A MULTIDIMENSIONAL AND PARTICIPATORY APPROACH FOR GREEN BUILDINGS ASSESSMENT

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The development of the decision making process for complex contexts has encouraged the involvement of different stakeholders in the evaluation procedures and tools. Multi-criteria evaluations are increasingly being used in deliberative evaluation process, addressing research experiences and applications towards this new challenge: to give a broader and stronger meaning and consistency to the outcomes of the decision making process. It means to open the decisional arena to different groups with different points of view and involve multiple weights in the multicriteria evaluation framework.
It's widely acknowledged that the need for evaluation tools aiding the complex decisions comes from the consciousness about uncertainty (Funtowicz & Ravetz 1994), that requires to focus more on the process than on the outcomes.

According to these general assumptions, the paper gives a critical review of assessment methods and tools developed in the field of the performance assessment of buildings' sustainability by the Green Building Challenge (GBC) process – launched by *Natural Resources Canada* in 1996 and managed by the *International Initiative for a Sustainable Built Environment* (iiSBE) in 2002 – in order to point out 1) their strenghts and weaknesses and 2) to understand the opportunities to adapt their evaluation framework to the principles of deliberative multicriteria evaluation (Proctor & Drechsler 2006). With reference to the outcomes of this analysis, the paper suggest to enforce the followings issues of the last version of Green Building evaluation tools, called Sustainable Building Tool (SBTool): the evaluation process, the choice of criteria and the weighting system. More in deep, the analysis highlights that weights assignment is the most critical stage, because it is based on preferences and priorities of some decision-makers only (experts, technicians and institutional ones), involved with the task of adapting the generic evaluation framework to the conditions of different context in various regions by tuning values and weights.

To solve this criticism it's important involve other stakeholders in the weighting stage, using specific participatory rules, in order to make the weights assignment as transparent as possible and to strengthen the legitimacy of decisions taken (Munda 2004).

1 The role of multicriteria evaluations in the decision making process

The Multicriteria decision aid (Mcda) methods have been significantly developed in the last thirty years, because of the increase of complexity and conflicts in decision making process (Bobbio 2004), launching research experiences towards the new challenge of giving broader meaning and stronger consistency to the outcomes of the decision making process[1]. These techniques could be considered as tools that support stakeholders and shareholders involved in Decision Making (DM) to organize the available information and to analyze the effects of every single choice, exploring people expectations and minimizing the probability of failure of the final decision (Mattia 2007)[2].

According to these general assumptions, in the last years the interest of the local administrations into the active involvement of citizens, stakeholders and shareholders in the decision making process, has also been experienced in several contexts, where the different initiatives impacted directly on the local communities (Bobbio 2004; Proctor & Drechsler 2006; Mattia 2007). This trend points out the growing demand of advanced methodologies of public involvement in the different stages of the decision making process because of the lack of participatory infrastructures that would be able to promote an effective contribution of those social groups that are generally excluded from the decisions (Bobbio 2004; Mattia 2007) and because of the increasing mistrust in the capability of the actual economical development model to ensure a sustainable and fair future to the contemporary society as a whole (Mattia 2007).

In this framework, the paper gives a critical review of assessment methods and tools developed in the field of the performance assessment of buildings' sustainability by the Green Building Challenge (Gbc) process – launched by Natural Resources Canada in 1996 and managed by the International Initiative for a Sustainable Built Environment (iiSBE) in 2002 – in order to point out: 1) their strenghts and weaknesses and 2) to understand the opportunities to adapt their evaluation framework to the principles of deliberative multicriteria evaluation (Proctor & Drechsler, 2006). The paper analyzes the Gbc methods both in the light of the concerning potential and critical issues in the operating phase and in the concern of the theoretical principles of the Mcda. This analysis is followed by the proposal of updating the evaluation model proposed by the Gbc, starting from a critical interpretation of its more recent version (SBTool), referring to four fundamental issues: *1)* the evaluation process, *2)* the spreadsheets structure, *3)* the assessment criteria and *4)* the weights allocation. Finally, some notes about the relevance of the evaluation as support and orientation tool for the decision making process are included.

