

# **A Risk Strategy for Mine Action**

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## Executive Summary

Landmines and unexploded ordnance (UXO) severely limit the utility of many areas around the world. Mined areas are clearly dangerous to work in and inhabit. The local population is forced to make a choice between moving out of the area or risking life and limb by staying. There are significant risks associated with every option, so clearing the mines can only improve their quality of life and relieve human suffering.

Currently, most demining operations rely on manual techniques to detect, remove and make safe the mines and UXO. They are sometimes supplemented by other techniques, such as mine detection dogs and mechanical vegetation clearance, but in the end they rely on people using hand-held equipment to find and remove the ordnance. Clearance is slow, but it can assure a reasonably high level of clearance. Accelerating clearance and reducing costs would provide obvious benefits, but Humanitarian mine action in poorer countries is generally restricted by the available resources.

One way of looking at this dilemma is as a risk management problem, where the people who are at risk are those using the land post-clearance, and in some cases pre-clearance. The residual risk will directly impact on their quality of life, for example restricting their use of the land. It might even be high enough to prevent them from using the land at all. An acceptable residual risk can be derived, based on comparative risks and the attitude of the land users. In some cases, this could be greater than that which is achieved by the best demining techniques, which might mean that a less demanding clearance level could be tolerated. Moreover, if people are using the land regardless of clearance, then more mines cleared should mean fewer casualties, although the relationship is not necessarily that simple.

A generic risk management methodology has been derived, and aspects of it were used to develop risk management strategies for Cambodia and Bosnia. These countries presented different problems and so required very different approaches. In Cambodia, the available resources are wholly inadequate to remove the risk from landmines in the medium-term. Moreover, the mine treatment options that might be practicable, even if they were available, are limited, because of the poor infrastructure and type of terrain where they would be applied. Nevertheless, there is some scope for using risk assessment to identify where the practicable mine treatment options (mainly manual demining and limiting the use of the land) could be applied best. This could mean partially treating areas, so that there is a significant possibility that mines remain, at least in the medium-term, and thus leading to some casualties in treated areas. Hopefully, this would be offset by reducing risks more effectively in other areas, thus reducing the total number of casualties. In addition, the effective land-use would be increased.

In Bosnia, more resources are available and can be practically applied, although the efficiency of some techniques, such as mechanical clearance, would still be expected to be much poorer than manual clearance. One of the problems in Bosnia is that partial clearance is unacceptable – land has to be designated as either suspected or *no visible risk*, which in practical terms mean zero risk of any mines remaining. It would be possible to reduce the risks with alternative mine treatments, while still accepting that the area could still contain mines, but this would require a policy shift at a higher level than the Mine Action Centre.

Other issues discussed in the report include:

- *Acceptance of non-negligible risk by all stakeholders*, including the people using the land (and actually at risk), mine clearance agencies, governments and donors. Each will be concerned about their own reputation and implications for future funding if there are casualties in treated areas, which will almost certainly arise from a risk-based strategy. It is important that this is understood and accepted if the risk-based strategy is to work.
- *Implications for manual demining*. A risk-based strategy intended to accelerate treated areas is not necessarily the same thing as poorer quality clearance in areas that are actually cleared. In the case of manual demining, current clearance standards would still need to be achieved, since poorer clearance would put the deminers themselves at unacceptably high risk. In any case, “pristine” quality manual demining will still be an essential element of any mine action strategy. It is noted that self-demining (i.e. demining by relatively untrained

villagers on their own land) is ongoing in some countries, but in a risk-based strategy this is taken to be an indication of the extent of the problem of landmines, rather than part of a medium-term solution.

- *Compatibility with International Standards.* It could be argued that the risk-based approach is incompatible with the international standards for mine clearance. These are only provided as guidance to national agencies, who formulate their own standards. They are extremely useful for many aspects of demining but, by the nature of standards, are difficult to adapt to a flexible risk-based approach. There is a nod towards risk-based thinking in the application of different quality standards for land-uses, graded by their sensitivity, and it is not that great a step to use risk as the basis for the clearance itself, rather than just the quality assurance checks.

Finally, the development of a generic risk strategy, as outlined for Cambodia and Bosnia, is discussed. The basic development is defined in terms of:

1. Scope the problem – data gathering
2. Identify context – what are the overall objectives and constraints
3. Initial strategy – develop an initial strategy based on the data available
4. Strategy development – as more data becomes available and the context changes

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# 1 Introduction

Landmines and unexploded ordnance (UXO) severely limit the utility of many areas around the world. Mined areas are clearly dangerous to work in and inhabit. The local population is forced to make a choice between moving out of the area or risking life and limb by staying. There are significant risks associated with every option, so clearing the mines can only improve their quality of life and relieve human suffering.

Currently, most demining operations rely on manual techniques to detect, remove and make safe the mines and UXO. They are sometimes supplemented by other techniques, such as mine detection dogs and mechanical vegetation clearance, but in the end they rely on people using hand-held equipment to find and remove the ordnance. Clearance is slow, but it can assure a reasonably high level of clearance. Accelerating clearance and reducing costs would provide obvious benefits, but there can be a trade-off between accelerating clearance and deteriorating clearance levels (i.e. the increasing the number of mines missed during clearance), which leave a worse post-clearance residual risk.

One way of looking at this dilemma is as a risk management problem, where the people who are at risk are those using the land post-clearance, and in some cases pre-clearance. The residual risk will directly impact on their quality of life, for example restricting their use of the land. It might even be high enough to prevent them from using the land at all. An acceptable residual risk can be derived, based on comparative risks and the attitude of the land users. In some cases, this could be greater than that which is achieved by the best demining techniques, which might mean that a less demanding clearance level could be tolerated. Moreover, if people are using the land regardless of clearance, then more mines cleared should mean fewer casualties, although the relationship is not necessarily that simple.

This study has examined these issues from a risk management perspective. A preliminary methodology was developed [1]. Outline risk strategies, based on the ideas in the methodology, were then developed for demining in Cambodia [2] and Bosnia-Herzegovina [3]. The strategies were distributed to interested parties, such as demining NGOs, Mine Action Groups, and donors, and their comments were taken on board in this final report. The studies are summarised in this report, as well as implementation issues that arose during the studies and from the comments on them.

## 2 Risk Management Concepts

Risk is a combination of a consequence severity (e.g. fatality from a hazard) and the likelihood of this consequence occurring. The basic consequence in this study is death or injury due to the presence of landmines.

The risk may change over time as landmines are cleared or activities change on the land. Therefore, the risk should be estimated for the different scenarios over time. For example, we could have the following options for clearing and using the land.

