▶ Are there risk spots in the community (e.g. pipelines crossing over roads, unstable ground zones where major ground movements could impact the pipeline)?

PREVENTION

As for industrial risk, preventive measures are identified by pinpointing the existence and enforcement of regulations or rules that tend to limit the probability of an accident. These rules can be local (e.g. restrictions on dangerous goods traffic on a given local route) or national (e.g. generalised application of ADR to road transport). Some criteria concerning the quality of roads and environment are also taken into account.

Reduction in the frequency and consequences of accidents involving dangerous goods is achieved by introducing preventive measures. Most of these are described in international regulations on the transport of dangerous goods, such as the United Nations Recommendations on the Transport of Dangerous Goods (UNRTDG). Applying a regulation based on these or similar principles is a first step, but it is also essential to assess how many transport operators actually meet the requirements of the regulations. The CRP tool does this by inviting users to answer the questions below. In some cases they are asked to select the percentage of situations where recommendations apply, in others they will answer 'Yes' or 'No'.

Prevention of road accidents involving hazardous goods

- ▶ Does the country apply regulations based on the United Nations Recommendations on the Transport of Dangerous Goods (UNRTDG, known as the 'Orange Book'), e.g. European regulations based on ADR?

In the boxes below, select the percentage of situations where the legal requirements are actually applied. If you do not know the exact figure, apply a rough estimate based on expert judgement using a qualitative approach (good situation: 60–80%, intermediate: 40–60% and bad: <20%)

- ▶ What percentage of road transport operators apply the regulation requirements in terms of:
 - **packaging**, which must be suitable and adequate and must follow the requirements in accordance with classification of the goods;

- **vehicles**, container, tank or wagon, which must meet special requirements in accordance with classification of the goods;
 - **labelling of packaging**, so that people handling the goods—including the emergency services in case of incident—can take appropriate precautions;
 - **placarding and use of regulatory signs on vehicles or containers**, which must bear the appropriate information;
 - **loading and unloading procedures**, which must be suited to the classification of the goods;
 - **safety equipment**, such as fire extinguishers, which must be carried by the vehicles;
 - appointment of qualified dangerous-goods **safety adviser**, when required by regulations;
 - **training of drivers**, not just to drive their vehicle but also on what to do if an accident occurs;
 - **notification** of accidents and emergencies by drivers;
 - **appropriate documentation** (as described in the UNRTDG), which must accompany the dangerous good; this contains information on the dangerous good and its hazards?
- ▶ Does the country or region apply more stringent regulations to vehicles dedicated to transport of dangerous goods (e.g. on the quality management certification, radio equipment, parking rules)?
 - ▶ Are regulations enforced; are TDG vehicles inspected regularly?
 - ▶ Do local regulations exist to limit the transit of hazardous goods in the community?
 - ▶ Are alternative routes defined after risk analysis?
 - ▶ Do local regulations exist to limit speed on hazardous pathways?
 - ▶ Do local regulations prohibit transit on very hazardous pathways?
 - ▶ Is the quality of roads good (road pavement, infrastructure)?
 - ▶ Is the quality of road equipment (e.g. road marking and signs) good?
 - ▶ Is the population (living close to roads, etc.) informed about risks arising from TDG?
 - ▶ Are industry and the local authorities known to make improvements after accidents or incidents?
 - ▶ Is the transport of high-risk materials during rush hours restricted, to reduce accident probability and the number of people exposed to risk?
 - ▶ Is the transport of dangerous goods restricted during hazardous weather conditions: low visibility due to fog, high winds, or slipperiness due to snow or ice?
 - ▶ Is parking of dangerous goods vehicles in the community restricted?
 - ▶ Is there a security plan covering the prevention of ill-intentioned actions against dangerous goods vehicles?

PROTECTION

Protective measures are measures that can reduce the consequences of an accident should it occur. Below are some examples of possible protection measures or measures to reduce vulnerability. CRP users are able to assess such measures in the chosen community by responding to a set of questions on these themes.

Road

- ▶ Are local vulnerability reduction measures applied (reinforced walls or windows, etc.)?
- ▶ Are specific protective devices (such as water curtains or walls) in place where the risk is highest (e.g. parking areas)?
- ▶ Do land use restrictions prevent additional elements of the surroundings from being exposed to potential hazardous phenomena?
- ▶ Is there a monitoring and warning system?
- ▶ Are emergency plans developed at plant level?
- ▶ Are emergency plans developed at community level (see Emergency Preparedness, below)?
- ▶ Do special roadside constructions limit the potential for severe consequences of spills (e.g. drainage systems or impermeable layers where roads pass through or near environmentally sensitive areas, water reservoirs, etc.)?

4.3 TROPICAL CYCLONES

A tropical cyclone is a tropical storm with winds that reach a constant speed of 119 km/h (74 miles per hour) or more. Tropical cyclone winds blow in a large spiral around a relatively calm centre known as the 'eye'. As they near land, these storms can bring torrential rains, high winds, and storm surges. Tropical cyclones can last from less than 24 hours to more than 2 weeks when over open waters, with an average duration of 6 days. They can follow a path of several hundreds of miles across a coastal line. Known as 'hurricanes' when they occur in the Atlantic Ocean, these extreme hydro-meteorological events are also called 'typhoons' in East Asia and in the north-western parts of the Pacific. The term 'cyclonic storms' is used in the Bay of Bengal, and 'tropical cyclones' for storms in South Indian, South Pacific and Australian waters.

