Context sensitive solutions to improve the roadway performance

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ABSTRACT

Context Sensitive Solutions (CSS) is an approach to transportation decision making and design that takes into consideration the community's needs and sensitivity to the area in which the infrastructure proposal is planned. CSS is the result of developing transportation projects that serve all users and are compatible with the environment and surroundings through which they pass. Successful CSS results from a collaborative and multidisciplinary approach to transportation planning and project development. CSS in the transportation planning and project development process identifies objectives, issues and concerns based on stakeholder and community input at each step of the process. The application of this approach in the initial phase of the design is fundamental for the evaluation of foreseeable impacts, both beneficial and adverse. The final result of the CSS approach should be a better understanding of the linkages between our society, our natural environment and the sustainable use of our endowed resources.

A model to support the CSS approach for the planning of a new and existing corridor is presented, it is a hierarchy model that aims to improve the performance outcomes of the plan by means of a set of 8 evaluation criteria and 22 attributes under 3 macro criteria: technical, economic and environmental. The consultation activity is an important activity and in order to accomplish consensus and to simulate the whole decision making process for a new corridor, the authors propose an interactive consultation of two stratified samples of fifty persons.

The first sample is composed of non-expert individuals but with a high level of instruction, the second one is composed expert individuals in various fields such as: civil engineering, landscape architecture, context sensitive design, economics, environment, construction management and various other key stakeholder groups.

The objective of this investigation is to identify the key criteria and factors of the decision making model and their relative importance. Questionnaires were prepared and distributed to aid in the determination of key criteria and factors during study. Collected data was processed and analyzed with statistical control charts; the relative importance of evaluation criteria was determined without considering scales on which the criteria were measured; and a sensitivity analysis of weights was developed and employed.

The model has been applied to select the best alternative for the San Vitorre-Termoli road in the middle of Italy. The range of alternatives, developed in five critical sections of the original path, were processed by the model. which was built with stakeholder inputs and support in the decision making process.

The alternatives were developed through an agency scoping and public involvement process to seek consensus on where expansion and/or relocation of the corridor should occur in the future. Each alternative was then evaluated by the Electre III method. It is a multi criteria method based on the use of the outranking relations. The outranking relations are built on two indices, namely the concordance index and the discordance index. Based on them, an alternative is "at least as good as" another, if a sufficient majority of criteria support this appraisal (concordance principle) and the opposition of the minority of criteria is not strong enough, to prevent it (discordance principle).

The results of the application confirm the validity of the model developed as a useful tool to support CSS and to overcome difficulties that emerge from interaction between the planning and evaluation activities.

Keywords: context sensitive solutions, context sensitive design, Communicating design to stakeholders.

INTRODUCTION AND OBJECTIVES

Context sensitive design (CSD) has been described as being "among the most significant concepts to emerge in highway project planning, design, and construction in recent years" (*1,2,3*). It is fundamental in transportation project to assess community acceptance according to purpose and need with project features equally relating to safety, mobility as well as the preservation of scenic, aesthetic, historical and environmental resources. It involves policy judgments in the balancing of competing interests. The concept has also been described using alternative terminology: "flexibility in design," "place-sensitive design" and most recently, "context-sensitive solutions" (CSS). Today's state of practice in highway planning, design and operations reflect an appreciation of the importance of context and the demand in order to find appropriate solutions for the local environment. CSS consists of a collaborative, interdisciplinary approach in which citizens become part of the design team (*4,5,6*).
This paper presents a model aimed at supporting this activity as regards the achievement of acceptance and so as to help the planners consider the need of the community whilst preparing the technical proposal. The model was built based on the concepts of the general context in order to identify a potential key strategy for the design proposal within sensitive areas and subsequently balancing interaction between technical choices, aesthetical and environmental values.

In order to obtain this balance, it has been necessary to reach the following objectives:

- Community acceptance;
- Environmental compatibility;
- Engineering and technical functionality;
- Financial feasibility;
- Timely delivery.

In order to successfully integrate a road proposal into its context, a number of factors need to taken into consideration and these they must be summarized as of the following general fields:

- Environmental aspects;
- Visual/Landscape aspects;
- Ecological aspects;
- Cultural aspects;
- Community-related aspects;
- Interpretative aspects;
- Aspects relating to safety/mobility;
- Economic aspects.

The strategy was prepared with the aid of the Public Administration and a multidisciplinary team in order to identify all possible critical elements which provide the direction and guidance regarding the project's management and design.