2 The evaluation framework of SBTool Model

Starting from the 90s, many different evaluation systems and tools of environmental performance assessment for buildings have been developed, as BREEAM in the United Kingdom, LEED in the United States (promoted by the US Green Building Council), ENERGY RATING in Denmark, ECOPROFILE in Norway, ECOEFFECT in Sweden, ESCALE in France, TOTAL QUALITY in Austria and the DGNB procedures in Germany. These tools are applied with the aim of facing the sustainability issues in the constructions sector with multiple different purposes, as *a)* combining the energy problems with economical and social concerns, *b)* enhancing relationships with urban plans, *c)* applying the appraisal procedures in the different stages of the building life-cycle, *d)* including the urban context and the site features in the evaluation, *e)* involving different stakeholders and shareholders (as designers, evaluators, users, investors and researchers) in the deliberative and evaluative phases and *f)* promoting the performance approach instead of mandatory ones (Oppio, 2002). It is important to remark that most of

[1] For this reason, as it is widely acknowledged that the need for evaluation tools aiding complex decisions comes from the consciousness about uncertainty (Funtowicz & Ravetz 1994), their most important requirement is the attention paid to the process, which should be as democratic and transparent as possible, to be able to face the problems of the legitimacy of multiple points of view (Proctor & Drechsler 2006).

[2] Looking at the multicriteria decision aid systems developed for the multiple criteria decision making, it is possible to identify some common features (Mattia 2007): *1)* the definition of different options to be analysed, starting from alternative criteria, *2)* the involvement of a wide range of stakeholders and shareholders and *3)* the concern for the uncertainty that forces the decision makers to assume a certain relativity about the process outcomes.

these earlier examples of assessment systems did not pursue all of the objectives previously mentioned at the same time. Furthermore, the environmental evaluation and certification systems could be divided into two principal categories: *a)* the eco-balances, applied to assess the environmental effects of the building process, and *b)* the multicriteria systems, based on the attribution of scores, that measure the extent to which the requirements used by tools to appraise the sustainability of building are met. These last ones generally include not only the environmental dimension of sustainability, but also the social and the economic issues.

In this context, the most significant tool is the *Sustainable Building Tool* (SBTool), that is the most recent development of the *Green Building Tool* (GBTOOL, 2KV1.81). The importance of this tool is given from its capability of considering crosswise the sustainability issues previously listed according to a broad multidimensional perspective.

Unlike the most widespread evaluation methods for the environmental sustainability, SBTool, as its previous version (GBTool), pays significant attention to the opportunity of seizing the assessment framework to the features of the local context. As a matter of fact, the requirements system could be considered as a general framework that allows the local organizations involved in the *GB process* to develop one or more rating structures that suit the characters of their own regions and areas.

The most recent version of the software configures the building performance assessment in a hierarchical system, using three progressive detail levels: *1.* Evaluation issues; *2.* Performance categories; *3.* Criteria. The criterion is the single performance parameter and, therefore, it is the lowest evaluation level in the hierarchy; the category is the intermediate appraisal stage, whereas the evaluation issues are the most general assessment ranks. This last level includes seven thematic areas, each one divided into performance categories and criteria, both quantitative and qualitative: *A)* Site Selection, Project Planning and Development; *B)* Energy and Resource Consumption; *C)* Environmental Loadings; *D)* Indoor Environmental Quality; *E)* Service Quality; *F)* Social and economic aspects; *G)* Cultural and Perceptual aspects.

Referring to the assessment stages, as in the previous version of this tool, the evaluation process is based on the importance assigned to different parameters; moreover, the performance analysis could be applied to four fundamental phases: Pre-design, Design, Construction or Operations. According to the long-term perspective for the sustainable development, the tool provides a group of specific requirements for the operating period. Furthermore, SBTool can be applied mainly to three different building types (out of a total amount of 18) separately or in a mixed-use project and both to new or existing constructions.

To be more exhaustive, the appraisal process consists of the following stages: *1)* selection of the assessment criteria with reference to different building types and to life cycle phases (*assessment checklist*); *2)* weighting the three levels of analysis, evaluation issues, performance categories and criteria (*weighting*); *3)* definition of the benchmark parameters (*benchmarking*); *4)* final assessment, referred to the previously defined benchmarks (*assessment*); *5)* report of the final relative and absolute performance results, respectively represented by a spider web diagram (describing the sustainability level achieved in each of the 7 issues) and by twelve sustainability indicators, called Environmental Sustainability Indexes (*results*).