PRESENCE

Tropical cyclones occur typically in areas located in the intertropical convergence zone. The geographical location of the community is thus of primary importance in deciding whether or not the hazard is present. The fact that the region has been hit by a cyclone in the past is clear evidence of the hazard being present. The questions for characterising the presence of the tropical cyclone hazard are:

- ▶ Has the community already been affected by a tropical cyclone?
- ▶ Has the community's region already been affected by a tropical cyclone?
- ▶ Is the community located on an identified cyclone path?
- ▶ Is the community in a seashore area in the intertropical convergence zone ?
- ▶ Is the community in the hinterland of a seashore area in the intertropical convergence zone?

KNOWLEDGE

This section covers the identification of existing, appropriate, specific knowledge sources on which a risk reduction strategy for tropical cyclones could be based. Knowledge of the tropical cyclone risk is considered to be good if records are kept of historical events, of their intensity and of the damage they have caused, and also if vulnerability studies have been conducted to assess the need to reinforce buildings and organise emergency response to cyclones.

- ▶ Are there meteorological studies on cyclones that have affected the community?
- ▶ Are records kept of all cyclones?
- ▶ Do the records mention intensity, damage and cyclone paths?
- ▶ Are there vulnerability studies available to assess the quality of buildings and their ability to withstand cyclones?
- ▶ Are there studies that assess the need for emergency response in the community and its potential organisation?
- ▶ Are there studies that assess the quality of collective protection (dikes, shelters, emergency response system) with regard to the potential intensity of a cyclone?

INTENSITY

It is not easy to assess the intensity of wind events from an a priori analysis. Assessment of intensity for such events is therefore based on a historical approach to events that have affected the community or surrounding areas with similar geomorphological characteristics. There are two options for assessment of the intensity of the hazard, depending on the availability of measurements or ground observations.

In the CRP tool, intensity can be qualified either in terms of wind speed or of ground damage. An intensity scale is proposed, based on an interpretation of the Saffir Simpson scale used to rate cyclones, and the Fujita-Pearson scale used, since 1971, to rate intensity by examining the damage caused by a tornado after it has passed over a man-made structure and by measuring the approximate path length and width. The CRP presents a scale which results from a combination of these two scales. The relation between the two scales and CRP intensity levels is illustrated by Tables 4 and 5.

Category	Central Pressure		Winds	Surge	Damage	CRP tool intensity level
	millibars	inches	mph	ft		
Category 1	980 or over	equal to or greater than 28.94	74–95	4–5	minimal	3
Category 2	965–979	28.50–28.91	96–110	6–8	moderate	4
Category 3	945–964	27.91–28.47	111–130	9–12	extensive	4
Category 4	920–944	27.17–27.88	131–155	13–18	extreme	5
Category 5	below 920	below 27.17	over 155	over 18	catastrophic	5

Table 4: the Saffir Simpson scale

Category	Wind speed	Path length and width	Damage	CRP tool intensity level
F0 – Gale Tornado	(40–72 mph)	P0 PATH length: 0.3–0.9 miles / P0 PATH width: 6–17 yards	Light damage: some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.	2
F1 – Moderate Tornado	(73–112 mph)	P1 PATH length: 1.0–3.1 miles / P1 PATH width: 18–55 yards	Moderate damage: the lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the road; attached garages may be destroyed.	3
F2 – Significant Tornado	(113–157 mph)	P2 PATH length: 3.2–9.9 miles / P2 PATH width: 56–175 yards	Considerable damage: entire roofs torn from frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.	4
F3 – Severe Tornado	(158–206 mph)	P3 PATH length: 10–31 miles / P3 PATH width: 176–566 yards	Severe damage: walls torn from well-constructed houses; trains overturned; most trees in forests uprooted; heavy cars lifted off ground and thrown.	5
F4 – Devastating Tornado	(207–260 mph)	P4 PATH length: 32–99 miles / P4 PATH width: 0.3–0.9 miles	Well-constructed houses levelled: structures with weak foundations blown off some distance; cars thrown and large missiles generated.	5
F5 – Incredible Tornado	(261–318 mph)	P5 PATH length: 100–315 miles / P5 PATH width: 1.0–3.1 miles	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air 100 yards or more; trees debarked; steel-reinforced concrete structures badly damaged.	5

Table 5: the Fujita-Pearson scale

FREQUENCY

Frequency can be assessed on the basis of historical data, although it may be difficult to go very far into the past. Books on local history, local newspapers or municipal records should be used for this purpose.

As for many natural events, frequency of tropical cyclones cannot be separated from intensity and it is essential to consider frequency in terms of an event that is used as a reference for intensity.

PREVENTION

Tropical cyclones cannot be prevented and preventive measures cannot therefore be proposed. However, this does not mean that no preparedness or protection are possible. Relevant measures when cyclones occur are presented in the following section.

PROTECTION

Protective measures comprise all of the measures that can be taken to reduce the consequences of cyclones when they occur. Measures cover the ability of buildings to withstand an event as well as the capacity of the population to be aware of an oncoming cyclone and to react properly to it.

- ▶ Are buildings designed according to appropriate building codes?
- ▶ Is there well dimensioned protection infrastructure to protect the community from flooding that could result from a cyclone?
- ▶ Is there a national warning system?
- ▶ Is there a local warning system?
- ▶ Does the warning system take account of the specific nature of the local situation?
- ▶ If the warning system is local, are local authorities trained to operate it?
- ▶ Is the population informed as to how to behave in case of a cyclone?
- ▶ Are sufficient shelters available for the population?
- ▶ Are drills organised to test the warning system?
- ▶ Has the warning system been audited or assessed?
- ▶ Have end-users been involved in the design of the system?
- ▶ Do the local authorities encourage and help families to make their own emergency plans?

