

A combination of Quality Function Deployment and Analytic Network Process to evaluate urban redevelopment projects: An application to the Belle de Mai – La Friche of Marseille, France

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Abstract. This paper proposes a methodological framework to integrate stakeholders' requirements and different aspects of urban redevelopment projects. We propose the application of the multi-criteria decision analysis techniques combined of Quality Function Deployment (QFD) and Analytic Network Process (ANP) in order to evaluate the revitalization projects for areas where an industrial past has vanished from an economical point of view, but still remains in the character of the buildings and the area. This work illustrates the application of the methodological framework in order to evaluate the principals aspects of the transformation of the site "Belle de Mai – La Friche" in Marseille, a former tobacco factory where, since the early 1990s, the 45,000 m² have been a centre for contemporary cultural and artistic events. Trough a combination of QFD and ANP we intend to verify the possibility of this procedure can contribute to the decision-making process and the general consensus.

Keywords: multi-criteria decision analysis; quality function deployment; analytic network process

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Introduction

The very often difficult relationship of interdependence that exist between economic regeneration policy and urban restoration of industrial zones have been established both theoretically and empirically; nonetheless, in administering territorial policies and in the actual theoretical studies, there is often a considerable gap between these two environments. Decision-making for sustainable development in the built environment requires new approaches which are able to integrate and synthesize the principal aspects of an urban system and different stakeholders' points of view (Munda, 2004).

The paper proposes the definition of a comparatively new integrated approach of two techniques in this contest, directed towards stimulating interaction between the various stakeholders, making a "creative competition" (Teisman, 1997), and building the consent. Moving in this direction, the following proposals are made:

- The use of the Analytic Network Process (ANP), (Saaty, 2000, 2006) belonging to the much broader family of multi-criteria analyses as an instrument for assessing territory and urban transformation strategies (Bottero *et*

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al 2008). The contribution that can be provided by multi-criteria assessments, particularly in the presence of complex problems that directly involve the various stakeholders, is stressed (Figueira *et al*, 2005).

- The integration with a marketing tool, the Quality Function Deployment (QFD), with its core scheme for strategic planning (Bergquist and Abeysekera, 1996; Govers, 1996), which can be represented by a decisional structure named the “House of Quality” (HOQ).

The combination of QFD and ANP methodologies is here applied to a case in Marseille where a former industrial zone has become a centre for artists, writers, musicians, theatre directors and producers. The zone, called “Belle de Mai- La Friche”, is an interesting case where a spontaneous development of temporary artistic and cultural spaces has created one of the main cultural facilities of Marseille. The process, begun 15 years ago, is still under construction.

After the introduction, the paper is organized as follows. First of all we present, very synthetically, the ANP and the QFD methodologies. Paragraph four stresses the principal aspects of the integrated approach of the two techniques. The integrated approach is better clarified by the application to the case study “Belle de Mai- La Friche”. We conclude the paper with some reflections on the combined use of the two techniques in order to evaluate the urban regeneration projects.

Analytic Network Process methodology

The Analytic Network Process (ANP) is a multi-criteria technique able to consider a wide range of quantitative-qualitative criteria, according to a complex model (Saaty 2000, 2006). The ANP structures a decision problem into a network and uses a system of pair-wise comparisons to measure the weights of the structure components and rank the alternatives. It consists in the control hierarchies, clusters, elements, interrelationship between clusters, and interrelationship between elements.

The ANP is a generalization of the Analytic Hierarchy Process (AHP), also introduced by Saaty (1980). Whereas AHP represents a framework with uni-directional hierarchical relationship, ANP allows for more complex interrelationships among decision levels and attributes. Figures 1-2 shows the structural difference between AHP and ANP. The ANP allows interaction and feedback within and between clusters and provides a detailed framework to include cluster of elements connected in any desired way in order to investigate the process of deriving ratio scale priorities from the distribution of influence among elements and clusters.