The particularity of the area made it necessary to characterize the main citizen associations towards which a series of evaluation criteria could be focused and in order to harmonize the entire decisional process. The interaction between planners, public administration and stakeholders has been conclusive in the composition of the model's elements and in their relative application, since this represents the strategy needed in order to obtain the balance from different points of view.

The application of model to the plan relating San Vittore Termoli roadway has been an opportunity to develop a possible key strategy to improve the road performance in a sensitive area using a CSS approach. In particular it allowed to identify how a road proposal may be integrated at best with the environmental context and how operational difficulties that emerge from the EIA study con be overcome expanding the communication between the planners and the community.

CONTEXT SENSITIVE SOLUTIONS – PERFORMANCE OF SAN VITTORE TERMOLI MOTORWAY

The San Vittore Termoli road is the corridor that connects the regions of Molise and Lazio in the middle of Italy. Approximately the 95% of its path is collocated in the Molise Region, while the 5% in the Lazio Region. The road path interests mountain areas, crossing rivers and territories characterized by environmental valence as shown in figure n.1.

FIGURE 1. San Vittore – Termoli road path.

The San Vittore Termoli road represents one of the two principal highway of Region Molise in fact, the accessibility just as the functionality of the internal regional area is subordinated to the correct functioning of the San Vittore Termoli motorway, by in fact optimizing the traveling time towards the more internal areas is also reduced or rather, essential requirements for the re-launching of the local economy are created.

In order to improve the functionality of total road system of Region Molise and the freight between the Termoli's port on Adriatic coast and logistic platforms interchange of Lazio Region, the National Transportation Agency (A.N.A.S.) supported by Transportation Minister developed the road improvement project .

The new project has been developed in thirteen sections for 135.1 km on the base of the existing path in order to minimize the construction costs. However as the original path as its improvement interests particular areas like:

- Historical area;
- Archeological area;
- Residential area ;
- Landslide;
- Rivers;
- Artesian stratums;
- ecological sites.

To improve the road performance compare to these particular areas different aspects were considered like: technical, maintenance, accessibility at the work zone, construction, acquisition area and building interference.
The planners evaluated for each section of new project the interaction between the possibility of use along the path of different typological structures like: natural tunnel, artificial tunnel, bridges and the aspects mentioned before in order to reduce the impacts and take into consideration the community's needs.

Therefore on the base of these considerations the planners developed in the five major critical sections different alternative road paths as shown in the figure n .2.

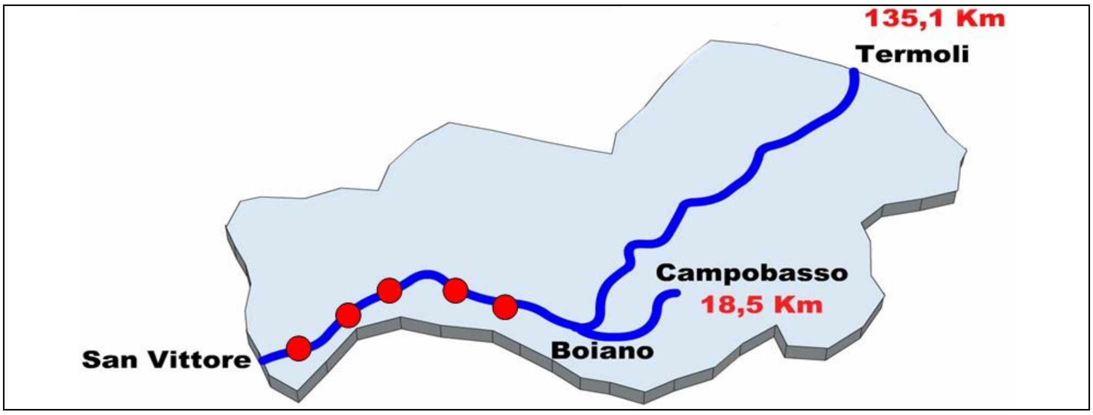

FIGURE 2. The five critical sections of the path.

For each critical section was developed an alternative road path considering the many constraints and opportunities just as the followings aspects:

- Safety - concerns various design elements of road design like: operating speed, minimum lane width, speed limit. It also interests the safety of the worker in function of the construction of different elements on the path like: bridges, natural and artificial tunnel etc.

- Mobility - concerns the conditions of vehicular traffic flows and support the drivers, the level of connection with local road net and the time to travel.

- Environment - concerns the different contributions to road design in the context in terms of air and noise pollution. Well-designed the road path and adequate markings will enhance driving experience and generally tend to reduce noise pollution.

- Aesthetics - concern elements needed in order to safeguard or the compensation measures required so as to guarantee a high aesthetic quality especially in particularly important sites.

