ENVIRONMENTAL GEOLOGY AND PLANNING

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Summary

Environmental geology is concerned with the impact of humans on the environment, as well as the influence of the environment on humans. Accordingly, environmental geology plays an important role in planning. The importance of this role undoubtedly will increase as the world population expands since land-use planning must become more important, especially as far as the development of urban areas and the growth of megacities are concerned. Because land is the surface expression of subsurface geology, then those involved with the planning process must appreciate and understand geology; that the earth is constantly changing, sometimes slowly, sometimes with dramatic effect. As a consequence, there is a continuing need for geological data to be gathered and processed. One of the principal ways by which geological data can be represented is on geological maps. A variety of geological maps are now being produced to help land-use planning, and they include environmental geology maps and hazard maps. Geological hazards are of particular importance in relation to planning, and may be natural or due to humans . Some of the most notable natural geological hazards include earthquakes, volcanic eruptions, floods, and landslides. These types of hazard occur again and again, and one type of hazard can trigger another. Hazards due to humans include contamination of land, pollution of groundwater, ground subsidence, and soil erosion. One of the important factors in planning therefore involves the reduction of the impact of hazards. This can be accomplished in various ways, from control measures to warning systems to restricted development, and may well involve a numbers of methods. However, before any of these methods can be put into effect an environmental evaluation must be made, which includes an assessment of the degree of risk. In other words, an environmental impact assessment allows decision-makers to formulate and implement plans. Regeneration of urban areas and of derelict land is vitally necessary in order that urban communities can live in better environments, and conservation is equally necessary.

1. Introduction

Environmental geology has been defined as the application of geological principles to the problems created by the occupancy and exploitation by humankind of the physical environment. However, environmental geology is not just the impact of humans on the geological environment, it also involves the impact of the geological environment on humans. For instance, natural geohazards such as volcanic eruptions, earthquakes, landslides, and floods are usually independent of humans but can have a devastating effect upon their environment. The activities of humans also can have notable effects on the environment. Both of these aspects are the concern of environmental geology. As such, environmental geology is of fundamental importance as far as planning and development of the environment is concerned. The latter must take due account of geohazards and must seek to reduce the number of adverse environmental impacts of society on nature. Accordingly, environmental geology needs to be intimately involved in the planning process, providing basic information necessary to develop acceptable conditions in which people can live. In addition, the increasing public awareness of the importance of the environment requires a deeper understanding of the geological processes at work within the environment.

Land-use planning becomes increasingly important as the human population of the world continues to expand. This is even more important in the context of urban planning in that today almost half the population lives in towns or cities. Most of this urbanization is occurring within developing countries. Obviously, the megacities of the future must be well planned if their inhabitants are to lead worthwhile lives. Accordingly, one of the principal objectives of land-use planning is to improve the quality of life and the general welfare of the community, and this can be achieved by producing better environments in which people live. Therefore, land-use planning should provide a system through which communities can address their development, and should address environmental management. Land-use planning, however, is not just concerned with creating decent living conditions; it has to make sure that these conditions function effectively. Unfortunately, this is not easy to achieve since the changing character of land use, particularly of urban areas, the subjective nature of what is desirable, and the conflicting expectations of people, complicate matters. Consequently, planning involves some degree of arbitration and of compromise, and planning action is an evolving process. Policies that develop from planning, lead to a certain course of action and, as such, may be controversial. As a consequence, ultimately planning policies must be the prerogatives of government, since legislation is necessary to put them into effect.

Human activities and land uses are spatially distributed, with some locations being very specifically determined. For instance, mineral resources determine where mining may occur, and if a deposit is economically viable or strategically necessary. Conversely, many land uses have no specific connection with locality and so may be situated in different places with similar suitability.

Therefore, land-use planning must seek to establish acceptable criteria for the location of each activity. So the problem of location of each activity may involve competing claims from different areas in order to bring about an overall optimization. Of course, the same area of land may be suitable for different uses, and so its use has to be resolved by the planning process.

Land-use planning represents an attempt to reduce the number of conflicts and adverse environmental impacts in relation to society and nature. In the first instance, land-use planning involves the collection and evaluation of relevant data to enable the formulation of plans. The resulting policies depend on economic, sociological, and political influences in addition to the perception of the problem. As noted above, land-use planning is a political process, with decisions usually being taken at various levels of government, depending on the project, after receiving advice from professional officers. It is the planner who makes the recommendations regarding planning proposals, but when a specialist topic is involved, then the recommendations are only as good as the advice received from a specialist. In the geological context, sufficient geological data should be provided to planners and engineers so that, ideally, they can develop the environment in harmony with nature. As indicated in Figure 1, geological information is required at all levels of planning and development from the initial identification of a social need to the construction stage. Even after construction, further involvement may be necessary in the form of advice on hazard monitoring, maintenance, or remedial works.

