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Risk maps and communication

John E.T. Moen *, Ben J.M. Ale

National Institute of Public Health and the Environment, P.O. Box 1, 3720 BA Bilthoven, Netherlands

Abstract

The use of maps to convey information on the environmental burden and accident risks is increasing. This development is associated with the redefinition of environmental problems in terms of spatial planning. The increased use of maps solves a number of communication problems but also introduces others. The examples given here form the basis for recommendations for future developments. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

Many contributors to the development of the field of risk analysis have rightfully argued that in many respects the process of risk assessment is a blend of art and science [1]. Development of a lingua franca for communication between risk assessors and those involved in risk management in various contexts is a key issue for further development in this area.

In a previous paper [2], we proposed the use of risk maps for structuring the discussions on risk and the many elements involved. Risk maps form the theme of this conference. The increased use of maps not only conforms to the increasing use of visual aids to convey information, but also to the tendency to redefine many environmental problems in terms of spatial planning [3], a recent development in environmental policy development in the Netherlands. Instead of addressing environmental problems by (further) reducing emissions due to certain activities, suitable locations for these activities are sought to allow the direct surroundings to cope with the emissions while preserving their function. The location of housing developments in relation to hazardous industrial facilities is an example of this line of thinking.

* Corresponding author. Tel.: +31 30 2742515; fax: +31 30 2744428; e-mail: john.moen@rivm.nl

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This paper summarises some of our experiences in risk mapping and the comments received. In general, the idea of risk mapping itself has been met with positive, mildly benevolent albeit critical reactions. One example shown in the paper was, interestingly enough, reason for quite some discussion afterwards with representatives of the nuclear industry.

2. Seeing what you want to see

In the paper mentioned above as an example of the use of maps to convey information, a map of the Netherlands was presented on which the individual risk was given. This example illustrated a preliminary result of the so-called CUMU project [4], to investigate whether the accumulation of differing environmental and major accident risks could be assessed and how this accumulation was distributed geographically. The map showed the distribution of the death risk due to regular industrial emissions of radionuclides in the Netherlands. According to this map, the highest risk was to be

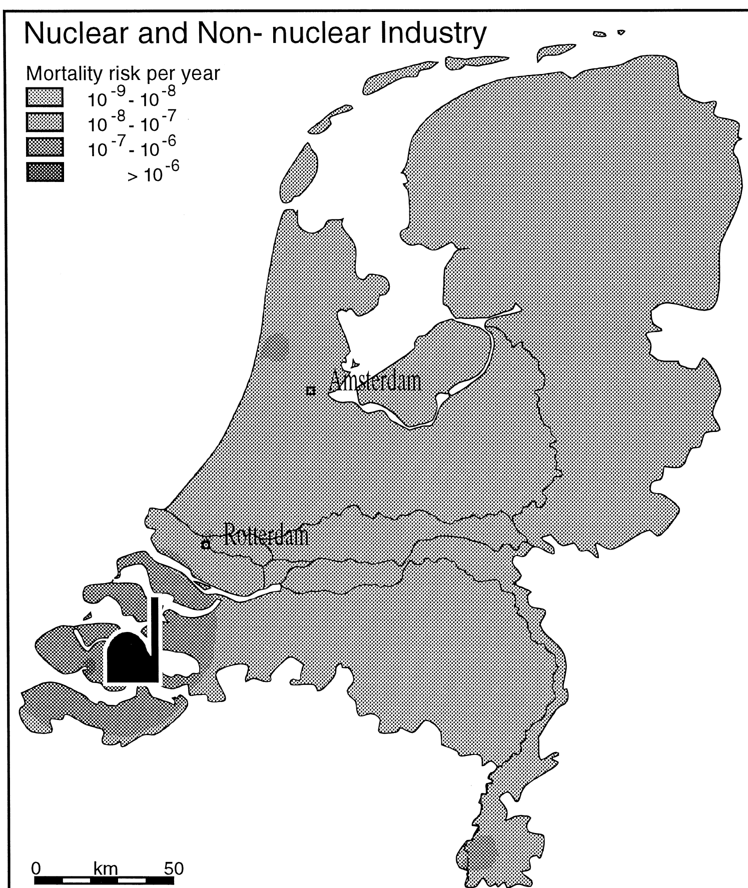

Fig. 1. Risks of exposure to radiation, location of nuclear power plant.