4.4 FLOODING

Flooding is the most frequent natural hazardous phenomenon. It can happen in a variety of circumstances and will differ according to the geographical characteristics of the area and meteorological causes of the flooding. The CRP tool covers five different types of floods: river floods, caused by the progressive increase of the water height in a river valley; flash floods, caused by heavy rains in a steep river basin; urban floods, caused by intense rain episodes in urban areas; coastal floods, caused by cyclones or earthquakes; and dike or dam overflows. Specific questions are asked to help characterise the risks associated with these different types of floods.

PRESENCE

The presence of a flood hazard is linked directly to the geographical characteristics of an area, as illustrated by the following questions:

- ▶ Is the community in a river valley?
- ▶ Is the community located in a steep river basin?
- ▶ Is the community in a coastal area?
- ▶ Is the community in a tropical cyclone area?
- ▶ Is the community located below the water level of a large water reserve (lake or sea) contained by a dike or a dam?

- ▶ Is the community in an urban area (with large artificial impermeable surfaces)?
- ▶ Is the community located in a flood-prone area in the associated programme on flood management database (http://www.apfm.info/database_area.htm) or in the Dartmouth Atlas of Global Flood Hazard (<http://www.dartmouth.edu/%7Efloods/Modis.html>)?

KNOWLEDGE

The knowledge of this risk is provided by hydrological studies which, generally, map the height of the floods for a given return period, usually 10 or 100 years. If no such study exists, it is necessary to rely either on historical evidence or on geographical indices. Knowledge of flood risk is assessed via the following questions:

- ▶ Are there historical data or landscape indices to estimate the area of a potential flood?
- ▶ Has the flooding risk been studied; are there hydrological studies available?
- ▶ Are there flooding hazard maps showing the extent of potential flooding associated with a return period?
- ▶ Are there flooding risk maps identifying the elements at risk?
- ▶ Are there flooding emergency response plans?

INTENSITY

The only way to estimate the potential intensity of a flood is to interpret past episodes or the results of hydrological studies. CRP users are therefore asked to provide the surface area of flooded zones. To be consistent with the definition of intensity for other hazards, this should correspond to the surface area of the flooded zone where lethal effect can be observed. This corresponds more or less to places where water speeds above 0.5 m/s and depths of more than 0.5 m can be observed. However, information on water depth and speeds is probably not easy to obtain. A default option is to enter the global flooded surface area measured on existing hazard maps or recalculated by transferring to a map of historical data on past floods.

- ▶ Basing your estimate on historical data, hazard maps or expert judgement:
- ▶ What is the area of the flooded zone for a reference potential flood?

Potential for domino effect

As for other hazards, the presence of dangerous goods in the flooded area can make the consequences more severe, notably in terms of water pollution.

- ▶ Are there hazardous chemicals stored in the floodable area?

FREQUENCY

If historical data or hydrological studies are available, intensity and frequency are directly linked. Hydrological studies usually estimate water levels associated with a given return period (10 or 100 years). If such studies are not available, geographical indices will allow estimation of the likelihood of a flood. The result is not a real estimate of frequency, but it does give a useful indication of the flood hazard in the community.

Users thus have two possibilities to estimate frequency:

- a) by providing the results of hydrological studies or indicating the frequency of the reference flood used to define the reference intensity; or
- b) by answering the 'risk factors' questionnaire which uses qualitative indicators of flooding risk to estimate the likelihood (rather than the frequency) of a future flood.

The questions from the 'risk factors' questionnaire are given below. They are grouped in subsections corresponding to the different types of floods: river floods, flash floods, urban floods, coastal floods and dam or dike overflows. The risk associated with each of these flood types is assessed separately.

The final global score corresponds to the maximum of the risk scores.

- ▶ Has the community been flooded in the past?
- ▶ Is the region or upstream area subject to intense rain episodes?
- ▶ Is the region or upstream area subject to long periods of rain?
- ▶ Are there large snow reserves upstream that could add their contribution to a heavy rain episode?
- ▶ Are parts of the upstream soil naturally impervious? Give percentage.
- ▶ Has part of the upstream area been made impervious (e.g. by building or paving the ground)? Give percentage.
- ▶ Has upstream soil retention capacity been reduced by removal of vegetation (e.g. for agricultural purposes or to provide fire wood)? Give percentage.

River flood

- ▶ Does part of the community lie in the major bed (or flood plain) of a river?
- ▶ Is part of the community built on an unconfined aquifer?

Flash flood

- ▶ Is part of the community built near a steep torrent or intermittent water stream in a steep river basin (slope >6%)?

Urban flood

- ▶ Does the community area include large impervious urban areas (built, paved)? Give percentage of impervious urban area.
- ▶ Are parts of the city able to concentrate water during heavy rain (roads or streets forming canyons)?

Coastal flood

- ▶ Is the community built near a seashore that is close to sea level?
- ▶ Is the community in a high seismic activity region?
- ▶ Is the community subject to tropical cyclones or extreme wind periods?

Dam or dike overflow

- ▶ Is the community built below the water level of a lake, sea or river, contained by dikes or a dam?
- ▶ Are the dikes properly dimensioned for events that could lead to an overflow (heavy rain or wind episodes, potential combination with tide effects)?
- ▶ Are the dikes properly maintained?
- ▶ Is the community subject to heavy wind episodes?
- ▶ Is the community in a high seismic activity region?

PREVENTION

Prevention measures for flooding aim to reduce the phenomenon by limiting the probability that heavy rain or a lengthy period of rain will produce a flood. This is done by creating obstacles that will slow the flow of water upstream of the area subject to flooding. Obstacles can be created by vegetation and by the absorption capacity of the ground, as well as by dams or expansion fields where the flood can be deviated and retained upstream of the community. On the other hand, it is essential that the water is able to flow away easily downstream, and that no obstacles form to retain the water and cause its level to rise.

Managing the water flow

- ▶ Are there plans to maintain appropriate vegetation upstream (to slow the water flow)?
Is part of the upstream area reserved for expansion fields (using empty areas as retention areas)?