- Economics - regards the total economical effort made in order to sustain the road construction and maintenance. Often funding is not sufficient for its realization taking into consideration the consequent difficulties for the planners, contractors and the citizens that negatively judge this as these expenses have come from public resources.

In order to comply the community's need and the consensus, all alternatives developed were introduced by planners to the citizen in the EIA study. The authors did not take part in the design phase but they had access to the design documents as well as to a comprehensive series of other documents related to the project specifications, however they encouraged the public administration for its application as to achieved the consensus about the path and harmonize the decision process as to reduce the unavoidable compensation measures.

Generally the consultation activity (*7*) is an important part of a CSS study and in order to achieve acceptance and to simulate the entire decisional process, the authors proposed an interactive consultation of two stratified samples consisting of fifty people each. The first simple was composed of people who were not experts in any particular field yet who had a high level of education, the second group was composed of experts in various fields such as: civil engineering, landscape and context design, economical, environmental and construction managers as well as different stakeholders.

A key component of the approach is that citizens play an active role in the planning, design, and construction phases of the intersection process. The proposed approach, included extensive and continuous dialogue with the stakeholders as well as an in-depth technical analysis of alternative improvement strategies, known as planning concepts. In particular, two surveys were developed, the initial phase was carried out in order to identify the general plan and existing conditions. In this phase an analysis of the set alternatives developed by the planners was carried out and the following tasks were considered in order to take any comments into consideration:

- The study of existing and future conditions in order to identify existing and future deficiencies;
- The identification of motorway improvement opportunities;
- The analysis of economical and environmental links;
- The analysis of alternative solutions defined by planners and the stimulation of new alternatives;
- The development of the model costs for any alternatives;
- The assessment of alternative design concepts for the implementation of the preferred solution;
- The identification of the assessment process and the selection of alternative solutions.

These tasks are very important and they must be inserted as a basis for the decisional process in order to improve the responsibility and the sharing of the project by the citizens involved.

This approach is one way of balancing conflicting project goals with environmental and economical aspects.
In the second survey, the authors illustrated the methodology used for the construction of the estimation model in compliance with Italian law provisions. In fact, with the purpose of obtaining construction authorization, it was necessary to conduct an EIA study. This is an evaluation of foreseeable positive and negative impacts. It is intended to help reveal mitigating measures as well as alternatives so as to optimize positive impacts while reducing or limiting negative ones. The end result of the EIA process should be a better understanding of the links between our society, natural environment and the sustainable use of our endowed resources.

For this reason, in this study, the authors proposed a hierarchic model the weights of which have been determined by availing of the same, previously described samples. Each sample consisted of fifty people, for the convenience of data management and based on successful past experience (*8*), these were subdivided into 5 groups of 10 people each. Each group was characterized by the presence of two experts in various technical disciplines: engineering, environmental science, economics etc. This formula was communicated to the stakeholders without being influenced at all; each group freely chose its experts.

This operation was fundamental in order to stimulate and put the interested sample into action. In this way they felt an integrated part of the plan.
The objective of this survey was the identification of key weight criteria as well as model decision-making factors and their relative importance. In fact, a questionnaire was prepared and different activities such as focus group discussions and interactive meetings were conducted during the study.

The Saaty (*9*), scale for pair-wise comparison was the method used by the authors. The results of the questionnaire were analyzed in terms of average and variance results and the results that were more than three times the variance value were eliminated.

The rating was performed in two phases. In the first phase, all experts and non-experts completed the questionnaire. In the second phase, the same questionnaire was submitted again but only to the people whose answers were outside the confidential interval (average ± variance) calculated with reference to the panel of experts. A confidential interval of the answers was shown to the people interviewed and they were asked to answer the questionnaire again. Following the conclusion of the second phase, a new confidence interval was calculated and answers outside the interval were removed. The analysis also calculated the evaluation of errors in weight judgment using the Saaty Eigenvector scaling method.

MODEL

The CSS study is usually applied in the public contracts works for the comparison of several plan alternatives, analyzing each step of the project alternatives, using a multidisciplinary approach to obtain the real impacts and consequently the compensation measures.

The objective of this paper is to discuss the use of this approach in order to overcome difficulties that emerge between the planning and construction phases. A hierarchy model was developed to support this approach. According to the CSS procedure, a group of experts in different disciplines was involved together with all stakeholders interested in the project of the San Vittore Termoli motorway.

Each project must be necessarily the result of an interactive process and the best project represents the point of equilibrium between technical, economic environmental aspects involved.