1. No one uses the land because there are too many mines. This has its own indirect risk, e.g. malnutrition due to insufficient resources, or travel to and residence in a refugee camp. The lack of land-use will also increase the vegetation cover on the land, making mine clearance more difficult.
2. The land is used despite the presence of mines, because there is no viable alternative. The direct risk of mine initiation is highest in this scenario, but it could still be lower than the indirect risks from not using the land (as described above).
3. The land user clears the land himself prior to using it. The deminer will probably have little or no training and no demining equipment. This could mean they have a high risk during the clearance operation and a high probability of missing one or more mines, giving an elevated risk of initiating a mine while they use the land.
4. The land is cleared by a professional organisation but not to the highest possible standard. There may still be a significant residual risk for the land user, albeit lower than before clearance.
5. The land is cleared to the highest possible standard by a professional organisation. The residual risk for the land user is minimised, and should be negligible.

There are three main measures of risk:

1. Annual individual risk – the likelihood of injury or death due to a landmine for an individual in a year. This could change through time as the mines are cleared, they explode, or they are shown not to exist in some areas.
2. Total individual risk – the likelihood of injury or death due to a land mine over the lifetime of an individual.
3. Societal risk – the likelihood of a number of injuries or deaths due to landmines in the affected population over a set period. If many people work in the affected region this could be an important factor in a cost-benefit assessment.

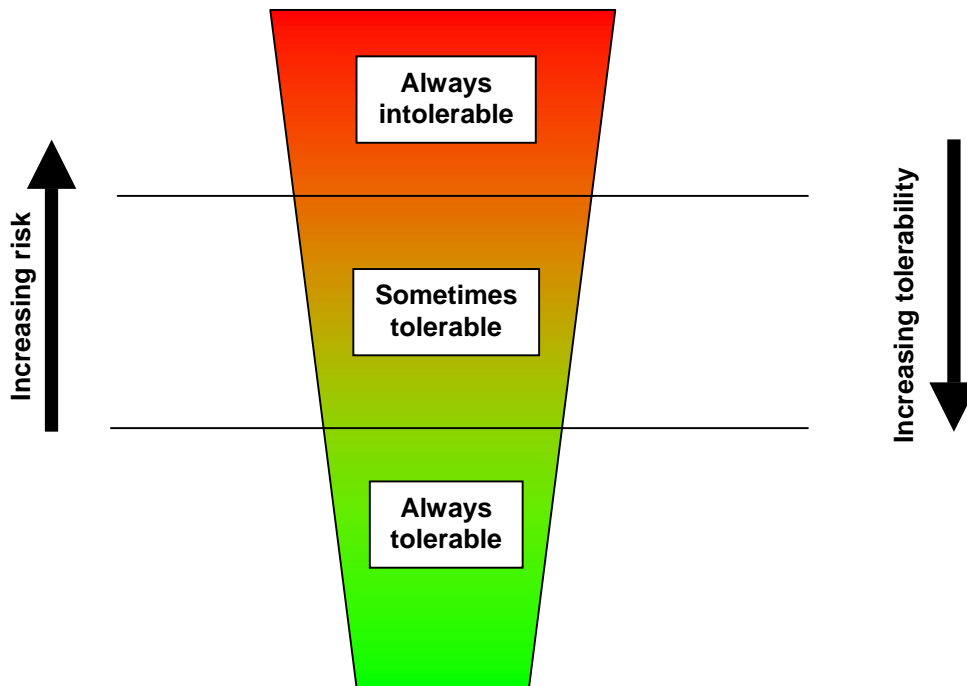
### 2.1 Individual Risk

Individual risk must be considered in terms of its tolerability. The tolerable risk levels may not be the same for all population groups. For example, a level of risk to a child may be less acceptable than to an adult who understands the risk and can make an informed and positive decision to accept it.

It should be emphasised that clearance is carried out in the context of people currently experiencing high risks due to the presence of mines. These can be direct risks from the mines themselves or indirect risks due to the mines influencing their behaviour. We should not assume that the current level of risk is *absolutely* unacceptable in all cases, at least in the short term, since people have adapted their way of life to the risk and do accept it due to the lack of a feasible alternative.

Risk tolerability can be classed in three groups, as shown in the figure below:

**Figure 2-1 Risk Tolerability Scale**

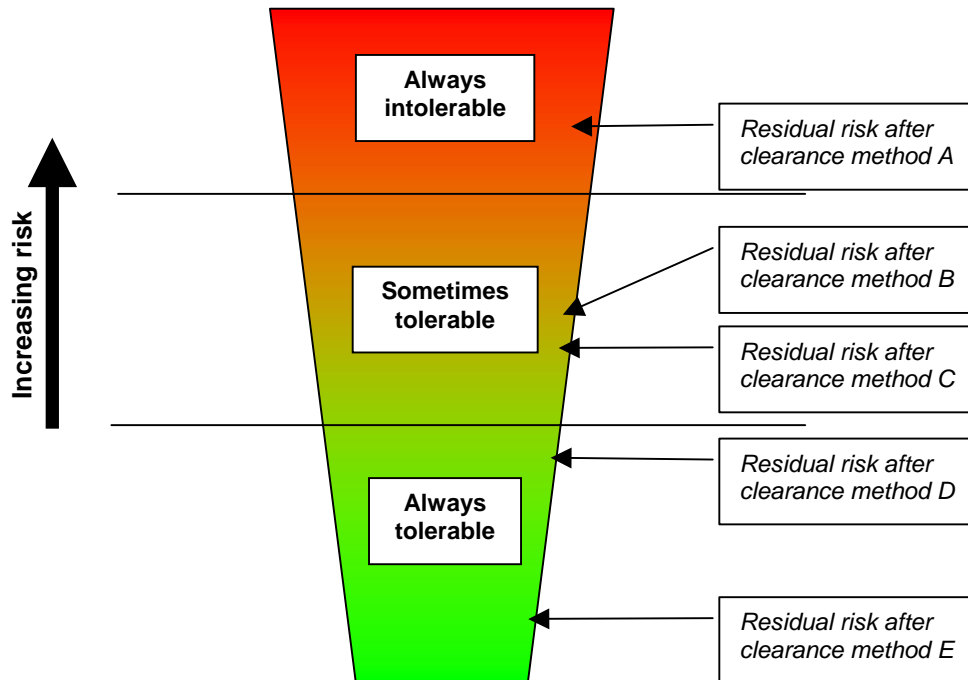


If the risks are intolerable, that means that the presence of mines on the land makes it unfit for use, because the people would consider the risk too great to work the land.

The “sometimes tolerable” region often covers a large range of risks. If the risks are in this region (which they often are), then a more complex judgement has to be made, accounting for the benefit that the activity brings. Another important consideration is the additional resource required to reduce the risk significantly – would the risk reduction achieved be justified by the additional resource usage.

For example, we might have the following situation for a particular land-use in an affected area:

**Figure 2-2 Risk Tolerability Examples**



We can say the following about the options:

- Method A could never be preferred, no matter how many advantages it has over the other options (e.g. very cheap) because the land would remain unusable if this method was used to clear it, which is no better than if the land had not been cleared at all.
- Methods D and E both achieve negligible risks (i.e. a risk level that is not a significant factor), therefore other factors (e.g. resource usage, cost, timescale) should be used to decide on the optimal method.
- Methods D and E would both be preferred to methods B and C on risk grounds. However, the additional risk reduction might not be justified if, say, the resources required by method D are considerably greater than those required by method C, and the available resources are limited
- Method C is slightly preferred to method B on risk grounds, but the difference is very small. Therefore, other factors are likely to be used to decide on the better of the two methods.