- ▶ Is there a plan to prevent upstream areas from becoming impervious?
- ▶ Are there upstream dams with appropriate management plans to reduce floods?
- ▶ Is the urban wastewater and rain collection network dimensioned for heavy rain episodes?
- ▶ Are there structures in the wastewater and rainwater collection system to absorb excess flow (collection basins)?
- ▶ Is there a possibility of flow diversion?

Limiting the obstacles to water flow in the potentially flooded areas (to prevent local level rise due to obstacles)

- ▶ Are there rules to prevent the building of obstacles (buildings, structures) in the potentially flooded area?
- ▶ Are structures such as bridges or narrow passages dimensioned for a flood and to let the water flow?
- ▶ Is vegetation managed to prevent piling up of floating or displaced material (e.g. wood, branches or stones)?
- ▶ Is the river bed properly managed (i.e. cleared of materials that could form obstacles to flow)?
- ▶ Is there a plan to stabilise materials (ground, stones, mud) upstream (without making the soil impervious)?

PROTECTION

Protective measures for flooding are all of the measures that protect people and their property from damage. They are not intended to prevent the water from rising. Flood protection measures may be collective (e.g. dikes) or individual (e.g. houses built with living areas above the highest water level). And finally, emergency measures such as warning and evacuation of people in case of a flood can be introduced.

Collective protection

- ▶ Are there dikes (or equivalent structures such as heightened roads) to protect the floodable areas?
- ▶ Are the dikes properly designed to withstand possible flood?
- ▶ Are the dikes maintained on a regular basis?

Vulnerability reduction measures

- ▶ Are critical networks (electricity, telephone, gas, etc.) built to be safe from flood?
- ▶ Are buildings built so that the living areas are above the highest flood level?
- ▶ Are buildings designed or reinforced to withstand the force of the water flow?
- ▶ Are buildings equipped to prevent flooding from the wastewater network?

Intervention, evacuation

- ▶ Is there warning in case of flood?
- ▶ Is there a suitable evacuation plan?
- ▶ Is the population informed as to what to do in case of a flood?
- ▶ Are exposed houses equipped with emergency equipment (small rowboats)?
- ▶ Is there an appropriate water removal system (pumps)?
- ▶ Are sufficient shelters available if evacuation becomes necessary?

4.5 WILDFIRES

Wildfires—also known as forest fires, vegetation fires or grass fires—are uncontrolled fires that usually occur in wildland areas, although they can also consume houses or agricultural resources. Common causes include lightning, human carelessness, arson, volcano eruption, and pyroclastic cloud from active volcanoes. (definition adapted from ‘Wikipedia’)

PRESENCE

The presence of a risk of wildfire is linked directly to the presence of a forest within the community area. The flammable character of the trees is taken into account for the assessment of the probability of wildfire. Presence is characterised via the following questions:

- ▶ Are there forests in the community area?
- ▶ Are there other types of flammable vegetation?

KNOWLEDGE

Assessing the wildfire risk involves identifying the areas where a fire is most likely to occur and the conditions under in which it could occur. The first of these factors relates to the type and state of vegetation, the second to meteorological conditions. Knowledge of the fire risk is assessed through the following questions:

- ▶ Has a fire risk assessment been done in the community?
- ▶ Are fire risk maps available?
- ▶ Does the risk assessment provide information to estimate risk level in relation to meteorological conditions?
- ▶ Does the risk assessment provide useful information for the intervention of firemen?

INTENSITY

For wildfires, intensity is assessed in terms of the surface area that would burn in case of fire. The difficulty here is in determining the surface area to be considered. A practical approach is to consider the maximum realistic surface area, i.e. the area of the single piece of forest that could be burned in case of fire.

- ▶ What is the maximum area (in ha) likely to burn in case of fire if no fire-fighting action is undertaken?

FREQUENCY

The frequency of fires can be assessed in two different ways: either from historical data, when available and relevant, or from a qualitative assessment of a set of criteria relating to the type of vegetation, the geographical configuration, winds, and potential ignition sources.

Historical assessment of frequency

Assessment of frequency can be based on historical data, i.e. counting the number of fires that have occurred in the community in the past. However, caution needs to be exercised when interpreting the historical data. For example, past wildfires may have led to changes in vegetation or to the implementation of fire prevention measures and an accompanying reduction in the fire hazard. The frequency scale applied here is the same as for the other types of hazards, with frequency expressed in terms of the number of accidents per unit time. In regions affected by wildfires, the frequency of major wildfires is often high with such events occurring every year. For these regions, the frequency level will probably be around 5.

Contextual assessment of likelihood of a wildfire

If historical data are not available, it is possible to assess a frequency level or rather a likelihood level by answering a set of questions, as presented below:

Assess the likelihood of wildfire in the community by answering the following questions:

Tree species

Some tree species are more prone to fire than others.

- ▶ What percentage of the forest consists of fire-prone species?

Topography

- ▶ What percentage of the forest area is located on wind-exposed slopes?

Climate

- ▶ How long does the dry season last?

Triggering factors

- ▶ Is the forest area affected by one or more of the following features:
 - lightning;
 - man-made fires for grazing purposes;
 - man-made fires due to arson, criminal fires;
 - man-made fires due to tourism and leisure activities;
 - man-made fires linked to transportation and industrial activities;
 - volcanic eruption?

PREVENTION

The prevention of forest fires is based on a threefold strategy: reduction in flammability of the forest and in the capacity of fire to progress; prevention of the presence of ignition sources; and stopping of fire at an early stage.