found in the south-western part of the Netherlands. Our colleagues in the nuclear sector immediately connected this with the location of the largest nuclear power-plant in the Netherlands, whose personnel saw themselves confronted with yet another attempt to put blame on an old scapegoat. But actually, on the scale used in this map, the risk presented by this plant literally sunk in the sea of regular radionuclide emissions from its neighbour, a large phosphate fertiliser plant. As psychology tells us, people do see things in their own context and according to their own expectations. This is not new to discussions on risk, but we should remain aware of this when using risk maps in the future for risk communication. Fig. 1 illustrates the scene just described, with the location of the one remaining operating nuclear power plant indicated as well. The conclusion seems obvious. In Fig. 2, we have the same picture but now with the main producers of phosphate fertiliser indicated. From this, it is apparent that the seemingly obvious conclusion, also drawn by people from this industry itself, is the wrong one. The risk shown on this map is not caused by nuclear power but by fertiliser production.

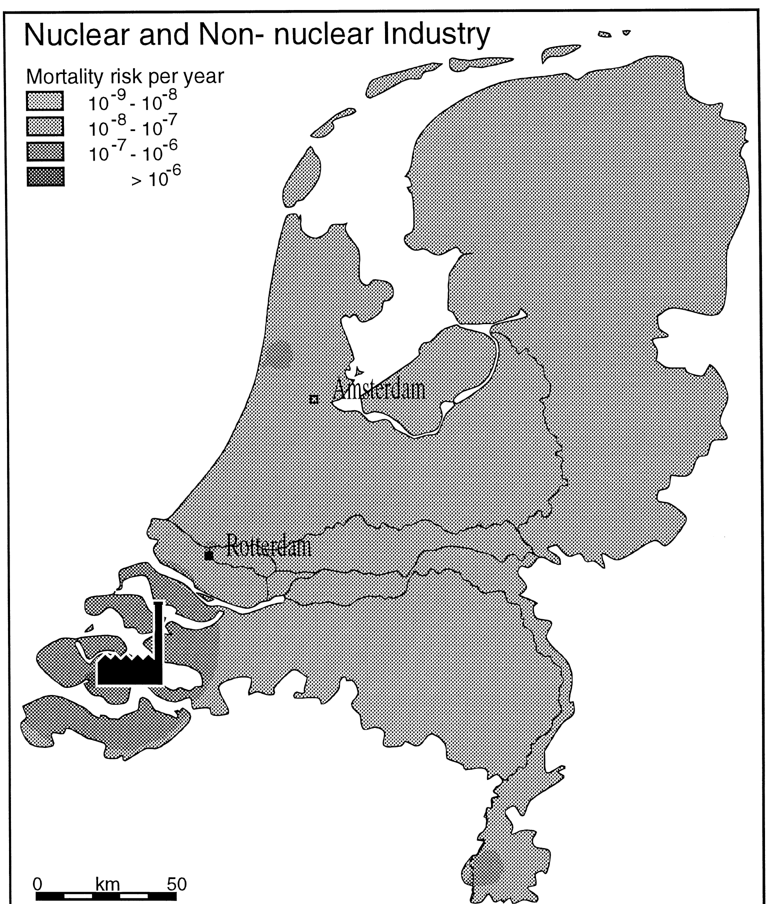

Fig. 2. Risk of exposure to radiation, location of fertiliser factory.

This is a good example to illustrate that information displayed on a map will be associated by the viewer with geographical information, such as the location of certain activities, even when this actually is not present on the map at all. Therefore, when maps are used to convey information or a message this information has to be unambiguous. This can be achieved, for instance, by indicating the main sources of risk or pollution together with the profiles. This will lead the viewer to the correct conclusion.

3. Maps and multi-dimensionality

A quantity displayed as contour lines on a map is reduced to a single dimension. This makes it effectively impossible to display societal risks when they are defined as relationships between numbers of people affected and frequencies or chances that these numbers will be exceeded.

Several authors [5,6] have argued that risk as expressed by the individual probability of death is too simple a measure for the multi-attributed entity risk. Societal risk has two attributes; however, it has already been proven necessary to reduce the number of attributes to one [7]. So, in practice, multi-dimensionality proves difficult, if not impossible, to handle in a practical decision-making process and reduction to a single dimension occurs. In fact, a project is underway at RIVM to translate the societal risk criteria in the Netherlands [8] into zoning distances, or relationships between distances and allowable density of population [9], with the purpose of taking the burden of deciding on the basis of more than a single criterion away from the decision-makers.

