ENVIRONMENTAL RISK AND NATURAL HAZARDS IN EIA'S

Simon Catchpole and Roberto Moreno, BGC Engineering Inc., Apoquindo 3039, Piso 10, Las Condes, Santiago Chile.

Introduction

Most people use a risk-based approach to everyday life, weighing up risks against rewards. It follows that in any serious industrial enterprise, there should be a risk assessment. The greater the risks and rewards, the more rigorous should be the risk assessment. Environmental Impact Assessments (EIA) should be a forum for the socio-environmental part of the risk assessment of an enterprise. The objective of this paper is to demonstrate the importance of considering environmental risk in EIA's and to illustrate the influence of natural hazards on environmental risk.

Risk Assessment in an EIA

In general, EIA's follow a procedure of forecasting the effect of overlaying a project on a pre-existing environment. This starts with an understanding of the baseline environment and a description of the project to be evaluated. The recognition of the environmental aspects of the project leads to the identification and assessment of potential effects on the environment. When the expected effects of the project are considered to have a high level of probability they are analyzed as *impacts*[1], whereas when there is a low level of probability they are addressed as *risks*[2]. As an example of an environmental impact, the regulation of river flow downstream of an operating hydroelectric dam is a certainty with 100% probability. As an example of an environmental risk, the overflowing of river diversion structures by flood flows during construction has a high level of uncertainty, perhaps in the 5-10% range. The uncertainty associated with risks may be a function of the natural variations in the environment, or alternatively a function of the level of care in the design, construction and operation of the project, or a combination of the two. Returning to this risk example, the overflowing of the diversion structures may be as a result of an unusual flood event, or it may be a result of an inadequate design, deficient construction or faulty operation of the diversion system.

In the risk analysis, as opposed to the impact analysis it is useful to distinguish the origins of the uncertainty, and to recognize the environmental *aspect*[3] as a *hazard*.[4] The conceptual procedure for an environmental risk assessment is similar to that of an impact assessment, substituting environmental

[1] Impact - An environmental impact is a change to the environment. Such change can be positive or negative. Environmental impacts are caused by environmental aspects. ISO 14001-2004

[2] Risk - A measure of the probability and severity of an adverse effect to health, property or the environment. AGS (2007)

[3] Aspect - If an activity, product, or service interacts with the environment, it has an environmental aspect. ISO 14001-2004

[4] Hazard - A source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these. (CSA 1997)

"*hazards*" for environmental "*aspects*", since "aspects" produce impacts, whereas "hazards" produce risks. The following figure compares the process for impact assessment with that of risk assessment.