We need to identify what risks are negligible (i.e. too small to affect anyone’s behaviour) and those that are never tolerable (i.e. make the land unusable for any practical purpose). For those situations where the residual risk is within the “judgement zone” we need to understand the “trade-offs” between residual risk, who is affected and how they might benefit from clearance, and mine clearance resource usage.

**2.2 Societal Risk**

Societal risk (i.e. likely number of casualties in the case of landmines) can be used to prioritise resources over a larger area than individual risk, which would be used to identify the acceptable methods in particular situations. It can also be used as one measure of the overall effectiveness of a risk-based strategy, since actual casualties can be identified, and are routinely (albeit not necessarily accurately) recorded in most countries.

The likely number of casualties depends on the level of risk in an area and the number of people at risk. If there is a small residual risk of remaining mines in some areas, then if there are sufficient areas with this risk and they are used, sooner or later a mine will be found, and possibly explode. For

example, the risk of a landmine casualty in a single area could be only one in a hundred. However, if this same risk was expressed in a thousand similar areas, then we could expect around ten casualties. Nevertheless, as a rule if the individual risk is reduced then the societal risk will be too.

Societal risk, in the context of landmines, is most useful in identifying those areas where the individual risk is highest. Areas where the number of casualties is relatively high (per capita) will generally be where risks are highest and can be reduced most effectively. This does not show how this might be achieved, which is best done through strategies based on individual risk (as described in the next section).

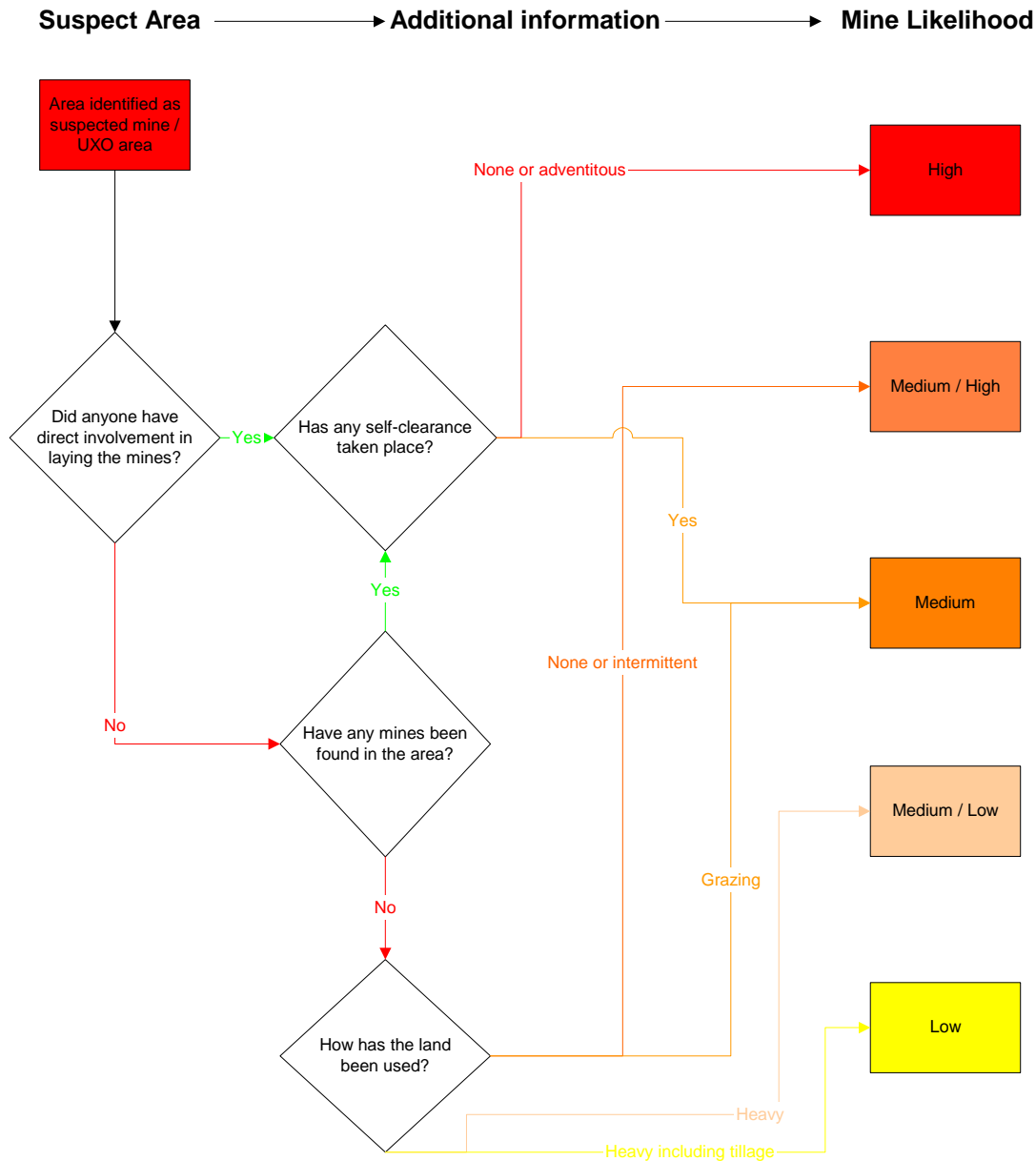
### 3 Risk Assessment

The risk of a mine causing injury depends on the likelihood that a mine (or a number of mines) is present, the mine type and condition, and how the person uses the land.

The likelihood of any mines being present can be anything from certain to extremely unlikely, and will change through time, as experience and knowledge of the land is updated and, in some cases, the land is investigated and possibly cleared to some degree. The risk assessment should investigate the probability of mines from the current situation, and estimate the probability of any mines remaining in future scenarios, such as after area reduction or clearance.

#### 3.1 Initial Risk Assessment

Prior to any investigation, there will be local knowledge and experience of the suspected area, possibly coupled with external information from people who laid the mines. A simple example of how this might be distilled into a qualitative assessment of the likelihood of any mines being present is shown below:



It is important that the considerations apply to the whole area that has been designated. If they do not, then the area must be partitioned so that they do apply to all of it. For example, people might have used part of the area heavily (e.g. as a path to water, or by children as a play area), but another part was rarely used. The area that has been heavily used is less likely to contain a mine than the rest of the area, even if it is part of the same suspected area. There will be some correlation between the areas, but it is difficult to make generalisations about this.

At this stage the number of mines in the areas (if there are any) is still unknown, although there may be some information on the likely mine density (heavy or sporadic) based on the number of mines found previously, the supposed reason for laying the mines, or any self-clearance by the villagers.