- ▶ Have special types of trees been planted to prevent forest fires?
- ▶ Are forests regularly cleared to remove low, easily flammable branches and vegetation?
- ▶ Are forest patterns designed to prevent fires?
- ▶ Are there patrol teams monitoring fire outbreaks in forest areas?
- ▶ Are forest areas monitored by scientists specialised in forestry?
- ▶ Are forests under watch for early warning of fire outbreaks?
- ▶ Are people warned of high fire hazard and safe behaviour?
- ▶ Are there rules to prevent smoking and the use of recreational fires?
- ▶ Is the access to forest restricted during high fire hazard periods?

PROTECTION

Fire protection is based on individual protection of houses and buildings and on the existence of a fire-fighting system including a warning system, firefighting forces, etc.

- ▶ Are houses and buildings equipped with firefighting equipment?
- ▶ Are houses and buildings surrounded by a safety zone with a low density of flammable material?
- ▶ Does the water network supply areas and buildings located near forest areas?
- ▶ Are fire force teams available in sufficient number?
- ▶ Are fire force teams trained on a regular basis?
- ▶ Is firefighting equipment adequate?
- ▶ Is firefighting equipment properly maintained?
- ▶ Is there a fire alert system?
- ▶ Is there a wildfire emergency plan available?
- ▶ Is the population informed as to the safe attitude to adopt in case of fire?

4.6 VOLCANOES

A volcano is a geological landform generated when magma (molten rock) wells up through a vent from the Earth's interior and erupts at the surface. The volcano hazard can be due to the presence of an active or dormant volcano. In some parts of the world, this hazard can also be linked to the possibility of a volcano appearing where none existed previously. Volcanoes can affect very wide areas and it is therefore essential not to limit hazard identification to a community but to also consider the presence of a volcano located kilometres away from it.

PRESENCE

Presence - actual

- ▶ Is there a volcano in or near the community area?
- ▶ Has the community been affected by volcanic eruption in the past?

Presence - possible

- ▶ Is the community located in or near a fault zone?
- ▶ Is the community located in or near an active subduction zone?

KNOWLEDGE

Assessing the risk from volcanoes involves identifying the hazards, i.e. the types of phenomena that can result from a volcanic eruption (lava, pyroclastic clouds, bombs or gases). It also involves an assessment of the frequency of eruption, either from historical data or from monitoring of volcanic activity.

- ▶ Is a volcano risk assessment available?
- ▶ Are there volcano hazard maps available?
- ▶ Does the risk assessment make a clear distinction between the types of hazards (pyroclastic clouds, bombs, gases or lavas)?
- ▶ Are there well documented historical data on past eruptions?
- ▶ Have the characteristics (type, extent, damage, duration) of past eruptions been reported?
- ▶ Are the risk analyses updated regularly on the basis of monitoring?

INTENSITY AND FREQUENCY

Frequency and intensity are assessed on the basis of historical data. For intensity, surface areas covered by lava or pyroclastic clouds or bombs are considered as references. When past events are very remote, it may be difficult to identify the affected zones easily without a geological survey.

Frequency

- ▶ On the basis of a historical or geological study, how frequent are eruptions?

Intensity

- ▶ What area within the community (in ha) was covered by lava flows during past eruptions?
- ▶ What area within the community (in ha) was reached by previous pyroclastic clouds, bombs etc.?

PREVENTION

There are no preventive measures to stop a volcano from erupting. The only risk control means are mitigation and emergency preparedness measures.

PROTECTION

In the case of volcanic eruption, protective or mitigating measures are of three main types: land-use restrictions to prevent building in areas where the effects of the volcano would be felt; monitoring; and emergency response.

- ▶ Is land-use regulated around the volcano?
- ▶ Are specific building codes imposed around the volcano?
- ▶ Has a technical network been installed to monitor the volcano?
- ▶ Is there an emergency plan designed that includes a volcanic eruption scenario?
- ▶ Is the population provided with information on volcanoes?
- ▶ Have other specific measures been taken to protect population?

4.7 EARTHQUAKE

Earthquakes result from and are powered by sudden releases of stored energy in the Earth's crust that propagate seismic waves. At the surface, earthquakes may manifest themselves by shaking or displacement of the ground; they can also cause tsunamis, which may lead to loss of life and destruction of property.

PRESENCE

It is not really possible to propose a criterion to judge the presence of seismic risk. Seismic risk is ever present, but with a greater or lesser degree of probability. To avoid considering situations where the risk level is negligible, the CRP formulates a 'presence' criterion which, in this case, is an 'absence' criterion:

- ▶ Is the community in a known non-seismic risk area?

If the answer to this question is 'yes', then seismic risk is considered to be absent.

KNOWLEDGE

The seismic risk assessment is based mainly on historical data or on geological evidence of past seismic activity.

- ▶ Are there historical data on past earthquakes?
- ▶ Has earthquake mapping been performed?
- ▶ Has earthquake micro-zoning been performed?

INTENSITY

Two scales are commonly used to measure the potential of an earthquake to cause damage:

- a) The magnitude scale, known as the Richter scale, which measures the energy produced by the earthquake at its epicentre.
- b) The intensity scale, which measures the damage caused by an earthquake at a given point. Intensity is measured on the Mercalli or MSK scale.

Practically speaking, there is no direct correspondence between the two scales as, for a same earthquake of given magnitude, different intensity levels will be observed at different distances from the epicentre. Intensity will be maximum near the epicentre and will decrease progressively when moving away.

However, both scales are used and are useful to characterise past events, and thus potential future events. The CRP uses both of them and establishes a loose correspondence between them by considering the potential damage produced by an earthquake of a given magnitude near its epicentre.

Table 6 shows the correspondence between the MSK and Richter scales, established only for use with the CRP tool. It is emphasised here that this correspondence is purely indicative and has no scientific basis.

