Geophysical Research Abstracts
Vol. 13, EGU2011-2619, 2011
EGU General Assembly 2011

A comprehensive methodological framework for valuating the intangible effects of the natural hazards.

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In general, damages, which can be easily specified in monetary terms, such as damages on assets, loss of production etc. are called tangible damages. Casualties, health effects or damages to ecological goods and to all kind of goods and services which are not traded in a market are far more difficult to assess in monetary terms. They are therefore indicated as intangibles. Hence, the "intangible" effects are defined as the costs of natural hazards which are not, or at least not easily measurable in monetary terms. The intangible effects are often not included in costs assessments of natural hazards leading to an incomplete and biased cost assessment. However, several methods exist which try to estimate these effects in a non-monetary or monetary form. Under this definition, this paper analyzes the cost-assessment of the human health and the environmental effects and provides a valuation framework of such a complex issue.

Particularly, the objectives of this paper are:
• To compile and analyze the methods for the assessment of health and environmental effects caused by natural hazards.
• To provide recommendations on the cost-assessment methods and to identify research needs and knowledge gaps for their application.

The paper is structured as follows: The first part presents and compiles the cost-assessment methods of the intangible effects which can be found in literature. In this context, it illustrates a general theoretical basis for estimating the intangible effects and analytically presents the cost-assessment methods that are applied or could potentially be applied. In order to compile the cost-assessment methods they are classified as revealed preferences, stated preferences and integrative decision-making processes, following the main principles of welfare and environmental economics. The revealed preference methods, also known as indirect valuation methods, look for related markets in which the environmental good is implicitly traded. Information derived from observed behavior in the surrogate markets is used to estimate willingness to pay (WTP), which represents individual's valuation of, or the benefits derived from, the environmental resource. The stated preference methods have been developed to solve the problem of valuing those goods that are not traded in any related market, by creating hypothetical markets (contingent valuation and choice modeling) and asking people directly about there willingness to pay or their preferences for certain improvements in environmental or health goods. Moreover, integrative methods are used to estimate the intangible costs: Cost-Benefit Analysis, (CBA) Multicriteria Analysis (MCA) and Cost-Effectiveness Analysis (CEA).

The second part evaluates the cost-assessment methods with regard to their applicability in a qualitative way by providing an analysis and comparison using various criteria such as scope, spatial scale, time scale, data availability, precision, resources required etc. Following the presentation of the cost-assessment methods, this part compiles and analyzes the cost-assessment methods in a qualitative way. The comparison of the various cost-assessment methods is achieved by using certain criteria. Each criterion is evaluated in a predefined qualitative scale of pre-defined answers.

Finally, the third part summarizes the most important conclusions concerning the application of different cost-assessment methods used for the estimation of the natural hazards' intangible costs. More specifically, this section explores the best or bad approaches and practices, identifies which methods assure the highest quality of the produced cost estimations and seeks for knowledge gaps that should be addressed by the scientific community.