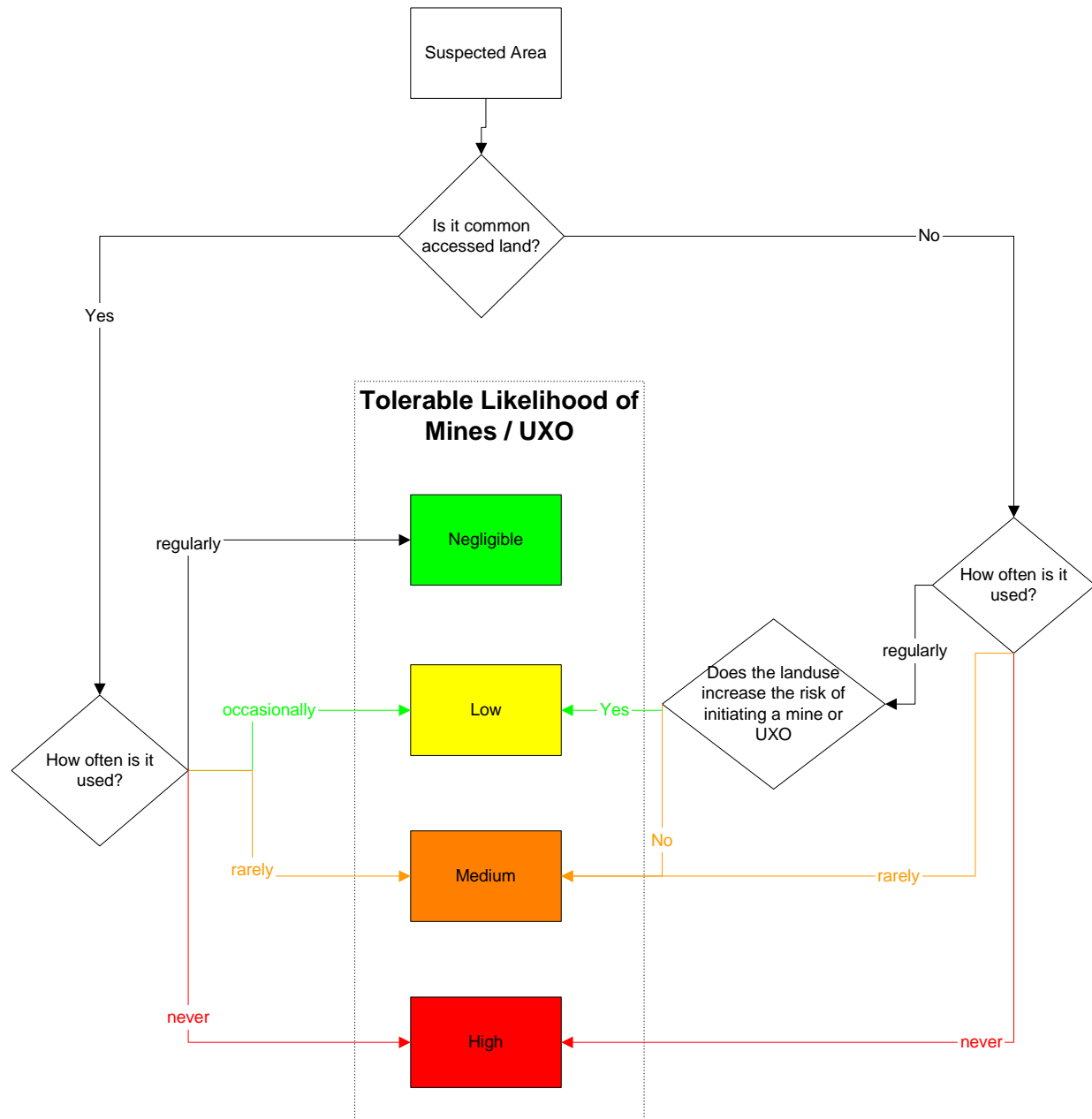
### 3.2 Land Use

The land use will be used to estimate the level of risk, who and how many people are at risk, and the benefits that individuals and the community derive from the land. This will be used to identify the appropriate options for mine action that could make the land fit for its intended purpose. The main characteristics of the land use are:

<p>1. Who will use the land?</p>	<p>Some groups, for example children, are generally more at risk, because they are less able to modify their behaviour to reduce their risks.                  If only one person (or perhaps one family) is using the land, then it is easier to train them to modify their behaviour on the land, and for them to control their risk. They also know the land better than others. They also derive direct benefit from the land.                  If the land is used mainly for grazing, then an animal is more likely to set off a mine than is a person. An animal casualty, although the loss of a valuable commodity, is clearly not as tragic an event as a human casualty. This would not be the case for UXO, which are generally set off by tampering with them – something an animal is unlikely to do.</p>
<p>2. How often the land will be used?</p>	<p>If the land is used heavily then it is more likely that a mine will be found and detonated prior to it becoming non-functional (e.g. through deterioration or an animal setting it off).</p>
<p>3. How will the land be used?</p>	<p>If the land is farmed and tilled, then buried mines may be more likely to be set off. Rice fields, when flooded, make it difficult to see the mines / UXO.</p>
<p>4. What are the benefits from using the land?</p>	<p>Some land-use is essential, for example routes to clean water. They might already be using these areas, despite knowing the potential for mines (even after a mine has exploded and injured someone).</p>

### 3.3 Assign Risk Bands

The tolerable likelihood of their being any mines in the area being used can then be related to the land use, as below:



The tolerable likelihood might depend on the timescale over which the mines might be present. For example, a low medium likelihood might be tolerated over a short period (say a year), but over the longer term the likelihood might have to be reduced further, since if there is a mine present it will remain a hazard until it is removed or becomes inactive (the latter could take a very long time), and it becomes more and more likely that eventually someone will initiate it. On the other hand, time will also reduce the likelihood if the land is used and no mines are found, which is why a more controlled use of the land would be preferred in this period for land where the mine risk is not negligible.

### 3.4 Agree Options for Treatment

Treatment measures could include a combination of the following:

1. Area reduction through, for example, mine detection dogs or mechanical clearance.
2. Mine clearance through, for example, manual demining teams or mechanical clearance.
3. Marking off areas to discourage access.

- Mine awareness programmes to teach people how to approach and use (or not) potentially mined areas, and advise them on what to do if they find a UXO or landmine.

Each of these measures requires resources to implement them. Manual mine clearance is the most resource intensive activity, but also provides the highest degree of confidence that no mines remain in the area. Mechanical clearance alone does not provide the same level of confidence, but can remove a lot of mines and, in those cases where no mines are found at all, can provide a reasonably high degree of confidence that no mines remain (because there never were any there).

An assessment of the potential benefits of mine action in reducing risks to tolerable levels should be performed. The following table shows how different mine clearance and area reduction measures might be used to reduce the risk of there being any remaining mines. This table is only an example; the actual performance of the area reduction and clearance methods will depend on the type of terrain, the type of mine used, the competence of the mine action teams, the quality of their equipment and, in the case of mechanical clearance, the capabilities of the machine.