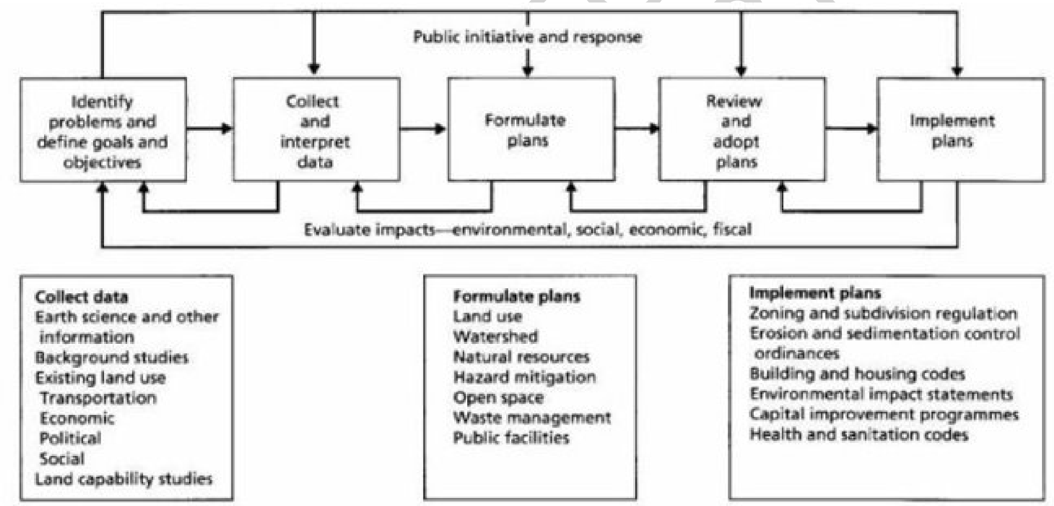

Figure 1. Diagram of the land-use planning process

The importance of geology in planning physical facilities and individual structures cannot be over-stressed, since land is the surface expression of underlying geology. Consequently, land-use planning can only be achieved satisfactorily if there is a proper understanding of the geology concerned. In addition, the development of land must be planned with the full realization of the natural forces that have brought it to its present state, taking into account the dynamic character of nature, so that development does not upset the delicate balance any more than is essential. Geology should therefore be the starting point of all planning. Accordingly, it is important that the planner, developer, and civil engineer should readily appreciate geological data. One of the principal ways of representing geological data is with maps. Maps represent a means of storing and transmitting information, in particular of conveying specific information about the spatial distribution of given factors or conditions. Unfortunately the conventional geological map is often inadequate for the needs of planners, developers, and civil engineers. Recently, however, various types of maps incorporating geological data have been developed for planning purposes. Such maps include morphological maps, engineering geomorphological maps, environmental geological maps, and engineering geological maps. Essentially they should be simple and provide some indication of those areas where there are and are not geological constraints on development.

In Britain the production of comprehensive suites of environmental geology maps began in the 1980s following a pilot study of the Glenrothes area of Scotland. This study produced 27 separate maps covering such aspects as stratigraphy, lithology of bedrock, superficial deposits, rockhead contours, engineering properties, mineral resources and workings, groundwater conditions, and landslip potential. The maps were primarily for the use of local and central planners, but also provided useful sources of information for civil engineers, developers, and mineral extraction companies. The main feature of the study was the presentation of each element of the geology on a separate map in a way that was easy for non-geologists to understand. Environmental potential maps present the constraints on developing areas with poor foundation conditions, that is, land that is contaminated or susceptible to landslip, flooding, or subsidence. They also can present those resources with respect to mineral, groundwater, or agricultural potential that might be used in development or that should not be sterilized by building over. Other methods of using and portraying geological information for planning purposes are in terms of terrain evaluation and geographical information systems.

Since land-use inevitably involves the different development of particular areas, some type of land classification(s) constitutes the basis on which land-use planning is carried out. However, land should also be graded according to its potential uses and capabilities. In other words, indices are required to assess the environmental status of natural resources and their potential. Such indices should establish limits, trends, and thresholds, as well as providing insight that offers some measure of the success of national and local programs dealing with environmental problems.

Over recent years public concern regarding the alteration and degradation of the environment has caused governmental and planning authorities to become more aware of the adverse effects of indiscriminate development. As a result, laws have been passed to help protect the environment from spoilation. Most policies dealing with land-use are concerned with those processes representing threats to life, health, or property, including, for instance, hazardous events and pollution of air or water; or with the exploitation, protection, or conservation of natural resources or the restoration of despoiled areas.