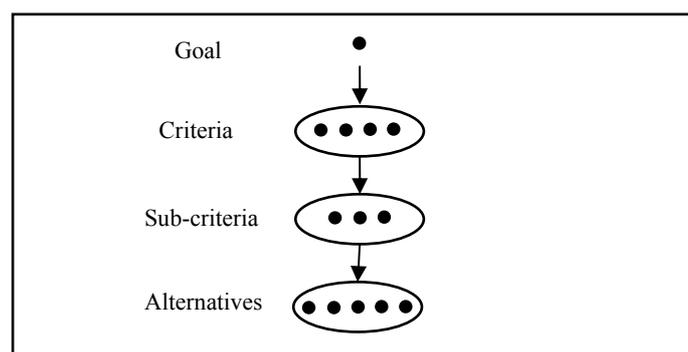


Fig. 1. Analytic Hierarchy Process structure (Source: Saaty 2006)

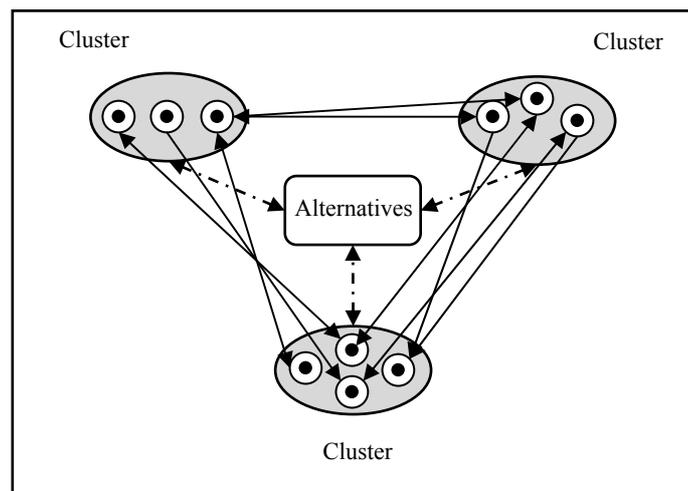


Fig. 2. Analytic Network Process structure (Source: Saaty 2006)

By incorporating interdependencies (i.e., addition of the feedback loops in the model), a supermatrix will be created. The supermatrix adjusts the relative weights in individual matrices to form a new “overall” matrix with the eigenvectors of the adjusted relative weights.

Overall, there are five major steps in the ANP process:

1. Develop a decision network hierarchy showing the relationships among the decision factors (structured in clusters and nodes);
2. Elicit pair wise comparison among the factors (clusters and nodes) influencing the decision;
3. Calculate relative-importance-weight vectors of the factors.
4. Form and normalize the supermatrix.
5. Calculate converged (‘stable’) weights from the normalised supermatrix.

To incorporate decision makers judgments about the various elements in the network in the ANP model we used pair wise comparison. The technique requires the decision makers to express their judgment by entering a number, using the fundamental scale by Saaty.

A very important role could be played by the ANP in a territorial transformation process, (inevitably of long duration) in which subsequent stakeholders are associated in a constantly-changing context and multi-criteria assessment processes permit benchmarking with a mixed set of objectives, that are often expressed in different units of measurement and linked together by various relationships of dependence, and also identification of new definitions of the problem (Bottero, Lami, Lombardi. 2008).

Quality function deployment methodology

Quality Function Deployment (Akao, Mizuno 1994) is a market oriented tool to transform user demands into design quality. This technique translates customer needs into appropriate technical requirements. House of Quality (HOQ) is a part of the QFD and it utilizes a planning matrix to relate what the customer wants, to how a firm is going to meet those needs. HOQ is a kind of conceptual map that provides the means for interfunctional planning and communication (Hauser and Clausing 1988, Karsak *et al* 2002). The HOQ is built using seven elements (Fig. 3):

1. *customer needs (WHATs)*: the product is described in the language of the customers, therefore this element is also known as ‘voice of the customers’. Customer needs tell the company “What to do” to satisfy their requirements. This information is usually gathered through focus groups or individual interviews in which the customers are encouraged to describe their needs and problems.
2. *product technical requirements (HOWs)*: also known as ‘voice of the company’, this element represents how the customer needs can be satisfied by the company.

3. *relative importance of the customer needs*: the customer needs must be collected, organized and rated so the company can work on the most important needs while disregarding relatively unimportance ones.
4. *relationships between WHATs and HOWs*: the relationship matrix indicates how much each product technical requirements (PTRs) affects each customer need. Its structure is a standard two dimensional matrix with cells relating to a combination of individual customer needs and technical requirements. Each combination of customer needs and technical requirements is considered in turn and the following question is asked: “How significant is technical requirements A in satisfying customer need 1”? The level or interrelationship discerned is weighted usually on a four point scale: high, medium, low, none.
5. *inner dependence among the product technical requirements (PTRs)*: the inner dependence is used to understand whether and how there are correlations between the PTRs and if these are positive or negative. For each matrix cell the following question is asked: “Does improving one requirement cause a deterioration or improvement in other technical requirements?”. These different levels of positive or negative interaction can be indicated with the use of different symbols. In this paper we used the following levels and symbols: strong (+++ or ---), medium (++ or --), weak (+ or -).