Weighting and benchmarking are two fundamental stages of the evaluation process. There are two weighting systems according to the different tool levels: *1)* the evaluation issues or the performance categories and *2)* the criteria. At the first level, weights go from 1 (that represents the lowest importance) to 5, except for issues and categories considered as *Mandatory*: in these cases, it must be assigned a weight that is higher than 3. The default weighting system gives the main importance to the environmental issues, assigning them an higher weight for the Energy and Resources consumption, for the Environmental Loadings and for the Indoor Environmental Quality. At the second level, it is possible to select the criteria to be included in the evaluation. In order to make the weighting process as impartial as possible, a score from 1 to 3 should be assigned to each criterion, referring to the extent (global or regional; urban or neighbourhood; building or site), the intensity (strong or direct; moderate or indirect; weak) and the duration (more than 50 years; more than 10 years; less than 10 years) of potential effects and impacts on the environment.

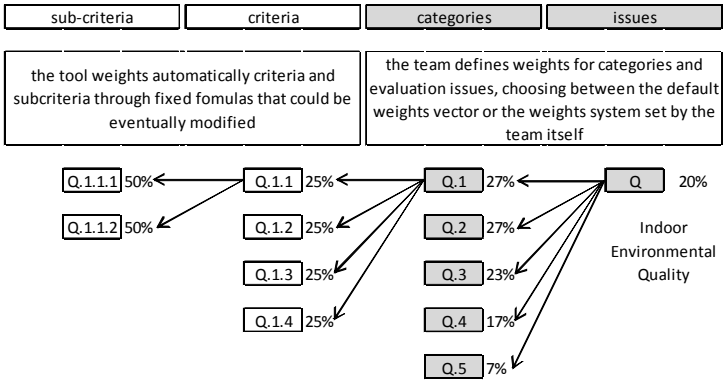

Figure 1: The hierarchical structure of the weighting system of SBTool (Mattia, 2007)

Concerning the benchmarking, the tool provides for a worksheet for each evaluation issue. Benchmarks could be expressed as numerical values or in text form and, although these standards could be both qualitative or quantitative, the performance values are fixed on a scale that ranges from -2 to 5, where -2 represents an extremely negative performance, 3 relates to a good construction practice and 5 is the best building procedure. The 0 value represents the lowest acceptable performance level, generally (but not always) defined by regional regulations and constructions standards. As this performance scale could vary according to the different features of the context in which the tool is applied, it is required that a third party subject sets the performance levels.

For each criterion the tool provides for a sheet that specifies the step of the building life cycle in which it could be applied, the intent, the indicator, the assessment method and the performance values scale. As it is possible to apply the evaluation procedure to different steps of the building life-cycle, SBTool can be considered contemporarily as an *ex-ante*, an *in itinere* and an *ex-post* evaluation tool, that allows the evaluators to verify the consistency of different project options for the intervention purpose, defined with reference to the benchmarks and to the features of the local context, in order to manage the entire construction process, from the options selection (Pre-design; Design) to the control of the energetic and environmental performance in the operating step. The comparison between initial requirements and operating results is undoubtedly meaningful for the improvement of the phases of programming, designing, constructing and managing buildings during a long-term period, but it is not enough to ensure the quality of the construction process and products. As a matter of fact, the initial requirements could not be achieved all together in the best way and at the same time: the absolute best solution is an illusion that a real Multicriteria decision making (Mcdm) process should avoid, searching for the most acceptable and efficient compromise (Mattia 2007), that is the only possible solution for problems with many different, multiple and sometimes conflicting objectives. The choice of the most satisfactory option could be done with reference to the performance acceptability limits, defined by technical regulations, or to the range between the minimum and maximum value of the performance itself, or to the concept of the marginal utility of economic goods (Bentivegna 1987).

In this perspective, it is clear that one of the most relevant characters of SBTool is its adaptability. Authorized evaluators can replace the general weights and benchmarks provided by the tool with their own system, ensuring that the appraisal will be relevant for their specific local conditions. Consistently to the key principles of the sustainable development – promoting specific actions for the local dimension, considering at the same time their broader impacts – this attention for the tool suitability to the regional context of the building represents the strength, that makes SBTool preferable to the previous assessment methods.

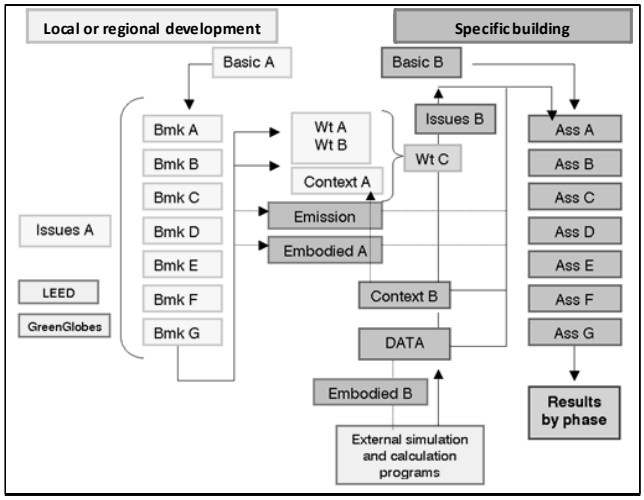

Figure 2: Structure and roles of the Gbc process (Mattia., 2007)

