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A Method for the Evaluation of the Risk Management Performance

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METHODOLOGICAL APPROACH USING INDICATORS

At present, no specific indicators exist in the countries, widely accepted, to valuate directly the performance of risk management or other relevant issues that reflect what we want to measure as risk management. One of the principle efforts at defining those aspects that define risk management has been made within the action framework led by the ISDR (2003) where various thematic areas, components and possible performance evaluation criteria are proposed in draft form (Cardona et al. 2003). In any case it is necessary to evaluate the variables in a qualitative way, using a scale that may run. The method of the Risk Management Index (RMI) described herein, was developed to evaluate risk management performance and effectiveness of countries within Latin America and the Caribbean under the framework of the Disaster Risk Management Indicators Program in Americas, led by the Institute of Environmental Studies (IDEA) of the National University of Colombia in Manizales, for the Inter-American Development Bank (IDB). Program reports, technical details and the application results for the countries in Americas can be consulted in the following web page: http://idea.unalmzl.edu.co. The effort to measure risk management, when faced with natural phenomena, using indicators is a major challenge from the conceptual, scientific, technical and numerical perspectives. Indicators must be transparent, robust, representative and easily understood by public policy makers at national, sub-national and the urban level. This evaluation methodology can be easily applied periodically, facilitating management risk aggregation and a comparison between countries, cities or regions, or any other territorial level. Also, the methodology should be easy to apply in different time periods, in order to analyse its evolution. In risk management assessment, it is necessary to use data with incommensurable units or information that only can be valuated using linguistic estimates. This is the reason why we are using multi-attribute (or multi-criteria) composite indicators and the fuzzy sets theory, as tools to evaluate the effectiveness of risk management.

THE RISK MANAGEMENT INDEX

The RMI was designed to assess disaster risk management performance, and therefore its effectiveness. It provides a quantitative measure of management based on predefined qualitative targets or benchmarks that risk management efforts should aim to achieve. The design of the RMI involved establishing a scale of achievement levels or the assessment of the distance between current conditions and an objective threshold or conditions in a reference country. The RMI was constructed by quantifying four public policies, each of which has six indicators. Risk Identification index, RMI_{RI}, is a measure of individual perceptions, how those perceptions are understood by society as a whole, and the objective assessment of risk. Risk

Reduction index, RMI_{RR}, involves prevention and mitigation measures. Disaster Management index, RMI_{DM}, involves measures of response and recovery, and governance and Financial Protection, RMI_{FP}, measures the degree of institutionalization and risk transfer. The RMI is defined as the average of the four composite indicators:

$$RMI = \left(RMI_{RI} + RMI_{RR} + RMI_{DM} + RMI_{FP}\right)/4 \tag{1}$$

Six indicators are proposed for each public policy. Together, these serve to characterize the risk management performance of a country, region or city. Following the performance evaluation of risk management method proposed by Carreño et al. (2004), the valuation of each indicator is estimated based on five performance levels (low, incipient, significant, outstanding, and optimal). This methodological approach permits the use of each reference level simultaneously as a performance target and allows for comparison and identification of results or achievements. Alternatively, RMI can be estimated as the weighted sum of crisped numeric values, instead of fuzzy sets of linguistic valuation. However, this simplification eliminates risk management non-linearity, having outcomes less appropriated. The sub-indices of risk management conditions for each type of public policy are obtained

$$RMI^{t}_{c(RI,RR,DM,FP)} = \frac{\sum_{i=1}^{N} w_i I^{t}_{ic}}{\sum_{i=1}^{N} w_i} \Big|_{(RI,RR,DM,FP)} \tag{2}$$

where, w_i is the weight assigned to each indicator, I^{t}_{ic} corresponding to each indicator for the territorial unity c in consideration and in the time period t, obtained by the defuzzification of the linguistic values. Figure 1.a shows the membership functions.

a)

b)

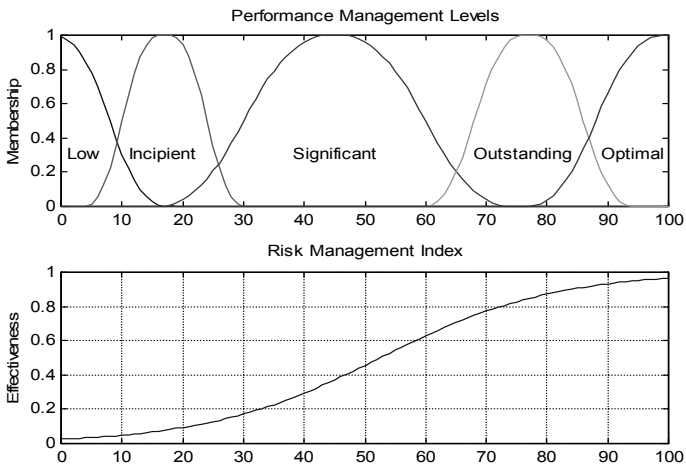

Figure 1. a) Functions representing qualification levels b) Effectiveness degree of risk management

The form and coverage of these membership functions follow a non-linear behaviour, in the form of a sigmoid, as proposed by Carreño et al. (2004) in order to characterize performance of risk management and the level of effectiveness. The response of a socio technical system to risk is equivalent to a level of adaptation according to the level of effectiveness of its technical structure and its organization. These produce various patterns of action, inaction, innovation and determination when faced with risk. Membership functions for fuzzy sets are defined, representing the qualification levels for the indicators and are used in processing the information. The value of the indicators is given in the x-axis of Figure 1.a and the membership degree for each level of qualification is given in the y-axis, where 1 is the total membership and 0 the non-membership. Risk management performance is defined by means of the membership of these functions, whose shape corresponds to the sigmoide function shows in Figure 1.b, in which the effectiveness of the risk management is represented as a function of the performance level. Figure 1.b shows that increasing risk management effectiveness is nonlinear as it is a complex process. Progress is slow in the beginning, but once risk management improves and becomes sustainable, performance and effective-ness also improve. Once performance reaches a high level, additional efforts increase effectiveness significantly. However, at the lower levels, improvements in risk management are negligible and unsustainable; as a result they have little or no effectiveness. The qualifications are processed using the Analytic Hierarchy Process (AHP) to assign weights, see Saaty (1980). Once these have been weighted and aggregated they form a fuzzy set from which it is hoped a reply or result will be obtained. In order to achieve this transformation we need to initiate a process of defuzzification of the obtained membership function and extract from this its crisp value. Qualification for each public policy is the result of the union of the weighted fuzzy sets

$$\mu_{RMI\,P} = \max\left(w_1 \times \mu_C(C_1), \mathrm{K}\ , w_N \times \mu_C(C_N)\right) \tag{3}$$

where w_1 to w_N are the weights of indicators, $\mu_C(C_1)$ to $\mu_C(C_N)$ are the membership functions of the estimates made for each indicator and μ_{RMIi} is the membership function of RMI qualification of each public policy p. The RMI value is obtained from the defuzzification of this membership function, using the method of centroid of area (COA).

$$\mu_{RMI\,P} = \max\left(w_1 \times \mu_C(C_1), \mathrm{K}\ , w_N \times \mu_C(C_N)\right) \tag{4}$$

This technique estimates the area and centroid of each set and obtains a concentrated value by dividing the sum of the product by the sum of the areas. Finally the average of the four indexes provides the total risk management index, RMI.

References

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