Many older industrial and urban areas are undergoing redevelopment and therefore there is a need to plan the new environment so that land with difficult ground conditions is avoided by building development or the cost of building on it is fully appreciated. Hence, planners require relevant information. In many urban areas data from site investigations are available and can be made use of to prepare engineering geological maps for planners.

Laws are now in force in many countries that require the investigation and evaluation of the consequences to the environment of all large projects. An environmental evaluation can be defined as an activity designed to identify and predict the impact on the well-being of humans of legislative proposals, policies, programs, projects and operational procedures, and to interpret and communicate information about impacts. As such, an environmental evaluation is a multidisciplinary process with a social component, as well as a technical component. Environmental evaluation now forms an established part of good development planning, and was formulated initially in the United States by way of the National Environmental Policy Act (1969). This Act entails the preparation of a formal statement on the consequences of any major federal activity on the environment. In other words, an environmental impact statement is required and this is accompanied by other relevant documents necessary to the decision-making process. An environmental impact statement therefore usually involves a description of the proposed scheme, its impact on the environment, particularly noting any adverse effects, and alternatives to the proposed scheme.

The aim of the environmental impact process is to improve the effectiveness of existing planning policy. It should bring together the requirements of the development and the constraints of the environment so that conflicts can be minimized. Thus, the primary purpose of environmental evaluation is to aid decision-making by national or local government by providing objective information relating to the effects on the environment of a project or course of action. A number of associated objectives follow from this. First, an environmental evaluation must provide objective information on which decisions can be made. It therefore involves data collection relevant to environmental impact prediction. The information must be comprehensive so that, after analysis and interpretation, it not only informs but also helps direct development planning. Environmental evaluation must be relevant and must involve comparative analyses of reasonable alternatives. Plans must be analyzed, so as to ensure that the benefits of a project are fully appreciated. The negative effects, as well as the positive effects, of development proposals have to be conveyed to the decision-makers. Solutions should be proposed to any problems that may arise as a result of interactions between the environment and the project. Geologists are invariably involved in environmental impact investigations.

Checklists are frequently used in environmental evaluation. These are comprehensive lists related to specific environmental parameters and specific human actions. They facilitate data gathering and presentation, help to order thinking, and alert against omission of possible environmental impacts. The matrix approach greatly expands the scope of checklists. Such an approach may have one data set related to environmental parameters and the other to human actions, with the two sets forming a cross-tabulation. A matrix system of analysis can act as a super checklist for those involved in the preparation of environmental impact statements, and also tends to make assessment more objective. The approach involves quantification of data, establishment of cause and effect relationships, and weighting of impacts. The matrix approach can highlight areas of particular concern, or those where further investigation is necessary. The method is adaptable. All cells in the matrix that represent a possible impact are evaluated individually, being scored in terms of the magnitude of the impact and its

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Biographical Sketch

Fred Bell graduated with a B.Sc. and M.Sc. from the University of Durham and received his Ph.D. from the University of Sheffield, UK in 1974. More recently, he received a D.Sc. from the University of Natal. He is a fellow of the Royal Society of South Africa, a fellow of the Institution of Civil Engineers and the Institution of Mining and Metallurgy, and a fellow of the Geological Society, being both a chartered engineer and a chartered geologist. He is the recipient of several awards.

Professor Bell now is a Visiting Research Associate at the British Geological Survey. Previously, he was Professor and Head of the Department of Geology and Applied Geology, University of Natal, Durban, South Africa, during which time he also was a Distinguished Visiting Professor, Department of Geological Engineering, University of Missouri-Rolla, USA.

Professor Bell's research subjects have included ground stability, subsidence, ground treatment, engineering behavior of soils (clays, expansive clays, saprolites, tills, laminated clays, dispersive and collapsible soils, sands), engineering behavior of rocks (sandstones, carbonates, evaporites, shales, basalts, dolerites, granites), cement, lime and PFA stabilization of clay soils, acid mine drainage, mining impacts, landfills, derelict and contaminated ground, rock durability in relation to tunneling, slope stability, aggregates, building stone, and geohazards.

In his professional activity Professor Bell has been involved in a variety of work in the UK, southern Africa, and Malaysia concerning site investigations; foundations; settlement problems on clays, fills and sands; old mine workings and subsidence; longwall mining and subsidence; ground treatment; groundwater resource assessment; slope stability; use of mudrocks for brickmaking; assessment of various rock types for aggregates; contaminated ground; acid mine drainage; landfills; and dam sites.

Professor Bell is author/editor of 17 books, several reprinted, one in its fourth edition, one translated into French, two into Italian and yet another into Malay, and an Indian edition (in English). He is also author of over 200 papers on geotechnical subjects. He has served on the editorial boards of five international journals and has been a series editor for three publishers.