3 Critical review of the evaluation model

After the description of the relevance of Mcda and Mcdm techniques in the decision making process and the description of the SBTool's features, the paper examines the current version of the evaluation system, whose improvement could increase the importance of using it as a tool that could support the decision making process for designing sustainable project options. The paper does not run upon the several and significant positive features of the tool, as they are considered as known. Instead, the critical review of the evaluation model is provided to underline the usefulness of this tool and to identify the limitations that could be solved to obtain a more effective and efficient tool from the point of view of the social and economic matters.

The first criticism of the software is the lack of analysis of social and economical issues, that represents, with the environmental matters, the three principal pillars of sustainability.

Moreover, the SBTool evaluation process allows the evaluators to seize the weights system to the specific conditions of the project (through the file *PROJECT SETTING*), even if exclusively considering the environmental issues (that are described in details through regional and local context criteria). Therefore, the adjustment of the weighting system is considerably significant, when it is applied to environmental issues (energy consumption, polluting emissions and so on), whereas it is not meaningful for social and economic criteria, like, from one side, perceptual matters and cultural topics, or, to the other side, costs and revenues.

Although SBTool evaluates the economical and social sustainability variables (in the thematic areas concerning the Social and Economical aspects, the Cultural and Perceptual aspects – and partially – the Service Quality), socio-economic data about the context are not required, on the contrary of the environmental information. As a matter of fact, sustainability evaluations should consider even the regional governance system, the relationships that exist between the different actors involved in the project and which are the deliberating subjects and how they could decide about alternatives of public interest: all this information is not currently available in SBTool and the model's update has taken it into account.

Another critical point of the assessment structure is that it is strictly linked to environmental and energy issues. The lack of a special attention to the social dimension concerns essentially to the following issues: exclusion of the project stakeholders contribution in the weighting and in the criteria selection phases and the lack of transparency in the choice of weights of issues and performance categories. In order to guarantee a decision-making process open at least to the most important stakeholders, it is necessary that the evaluation system and, then, even the weighting phase would be developed in the

wider involvement of the actors that could be directly or indirectly interested in the project. At this level, the actors contribution could be active (providing resources, knowledge and similar inputs about the economical, environmental and social issues) or passive (considering only effects and impacts on the subject). The evaluation system should convert in objective terms (e.g. in numeric values) all the previous issues, in order to give a proactive and effective contribution, even from the social point of view, to the weighting of each SBTool parameter. For the purpose of identifying the key actors in the decision making process, it is possible to use the stakeholder and shareholders analysis, a process that allows the evaluators to involve different interested groups, enabling the identification of institutions and relations which, if ignored, can have negative influence on projects and policies or, if considered, can be built upon to strengthen them. At this end, it is to be pointed out that the actual version of the evaluation system prevents even non institutional actors from expressing preferences and opinions related to the project appraisal. The third party subject, that should select the parameters' weights, as well as being neutral, should have technical capabilities, cultural knowledge and decisional independence, in order to be able to select parameters' values in a way that is as fair and impartial as possible. For these reasons, citizens are not involved in the evaluation stages. That is why the PROJECT SETTING file can be considered a weakness point of the tool, because weights are not selected by non institutional subjects.

The lack of transparency in the weighting phase is a significant critical element even for the evaluation structure. As a matter of fact, the SBTool worksheets are filled separately from three different subjects. Only one has the duty of choosing the weights of all the parameters used in the assessment structure. As well as the criteria are defined exclusively by a single actor, the percentage of weights are identified on the basis of reasons that are not openly described. As it is applied at the criteria level, the quantitative evaluation of effects on the context ensures a minimum degree of transparency and objectivity, therefore even weights of the evaluation issues and of the performance categories should be assigned according to more general matters, as urban development policies, strategies and plans.

Between the weaknesses, it is pointed out the length of the whole evaluation procedure, that depends on the project complexity and on the number of criteria to be assessed. The collection of data about the emissions of single combustibles used to define the Primary energy factor, for example, requires quite long time, that could be minimized only by the quantity and the quality of available documents and reports.

