A DSS FRAMEWORK FOR SELECTING PROJECTS IN SEISMIC AREAS

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Selecting the best set of projects is a crucial decision in many organizations. Seismic risk could greatly influence the investment process in seismic areas. Current research proposes an integrated multi criteria based methodology that not only able to integrate range of financial and non-financial factors, it also participate the decision makers (DMs) in complex applications by decomposing the process into flexible and logical stages. Unconventional seismic risk assessment is considered jointly with conventional cost benefit analysis. There are many challenges for integrating financial and no-financial factors that make it difficult to be solved by normal tools. On the basis of indicator system, a new DSS framework is suggested that includes seismic risk index jointly with financial factors in a common scale.

Keywords: decision support system, management Info system, modelling.

INTRODUCTION

Selection of the best set of projects for investment is a crucial decision in many organizations. Monetary resources are valuable and it is vital for a government to ensure they get the best return on their investment. Critical decisions for any investment are usually made over the appraisal stage. These decisions are either related to viability or feasibility of the investment considering risk and uncertainty even though the investment is potentially profitable. To guarantee a successful investment, it is required to fully consider the multiple aspects of the projects within its life cycle such as regular financial and non financial factors.

Investment process might be endangered by disasters when the risk and consequences of threats are high. Earthquake events are known as major threat to the development process in prone areas. Despite of many research conducted in financial engineering, there is still no comprehensive framework able to take seismic risk effects into consideration. Furthermore, the previous efforts have failed to bring all significant factors for investment selection together. Many of these DSSs couldn't either consider the interdependency between factors effectively, or take the range of uncertainty into calculation.

Moreover, there are many situations that non-financial factors might also influence the financial factors. For example, seismic risk is a major threat for investment in many countries might affect overall investment decision (e.g. decisions about building a dam or bridges in seismic area).Examining investment literature,some major challenges have been perceived as follows(Levine 2005; Kilford 2008).

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- Insufficient measurement methodologies to determine and integrate project costs, benefits and risks specifically in seismic prone areas.
- Complex nature of decision making where number of potential projects increasing.
- Difficulty in aligning projects and achieving consensus about project priorities.

Thus, to encounter with above mentioned challenges, an appropriate DSS is needed to consider projects economical and risk factors and to ensure the resources spent economically, efficiently and effectively.

REQUIREMENTS OF A DSS

Critical decisions for any investment are usually made over the appraisal stage. These decisions are either related to viability or feasibility of the investment considering risk and uncertainty even though the investment is potentially profitable. Thus the decision process is often required incorporating range of risk factors as well as conventional financial analysis. Decision Support Systems (DSSs) assist DMs in solving problems more efficiently or making better decisions by the use of computer (Sainford *et al.* 1990). It represents an effective combination of many components (e.g. Software, tools, data / knowledge base) which is created for solving complex or ill-structured problems (Arinze *et al.* 1992; Klein *et al.* 1995).

Many researchers discussed about the characteristic of an ideal DSS.For example, while Little (1970) discussed about primary factors such as simplicity, easy to scrutiny, robustness and adaptability, Turban *et al.* (2005), articulated more complete list of fourteen characteristics to develop a successful DSS. Hence, a comprehensive DSS should be able to manage models, data and play as a user interface with DMs and analysts as well. To establish a framework for DSS, it is necessary to define the requirements explicitly. The basic requirements for prospective DSS can be classified as below.

Decision making aspects

- Ability to interact with various evaluation and selection methods.
- Ability to integrate tangible and intangible factors.
- Ability to provide a unified metric for comparison and alternatives priority.
- Ability to consider uncertainty within the process.

Financial aspects

- Ability to measure performance of investments through conventional techniques (e.g. B/C,NPV,IRR).
- Ability to consider time dependency of financial factors.
- Ability to consider varied cash flow characteristic.

Seismic risk aspects (Non-financial)

- Ability to incorporate seismic risk factors.

Several models have been developed to facilitate evaluating and selecting the economically justified projects where the returns outweigh its costs. The projects with highest return are supposed more attractive when their revenue exceeding the cost (Wijnmalen 2007). Usually, the investor and equity holders as main users of performance measures employ NPV, payback period, cash flows as well as their IRR and B/C ratio to evaluate the project investment. The most widely used financial performance measure in public project investment is recognized B/C ratio(CBA) as it incorporate both benefits accrued to the community as long as cost incurred by organization. Thus in the large scale investment, B/C ratio is often employed to provide overall performance(not restricted to economic matters) as well as other financial measures such as overall cumulative project cash flows,NPV and PBP. However, while economical approaches such as CBA (B/C), NPV, IRR consider only tangibles cost and benefits assessed in monetary terms, MC methods taken into account also intangibles parameters through a subjective judgements based on “compromise” principle.