Intensity level in the CRP tool	Level on the MSK scale	MSK: force	MSK: behavioural effects	MSK: structural effects	Level on the Richter scale
1	V and less	Fairly strong	Widely felt outdoors	Interior plaster cracks, hanging objects swing, tables shift	4.5
2	VI	Strong	Fright	Damage to chimneys and masonry	5
3	VII	Very strong	Many people flee their dwellings	Serious damage to buildings in poor condition, chimneys collapse	6
4	VIII	Damaging	General fright	Many old houses undergo partial collapse, breaks in canals	6.5
5	IX and above	Destructive to very catastrophic	Panic	Large breaks in substandard structures, damage to well-constructed houses, underground pipe breakages. Surface and underground structures completely destroyed	7

Table 6: loose correspondence between the MSK and Richter scales proposed in the CRP tool. (Note: correspondence is purely indicative and is established here solely for the purposes of the CRP tool. It is not applicable in other circumstances as there is no theoretical basis for correspondence between the scales).

Potential for domino effect

A seismic risk is more likely than any other to produce domino effects if hazardous plants (chemical, nuclear or dams) are located in the community.

- ▶ Are there hazardous plants in the community area?
- ▶ Are there dams in the community area?
- ▶ Are industrial facilities of earthquake-resistant design?
- ▶ Are dams of earthquake-resistant design?

FREQUENCY

Apart from elaborate probabilistic risk studies or analysis of historical data, there is no easy way to estimate the frequency of earthquakes. In some countries, seismic risk zones corresponding to the return periods of earthquakes of given intensities have been defined on the basis of a global risk analysis. If such information is available, it should be used to define both the intensity and the frequency of a reference earthquake and to answer the intensity and frequency parts of the questionnaire in the CRP tool.

PREVENTION

There are no measures that can prevent an earthquake from occurring.

PROTECTION

The main aim of protection is to limit the consequences of an earthquake by designing buildings to be earthquake-resistant and by informing and training the population to react safely in case of an earthquake.

- ▶ Are new buildings of earthquake-resistant design?
- ▶ Are existing buildings retrofitted to withstand earthquakes?
- ▶ Are homeowners prohibited or prevented from carrying out their own building activities?
- ▶ Are earthquake-resistant building codes actually enforced?
- ▶ Is the public informed about earthquake risk?
- ▶ Is the public provided with instructions for earthquake-safe behaviour?
- ▶ Do authorities conduct post-earthquake assessment missions?

4.8 LANDSLIDES

The term landslide covers a wide range of ground movements such as rock falls, deep failure of slopes and shallow debris flows. Although gravity acting on an over-steepened slope is the primary reason for a landslide, there are other contributing factors:

- erosion by rivers, glaciers, or ocean waves creates over-steepened slopes;
- rock and soil slopes are weakened through saturation by snowmelt or heavy rains;
- earthquakes create stresses that cause weak slopes to fail;
- earthquakes of magnitude 4.0 and greater have been known to trigger landslides;
- volcanic eruptions produce loose ash deposits, heavy rain, and debris flows;
- excess weight from accumulation of rain or snow, stockpiling of rock or ore, waste piles, or man-made structures may stress weak slopes and structures to failure.

Slope material that becomes saturated with water may develop a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses, and cars, thus blocking bridges and tributaries causing flooding along its path (USGS, Landslide Hazards Program).

PRESENCE

In the CRP tool, the presence of the landslide hazard is characterised by the following questions.

- ▶ Are there slopes with angles above 5° in the community area?
- ▶ Is there geomorphological or historical evidence of past landslides?
- ▶ Is the community partly built on soils that are highly reactive to water saturation?

KNOWLEDGE

The landslide hazard has been studied for years and many methodologies have been developed to produce ground stability studies. Knowledge of the risk can be assessed through the following questions:

- ▶ Are there ground stability and/or landslide susceptibility studies?
- ▶ Is there a landslide hazard map?
- ▶ Is there a landslide risk map, i.e. including a land use and vulnerability study?

INTENSITY

The intensity of a landslide is a combination of the quantity of material moved by the landslide and the amplitude of the ground movement. As it has not been possible to develop a single scale that would integrate both these dimensions, intensity is measured in the CRP tool with the same surface area scale as for other risks such as flood or industrial risk.

Based on landslide susceptibility studies, historical data or expert judgement, what would be the surface area of the largest landslide likely to occur in the community?

FREQUENCY

Landslide frequency can be assessed in two ways. It can be:

- a) Based on landslide hazard studies or on a historical approach. Users are asked: what is the expected frequency of the landslide corresponding to the intensity selected in the preceding Intensity section?
- b) Based on qualitative assessment of the following landslides hazard factors:
 - ▶ Lithology:
 - Hard rock
 - Older well compacted fluvial fill material
 - Clayey soil with naturally formed surface
 - Medium hard rock or well compacted fluvial fill material
 - Older, well compacted debris comprising mostly rock pieces mixed with clayed/sandy soil
 - Soft rock
 - Sandy soil with naturally formed surface
 - Highly weathered soft rock susceptible to erosion
 - Younger loose material, debris comprising mostly rock pieces mixed with clay/sandy soil
 - ▶ Relative relief
 - <100 m
 - 100–300 m
 - >300 m
 - ▶ Land use and land cover
 - Agricultural land/ populated flat land
 - Thickly vegetated forest area
 - Moderately vegetated area
 - Sparsely vegetated area with lesser ground cover
 - Barren land
 - ▶ Ground water conditions
 - Dry
 - Damp
 - Wet
 - Dripping
 - Flowing
 - ▶ Presence of ground stability perturbation factors such as:
 - Frequent earthquakes of magnitude above 4
 - Frequent volcanic eruptions
 - Frequent heavy rains
 - Works: building, excavation
 - Excess weight from accumulation of rain or snow or man-made structures

Potential for domino effect

A landslide can cause serious damage to industrial plants or transport infrastructure. Pipelines are particularly exposed, as indicated by the following question:

- ▶ Are there hazardous chemical plants or storage, or pipelines or other forms of transport of hazardous goods in the potential impact area?