**Table 1 Mine Risk Post-Clearance**

Mine Action	Mines found during action	Pre-action risk of mines	Post-action risk of remaining mines
Mine detection dogs (no clearance)	None	High	Medium / Low
		Medium	Low / Negligible
		Low	Negligible
	1 or more / ha	Any (i.e. high, medium or low)	High
Mechanical clearance	None	High	Medium / Low
		Medium	Low
		Low	Low / Negligible
	1-2 /ha	Any	Medium
	3-10 / ha	Any	Medium / High
	>10 / ha	Any	High
Comprehensive manual clearance	None	Any	Negligible
	1 or more / ha	Any	Low / Negligible

As can be seen from the above table, the actual reduction in risk is dependent on the number of mines found. This is based on the principle that the more mines that are found, then the more likely it is than one was missed, because there were more there in the first place. This is an unknown quantity prior to treatment of the land, although there could be some information on the potential mine density in the affected area. Therefore, some judgement has to be made as to each mine action's potential for reducing risk to a tolerable level, based on the above table. For example, in general, mechanical clearance by itself is unlikely to remediate an area where there are thought to be a lot of mines or a high-risk area to a negligible risk area. Therefore it should not be used as the sole treatment for high-risk areas when they are to be used for common regular access, because there should be a negligible residual risk of mine contamination in these areas.

In addition to the above methods, areas can be marked off to discourage access. This is not a treatment in itself, but it can be an effective method to reduce risks in the short term and, if controls are maintained, in the longer term. This means that the land is not used at all and this must be recognised in the land-use planning agreed with the community. It might be possible to introduce a different sort of marking for areas with a lower risk that are not for common access, but are to be used by a single family for farming. In this case, general access should be prevented to reduce the overall risk of casualties in the area. However, different markings could be confusing and might lead to some people, especially children, not respecting the markings for higher risk areas, thus increasing casualties.

These methods can be combined to reduce the risks further. For example, if mechanical clearance is carried out first on a medium risk area and no mines are found then this area becomes a low risk area. If mine detection dogs cannot find any mines in the area after mechanical clearance then the overall risk of any mines remaining becomes negligible.

There could also be practical difficulties with some of the treatment methods, which would mean that either the treatment method is unavailable (e.g. infrastructure would not support mechanical methods, climate means that dogs are ineffective, not enough men available for manual demining), or there is a significant probability that it would not work very well (e.g. breakdown of mechanical equipment). Clearly an unavailable or infeasible method cannot be considered, but the risk of failure (or at least the risk that the performance does not meet expectations) ought to be included in the assessment of the options, even if the treatment method is available and thought to be feasible in the conditions. If the method does not meet expectations, then the resource will have been wasted if the post-action residual risk is greater than required. This is especially relevant for mechanical methods, because their performance is known to be highly variable.

In the end, mine action could be a combination of area reduction, mine clearance, post-clearance checks, marking off areas, and education on how the land should be used. The overall objective is to reduce the risk from mines and UXO so that the land is fit for purpose. The suite of mine actions that are chosen will depend on:

1. The current risks from mines
2. The requirements for land-use, which will determine the tolerable risk from each area
3. The ability of the mine actions to reduce the risks to tolerable levels in these areas
4. The reliability of the performance of the mine actions
5. The timescale over which the risk reduction should be achieved
6. The available resources, now and in the future.

There could be some flexibility in the plan. For example, if mechanical clearance is specified for an area, it might find more mines than expected, which would increase the post-clearance risk, because it is more likely that some were missed. In this case, further treatment might be required to achieve the necessary risk level, for example using dogs to check the area, manual clearance, or changing the intended land-use.

There may have to be some changes to the initial plans for the area in order to accommodate what can be reasonably achieved through mine action. This may have to be an iterative process, where what residual risk is tolerable, what can be reasonably achieved with the available resources, and how the people want to use the land have to be reconciled and agreed.

### **3.5 Post-Treatment Reassessment**

After the initial treatment, there will be more information on the original mine / UXO distribution. This will allow a better estimate of the risks in each area, using a risk revision table such as Table 1.

If the treatment does not achieve the risk objectives, then the land-use, additional treatment and tolerable risks should be reassessed. This could lead to additional treatment for the land. However, in some cases, this might not be practical. For example, there are no dogs available to check the land, or it is considered that manual demining teams are better deployed in essential areas only to maximise risk reduction. In this case, the intended land-use might have to be revised to a less risky application or the land marked-off completely.

### **3.6 Post-Treatment Land-Use and Monitoring**

Once the treatments have been applied, the areas are ready to be handed to the community for the intended land-use. It is vital that the community fully understand how they can use the land to keep their risk tolerable. This is particularly important for land that carries a non-negligible risk of remaining mines; inappropriate use of this type of land will increase risks.

There should be procedures in place for reporting any missed mines and UXO. This has two functions. First, the risk can be reassessed if a missed mine is found, and appropriate action taken. Secondly, the effectiveness of the treatments can be monitored, and this information can be used in future assessments in other areas.

Finally, the area should be revisited after a period (say 6 months to a year) to ensure that the land is being used in the way that was intended. If the land is being used in a more risky manner, then the

community should be made aware of the increased risk. If land is not being used, despite the treatment, then it might be that the community still feel that the risk is intolerable for the benefit that they gain from using the land. In either case, the tolerable levels of risk, defined above, might have to be revised.

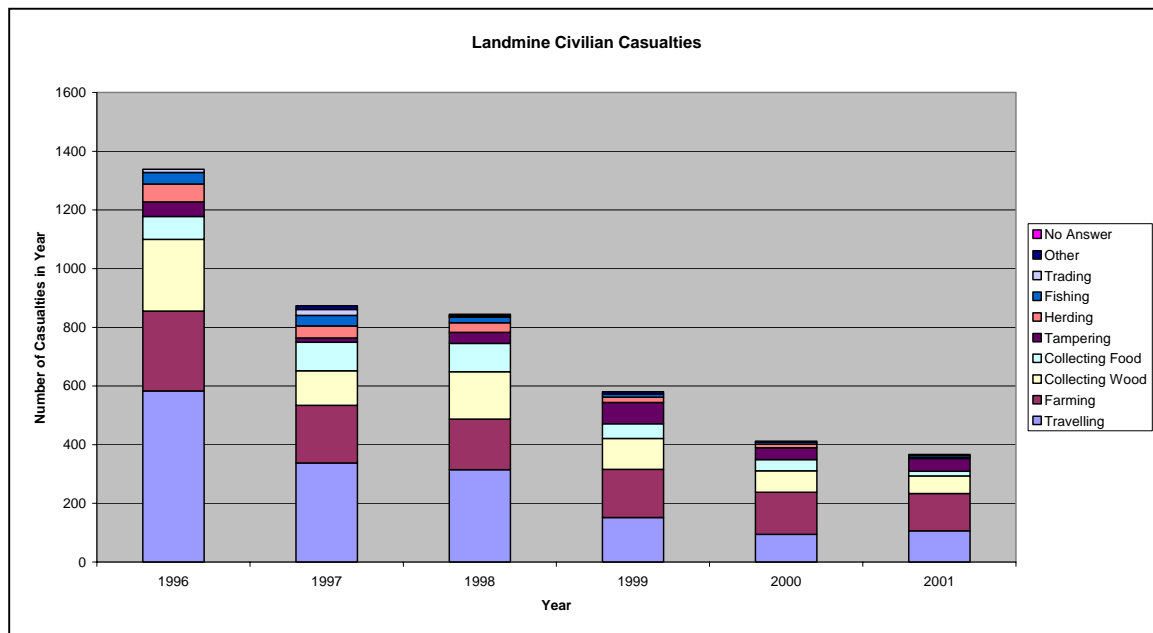
There could be an opportunity to reassess the risks for areas where no mines have been found. For example, if land had not been used before, but since treatment it had been intensively farmed and no mines found, it might be possible to relax restrictions on the land-use, so a different, more risky (if there were any mines left in the area), type of farming was allowed.