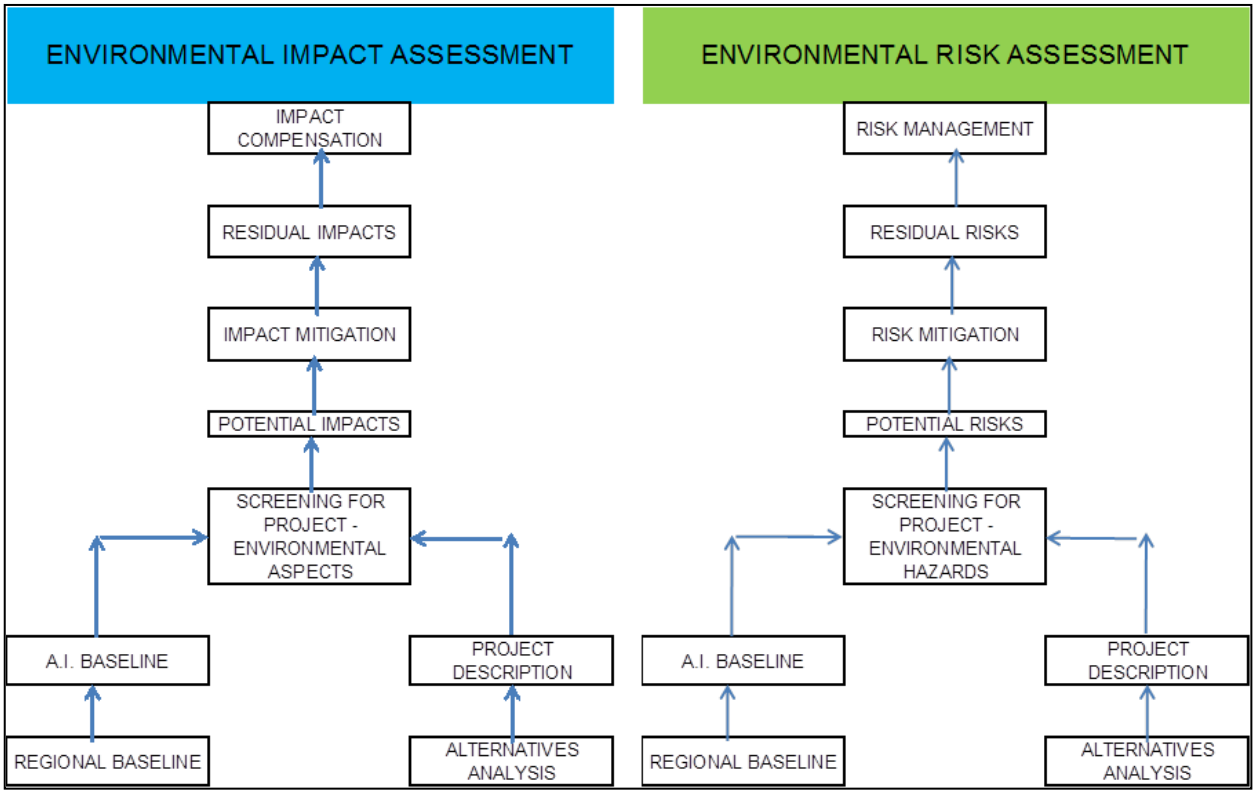


Figure 1: Processes for impact and risk assessments

Incorporating Natural Hazards into an EIA

Given that environmental risks may be generated by natural events as well as human fallibility, a thorough environmental risk analysis will include the effects of natural hazards. The incorporation of natural hazards into an EIA requires examination of the different components of the atmosphere, hydrosphere, geosphere and biosphere. There is a natural tendency of each of these systems which are normally in equilibrium to pass through sudden adjustments or extreme events, such as earthquakes and storms, leading to natural risks. A suggested classification of the various types of natural hazards that produce risks to human enterprises is as follows: seismic hazards and the related tsunami hazards, surface geological hazards and the related hydrological-hazards, and storm hazards and avalanche hazards. This is illustrated in Figure 2 of the environmental components that make up the natural world.