Currently, although the use of MC methodologies in project appraisal has grown increasingly, it does not imply that CBA should be underestimated or downgraded. As CBA is seldom used in isolation with decision making tools, relying on it as a lone method of appraisal may open the criticisms regarding the validity of some basic assumptions of the methodology. These include its disregard of the equity in project appraisal; the potential for selecting whatever discount rate is chosen and the use of money as the sole measure of proposal’s worth (Rogers 2001). Therefore, to avoid these pitfalls, many prudent DMs supplement the CBA with some form of MCA as an adjunct to the purely economic analysis. For example, in 1998, the Department of the Environment, Transport and the Regions of UK published in their “New Approach To Appraisal (NATA)”(1998), a framework for prioritizing between road transport proposals which integrates CBA and MCA through identifying and assessing all the options on a common criteria such as economic, safety, social and environmental. Thus, the prospective model needs to synchronize the CBA and MCA within the same framework to achieve the basic requirements effectively.

PROJECT SELECTION FRAMEWORK

Having defined the main components of the DSS, project selection framework could be conceptualized. The framework is set in two phases consist of screening, evaluation and selection of the projects as illustrated in Figure 1.General characteristic of the proposal projects are to be complied with the requirements and criteria in the first phase. These requirements are already defined based on organizations objectives. The screened projects are then to be evaluated and selected through out the second phase. This phase help organization to ensure that: (1) the objectives will be fully achieved; (2) trade-off between financial (e.g. cost and benefits) and non-financial factors (e.g. risk) among screened projects have been undertaken before considerable amounts of scarce resource are allocated. The main contribution of this phase would be participating the DMs in application, decomposing and structuring the decision making problems.

Phase 0: Benchmarking and Screening

Having accepted the premise that resources consideration is the most significant factor when making project selection decisions, organizations often require to conduct an in-depth analysing and screening before evaluating the projects. Such pre-evaluations would be of important task as they use the appropriate judgment on the basis the role they are supposed to play in business. Furthermore, it is necessary to classify the investments appraisal before evaluating and ranking the projects. Screening the projects investment requires a true perception of the overall prospective of business development, plus the realistic appraisal of each proposed project, to ensure that the benefits can be achieved at an acceptable level of cost. Besides, minimum requirements as well as new refined criteria should be applied in both screening and evaluation of investment for making go/no go decisions. The requirements and criteria may be documented for projects through a checklist that provides the general criteria to be met by project such as: (1) control whether the project is being reviewed at the right level of organization;(2) control whether projects meet the minimum acceptance criteria; and (3) control what level of management scrutiny is available, given the project's size, type and risk (McCowan 2002).