The information recorded in the “roof” matrix is useful for the design team. Firstly, it highlights where a focused design improvement could lead to a range of benefits to the product. Secondly, it focuses attention on the positive and the negative relationship of the design which can represented opportunities for innovative solutions.

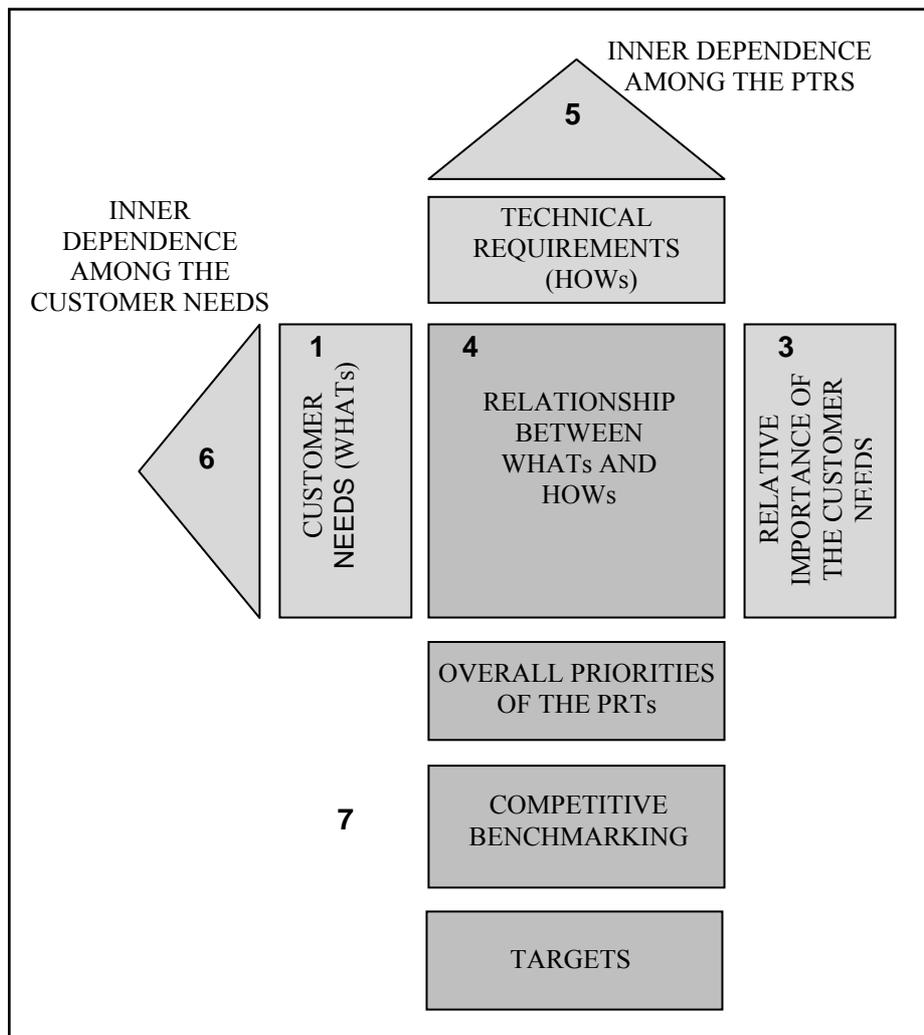


Fig. 3. House of Quality (HOQ) (source Akao, Mizuno 1994)

6. *inner dependence among customer needs*: the inner dependence among customer needs describe the relationship between customers requirements;
7. *overall priorities of the PTRs, Competitive Benchmarking and Targets*:
 - a. *overall priorities*: to get the overall priorities we consider the relationship matrix (WHATs and HOWs) and the relative importance of the customers needs. Each interrelationship is multiplied by the relative importance of the customer needs.
 - b. *competitive benchmarking*: Each of the technical requirements that have been indentified as important product characteristic can be measured both for the company's own existing product and the available competitive products. This illustrates the relative technical position of the existing product and helps to identify the target levels of performance to be achieved by a new product. In this paper we used this section to analyze the requirements of alternative scenarios.
 - c. *targets*: the final output of the HOQ is a set of engineering target values to be met by the new product design. To get the targets we consider simultaneously: customer needs and its relative importance, the relationship matrix, the overall priorities, the competitors' performance and organization's current performance, that is, in our case the actual ability to achieve the transformation.