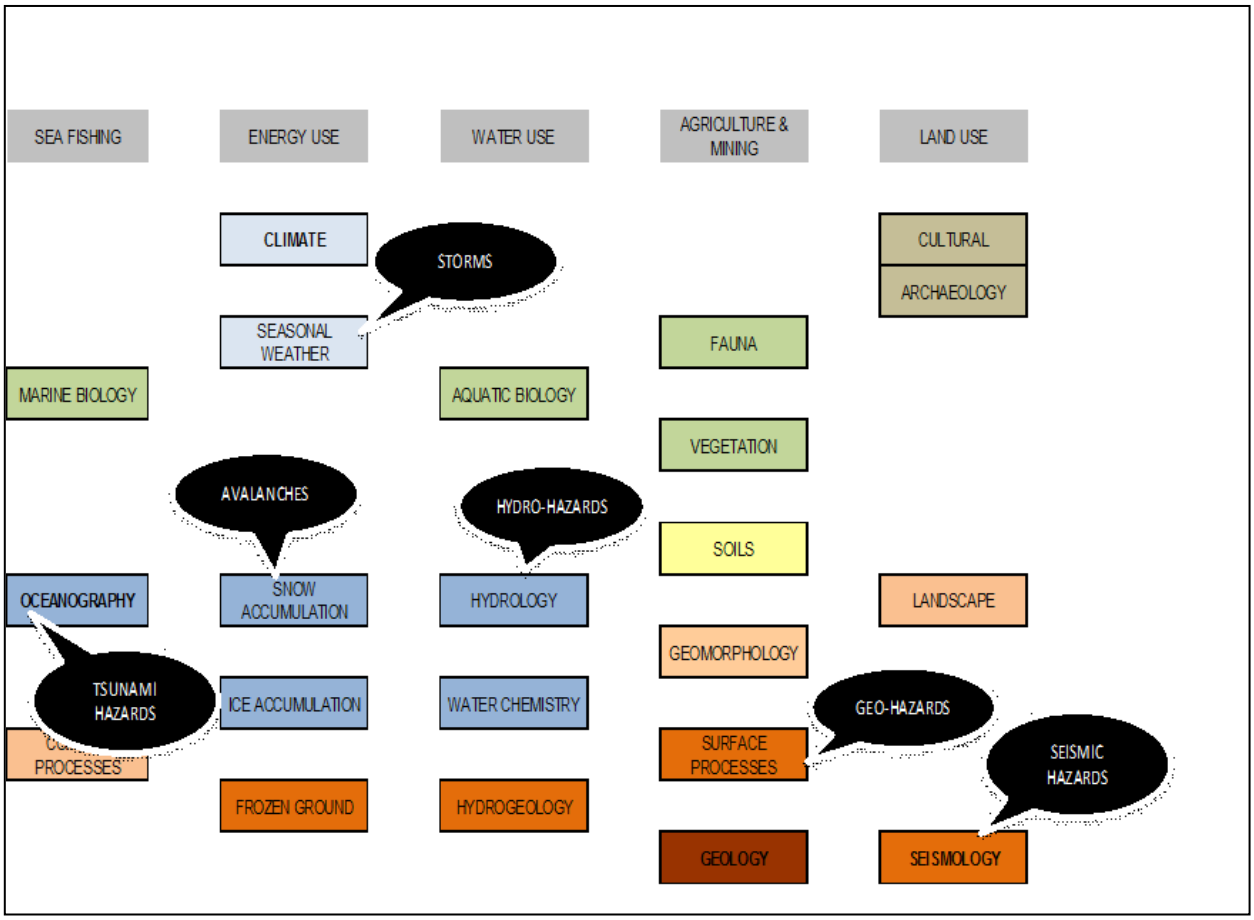


Figure 2: Environmental components and natural hazards

In an EIA, a baseline of the natural hazards in the environment should be established. Then, an analysis should be carried out of ways in which the project activities might modify those hazards and the risks they present to the receiving environment, either by changing the probability of occurrence of natural hazards, or by changing the consequences of those hazards. An example of the former is the destabilization of natural slopes by civil excavations, leading to increased risk to riverine habitat downslope. An example of the latter is the effect of the construction of a reservoir dam that could fail under seismic stress, leading to catastrophic flooding downstream of the dam.

In conclusion, not only the potential environmental impacts of the project should be assessed, but also the effects of natural hazards in enhancing the risks of environmental impacts. This can be illustrated with the use of an environmental cause and effects matrix, which is a tool for identifying potential impacts and risks. Figure 3 shows an example of a matrix that identifies not only environmental impacts (blue) and environmental risks due to project works (green), but also natural hazards influenced by the project (orange) and environmental risks (yellow) that result from the emplacement of the project in an area of natural hazards (i.e. geohazards).

COMPONENT	ENVIRONMENTAL ASPECT OR HAZARD	PREPARATION WORKS			PERMANENT DAM				WATER INTAKE				COMMISSIONING		
		SURFACE WATER DIVERSION	SITE CLEARING	COFFER DAM CONSTRUCTION	EXCAVATION TO BASE LEVEL	MATERIALS MANAGEMENT	DAM WALL CONSTRUCTION	COMPLEMENTARY WORKS	EXCAVATION OF PORTAL	TUNNEL ADVANCE	WASTE ROCK REMOVAL	WATER MANAGEMENT	FILLING OF RESERVOIR	DAMMING OF RIVER FLOW	DISCHARGE OF FLOOD FLOWS
GEOMORPHOLOGY	MODIFICATION OF SLOPES	R	R	I	I		I	R	I				R		
	LANDSLIDE IN CATCHMENT	R	R					R					R		
	MODIFICATION OF WATER COURSES	I					I						I	I	
SOIL	REMOVAL / DISTURBANCE OF SOIL	R	R		I			R	I				R		
	INCREASED EROSION RATE	R	R					R	R				R		R
HYDROLOGY	MODIFICATION OF FLOW REGIME	I		I			I						I	I	I
	MODIFICATION OF SLOPE RUNOFF	R	R					R	I				R		
	INCREASED SEDIMENT LOAD	R	R					R				R	R		I
	MODIFICATION OF RECHARGE TO GROUNDWATER	I					I						I	I	I
	FLOOD EVENTS IN CATCHMENT	R											R		
I	*EXPECTED IMPACT*														
R	*ENVIRONMENTAL RISK*														
R	*EFFECT ON GEOHAZARD RISK*														
R	*ENHANCED ENVIRONMENTAL RISK*														

Figure 3: Identification of environmental impacts and risks enhanced by natural hazards