To communicate this concept to the citizens and to share it before the evaluation phase of alternatives is fundamental in order to reduce the distance between the various points of view. In fact, only after to have shared and comprised the general plan during the focus group it is possible to estimate the alternatives in terms of impacts positive and negative. Generally a road path is strategic for the territory's valence, consequently it must be suitability compare to all scenarios presents and futures, it must be shared from all the points of view or at least from the majority of them. Therefore the authors have built a hierarchical model according to the CSS approach with a specific objective: select the best road path and improve its performance with the consensus.

This activity was a key strategy for the design proposal set in a critical area, in fact it was not only necessary to consider the community's needs to preserve scenic, aesthetic, historical and environmental resources but also to harmonize the project with technical aspects such as mobility, safety and its economic budget.

A model to support the CSS study in the road plan was presented referring to a hierarchy model that aimed to improve the road performance via a series of 8 evaluation criteria and 22 attributes under 3 macro-criteria technical, economic and environmental as shown in figure n.3.

GOAL	CRITERIA	SUB CRITERIA	ATTRIBUTES / INDICATORS	
SELECT THE BEST ALTERNATIVE	*Environmental*	**Air**	**1.** Sensitivity to harmful dust and gas	Ng
			2. Sensitivity to noise	Nr
		Water	**3.** Deep stratum pollution	Ip
			4. Physical interference with deep stratums	Gf
			5. Superficial water pollution	Re
			6. Physical interference with superficial waters	Ni
		Soil	**7.** Consumption of materials and anthropic impact on areas	V
			8. Noise and vibrations	Iv
			9. Land erosion	Er
			10. Landslides and landslide risks	Fr
		Natural Resource	**11.** Flora and biodiversity	Le
			12. Fauna	Lf
			13. Environmental value of the area	Lv
	Technical	**Safety**	**14.** Comfort of travel	Dh
			15. Drivers' safety	Na
			16. Workers' safety	Od
		Mobility	**17.** Local net connection	Cn
			18. Level of Comfort while travelling	Tp
	Economic	**Value of the road**	**19.** Value of acquisition areas	Es
			20. Value of design and construction	Pr
			21. Value of maintenance	Gm
		Economic development	**22.** Economic development of the area	Se

FIGURE 3. Hierarchy model.

The model was created according to the general Italian law provisions and basic CSS principles.
To build the model a survey was performed, in the first phase a focus group was conducted analyzing the project, the context and community's need. In this survey with the support of the stakeholders involved the authors have also evaluated the criteria, sub criteria and indicators that reflect the performance road levels to satisfy and the community 's expectations.
The hierarchic framework has three levels under the general objective and initially this was larger including other sub-levels and further sub-criteria, then during meetings where the principles were illustrated, according to which we intended to construct the model, some of the sub-levels and sub-criteria were eliminated both due to problems of redundancy and to facilitate data management.
In the second phase of the first survey, a questionnaire was prepared in order to indentify the key wight criteria and their relative importance. The authors proposed the AHP approach and the analysis also calculated the evaluation of errors in weight judgment using the Saaty Eigenvector scaling method(*9*).

Therefore the authors proposed the model shown in figure n.3 with a simple, easy-to-manage framework.

The model used to evaluate the best alternative is a hierarchical system which subdivides larger impacts of the project into smaller elements called sub-criteria and indicators. The indicators are very important as they must be:

- Manageable;
- Independent;
- Measurable.

They can be qualitative and quantitative, but it is necessary that they are representative of the performance level measurement of the road proposal compared to the sub and model criteria. This model was also developed, with the objective of achieving acceptance as well as stimulating the entire decisional process, in fact the authors proposed an interactive consultation of two stratified samples of fifty people each.
The model supports the planner during the selection of the alternative with the best performance whilst respecting the environmental, technical an economical elements of the project.
Each alternative developed in the five critical section was processed by the model, the relative performances were measured by using indicators compared to the criteria and sub-criteria shown in the previously introduced model.
In order to measure the performance of different alternatives, maps were used for both collecting and presenting information. Besides general topographic maps, more information is needed in environmental studies concerning geology, land use, hydrology, road and railroad networks, vegetation, agriculture, etc. Consequently the use of specific maps called thematic maps are of particular interest for the evaluation of interferences relating to the project. Thematic maps can be in a conventional form or in the form of a Geographical Information System (GiS) .A GiS is a computer–based database that includes spatial references to different variables stored, so that maps can be easily and relatively quickly displayed, combined and analyzed.
In this work different maps were used referring to:

- Geology;
- Ecological sites;
- Vegetation;
- Historical sites;
- Visual;
- Health;
- Water;
- Settlements;
- Severity.