Finally, SBTool is affected by some methodological problems, as the arbitrariness in the mandatory criteria selection and the strictness of the distribution of the weights of criteria into multifunctional projects. As afterwards described, in order to guarantee a minimum sustainability level of buildings' performance it's necessary to identify minimum thresholds to be respected according to different uses. Moreover, SBTool does not allow to differentiate the contribution of every use in the total score achieved by a project. The problem is increased when the intervention to be assessed includes more than one use, different buildings and open spaces.

4 Addressing the SBTool model to the Social Multi-Criteria Decision Analysis (Smcda)

From the previous analysis it is outlined that it is necessary to modify the current version of SBTool's evaluation framework. The most obvious criticism comes from the weighting phase that, as previously described, has a central role in the evaluation process. More in depth, the research has tried to solve the followings weaknesses: 1) the limited development of the weights' assignment by comparison with the other steps of the assessment process and 2) the stakeholders, shareholders and users exclusion from the decision-making process.

It is meaningful, therefore, to open the weights selection stage, according to specific participation rules, in order to make the weighting determination process as shared and transparent as possible. At the same time, the parameters selection stage should be modified to promote the involvement of stakeholders and shareholders (even not institutional ones).

In this context, a different evaluation process is proposed, in order to solve the principal weakness points of the current software version. In the evaluation procedure shown afterwards, the weights of parameters are defined according to objective and subjective preferences. At this purpose, has been used these evaluation techniques: the stakeholder analysis (Jacobs 1996; Schmeer 1999; Bryson 2004; UE-Cespi

2007), the stakeholder consensus analysis (Elgizouli *et al*. 2005) and the impacts evaluation (Leeuw & Vaessen 2009). In this sense, the context analysis has also been developed, including new social and economical indicators:
1) *energy intensity* (Mwh/€)[3];
2) *Number of renewable energy system* (number)[4];
3) *Crime rate* (number)[5];
4) *Poverty range* (%)[6];
5) *Family per capita Gross domestic product* (Euros)[7];
6) *Families that state to have at least a problem* (scarce luminosity, seepages, crumbling frames or floors) *in their house for 100 families* (%)[8];
7) *Families average monthly expenses for furniture, household electrical appliances and house services* (Euros)[9];
8) *Housing space* (square meters)[10].

Still referring to the context analysis, in order to outline a detailed framework of the possible connections between context indexes and evaluation criteria, an objective tree for every specific thematic area has been created: in this case the hierarchical structure of SBTool in thematic areas, categories and criteria has made it easier, because the "branches" of the objective tree were previously organized. For each criterion up to 3 context indicators have been identified. The relevance of each indicator is given by the percentage of criteria that it influences on the total number of criteria for any evaluation issue. Therefore, the context analysis process has been developed through the following stages: *1)* benchmarking, *2)* context performance indicators calculation, *3)* scores assigning. Once all indicators have been calculated, the sustainability level of the context, with reference to the SBTool thematic areas, is obtained. About the scores assigning step, it is important to consider that the context analysis contributes for the 50% to the weight of each evaluation issue: 50 scores are automatically distributed among them, proportionally to their non-sustainability level. More in depth, the mathematical formula describing this distribution rule of the scores is:

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[3] Connection between energy consumptions and Gross domestic product; this indicator represents a productivity factor of the energy resources use and it is associated to five SBTool classes (Enea, 2005): A (Site selection, Project and Urban development) – Project category; B (Energy consumption and resources) – Renewable energy consumption and Non-renewable energy consumption categories; C (Environmental loadings) – Greenhouse effect gases emission and other atmospheric emissions categories; E (Service quality) – Verifiability, flexibility and adaptability and Operational performance maintenance categories; F (Social and economical issues) – Economical matters category.

[4] Number of systems using renewable energy resources in the reference context; this index is related to the classes named A – Project category, and B – Renewable energy class.

[5] Number of violent crimes (slaughter felonies, fraudulent homicides, infanticides, manslaughters, attempted homicides, fraudulent lesions, sexual assaults, kidnappings, bombings and incendiary attempts, more or less serious robberies) for 10.000 inhabitants, relating to SBTool classes (cf. data produced from Istat, the Italian statistics national agency) named E – Operational phases safety category, and F – Social matters class.

[6] The incidence of relative poverty calculated as the connection between families (and the number of people in families) with the family equivalent consumptions lower than the poverty line and the total number of inhabitant families (and people); it is referred (cf. Ires and Sisreg data) to the F thematic area in all its categories.