Combination of quality function deployment (QFD) and analytic network process (ANP): Principals and aspects

If the use of the AHP technique to determine the representation of the voice of the customer in the HoQ is consolidated (Akao, 1972, Sullivan, 1986, Hauser, Clausing 1988), the use of ANP in the HoQ is still quite limited. Quality Function Deployment with Analytic Network Process were used to estimate non-market net benefits (Parra Lopez, *et al* 2008). In formulating goal programming models that include multiple qualitative goals, a method based on pairwise comparison such as AHP and ANP appears to be an effective means for assessing relative weights (Karsak *et al* 2002). In the ANP method the customer needs and product technical requirements are the network nodes, and ANP was used to estimate the importance of these nodes. The ANP outcomes were used to complete the HOQ. Moreover, it has to be underlined that the use of ANP in the HoQ is particularly rare in the evaluation of urban transformation projects (Abastante *et al*, 2010).

The ANP network most commonly used in combination with the HOQ is shown in fig. 4 (Parra Lopez, *et al* 2008; Karsak *et al* 2002). Its structure consists of three clusters: the cluster of the goal, the cluster of the WHATs, and the cluster of the HOWs. This is the case of hierarchy with inner dependence within components and no feedback. The customer needs correspond to the criteria whereas the PTRs correspond to the alternatives, both of which have inner dependence within themselves. HOWs must be evaluated with respect to their contribution to satisfy each WHAT, however, there is no feedback, so the customer needs are not dependent on the PTRs.

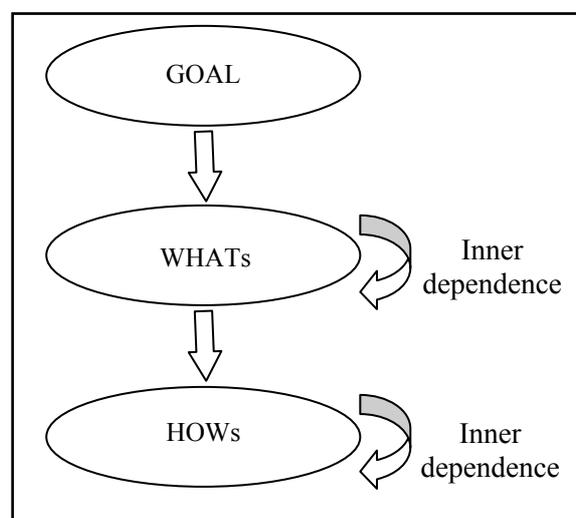


Fig. 4. ANP with inner dependence and no feedback (Parra Lopez, *et al* 2008; Karsak *et al* 2002)

The HoQ matrix forms the basis for inserting the network model ANP. The advantage of combining two different techniques is a greater scientific precision in the allocation of weights at the level of “What’s” while maintaining the simple and intuitive scheme of HoQ.

Even if the application of the two techniques together brings benefits, it does not solve all the problems already encountered in the techniques used individually. Table one describes the pros and cons of each technique. It also identifies the commonalities, differences, synergies and conflicts between the two techniques when used together.

Table 1. QFD and ANP in comparison.

Technique	Pros	Cons
QFD	<ul style="list-style-type: none"> - Clear visualization of all problem components. - Opportunity to compare products already on the market. - Better integration of the weaker stakeholders through the ‘voice of customers’. 	<ul style="list-style-type: none"> - Rigid structure. - Designed for an industrial product.
ANP	<ul style="list-style-type: none"> - Detailed structure of decision-making - Flexible structure 	<ul style="list-style-type: none"> - Many questions - Network is not always clear
Quality Function Deployment(QFD) & Analytic Network Process(ANP)		
=	commonalities	- QFD and ANP aimed to optimize the product
≠	differences	- QFD is a marketing tool ≠ ANP is decision-making tool
++	synergy	- Better structuring of the problem
--	conflicts	- In simple cases would be sufficient to apply one technique: ANP or QFD

The case study: Transformation of the site “Belle de Mai – La friche” in Marseille

The Belle de Mai industrial zone

Marseille has been elected the European capital of culture for the year 2013. The choice is related to the transformation process in act since 1995 in the French city, when the City of Marseille initiated an urban renovation plan for districts that had suffered from the industrial-port crisis. It was the largest real estate operation in France, and probably the largest urban renovation project in Europe.

The project, called “Euroméditerranée”, is international in scope, involving the renovation of an area of 480 hectares in the heart of the city (at the beginning the area was smaller, equal to 313 hectares), between the commercial harbour, the Old Port and the high-speed train (TGV) station.