Others maps were specially constructed in order to identify the feasibility of the alternative, in particular each area of the territory was subdivided in areas of 500*500 m in which some details were homogeneous such as: soil, drainage, vegetation etc. For some model indicators a specific map was elaborated or alternatively, the actual value was calculated as in the case of indicator Ng. It represents the number of citizens affected by harmful dust and gas. Its value was calculated as the number of equivalent citizens compared to the surface of a standard building measuring 40.0 sq. m with an offset from the ramp or road axes measuring 150 m and 200 m and used for urban purposes (housing, hospitals, industries etc.). The data collected data for each alternative was processed by the model and the relative performance was calculated compared to the criteria and sub-criteria using a multicriteria method.

EVALUATION METHOD

The model was applied to evaluate the alternatives developed by planners in the five critical sections. The weights shown in the next table have been determined involving the stakeholders in the decision process used an AHP approach. During the second survey the authors presented the evaluation method and its principles. In particular they used the ELECTRE III method (Elimination Et Choix Traduisant la REalite) (*10*). It is particularly suited to aiding the choice between project alternatives on the basis of mainly environmental criteria. The multicriteria method requires values of three criterion thresholds, the indifference threshold (*q*), the preference threshold (*p*) and the veto threshold (*v*).

These allow the uncertainties inherent in the criteria valuations to be incorporated into the decision process and these thresholds which govern the outranking relationship of one project option over another represent the effect stakeholder's preference or resistance on the difference between any two criterion scores.

TABLE 1: Model Weights

Cr	Wk
1	0.08
2	0.016
5	0.028
6	0.028
7	0.021
9	0.021
10	0.058

Cr	Wk
11	0.068
12	0.027
15	0.064
16	0.019
17	0.06
18	0.077
19	0.018

Cr	Wk
20	0.018
21	0.018
22	0.055

The goal is then to select the best alternative given the performance values of each alternative with respect to each criterion (given as an m× n decision matrix) and the corresponding weights of the criteria. For modeling the preference information between each pair of alternatives, such as *ai* and *aj* (i,j = 1, . . . ,k), the evaluation method uses the concept of outranking relations.

A true outranking relation of *ai →aj* (also denoted as *ai* S *aj*) implies that *ai* is preferred to *aj* if *ai* is at least as good as *aj* on a majority of criteria and if it is not significantly bad on any other criteria (i.e., the difference between the two are within a predefined threshold) (*11*).
By establishing such a relation between each and every pair of alternatives, it is possible then eliminate the dominated alternatives and arrive at the nondominated solutions. The construction of the outranking relations, however, is not an unambiguous task, particularly in the presence of conflicting multiple criteria.

The identification of an outranking relation between *ai* and *ak* requires two sets of comparisons: one among the criteria in which *gk(ai)* is superior to *gk(aj),* one among the criteria in which *gk(ai)* is not superior to *gk(aj).*

In other words, the evaluation method need to separately examine both the criteria that vote for *ai → aj* and those that veto such relation. These two sets of comparisons are performed based on the socalled concordance (Cij) and discordance (Dij) tests. The concordance test allows the decision maker (DM) to verify if *ai* is at least as good as *ak*, such a test is binary in nature: the concordance index is 1 when the test is passed and it is 0 when the test is failed. For example, if the criterion *gk* is to be maximized, the condition *gk(ai) < gk(aj)* results in a failed concordance test, whereas the condition *gk(ai) ≥ gk(aj)* results in a passed test.

The Electre III method was applied to the model in order to measure the performance of different alternatives developed for the "San Vittore Termoli "motorway.

The outranking relations were modelled through three relationships as shown:

$$aP_j b \Leftrightarrow g_i(a) > g_j(b) + p_j$$
$$aR_j b \Leftrightarrow q_j < g_j(a) - g_j(b) \le p_j$$
$$aI_j b \Leftrightarrow \left|g_i(a) - g_j(b)\right| \le q_j$$

where:

- ***P*** that expresses preference and it is neither symmetric, nor transitive; ***I*** that expresses indifference regarding the two alternatives and it is both symmetric and transitive; ***R***, that expresses non-comparability, which is also both symmetric and transitive.
- The indifference threshold q_j is the largest difference of performances significant for indifference and the preference threshold p_j, is the largest difference of performances not significant for a strict preference.
- The veto threshold v_j is the smallest difference between the performances of two alternatives, above which the user thinks that it is not possible to support the idea that the worse of the two alternatives may be comprehensively considered as good as the better one, even if its performances on all the other criteria are better.

