J. CHYBA
Morava River Board, and Faculty of Law, Masaryk University,
Brno, Czech Republic
Chyba@pmo.cz

GD 3

LIABILITY FOR PREDICTION IN GEOPHYSICS AND HYDROLOGY

1. Introduction

Liability is the crucial problem of law, and law is the „hard core“ of ethics. Until recently, the problem of liability had appeared rather abstract to Earth scientists, in contradiction to surgeons or civil engineers who face continuously the danger of being accused for a real or pretended damage. The situation has changed dramatically after the earthquake of Aquila, Italy. The earthquake of magnitude 6.3 occurred on the 6th of April 2009 after a series of shocks of lesser magnitude. The town of Aquila was destroyed and more than 300 people were killed. Subsequently, 6 seismologists and one civil servant of the national Committee for Risks were accused and condemned to several years of jail, which caused a world-wide discussion. Most of the scientists involved in the discussion protested against the trial saying that the earthquake was unpredictable and thus no one can be responsible for the harm. However, this opinion is not unanimous and other specialists claim that the disaster was caused by a gross negligence. It is not my aim to enter into the details of the individual case. I will rather analyze the problem of liability from the legal point of view with special respect to the position of an expert in Earth Science.

2. Definition of liability

Following Hornby (1978) „liability is the state of being liable“ and „liable is responsible according to law“. The theory of law mostly defines liability as a secondary obligation, which arises under conditions defined by law, usually as a consequence of breaking the primary obligation. Liability can exist only if four conditions are fulfilled: characteristics of subject, characteristics of object, characteristics of behaviour and characteristics of mind.

3. Characteristics of subject

A person is liable only if he or she is able to foresee the consequence of his or her activity. Generally, minor or demented persons are not liable or their liability is limited. On the other hand, the liability of persons in special positions, including experts, is higher than that of other people. It is so because of higher knowledge or power and more damage they may cause. Two different situations must be distinguished:

- The expert acting as a person in an official position.
- The expert acting out of his official position, nevertheless with a reputation resulting from his qualification, university degrees etc. In this position, the liability is lesser than in the former case but still may be high – consider e.g. a false alarm caused by a newspaper article or web communication.

4. Characteristics of object

The object of liability is defined as an ethical value, which is under protection of law and to which harm has been done by the behaviour of the subject. From Plato through medieval Arabic philosophers to David Hilbert´s *„Wir müssen wissen, wir werden wissen,"* knowledge has been considered as an ethical value in itself; however, knowledge itself is not protected by law in most legal systems. Thus liability arises when a false information implies injury to other ethical values, such as protection of life, health or propriety.

5. Characteristics of behaviour and damage

Wrongful behaviour, damage or danger and the causal link between the behaviour and the damage or danger are conditions for liability. The behaviour may be active (wrongful activity) or omissible (no activity when an activity is required by law or common sense). In case of the objective liability, the damage as consequence of an activity implies liability, even if the activity is lawful: a surgeon is liable for an injury which is done to a patient by a fault of a medical instrument.

6. Characteristics of mind

Intentional harm (*dolus*) or negligence (*culpa, neglegentia*) are conditions to liability. However, in cases defined by law as objective liability, the state of mind is not relevant and liability arises whenever injury is caused by an activity.

7. Types of liability

There are several types of liability, three of which are relevant in the prediction of Earth processes:

- Criminal liability relates to an intentional damage or a very serious negligence. Only a court of justice may decide in criminal cases. There are several possibilities of punishment such as fines, imprisonment or even death (in some countries). Reparation of damage is mostly imposed to the criminal as a part of the sentence.

- Administrative liability may in some cases relate to damage which arises as a result of activities defined by law or international treaty, e.g. accumulation of water (directive EU…), even without injuring a law (objective liability). An administrative body decides of punishment and reparation; only reparation appears in case of objective liability.
- Civil liability refers only to reparation of damage. Unlike administrative liability, civil liability refers to a private interest. Courts of justice decide in such cases. A person whose activity resulted in any damage may be sentenced to reparation even if there was neither intention nor negligence.

8. Political and economical aspects

An expert delivering his prediction is exposed to many pressures. In general, the expert´s opinion is a result of a hard work, requiring a high qualification and thus the expert should be adequately remunerated. On the other hand, the expert may be influenced to distort his opinion in favour of the person who pays. It may seem to be the best solution when the expert´s opinion is delivered by a board which is installed by law and paid from public money. This seems to be the case of Aquila, but the result is not encouraging. The experts working for a State board are generally under pressure of politicians, who need only positive news. In fact: „*…evacuation as mitigation action is rarely cost – effective*“ (van Stiphout et al., 2010). On the other hand, an expert can hardly say that a serious prediction of such phenomena as flood or earthquake is not possible. However, the public presentation of opinions or recommendations is always very dangerous because a public statement necessarily involves a simplification of the problem.