[7] The Gross domestic product referred to market prices is the final result of the productive activities of the resident units and it is the sum of the values added to activities market prices, decreased from the credit services and increased of Vat and indirect export taxes; this indicator is associated to the SBTool class (cf. data produced from Ires and Sisreg, respectively the Regional institute for economical and social studies and the Regional social indicators system) named F, but only to the Economical matters category.

[8] Calculated in percentage of families that encounter troubles concerning the lighting, water resistance and construction components quality (frames, shutters, floors and so on). This parameter could be used only for the appraisal of residential interventions and it is associated to the classes (cf. Istat data): B – Non-renewable energy consumptions in the life-cycle and Potable water categories; E – Verifiability, flexibility and adaptability and Operational performance maintenance categories; F – Economical matters category.

[9] Monthly operating average expenses of a family for facilities and services; this parameter could be used only for the appraisal of residential interventions and it is connected to the classes (cf. Istat data): E – Verifiability, flexibility and adaptability category; F – Economical matters category.

[10] Available space expressed in square meters per occupier in houses; this parameter could be used only for the appraisal of residential interventions and it is referred to the classes (cf. Ires and Sisreg data): E – Efficiency category; F – Social matters category.

$$P_i = \frac{S_r - S}{\sum_i^6 (S_r - S)} \cdot 50$$

where P_i are the scores assigned to the *i*-th evaluation issue, S_r the reference sustainability level for the *i*-th evaluation issue and S_i the context sustainability level of the *i*-th evaluation issue.

The criteria impacts analysis is applied in order to evaluate the effects of evaluation factors on the context. This kind of analysis is already available in SBTool, but the inclusion of a subjective component in the decision making process – the stakeholders – introduces significant changes to this appraisal stage. The modifications involve the measurement scale of the impact factors: whereas in the current SBTool version the impacts are assessed by numerical values (e.g. the range in km, the duration in years) that some times could be misleading, in the implementation proposal of the tool they are assessed by a qualitative scale[11].

The weighting construction for each single parameter is then developed in this sequence: *1)* Decisional stakeholders opinions: weights in the SBTool system are distributed between thematic areas, categories and criteria; *2)* Non decisional stakeholders opinions, involving thematic areas and categories; *3)* Context, that refers to thematic areas; *4)* Criteria impacts.

After these analyses, the weight of each single parameter has been developed as described. It is essential to consider separately the different evaluation levels, because in every stage 100 scores are distributed proportionally to preferences resulting from the previous analysis. At the evaluation issue level, the final weights are given by the sum of the scores assigned according to the comparison between the stakeholders opinions (50 scores) and the context analysis outcomes (50 scores). The performance categories weights, instead, are obtained by the scores got through the comparison between the stakeholders preferences (100 scores). Finally, the weights of every single criterion have been defined by the sum of the scores achieved by the Decisional stakeholders preferences (50 scores) and by the impacts analysis (50 scores).

It emerges thereby that the weights at different levels are given, except for the performance categories, from the crossing evaluation of subjective (stakeholders) and objective (context and criteria impacts) preferences. This system guarantees an equilibrium between the stated judgements.

[11] Referring to the impact duration, for example, coherently to the sustainability concept and with the Life-cycle approach, the Life-cycle stages (design, construction, operation and dismission) have been considered instead of the number of years. Thus, the main phases of the impact analysis are: *1)* single components evaluation for the impacts of criteria (range, intensity, duration), *2)* analysis of the contribution of each criterion, *3)* score assigning.

5 Conclusions and future developments

The process suggested to solve the current criticisms of SBTool in a social Mcdm, is coherent with the purpose highlighted in the critical analysis of the evaluation model. Integration between multicriteria analysis and participation methods has been particularly taken into consideration, in order to strengthen the iterative and interactive character of the appraisal process. Actors involved in the decision making process are able to assume final decisions consciously because of the opportunity of verifying the impacts of their choices according to the available information and their expectations into a transparent evaluation framework. In this perspective, the implemented tool, as previously described, could be considered as a sort of decisional multicriteria analysis, depending on its own relevance in the improvement of decision making capabilities improvement, since it makes explicit, rational and efficient the selection between multiple and/or conflicting goals. In this context, assessment is considered as an explorative and constructive activity, based on the use of specific procedures and techniques, in order to verify the level of needs satisfaction in a local context, to activate knowledge and reflection on the process and on the project outcomes, contributing to improve the transparency and to strengthen the legitimacy of the taken decisions (Munda 2004).

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