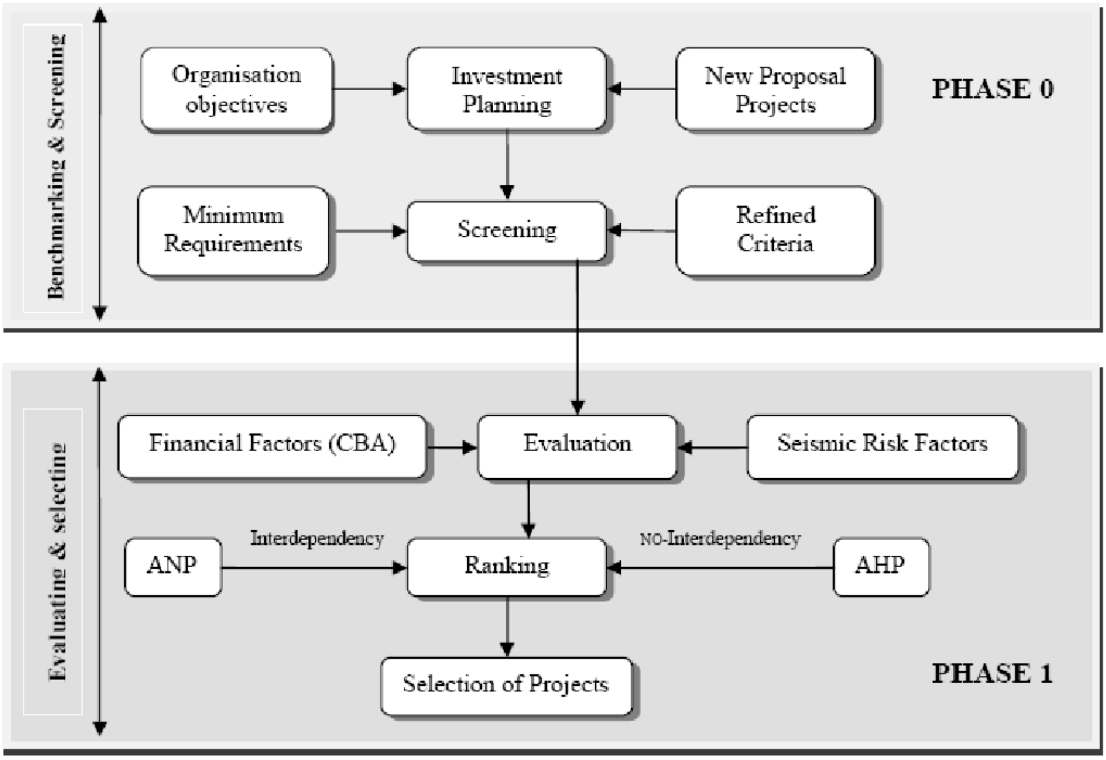

Figure 1: Project selection process

Phase 1: Evaluating and Selecting Projects

Evaluation is a critical step in project selection as it incorporates wide range of factors that contribute in overall weights of the options. The screened proposals are to be evaluated on the basis of financial and non-financial measures. These measures may be tangibles and/or intangibles with different units, types and scales. Thus it is utmost important the factors are set and adjusts in term of magnitude and commensurability to prevent the likely flaw raised within the process. Depending on whether there is any interdependency between factors or attributes, the tools of analysis can be chosen appropriately. For the simple process without any interrelated factors, the AHP is preferred. Alternatively, ANP can be used where interdependency exists among factors and/or alternatives. No matter what technique is implemented, the weighted attributes can be then combined to generate the real ranking in regard to contributed factors.

IDENTIFICATION OF DSS COMPONENTS

There is wide range of financial and non-financial components contributing within the DSS framework that each one might deeply influence the project selection on its own. Financial factors are the first indicator that reflects feasibility and viability of the project proposal. They should be able to capture the true degree of uncertainty through the lifecycle of a project well. To accommodate the uncertainty through different parameters within a project, the risk analysis should be undertaken over both financial and non-financial factors. For example, seismic risk may jeopardize the high profitable projects and increase the overall cost of projects.

Furthermore, components could also interact with each other in certain situations. While the projects aim to increase the return; they may face some degree of risk associated with them. Risk and return could greatly affect each other. For example the projects with higher return usually involves with higher risk. Thus the measurement of each component should be accompanied with likely inter-relation within the system. However the measurement of different factors with range of subjectivity is a complex problem and needed appropriate tool which combines quantitative and qualitative assessment into a single overall measure of value for each alternative. AHP has been chosen to a) Integrate different module; b) Interact with other components with different range (quantitative, qualitative); c) provide a single priority scale among alternatives. The main issues within the components are illustrated in Figure 2.