9. Some experience

9. 1. Flood prediction

A long-term prediction of an individual flood is not possible; a flood arises as a result of meteorological events, which are caused by non-linear atmospheric processes. It is possible to predict the progression of a flood in time and space if data on rain and flow rate in all tributaries are available with sufficient density. From a mathematical point of view, the prediction is based on a multidimensional auto-regression (e.g. Anděl, 1976, p. 247). There is neither conceptual nor mathematical problem, but measuring the flow rate of a huge masse of water with sufficient precision is sometimes difficult. The straightforward prediction is in this case possible only because the non-linear term in the Navier-Stokes equation may be neglected with sufficient precision and thus the linear model for the flow may be applied. Mostly, the computation is not even performed and the hydrologists deliver predictions only on the basis of their practical experience.

9. 2. Erosion processes

Tangential tension is calculated in a linear model by the equation $\tau = \rho g R i_E$, where ρ is density, g gravitational acceleration, R hydraulic radius and i_E slope (gradient) of energy (Kolář et al., 1983, p. 153). Successive erosion may be calculated as $dm/dt = SC\ (\tau - \tau_k)$

(Wan, Fell 2002), where m is the eroded mass, S is the eroded surface, C is an empirical constant (determined by calibration) and τ_k is critical tension, which depends on the character of rock. The calculation seems to be straightforward, but in this case, the non-linearity is essential. It has been observed that after many years of steady state the rock is suddenly eroded in blocks. This was e.g. the case of the proposed sand and gravel quarry near the river Bečva (Czech Republic), where during a flood in 2002 the river bank was eroded in the width of some 40 m, even though the theoretical calculation based on the above equations predicted 0,5m per year at most. In this case, I recommended the „safe" distance between the river bank and the edge of the quarry to be twice the value of erosion during 100 years, resulting from the linear-made model. Obviously, this solution implies economic loss owing to the reduction of the volume of excavated minerals.

9. 3. Frequency of catastrophic events

Unlike individual events, the frequency of floods, earthquakes and similar events may be reliably predicted, starting from their time-distribution in the past. Historical or geological evidence may be used in combination with statistical techniques. The method is very useful mainly for identification of endangered sites and scaling the urgency of preventive measures. In this case, there is no liability for the individual event; the expert is liable for a proper choice of data and correct application of mathematical methods.

10. Conclusion

The expert must properly evaluate all relevant data. A prediction should emphasize the degree of uncertainty, it is urgent to resist political demand for appeasing prediction. The only general rule seems to be the early elimination of future risk. E.g. the expert should be asked early in the process of regional planning whether a given area is exposed to the risk of earthquakes. It is too late to ask whether an earthquake will occur at a given moment: the answer to such a question can be delivered only in terms of probability.
It results from the above analysis that all types of liability may be applied in case of a wrong prediction; only a court of justice (or an administrative board, defined by the national law) can decide, whether the conditions of liability are met in a specific case. Three possible situations were analysed in the above paragraphs 9.1, 9.2, 9.3. The situation mentioned in 9.3 seems to be the least dangerous, because there is no immediate check of successful or erroneous prediction. The situations mentioned in 9.1, 9.2 seem to be very similar to each other, yet there is a different degree of uncertainty. In 9.1, the non–linearity of the problem may be neglected and a fairly reliable prediction is possible. In 9.2, the problem must be treated as basically non–linear and no simplification is possible. It is an interesting challenge for further research to compare both situations from a more general point of view and to define general conditions for a prediction of Earth processes.

References

Anděl, J. (1976): Statistická analýza časových řad *(Statistical Analysis of TimeSeries).* SNTL Praha.

Hornby, A. S. (1978): Oxford Student´s Dictionary of Current English. Oxford University Press.

Kolář, V. - Patočka, C. - Bém, J. (1983): Hydraulika *(Hydraulics)*. SNTL/ALFA, Praha.

Van Stiphout, T. - Wiemer, S. - Mazzocchi, W. (2010): Are short-term evacuations warranted? Case of the 2009 l´Aquila earthquake. Geophysical Research Letters, vol. 37, Issue 6.

Wan, C.F. - Fell, R. (2002): Investigation of internal erosion and piping of soils in embankment dams by the slot erosion test and the hole erosion test – interpretative report, The University of New South Wales, Sydney.

Author: *JUDr. RNDr. Jaroslav Chyba, DrSc., Water manager of the Morava River Board and member of the academic staff of the Faculty of Law, Masaryk University, Brno.*