PREVENTION

The main focus of prevention is to increase ground stability. Protection is covered by the following questions:

- ▶ Is forest cover maintained in areas subject to ground movement?
- ▶ Is a logging ban established and enforced in these areas?
- ▶ Are slope/ground stabilisation structures built in areas subject to ground movement?
- ▶ Is there adequate underground water management to reduce damage due to water flow?

PROTECTION

Protection measures are of two types:

- a) Protection or reinforcement of houses and buildings so that they can withstand a potential landslide
- b) Reduction of vulnerability, by applying land-use restriction measures.
 - ▶ Are built areas protected from falling rocks and mudflows?
 - ▶ Are roads protected from falling rocks and mudflows?
 - ▶ Are there special land-use regulations in areas subject to ground movement?
 - ▶ Are these regulations actually enforced in urban development?
 - ▶ Are there special building codes for ground movements in the community area?
 - ▶ Are these building codes actually enforced in building activities?

4.9 TSUNAMI

'Tsunami' is a Japanese word meaning 'harbour wave', applied to the phenomenon because of the devastating effects these waves have had on low-lying Japanese coastal communities. A tsunami is a series of waves caused by undersea or coastal seismic activity or by meteorological events such as cyclones. Tsunamis originate when underwater earthquakes, landslides, volcanic activity, eruptions or similar events displace sea water on a massive scale. They can also be caused by the massive displacement of water due to intense winds caused by a storm or a cyclone, potentially reinforced by tide and/or by heavy rains.

PRESENCE

For a tsunami hazard to be present, there must be at least one community located near to a seashore. There must also be the possibility of an earthquake on the seabed or eruption of an underwater volcano in the 'relative' vicinity of the community ('relative' because an earthquake or volcano can produce a tsunami at places hundreds of kilometres away). The latter condition is very specific to certain geographical areas. The following questions assess these criteria.

- ▶ Is the community on a seashore?
- ▶ Is the community near a subduction zone?
- ▶ Is the community in an area of seismic activity?
- ▶ Is the community near an active volcanic zone?
- ▶ Has the community already been affected by a tsunami?
- ▶ Is the community located on the Pacific Ocean shore?
- ▶ Is the community located on the Mediterranean Sea shore?
- ▶ Is the community located on the Indian Ocean shore?

KNOWLEDGE

Knowledge of the tsunami risk is obtained by a specific risk assessment aimed at determining the probability of a tsunami-generating event and the height of the resulting wave. Studies are not easy

because they involve elements from very remote and scattered hazard sources and local studies based on very hypothetical data.

- ▶ Are marine geology and paleosismology studies available for the community?
- ▶ Are paleotsunaminological studies or historical records available?
- ▶ Has a tsunami hazard assessment been made in the past?
- ▶ Has potential run-up for tsunami been assessed ?

INTENSITY

For tsunamis, as for other types of hazards, intensity is assessed in terms of surface area, in this case the area flooded by the tsunami. There are intensity scales that characterise tsunamis in terms of water height. However, the effect of a given water height very much depends on the structure of the sea shore. A given water height will not have the same effect on a steeply sloping sea shore as on a shore where the slope is gradual (in exactly the same way as a river flood would not have the same effect in a steep-banked valley or in a plain).

As in the case of river flooding, CRP users are invited to characterise the surface area potentially affected by the tsunami wave.

FREQUENCY

It is extremely difficult to assess the frequency of tsunamis. The CRP tool proposes a scroll-down menu to be used if a frequency estimate has been made in a previous tsunami risk assessment study.

PREVENTION

There are no measures able to prevent the occurrence of a tsunami. The only measures that can be taken are protective ones, vulnerability reduction measures and emergency preparedness.

PROTECTION

There are three types of protection measures: preventing building in the area that could be hit by a tsunami; construction of buildings that are appropriate for the tsunami threat; introduction of a warning system, so that the people can escape the area before the wave reaches it.

Are there land-use regulations in place, prohibiting building in the danger zone? (potential flood areas may be designated as parks or sports areas.)

- ▶ Has land use in tsunami hazard areas been reviewed so that no critical facilities such as hospitals and police stations, high-occupancy buildings such as auditoriums or schools, or petroleum-storage tank plants are located where there is a tsunami hazard?
- ▶ Are there building codes or guidelines (for example, for construction of houses on stilts to survive the waves or use of reinforced concrete structures)? (Buildings such as hotels can be constructed with the first floor living area above potential wave height. Structural columns must resist the impact; walls are expendable).
- ▶ Are land-use regulations actually enforced?
- ▶ Are buildings designed according to tsunami-specific building codes, if these exist?
- ▶ Are there anti-tsunami dikes built along seashores, or barriers or buffers such as special breakwaters or seawalls?
- ▶ Is there a tsunami early warning system?
- ▶ Is there a tsunami disaster management plan?
- ▶ Has the population received information on tsunamis?
- ▶ Has the population received training on tsunamis?
- ▶ Have tsunami evacuation routes been built and are their locations publicised?
- ▶ Have signs been posted directing people to higher ground away from the coast?