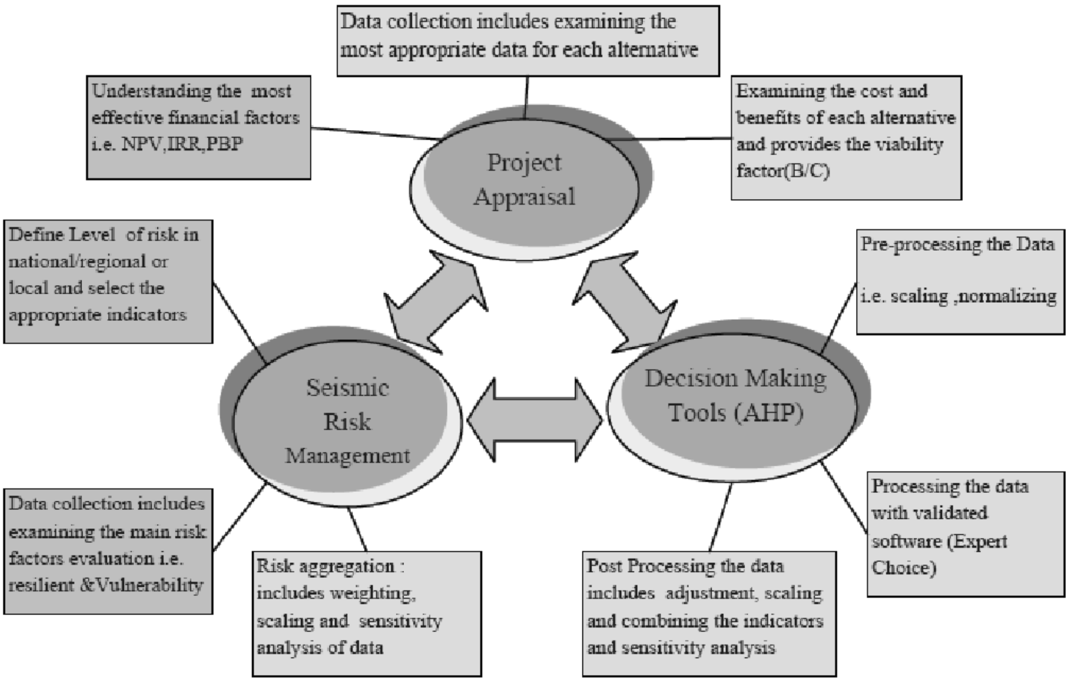

Figure 2: Framework of DSS components

SEISMIC RISK MANAGEMENT (SRM)

Having accepted the risk management as “the reaction to perceived risks”, SRM could be applied in decision process to reduce the impact of earthquake (FEMA 2004).To incorporate the seismic risk effects into financial model,a seismic risk framework should be defined. Different concepts on SRM have been proposed in various analytical frameworks attempts to systemize the model through the conventional and holistic view. Conventional approaches often requires detailed inventory database of the structures and facilities in the region, which is not always available in many areas (Chen *et al.* 1997).Holistic models, in addition, consider socio-economic characteristics of different units in regions as well as seismic coping capacity or degree of resilience (Carreno *et al.* 2009). A holistic framework presented by Davidson (1997) considers seismic risk from economical point of view. This framework assumes a composite risk index as product of four indicators such as hazard, vulnerability, exposure and capacity measures as shown in Figure 3. In contrast to conventional loss estimation methods which takes the seismic risk in term of physical damages, victims and economic equivalent loss, the holistic models tries to add more factors by the means of economical, social, organizational and institutional.

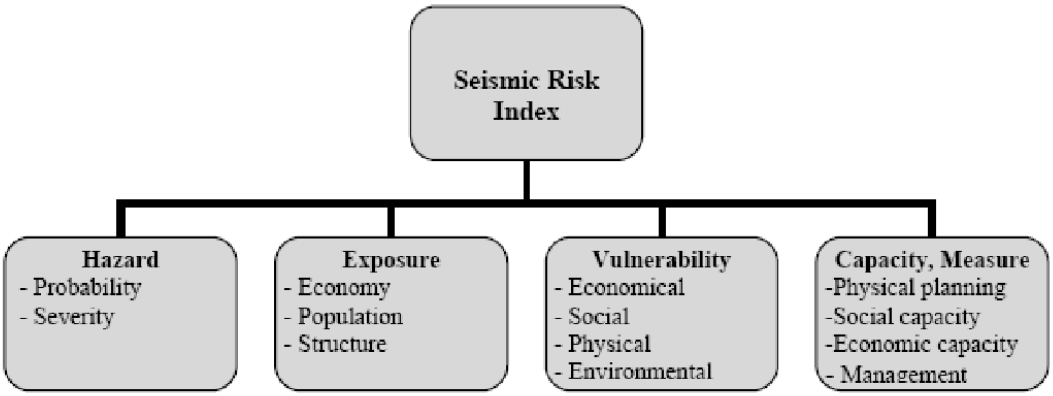

Figure 3: The conceptual framework to SRM (Davidson 1997, Bollin 2003)

Composite risk index allow comparing different points of investment by the mean of relative scale. It employs different subjective indicators to reflect multiple aspects of risk, vulnerability, preparedness and mitigation (Birkmann 2007).Various indicators can be designed for risk analysis and risk management purposes. Using indicators to estimate or measure risks provide a common scale that allows integration the factors relating to seismic risk with financial based factors.