In that respect, maps do meet the demands of risk information users.

However, the process in which a multi-dimensional or multi-attributed entity is expressed as a single measure will depend on choices that are not exclusively scientific. In fact, most choices will be political. It is therefore necessary to have an explicit reduction provided along with the map and an explanation of consequences of these choices.

As an example one can compare the risk of air traffic in the Netherlands with that of road traffic.

When these risks are compared on the basis of the mean numbers of fatalities per year (1500 for road and 1 for air) road traffic is obviously much riskier. When compared however on the basis of maximum numbers of fatalities in a single accident (100 for road and 1000 for air) air traffic is much riskier than road traffic. From this simple example, the comparison of two sources of risk is clearly not self-evident, let alone the accumulation of various risks into a geographical distributed risk profile.

It should be possible to display the geographical distribution of a two-dimensional entity by using a (quasi) 3D image which will display one dimension as mountain height and the other as changing colour.

4. Harmonisation

Displaying more than one quantity on a map can serve several purposes. The simplest is to indicate their spatial relationship and whether they occupy or influence the same area. In this case, the quantities or items displayed do not have to have the same measure.

Still it should be borne in mind that even seemingly simple aspects such as the use of colours or patterns can convey a hidden message. Compare, for instance, the example given in Fig. 2 with the example given in Fig. 3.

In Fig. 3, the individual risk of death is given for exposure to radiation from nuclear installations in the Netherlands. These values range from 10^{-11} to 10^{-8} (per year), while in Fig. 1 the values range from 10^{-8} to 10^{-5} (per year). Using an automatic function to attribute colours or shading, colours are assigned to largely different risks, depending on the range present in the figure. The suggestion that follows from this use of colours is that these risks are similar in severity.

Using the colour red gives the impression that something is seriously wrong. Red is associated with danger, while green is associated with safety. It is not by accident that the use of red as colour in the bar graphs of the Netherlands environmental outlook is carefully avoided.

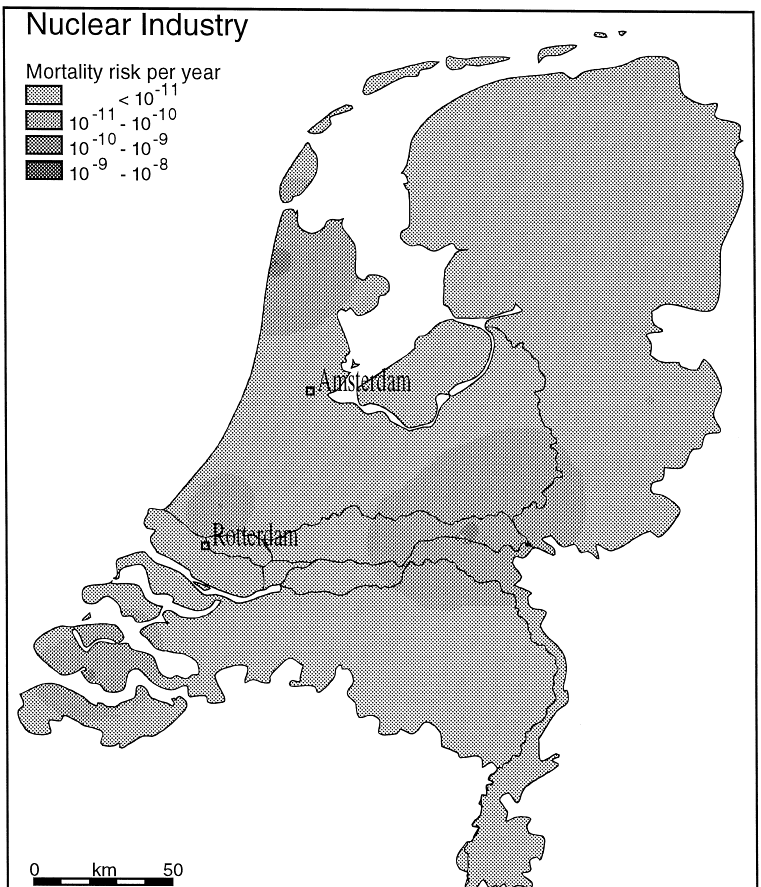

Fig. 3. Risks of exposure to radiation from nuclear installations in the Netherlands.