In the next table are presented for each model's element the thresholds, while in the next figure is shown the final order graph representative of the preference between the different alternatives proposed.
The table shows the thresholds values of the element compare to the criteria and sub criteria that must be maximized or minimized.

TABLE 2: Preferences, indifference and veto thresholds

Attributes	Min. Value	Max.Value	qk	pk	vk
1	82	500	52.25	209	334.4
2	102	650	68.5	274	438.4
3	3.65	100	12.04375	48.175	77.08
4	0	50	6.25	25	40
5	1	50	6.125	24.5	39.2
6	1	70	8.625	34.5	55.2
7	349732.8	9999999	1206283.275	4825133.1	7720212.96
8	18	200	22.75	91	145.6
9	0	30	3.75	15	24
10	0	30	3.75	15	24
11	1443.6	50000	6069.55	24278.2	38845.12
12	7987.4	60000	6501.575	26006.3	41610.08
13	1130	30000	3608.75	14435	23096
14	0	5	0.625	2,5	4
15	-0.025	2.5	0.315625	1.2625	2.02
16	1	35	4.25	17	27.2
17	30	10500	1308.75	5235	8376
18	0.095	0.5	0.050625	0.2025	0.324
19	102128	999999	112233.875	448935.5	718296.8
20	200000	998753321	124974999.9	499899999.5	799839999.2
21	219000	999000	97500	390000	624000
22	1	5	0.5	2	3.2

In Electre III (*7,8*), the comparison of alternatives in the way that has just been described leads to the building for each pair of alternatives (a, b) of a concordance index, that is expressed as:

If $g_i(a) \leq g_j(b) - p_j(b)$ then $c_j(a,b) = 0$;

If $g_i(b) - p_j(b) < g_j(a) \leq g_j(b) - q_j(b)$ then $0 < c_j(a,b) = \dfrac{p_j(b) - [g_j(b) - g_j(a)]}{p_j(b) - q_j(b)} \leq 1$;

If $g_i(a) > g_j(b) - q_j(b)$ then $c_j(a,b) = 1$.

where:

- p_j(b) is the preference threshold for criterion g_j and alternative b;
- q_j (b) is the corresponding indifference threshold.

Then, all the indices of an alternative are added, giving its total *concordance index* C(a,b) for the term "alternative *a* is at least as good as alternative *b*, regarding the whole set of criteria" as:

$$C(a,b) = \frac{\sum_{j=1}^{n} k_j \cdot c_j(a,b)}{\sum_{j=1}^{n} k_j} \quad (2)$$

where k_j is the weight of criterion *j*.

The discordance index D_j(a,b) expresses the opposition to the term "alternative *a* is at least as good as alternative *b*, regarding criterion j" and is estimated by the relation:

If $g_i(a) > g_j(b) - p_j(b)$ then $D_j(a,b) = 0$;

If $g_i(b) - v_j(b) < g_i(a) \le g_j(b) - p_j(b)$ then $0 < D_j(a,b) = \dfrac{g_j(b) - g_j(a) - p_j(b)}{v_j(b) - p_j(b)} \le 1$;

If $g_i(a) \le g_j(b) - v_j(b)$ then $D_j(a,b) = 1$;

where $v_j(b)$ is the veto threshold.

In this work the authors proposed a correlation between Saaty's scale used to evaluate the relative importance of the criteria and concordance/discordance index as shown in the next figures.

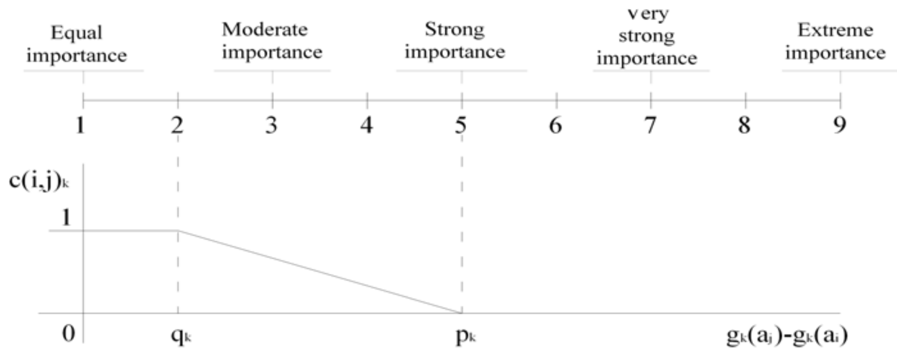

FIGURE 4. Correlation Saaty's Scale – Concordance index.