## 4 Case Studies

Cambodia and Bosnia-Herzegovina were visited, as part of the study, in order to put forward some of the ideas and discuss their potential application within the mine action strategies for each country. A summary of the main issues that arose is provided below.

### 4.1 Cambodia

The landmine problem is particularly acute in Cambodia, where the current level of resources for mine action is wholly inadequate to clear most of the affected areas in the medium term (i.e. before 2010). That is not to say that considerable progress has not been made in recent years. The casualty rate in 1996 was over 1300, whereas this had been reduced to less than 400 by 2001 (see breakdown for landmine casualties below).



The rapid reduction in casualties from 1996 to 2000 has slowed down, such that there was virtually no overall improvement to 2001. This could be because people have returned to their villages and are now trying to farm the land around them. Although the suspected mined area in Cambodia is very large at over 4000 km<sup>2</sup>, the area that is actually mined is probably closer to 1000 km<sup>2</sup>. However, this has not all been positively identified, so considerable effort would still be required to reduce the suspected area.

There are three main clearance agencies working in Cambodia: the CMAC (Cambodia’s clearance group), the Halo Trust and MAG. In addition, the Cambodian Army clears some mines, although they do not appear to do much clearance for humanitarian purposes. Approximately 14 km<sup>2</sup> per year were cleared by the main agencies (excluding the Army) in 2000-2001, removing about 24,000 AP mines, 800 AT mines and 75,000 UXO per year in the same period. Clearance at this rate would clear less than 15% of the likely contaminated areas by 2010, so prioritisation of clearance is essential. Risk management offers a way to developing a strategy for this.

Many of the casualties over the last few years have been concentrated in a few communes, as shown in the table below:

**Table 2 Casualty Breakdown by Worst Communes**

Communes ordered by casualties	Casualties in these communes	% of total casualties	Villages in communes	% of suspected villages	Average casualties per village
<b>Worst 10</b>	571	31%	117	1.8%	4.9
<b>11 – 20</b>	285	16%	81	1.3%	3.5
<b>21 – 30</b>	209	12%	70	1.1%	3.0
<b>31 – 40</b>	152	8%	80	1.2%	1.9
<b>41 – 50</b>	115	6%	79	1.2%	1.5
<b>51 – 60</b>	91	5%	86	1.3%	1.1
<b>Worst 60</b>	<b>1423</b>	<b>78%</b>	<b>513</b>	<b>8.0%</b>	<b>2.8</b>

That is, since 1999 78% of the casualties have been from 513 villages (out of 1,400 confirmed as being contaminated and over 6,000 that are suspected). Assuming the average mine contamination per village for the most affected villages is similar to the countrywide average, the contaminated area in the 513 villages would be about 350 km<sup>2</sup>. At current clearance rates, this would take over 20 years to clear. A risk-based strategy would identify the most “risky” villages (based on casualty rates and potential land-usage), but even if the highest risk areas were identified and cleared, there might be expected to be only a gradual reduction in casualties from the current rate. If we assume that the casualty rate remains the same in these areas until they are cleared<sup>1</sup>, then Cambodia could face a further 5,000 casualties in the next 10 years. This does not account for land-use extending beyond the current boundaries, as pressures on the land increase and more people return to potentially contaminated areas.

If treatment could be accelerated then the number of casualties would be reduced, as long as the quality of clearance was maintained. Even if the quality was not maintained (i.e. a higher risk of leaving an active mine in place), there could still be a case for accelerating treatment rates, if this could be achieved in practice. For example, if twice as many villages could be treated each year, but the casualty rate in “cleared” villages was still 1 in every 10 villages (i.e. one active mine left that causes a casualty before it explodes, is found or becomes inoperative), then the total number of casualties over ten years could be reduced by 1,000. If four times as many villages were treated, then the rate could be reduced by 2,000. Moreover, the villages that were cleared would become more sustainable, because more land could be used.

Of course, this is of no use if faster treatment cannot be achieved. It should be emphasised that we are talking about faster village treatment; faster mine clearance could be an important contributor to that, but we should also consider methods by which land can remain uncleared, still have a small risk of mine being present, but can still be used in a defined way. The designation of land, using a risk-based method as described previously to assign an acceptable risk of mines being present, would be an important input into this process. Thus, mine treatment would be a combination of a risk-based assessment, survey and area reduction, and different clearance methods. This is already practised to some extent, but a more rigorous application of risk assessment and perhaps a greater willingness to leave potentially mined land uncleared, yet still used by some people in the community, could reap benefits.

## 4.2 Bosnia

The 2000 km<sup>2</sup> suspect areas have been broken down into three priority classes:

- I. **Priority I** (229 km<sup>2</sup>)
  - locations in regular civilian use
  - repatriation of refugees and displaced persons
  - renewal and reconstruction of infrastructure
- II. **Priority II** (590 km<sup>2</sup>)
  - areas in the immediate vicinity of Priority 1 areas
  - locations in temporary use

<sup>1</sup> In the scenario that the land-use was unchanged, and the mines did not become inactive through other means.

- areas which enable people to make a living such as agricultural land and forestry

### III. Priority III (1,312 km<sup>2</sup>) - all remaining areas

There are around 100 casualties each year (about a third are fatal, half are due to landmines, the other half due to UXO). Half of these are in Priority I areas.

There are some constraints on the treatment programme:

- |                            |   |
|----------------------------|---|
| 1. Land designation        | Treated suspected mined land can only be designated as “no visible risk” or “suspect”. Suspect land can be marked, but it cannot be used (or at least its use cannot be authorised), and there is no middle ground. The current legal framework in BiH would make it impossible to authorise any use of land that might contain mines, however low the probability. |
| 2. Money                   | Survey and treatment have to be paid for, and there are limited funds available. As the emphasis moves towards lower priority areas, there will be less justification for full clearance to “no visible risk”.  |
| 3. Resources               | There are sufficient mine clearance resources in BiH to carry out the 2003 programme. However if, for example, there are proposals to increase significantly the use of mechanical treatment, this might not be achievable if the equipment is not available in BiH.  |
| 4. Allocation of resources | There are political pressures to allocate resources proportionally. This might not be consistent with other priorities.   |

The requirement to designate land as either “suspect” or “no visible risk” present considerable difficulties to a risk-based strategy, as described earlier. In order to clear Priority I and II areas, they all have to be declared “no visible risk”, which is effectively interpreted as “zero mines”. It would not be possible to accelerate meeting the overall objectives, or using fewer resources to meet them, by leaving land with a small residual risk of a mine remaining on it for limited usage. However, this could be employed to increase usage on Priority III areas, as long as it was accepted that the land was not fully cleared, and could not be designated as such.