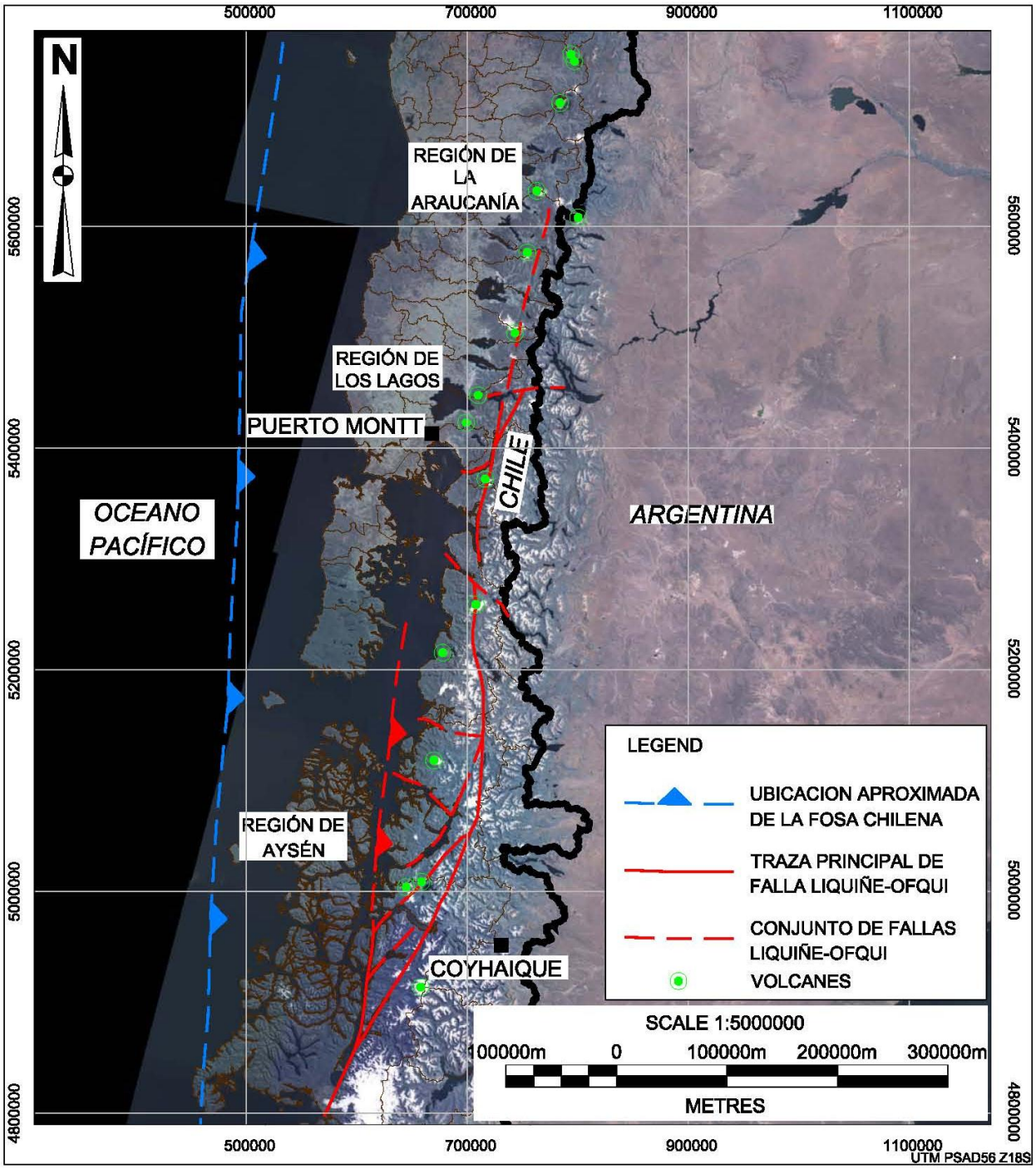
Risk Management

Finally, environmental risk has to be managed, within an overall project risks management program presented in the EIA. This requires additions to an environmental management plan. In a conventional EMP, the potential impacts that have been identified and assessed are mitigated, and after mitigation any residual impacts are compensated. An environmental risks program involves additionally the use of a "risk register", which includes the identification, assessment and mitigation of the risks. Since it is not useful to compensate residual risks, the corresponding activity is residual risk management.

Examples from EIA's for hydroelectric projects in the Andes

Hydroelectric projects in the Andes are particularly prone to natural hazards, which must be considered in addition to their inherent environmental and social effects. In Figure 4 it can be observed that the region in which hydroelectric projects are proposed is associated with major tectonic and volcanic features. As a result, they are subject to natural hazards such as: seismic stress, soil liquefaction, tsunamis, volcanic ash fallout, pyroclastic flows, diverse landslide hazards, and river floods. Several of these natural hazards such as landslide, liquefaction and river flooding may be modified by the hydroelectric facilities, for instance as construction diversions modify river flooding patterns, and reservoir filling affects pore pressures in adjacent hill slopes or saturates soils which may become susceptible to seismically induced liquefaction. Furthermore, the risks to human life of natural hazards like seismic stress and pyroclastic flows may be modified by the insertion of water retention structures in the risk pathways. Therefore, these natural hazards should be factored into the socio-environmental risk analysis since they may modify the risks of a plethora of undesirable events. Socio-environmental

risks that may be enhanced by natural hazards include: risks to downstream population, to the



workforce on site, to lake-margin habitat and to water quality and aquatic life.

Figure 4: Location of tectonic features and volcanoes

Conclusion

A risk based approach to environmental assessment enables all the environmental risks for a project to be identified, including those enhanced by the effects of natural hazards. Once identified, the environmental risks may be assessed and managed with the aid of a risk management register.

References:

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