COST BENEFIT ANALYSIS

Cost benefit analysis (CBA) is one of the most common way toward assessing the profitability of an investment. It supports all the financial and non-financial dimensions by converting all factors into common economical scale. Cost–benefit analysis (CBA) seeks to identify the impact of projects on development affected at various points in time, and so estimate the aggregate value which each project gains or loses(Barrow 2006). Although there is large amount of literature on CBA, its shortcomings on environmental impacts has not been investigated. Widespread dissatisfaction with CBA’s effectiveness in valuing environmental issues has led to many suggested improvements or alternatives, some favouring quantitative approaches, and others qualitative (Barrow 2006; Munda *et al.*1994).

Several economists tried to improve the environmental sensitivity of cost–benefit analysis, and there have been many attempts to incorporate economic evaluation into environmental impact assessment (James, 1994). A typical investment appraisal considers only of the benefits and costs of the project to the private firm – its effect on revenues and costs and hence on profit; However the project may have wider implications – environmental and social impacts, for example – but if these do not affect the firm’s profits – its “bottom line” – they are often omitted from the analysis process (Campbell and Brown 2003).

INTEGRATION OF THE COMPONENTS

Having identified the components of the model, it is needed to structure and define the position of each module in relation with each other. Structuring a hierarchy or network requires integrating quantitative and qualitative information which may have a great impact on final result. The process provides four key stages which include data collection, pre-processing, processing (software analysis) and post-processing.To get the best result of the model, and input and output of each component should be fully integrated as it is shown in Figure 4.

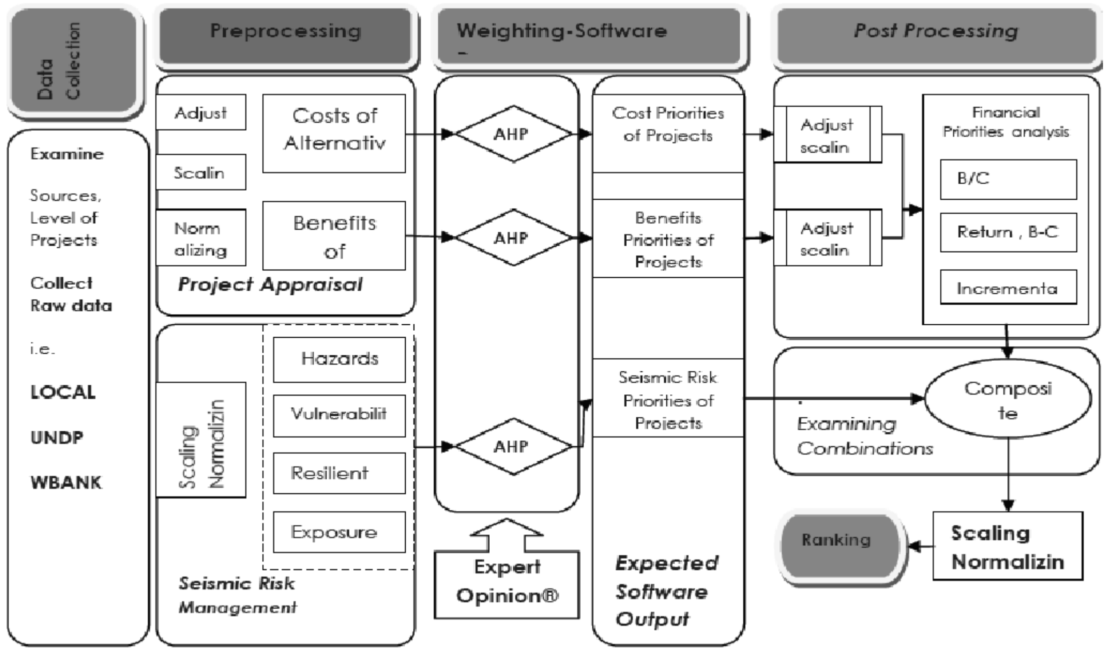

Figure 4: Integration of Input / Output of each component within the model

PRE-PROCESSING

As it can be seen in previous tables, due to wide range of information and great subjectivity, there are different information in term of type, range, size and unit. In order to prepare the raw information as a input data for the software processing, some preliminary modification and conversion should be carried out in order to adjust and compare all attributes in a common scale.