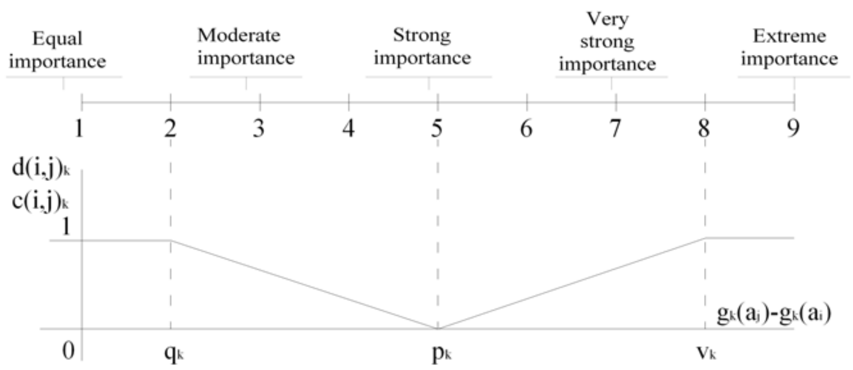

FIGURE 5. Correlation Saaty's Scale – Discordance index.

For every term “a outranks b”, the creditability degree σs (a,b) is estimated as following:

If F is the sample of criteria, we define as:

$$\overline{F}(d,b) = \{ j \in F \,/\, D_j(a,b) > C(a,b) \}$$

and

$$\sigma\ (a,b) = \begin{cases} C(a,b) & \text{if } F(a,b) = \varnothing \\ C(a,b)\prod_{j\in F}\dfrac{1-D_j(a,b)}{1-C_j(a,b)} & \text{if } F(a,b) \neq \varnothing \end{cases}$$

The ranking algorithm of ELECTRE III uses the credibility matrix (the matrix of *σs* (*a*,*b*)) to build two rankings using descending and ascending distillation: *descending distillation* selects at first the best alternatives to end the process with the ones. On the contrary the *ascending distillation* selects first the worst alternatives to the process with the best ones. An alternative which is incomparable to a group of others will be positioned at the end of this group in the descending distillation and at the top in the ascending distillation.

The differences between the distillations, allows the decision maker to detect the alternatives that exhibit special sensitivity, regarding non-comparability and to examine analytically. In this application the intersection between the two distillations: descending and ascending gives the same result as shown in the next figure.

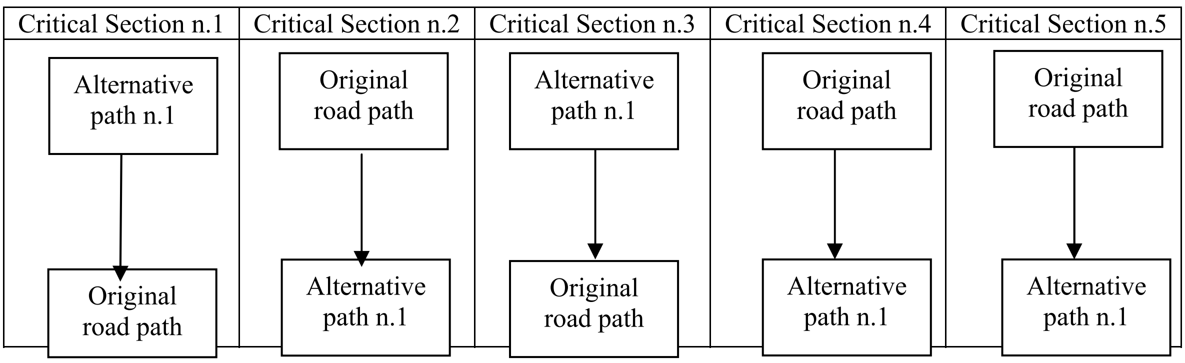

FIGURE 6. Final graph – results of comparison.

The alternatives under study were processed using the model presented and whilst the contribution of two stratified samples of fifty persons. They were involved in the consultation activities and several tasks were performed like : focus group and meeting in which were submitted a questionnaire in order to evaluate the key criteria and their relative importance.

A model was built during the consultation activity and the Electre method was presented to each group of stakeholder in order to transfer the community’s need in the decision making process. The threshold values were calculated compare to the preferences expressed by stakeholders in the questionnaire and in function of the criteria that have been maximized or minimized. Each alternatives developed by planner was processed by hierarchic framework and the relative performance was measured through the indicators’ values and by the application of the Electre method. Each indicator selected was shared from the samples involved according to their expectancies and Italian EIA (Environmental Impact Assessment) procedure.

The next figure shows the road path shared for the five critical section.