The recommendations for the Bosnian clearance programme are:

- |   |  |
|---|--|
| 1. Take risk explicitly into account in the prioritisation and strategy   | This is already accounted for, but a more quantitative, objective approach is recommended. Risk would just be one factor in the strategy, albeit a very important one.   |
| 2. Improve the database so that the results of general survey, technical survey, marking, clearance and casualties can be used to inform decisions. | This will require linking these elements so that the probability of mines being present at each stage of the process can be quantified. This could be combined with the surveyors’ experience in providing a quantitative approach to the risk from mines. In particular, an expert system could be developed (e.g. using a Bayesian Belief Network (see, for example, [4]) that explicitly uses the information about a site and combines it with expert knowledge, to get a risk.<br><br>This would provide the backup information to implement Recommendation 1, such as the effectiveness of each treatment in reducing risks (either through casualties, or removing mines, or accurately proving that no mines exist). |
| 3. Consider extending the use of machines and dogs to remove mines from Priority II and III areas.  | These would not necessarily produce areas with “no visible risk”, but could be employed in areas that people use (as shown by casualty figures). However, there would have to be strict controls on the circumstance in which this was employed, and it may not be compatible with the current legal framework in BiH.   |
| 4. Consider using land in such a way as to reduce the risk should any mines exist on the land.  | The risk could be reduced by limiting access to the land and, for example, using machines for working the land as much as possible, and keeping to strict pathways. However, there could be problems associated with liability for any mine accident that did occur on the land.   |

## 5 Implementation Issues

A risk-based strategy can deliver a well directed mine action programme that has the potential to minimise future casualties while increasing the amount of available land. However, there are several drawbacks that might restrict its general application. These are discussed below.

### **Acceptance of non-negligible risk**

One hurdle is the acceptance of a non-negligible risk post-treatment. It is important that all stakeholders (the people at risk, mine clearance organisations, governments and donors) fully understand what is involved in leaving areas with a non-negligible risk, and are prepared to accept the occasional casualty in a treated area, on the grounds that more lives are being saved elsewhere. The problem here is that a casualty in a treated area can be identified, and the responsibility for leaving the mine in place can be assigned, whereas any “saved” casualties can only be hypothesised. It is easier to place the blame for something that has gone wrong than to take any credit for something that has not happened.

This is a particularly acute problem in Bosnia, for example, because the clearance organisations work under strict liability for any areas that they declare mine free, and there is no way to identify an area as “probably cleared”, still presenting a significant risk for some land-uses, but available for other, safer activities.

### **Reputation of Clearance Organisation**

The clearance organisations will also be concerned that their reputations could suffer if they treat land, but possibly leave a mine in place. One selling point for non-national mine clearance groups is the exceptional quality of their mine clearance procedures, and they use this to persuade donors to give money to them rather than other organisations. In this case, it could be difficult to convince them to “lower” their clearance standards in some countries, where it might be appropriate in a risk-based strategy to improve the overall casualty rate, because they might believe that their funding for work in other countries, where pristine clearance is always required, might suffer.

### **Manual Demining by Professional Organisations**

In addition to the community who will use the areas, another group potentially at risk are the deminers themselves. A manual deminer should not leave mines in place while he is working in an area (not deliberately, but because he is working to a lower standard, in order to clear more quickly); he will cover a very large area during his working lifetime clearing mines, so the actual risk could be significant for an individual. This is unlikely to be acceptable for the individual, and impossible to insure for his employers. Therefore, manual demining to a less pristine standard is impractical for a professional organisation and unacceptable for a professional deminer.

### **Self-Demining**

Nevertheless, demining to less pristine standards is already carried out in some places (e.g. Cambodian villages) by people in the community, who are generally untrained with the possible exception of basic military training, and have no equipment such as metal detectors. Although these people are generally willing to try to clear mined areas for their own use and benefit, they are less willing to do so for others. It might be possible to give people basic training in demining (additional to the general information provided in mine awareness programmes), but they would still be unsupervised, and the risks they take while demining are unlikely to be greatly reduced. Moreover, without proper equipment, it is difficult to see how clearance could be improved significantly over what they achieve currently with ad hoc methods. To improve the clearance levels by the villagers themselves while reducing the risks that they undergo is unlikely to be cost-effective, given the level of training and equipment that would be required and the limited amount of land one villager would need to clear for his own use. In order to make it cost-effective, the trained villager would have to clear other peoples' land, which would be little different from the current situation, where trained professional deminers (often sourced from the region) clear land.

### **Excuse for Poor Clearance**

There is also the danger that a risk-based approach can be used as a cover for poor clearance. It is essential that the long-term clearance rates are monitored and evaluated across clearance organisations and treatment methods, so that there is some assurance the risk objectives have indeed

been met. For example, if the risk objective had been a low likelihood (but not zero likelihood) of any mines being left in place, then one should expect very few mines to be found subsequently. An occasional mine found might be acceptable, in the context of overall risk reduction, but there has to be some criterion for when “too many” mines are found, so that the treatment method, clearance organisation or land-use can be re-evaluated.

This would mean continual updating and reappraisal of the risk-reduction tables for a particular country (such as Table 1). In addition, the evaluation of the initial risk should also be updated in the light of evidence. One method for achieving this is the use of Bayesian Belief Networks, where the initial expert judgement on the likelihood of mines being present is formally captured, and then updated as actual data on mines is gathered [4],

### **Compatibility with International Standards**

It could be argued that the risk-based approach is incompatible with the international standards for mine clearance. These are only provided as guidance to national agencies, who formulate their own standards. They are extremely useful for many aspects of demining but, by the nature of standards, are difficult to adapt to a flexible risk-based approach. There is a nod towards risk-based thinking in the application of different quality standards for land-uses, graded by their sensitivity, and it is not that great a step to use risk as the basis for the clearance itself, rather than just the quality assurance checks.

### **Country-Specific Risk Strategies**

A risk-based strategy would be very country-specific, because the circumstances can be very different. This applies even more to the specific procedures, such as the evaluation of the initial risk, the capability of different mine actions to reduce the risk, the availability and feasibility of each mine action, the community’s acceptance of different risks, and the legal framework in which the clearance will take place.

### **Prioritisation**

Mine action will be limited by available resources (financial, manpower and equipment). Therefore, it is important to prioritise mine action so that the resources are put to best use. Risk assessment can be an important factor in this process. For example, the potential reduction in casualties (societal risk) can be estimated (as above) for various mine actions, and this can be factored in to obtain an optimal strategy. Tolerable and intolerable individual risk bands can also be used to identify where a particular mine action is feasible, although this is better applied for individual actions rather than as a general strategy.