Pre-processing includes a set of mathematical modifications such as adjusting, scaling and normalizing in order to transform/convert from different domain (0,+∞) to a same domain(0,1).Then it is possible to compare and combine the multiple indicators from different range. However, this conversion may associate with uncertainties and may even require to re-scaled and re-adjusted for later interpretation.

X'_i refers to the unitless scaled(transformed) values of the indicators which can be derived from many techniques such as linear function.

$$X_i' = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad , \quad X_i' \in [0,1] \qquad (1)$$

The scaling technique shown in (1) is adopted among possible scaling methods because it is not sample specific and thus no result is depended upon adoption of the indicators; However it requires making different assessments of Xmax (Max possible) and Xmin(Min possible) values.

PROCESSING (SOFTWARE ANALYSIS)

The key stage of the model is to find out the priority weights of indicators which have been contributed in each set of category. This process requires precise loading the data that resulted from pair wise comparison to be undertaken separately for the cost, benefit and risk of each project. The importance of each indicator requires it to be judged by a group of expert individually.

AHP as a common multi criteria(MC) based framework has been applied to the range of financial and engineering problems where prioritizing and selecting set of alternative against some criteria, are intended. Archer *et al.* (1999) for example implemented this method for R&D portfolio selection. Popularity and widely use of AHP has been gained by making several abilities in decision making such as: (1) ability to easily structuring the problem;(2) dealing with both tangible and intangible criteria;(3) simplicity and flexibility due to well-structured hierarchy in process;(4) due to system thinking, it provides details on the structure and function of a system that enables the full overview of the criteria and alternatives during the process. However, some researchers argue about shortcoming of this tool such as: (1) subjectivity in process produces subjective results;(2) Since, no set rules is defined for how hierarchy should be and how many level may require, the structure can be complete or incomplete;(3)As the number of levels and corresponding elements increases,the number of required pair comparison rises dramatically which make it cumbersome process (Wedley 1990);(4) Rank reversal problem where new alternatives is added or deleted the judgment may not consistent any more.

Expert Choice has been employed as the main software which enables DMs to prioritize objectives and evaluate alternatives and align the significant organizational decisions. The software is able to reflect the uncertainty of the results based on input data by providing a powerful graphical sensitivity analysis that help eliminating ill assessed or out of range values.

The expected output of this stage (software process) is three set of priority scales include.

Set Weights of benefits: (wb1, wb2, …, wbn) $\sum$ wbi=1 .
Set Weights of costs: (wc1, wc2, …, wcn) $\sum$ wci=1 .
Set Weights of risks: (wr1, wr2, …, wrn) $\sum$ wri=1

POST-PROCESSING

From previous phase, each project now has a set of benefit, cost and risk and its corresponding weights. But it is not still possible to judge about which one is preferred and what are the following projects are. Therefore, a set of mathematical combination of parameters (i.e. B, C, R) could help one to judge better in a systemized way. This stage would start with examining different combinations (or scenarios) of indicators to justify the best decision. The mathematical combination of indicators makes a composite priority scales which enable decision makers to easily computerize the process for different cases with different range. Although few studies suggested some combinations for composite priorities, most of them either have not been verified yet in practice or limited in application and range. For example there is no combination still suggested particularly for combining and incorporating seismic risk (or even environmental risk) into the business decision making or investment in general. Thus, due to young branch of research, it is necessary to examine many combinations to find out the most appropriate mathematical combination suite for projects, specifically in seismic areas. For this reason, as indicated in Figure 7.2, risk data resulted from previous stage (Software) as well as financial data should be used to verify the multiple combinations in practice to produce the reliable composite priority scale and provide the final ranking subsequently.

CONCLUSION

Project selection process assist decision makers (DMs) to ensure the organizations: 1) select those projects underpinning the mission needs; and 2) identifies and analyses the project 's risk and proposed benefits before a significant amount of funds and resources are allocated. From the critical point of view, the overall objective of this phase is understanding management and developing the application of a structured DM process.

The new DSS framework is set up in three phases which integrates sets of conventional and non-conventional methods on a common economical platform. The methodology shows: (1) how the AHP can be used to model the risk as a separate modifier of the other values and which sort of ratio scales might be misleading in practice; and (2) It also ascertains how the combination of CBA with a MC approach (e.g. AHP) enables the use and integration the variety of financial and non-financial attributes with range of tangible and intangible in nature;(3)The conjunction of the AHP with combinatory allocation within the benefit-cost framework offers a reliable procedure for evaluating and selecting the project's proposals at feasibility stages(appraisal).

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