5. LIMITS OF THE COMMUNITY RISK PROFILE AND PERSPECTIVES FOR IMPROVEMENT

5.1 RISK ASSESSMENT QUESTIONNAIRES

Establishing a list of risk assessment questions is not an easy task. The authors of the CRP have used the bibliography given below to establish the CRP questions, bearing in mind that the CRP tool should be easy to use and understand. It is probable that many relevant questions are not asked and that some that are asked could be clarified for easier use. Improvements to the CRP will very probably appear necessary after a period of use by communities and feedback from users is essential to allow the CRP to evolve and become a powerful tool for the improvement of risk management in communities.

5.1 SCORING AND CALCULATING RISK CRITERIA

The final risk score is based on combinations of marks given by the user. As an initial approach, it was decided to attribute the same weight to all of the risk assessment criteria except where specific models exist with specifically defined weighting factors (the case, for example, for landslides). A first development of the CRP tool will be the use of multicriteria methodologies to define the appropriate weighting factors to be used for each risk from expert elicitation. The risk scoring scales could also be revised on the basis of feedback from users, to fit better with their needs and with the actual risk levels observed in the communities.

6. REFERENCES AND USEFUL READING

6.1 GENERAL RESOURCES

APELL booklet

UNEP DTIE (1998). APELL, Awareness and Preparedness for Emergencies at Local Level: A Process for Responding to Technological Accidents. Paris.

UNEP DTIE Natural Disasters web page

<http://www.unep.fr/scp/sp/disaster/natural.htm>

6.2 INDUSTRY

International Atomic Energy Agency (IAEA) (1996). Manual for the Classification and Prioritisation of Risks due to Major Accidents in Process and Related Industries.

Ref: IAEA-TECDOC-727.

APELL for Mining

http://www.mineralresourcesforum.org/initiatives/apell/docs/APELL_for_Mining.pdf

UNEP DTIE (1992). Hazard Identification and Evaluation in a Local Community.

<http://www.unep.fr/scp/publications/pdf/WEBx0062xPA-HazardId.pdf>

6.3 TRANSPORT OF DANGEROUS GOODS

UNRTDG: UN Recommendations on the Transport of Dangerous Goods. Model Regulations.

http://www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html

ADR (2005): European Agreement Concerning the International Carriage of Dangerous Goods by Road.

<http://www.unece.org/trans/danger/publi/adr/adr2005/05ContentsE.html>

ADN: European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways.

<http://www.unece.org/trans/danger/adn-agree.html>

6.4 TROPICAL CYCLONES

Useful information can be found at : <http://www.hurricane.com/>

The USGS - Natural Hazards - Hurricanes web page

<http://www.usgs.gov/hazards/hurricanes/>

International Hurricane research centre of the Florida International University

<http://www.ihc.fiu.edu/>

6.5 FLOODS

The associated programme on flood management

<http://www.apfm.info/index.htm>

The Dartmouth Atlas of Global Flood Hazard

<http://www.dartmouth.edu/%7Efloods/Modis.html>

APELL and Floods, A Community-based Approach for Disaster Reduction

<http://www.unep.fr/scp/sp/publications/brochures/pdf/APELL-Floods.pdf>

The USGS - Natural Hazards - Floods web page

<http://www.usgs.gov/hazards/floods/>

La documentation Française (2002). Plan de prévention des risques naturels (PPR), risques d'inondation, mesures de prévention. Paris.

6.6 WILDFIRES

The USGS Natural Hazards - Wildfires web page

<http://www.usgs.gov/hazards/wildfires/>

6.7 VOLCANO

The USGS - Natural Hazards - Volcanoes web page

<http://www.usgs.gov/hazards/volcanoes/>

6.8 EARTHQUAKE

The USGS - Natural Hazards - Earthquakes web page

<http://www.usgs.gov/hazards/earthquakes/>

APELL for Earthquake Risk, A community-based Approach for Disaster Reduction

<http://www.unep.fr/scp/sp/publications/brochures/pdf/APELL-EarthquakeRisk.pdf>

6.9 LANDSLIDES

The USGS - Natural Hazards - Landslides web page

<http://www.usgs.gov/hazards/landslides/>

The landslide risk assessment criteria were extracted from the following publication:

R. Anbalagan (1992). Terrain Evaluation and Landslide Hazard Zonation for Environmental Regeneration and Land Use Planning in Mountainous Terrain. Landslides, Glissements de terrain, proceedings of the sixth international symposium, February 1992. (Ed. David H.Bell, A.A.Balkema, Rotterdam, Brookfield), p. 861-868.

6.10 TSUNAMI

UNEP Tsunami web page

<http://www.unep.org/Tsunami/>

The USGS - Natural Hazards - Tsunamis web page

<http://www.usgs.gov/hazards/tsunamis/>

APELL and Tsunamis A Community-based Approach for Disaster Reduction

<http://www.unep.fr/scp/sp/publications/brochures/pdf/APELL-Tsunamis.pdf>

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

- > sustainable consumption and production,
- > the efficient use of renewable energy,
- > adequate management of chemicals,
- > the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

- > **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
- > **Production and Consumption** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
- > **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- > **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- > **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- > **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

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Most communities face risks which they have to assess and manage. Risks may arise from human activities such as industrial accidents, or they may be of natural origin such as floods, earthquakes, etc. Risks need to be taken into account in the decision making process of the overall disaster management policy of such communities.

Assessing risks is not an easy task. It requires conducting in-depth studies, which will only be justified if the expected level of risk is high. Against this background, UNEP decided to develop this Community Risk Profile (CRP) tool to provide communities with a means of making a rough estimate of various types of risks they are exposed to, supporting the decision making process, especially as to whether or not further assessments are needed. The CRP is not, therefore, a risk assessment tool. It is a tool that will provide users with a qualitative approach to characterise an expected level of risk and thus decide on the necessity for further assessment. It is also a tool that can be used to support awareness raising and capacity building activities.

The CRP tool itself is in the form of a set of Excel spreadsheets which use is described in detail in this manual.