## 6 Outline Strategy Development

We have carried out two case studies (Section 4) to help us to see how risk management principles can be incorporated into a humanitarian mine treatment strategy. This section describes a more generic procedure for incorporating risk management.

There are four stages:

5. Scope the problem – data gathering
6. Identify context – what are the overall objectives and constraints
7. Initial strategy – develop an initial strategy based on the data available
8. Strategy development – as more data becomes available and the context changes

### 6.1 Scope Problem

The first thing to do is to understand the scale of the problem in terms of:

1. Number of landmines present
2. Area affected
3. Number of casualties, including the trend from year to year
4. Current clearance rates (mines, area)

A Level 1 survey, by itself, is of little use in a risk assessment, because the uncertainties are very great (generally a high degree of conservatism in designating potentially contaminated areas). If a Level 2 survey has not been carried out on a significant proportion of the potentially contaminated areas where people are expected to be at risk in the next few years, then this would be the first step in the development of a risk-based strategy.

The clearance rates show the current rate of progress, in terms of area and total mines / UXO cleared. Together with the expected total contaminated area, they can be used to estimate the timescales over which the country will be cleared. Areas that are shown to have never contained mines, despite having been identified as such by a Level 1 survey, can be used to estimate the fraction of the Level 1 survey areas that actually contain mines, and thus provide a more accurate estimate of the risk if Level 2 surveys have not been completed for most of the affected area. If the clearance is particularly well-developed and well recorded, this will provide invaluable information to help identify the areas most likely to be mined, of those that have been identified as possibly mined.

Nevertheless, this will only provide a very rough estimate, because clearance rates will vary in the future, as funding, terrain and treatment methods vary. Moreover, they are not a direct indicator of risk reduction, because this also depends on land usage and mine awareness.

The number of landmines, area affected, clearance and casualty rates in the two case studies were obtained from a combination of recent Landmine Monitor reports, which are themselves based on a variety of sources, direct communication with the national MAC, and analysis of casualty databases provided by the MAC.

Although numbers of landmines and areas can be important in terms of future risks, the most important information is the numbers of casualties. This was provided by CMVIS in Cambodia and by the BHMIC in Bosnia – these were both excellent sources of information for the most recent years. This does not tell the whole story, because some areas are not inhabited because of the presence of mines, but they indicate the areas of highest priority.

### 6.2 Identify Context for Risk Assessment

Country-specific circumstances will determine how and to what extent risk assessment can be employed in a mine treatment strategy. For example, in Cambodia the options for mine clearance are limited by the terrain and infrastructure deficiencies, so the risk strategy was focussed on prioritisation of areas for clearance. In Bosnia, there is the potential for using different treatment methods, but these

are constrained by strict liability for casualties on treated land, which means that there is no scope for less pristine clearance for lower risk land uses.

There are two main objectives for mine treatment: the first is to reduce current casualty levels by clearing inhabited areas, and the second is to increase land usage by clearing areas made uninhabitable by mines. The former was the primary aim in Cambodia, because land pressures and lack of alternatives made living and working near mined areas unavoidable (and casualties high). The latter was the main focus in Bosnia, where returning refugees from conflict areas was usually the priority. Nevertheless, there were still significant casualties in Bosnia that demanded immediate action.

### 6.3 Initial Strategy

Risk is the frequency of injury or fatalities occurring, expressed either as the probability per individual or the likely numbers impacted. In order to calculate the current levels of risk, the information found earlier must be manipulated. The aim is to categorise the communities in terms of the risk that they currently experience, the numbers of people at risk, and thus the benefit that mine treatment might have in terms of reducing risk. Thus for each community we need:

1. Number of people in community
2. Area affected
3. Recent casualty rates – these should be averaged over the region affected
4. Potential future casualty rates (assuming required land-use to make community viable)
5. Potential reduction in risk (i.e. casualty rates after alternative mine treatments)
6. Timescales for treatments
7. Tolerable individual risk (possibly related to current risks)

Initially, this can only be done at a fairly broad level. It would be assumed that full, quality assured manual mine clearance would reduce risks to effectively zero. Less effective treatment techniques, such as mechanical clearance, sealing off areas, can still reduce risk but not necessarily to zero, and will possibly limit future land-uses and will require monitoring in the future. A nominal improvement in risk has been assigned in this exercise for treatments other than manual clearance – it has been assumed that alternative treatments can still reduce risks significantly, at least in the short-term.

The other important factor is how quickly the treatment can be implemented. Clearly, marking off areas and preventing access can be implemented much more quickly than manual clearance (although they will not be as effective in reducing risk). In addition, in some cases mechanical clearance can be carried out quickly, albeit not always with the same level of clearance. If they can be implemented more quickly, they can save more lives than more rigorous methods, because there is the potential to reduce the risk in more areas, or provide access to more areas. Again, a nominal, but significant, improvement in treatment time over manual clearance has been assumed in this exercise.

The actual potential for improvement will be specific to the community. Ideally, we would know precisely how well treatments will work and how quickly they can be implemented, but this will not be known accurately for many treatments. Nevertheless, it will be possible to make an estimate based on past experience and this should be used in the creation of the initial strategy. As experience is gained in the country these estimates should be refined.

The overall societal risk (defined in terms of the number of casualties) from various strategies can be estimated by:

$$\sum_{\text{Areas to be treated}} \text{Current Casualties} \times \text{Risk Reduction}(\text{treatment})$$

A treatment for an area might include several actions (e.g. combination or area marking, limited land use and clearance). For faster treatments, there will be more areas that can be treated. For example, if there are three areas, each which has 1 casualty per year, and there are two potential treatments; the first will remove all mines but only one community can be treated each year; the second method can treat all three communities but there is a 1 in 10 chance that a mine will be left in each community that will eventually cause a casualty. Using the first method will probably lead to 3 new casualties (2 in the

first year while there are two areas untreated, one in the second year). Using the second method will probably lead to no casualties, although there is about a one in five chance that there will be one eventually.

As noted earlier, although the risk reduction may be significant in terms of reduced numbers of casualties, there is a further constraint – tolerable individual risk. In Bosnia this has been set to zero, so the risk strategy has been restricted to identifying which areas to clear, although there may be scope for a limited use of other methods. In Cambodia, it is not as limiting because the treatments are currently focussed on areas where people are already at significant risk. Nevertheless, local support for a risk strategy requires that individual risk must be tolerable. It has been assumed here that one casualty per 10 villages might be acceptable, at least in the medium term, in those Cambodian communities where the current rate is much higher. A more sophisticated method for examining individual risk was presented earlier.

## **6.4 Strategy Development**

The strategy will have to be developed over time as more information becomes available and the effectiveness of each treatment can be compared against the initial estimates. It should be borne in mind that the types of mine contamination may change as time goes on, since the most badly affected areas will be most likely to be treated first. In addition, objectives will also change – as casualties are reduced then the focus is more likely to move towards increasing land-use in previously uninhabitable areas. Here, tolerable individual risk is likely to be much more important.

## 7 Reference

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