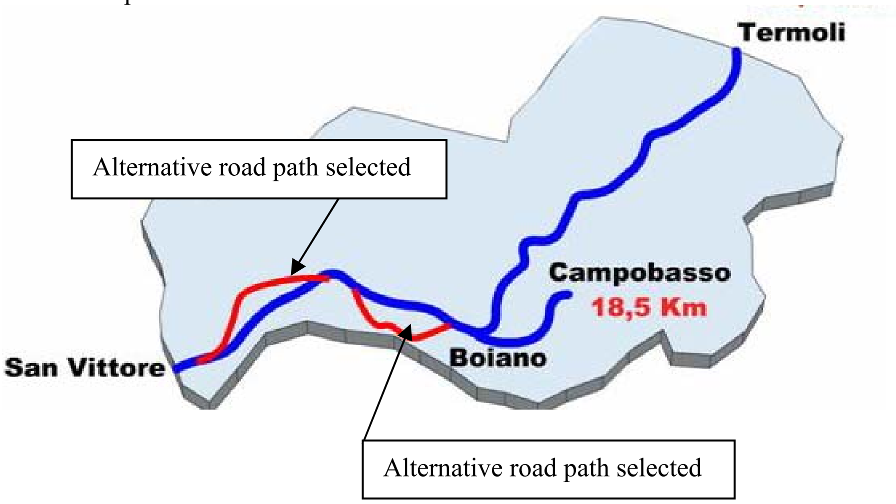

FIGURE 7. The best road path of San Vittore -Termoli motorway.

CONCLUSION

The model application and the performed procedure to evaluate the community's need through the weights of criteria represent a key strategy to aid the planners and governments in the planning phase and in the consensus determinations and agreements when public financing is employed. When it is applied on the competitive comparison between alternative planning proposals, this model assumes the role of objectivity regarding adherence and performance related to the targets of environmental and technical sustainability.

The consultation activity is fundamental to achieving consensus determinations and in simulating the whole decision making process based upon the preferences of the stakeholders and the local community in terms of consequent benefits:

- Public acceptance, trust and support;
- Positive relationships with stakeholders;
- Create partners rather than opponents;
- Timely decisions;
- Improved project process;
- Decisions that last.

Moreover use of the Electre III, representing a decision making process with its contradictions, has permitted :

- use of both quantitative and qualitative criteria;
- acceptance and integration of the concept of non-comparability of alternatives, in the whole procedure of classification or ranking;
- treatment of non-comparability, with two approximations, so as to focus on the alternatives that exhibit special characteristics;
- simplicity of comparisons and consequential~~ly~~ understanding of the results;
- convenience in the application of the method, manually or with a personal computer.

The application to the San Vittore Termoli road path confirms the validity of the model and its benefits in the evaluation of the suitability of a new or existing road alignment when critical areas are of a concern.

REFEREENCES

1. NCHRP. NCHRP Report 480: A guide to best practices for achieving context sensitive solutions. TRB, National Research Council, Washington D.C. 2002.
2. AASHTO GREEN BOOK: A Policy on Geometric Design of Highways and Streets , 5th Edition.
3. Jones, R. Context-sensitive design: Will the vision overcome liability concerns? *Transportation Research Record: Journal of the Transportation Research Board No.* 1890,
4. Thinking Beyond the Pavement: National Workshop on Integrating Highway Development with Communities and the Environment While Maintaining Safety and Performance. Maryland State Highway Administration, May 1998. ww.sha.state.md.us/events/oce/thinkingbeyondpavement/tbtp.pdf.
5. Ewing, R. Impediments to context-sensitive main street design. Transportation Quarterly. 56(4):51-64. 2002.
6. "Context-Sensitive Design Around the Country." Transportation Research E-Circular. Edited. Nikiforos Stamatiadis. Washington, D.C.: Transportation Research Board, 2006.
7. Thinking Beyond the Pavement: National Workshop on Integrating Highway Development with Communities and the Environment While Maintaining Safety and Performance. Maryland State Highway Administration, May 1998. ww.sha.state.md.us/events/oce/thinkingbeyondpavement/tbtp.pdf.
8. Discetti P., and Lamberti R.. Value Engineering for context sensitive solutions. *in Transportation Research Board Annul Meeting.* W. DC, January 2009.
9. Saaty, T.L. (1980), *The Analytic Hierarchy Process*, McGraw-Hill, New York, NY.
10. Roy, B., ELECTRE III: Un algorithme de classements fonde sur une représentation flue des préférences en présence de critères multiples, Cahiers du CERO, 20 (1) 3-24. (1978).
11. Roy, B., and Bouyssou, D., Aide multicritere a la decision: Methodes et cas, Economica, Paris, 1993.