5. Smearing

Another point of focus in using maps has to do with the influence of size, scale and resolution. Compare, for instance, Figs. 4 and 5. In Fig. 4, the individual risk for third party fatalities from industrial accidents and accidents during transportation is given for the whole country, while in Fig. 5 only a small part of the country is represented. These risks are very localised. It is not so much that a large section of the population is exposed, although the number is still significant, but that a fraction of the population is exposed to risks of possibly 1000 to 10 000 times more than the remainder of the population which poses the problem.

When a map such as the one in Fig. 4 is put into production the local risk elevations are still visible, even though this is poor. However, when reduced by half or more the risks become smeared over the map and are no longer visible. It has occurred more than

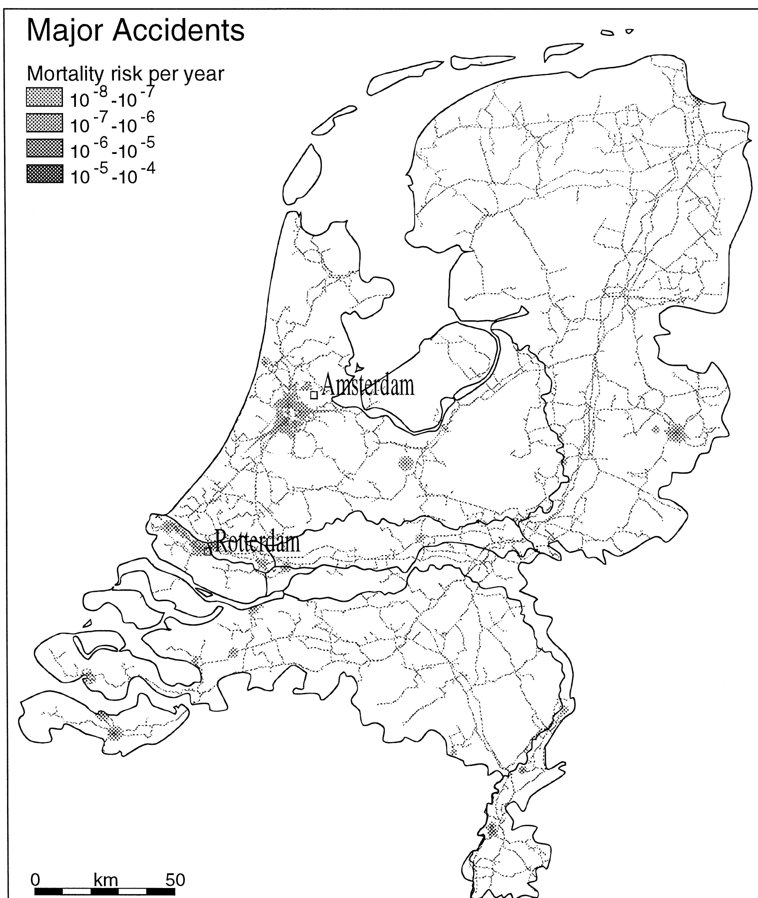

Fig. 4. Individual risk of death by major accidents, whole country.

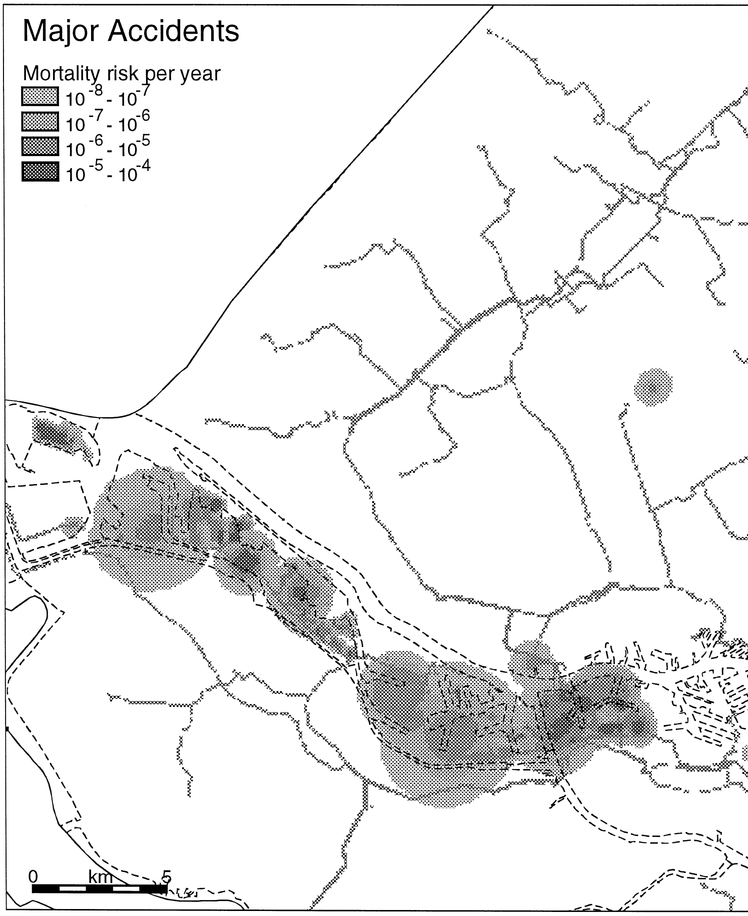

Fig. 5. Individual risk of death by major accidents; Rijnmond area.

once, that the authors have been asked why these risks pose such a major political problem. This is because the extent of this risk is not visible on the map, certainly not when compared with the extent of the problem indicated in Figs. 1 and 2. The problems due to the noise burden are similar to those due to industrial risk. The local elevation is the problem, not the spatial extent of the noise burden.

To sum up then, the relevance of entities for which the spatial extent is small and only their locally elevated intensity is significant, is difficult to convey on a map also showing entities with the large spatial extent.

6. Conclusion

Conveying messages on risks and other environmental problems by displaying them on a map is an increasing and apparently appealing approach. It is associated with the current way of thinking, in which many environmental problems are redefined as problems of spatial planning [3].

This development is leading to increasing demands on the consistency and quality of these maps. The original map may convey the message as intended, its meaning may change in the process or production of the final document.

It would therefore be advisable to improve existing standards of map-making by introducing a code of practice for representing information on geographically distributed, but not geographical, entities. This would help producing unambiguous and unbiased information for the public.

Such a code of practice should at the very least include: the relationship between size, scale and resolution, a consistent use of colours and an indication of the reduction process from multi-dimensional quantities to a single dimension.

By using consistent methods of representing multi-dimensional, geographically distributed entities a map can become more than a pretty picture; in fact, it will function more as a means of communication on complicated environmental problems to the public.

References

[1] E. North, Limitations, definitions, principles and methods of risk analysis, Rev. Sci. Technol. Off. Int. Epiz. 14 (4) (1995) 913–923.
[2] J.E.T. Moen, B.J.M. Ale, Risk comparison and communication in research and policy, in: Proceedings of the 1996 International Congress on Radiation Protection (IRPA9), Vienna, 1996.
[3] M. De Boer, Milieu, Ruimte en Wonen, Ministerie VROM, VROM, The Hague, nr. 95286/h/6-95 13641/172, 1995.
[4] K.D. van den Hout, B.J.M. Ale, E. Buringh, H.M.E. Miedema, in: M. Pruppers (Ed.), Cumulatie van milieurisico's voor de mens: geografische verschillen in Nederland, RIVM rapport nr. 610127001; TNO rapport nr. R96/132, 1996.
[5] J.A. Vlek, Beslissen over risico-acceptatie, Health Council of the Netherlands, The Hague, nr. A90/10, 1990.
[6] Health Council of the Netherlands, Committee on risk measures and risk assessment, Risk is More than Just a Number, The Hague, HC publication nr. 1996/03E, 1996.
[7] Premises for Risk Management, Second Chamber of Parliament, Netherlands, 1988–1989, 21137, nr. 1–2.
[8] J.A. Vrijling, W. van Hengel, S.E. van Maanen, The application of the concept of societal risk to various activities in the Netherlands, in: P.C. Cacciabue, I.A. Papazoglou, Probabilistic Safety Assessment and Management, Crete, 1996.
[9] B.J.M. Ale, G.M.H. Lahey, P.A.M. Uijt de Haag, Zoning Instruments for Major Accident Prevention, 5th World Congress on Chemical Engineering, San Diego, July, 1996.