Euroméditerranée brings together major public players: the State and local authorities, who, grouped in the the Etablissement Public d’Aménagement (Public Planning Authority), decide the major directions of the projects.

Located right in the centre of Marseille, the new extension will, over the next 15 years, acquire 2,000,000 sq. mtrs of housing, offices, retail outlets and amenities as well as a 14- hectare park. This will accommodate a population of 30,000. The business district will double and 100,000 sq. mtrs of new metropolitan infrastructure is scheduled, including conference centres, urban parks, sports amenities and other amenities for fields such as training and learning, tourism, culture, leisure and health.

The transformation of the city centre initiated by Euroméditerranée has now reached the stage of refurbishment of almost three kms of seafront. Renowned architects such as Hadid, Fuksas, Nouvel, Lion and Ricciotti are all involved in the metamorphosis and the creation of the new seaboard. The idea is that the projects designed by these great names in architecture will strengthen Marseille's international influence and bring the city a new skyline, marked by ambitious building design.

The main goals of the project were initially particularly economic-oriented: to foster economic development and job creation; to enhance the influence of Marseille through the provision of important amenities; to promote urban renewal and urban design and to improve the quality of local life.

During the years, the focus was slightly re-oriented from an economic regeneration program to a cultural one. Culture is one of the principle driving forces used by the Euro-Mediterranean Agency to reinforce the metropolitan elements of Marseille. The redevelopment of the Belle de Mai industrial zone is a clear example of this strategy, with a media centre that constitutes an essential tool for linking the economy to culture, a heritage centre that hosts the new City Archives and a branch of the National Audiovisual Institute, and a performing centre that unites leading figures in arts production. Since 1995, this major multidisciplinary urban site has become an international artistic benchmark.

Euroméditerranée has been transforming and strengthening the international development of Marseille over the last few years. In order to give an even greater impetus to the dynamic growth already felt there, an extension of the scheme was initiated in 2006 and formalised by a decree in 2007.

One project launched by the Association Système Friche Theater (SFT) had the objective of conquering "new territories of creation". It was backed by the Head of Culture that decided to devote the space of an old disused tobacco factory to the creation of a permanent culture laboratory. Today "La Friche" is an area of research dedicated to contemporary creation in all its forms: theater, dance, circus, street performers, visual art, digital music and cinema.

The numbers of "La Friche", now one of the largest multi-cultural centers of France, are: 180 international partners, 500 events a year, 45,000 square meters of working space, 60 professional facilities, 400 people in daily activities, 1000 artists each year, 30,000 hours of training, 105,000 visitors a year. It rents available spaces at accessible prices to those who want to produce and represent art.

Application to the case study

The decision to use "La Friche" in Marseille as a case study is linked to the ongoing character of the transformation, where many industrial areas have still to be retrieved and transformed, to the particularity of the intervention where the economic development of the industrial heritage has sprung from a 'spontaneous' cultural project and to the importance of the intervention both at local, and regional level.

The application of combined QFD and ANP, gives a methodological framework to integrate stakeholders' requirements and different aspects of this urban redevelopment project. This framework has been developed on the basis of a study of the literature and a series of informal discussions and interviews with various academics and researchers. The construction of the model can be divided into 5 steps illustrated in Table 2.

Table 2. ANP-QFD model: construction steps.

Step 1	Identify the customer needs and the product technical requirements.
Step 2	Fill in the matrices of interdependence within the HOQ.
Step 3	Determine the overall priorities of the customer needs using the ANP model.
Step 4	Insert ANP outputs in the HOQ
Step 5	Determine the overall priorities of the product technical requirements using the HOQ approach.

Step 1: *Identify the customer needs and the product technical requirements*: the customer needs and the product technical requirements were grouped into clusters. For each cluster a title was chosen which encapsulated the meaning contained within that group.

For the "customer needs" three clusters were identified:

- Project sustainability
- Area impact
- Metropolitan impacts

The "product technical requirements" were grouped into six clusters:

- Environment aspects
- Economic aspects

- Morphological and functional aspects
- Accessibility aspects
- Logistic aspects
- Architectural and urban aspects

Step 2. *Fill in the matrix of interdependence within the HOQ:* Table 3 shows the relationships between WHATs and HOWs. This matrix is considered the most important in the HOQ approach. The level or interrelationship discerned is weighted on a four point scale: high (9), medium (3), low (1), none.

Step 3. *Determine the overall priorities of the customer needs using the ANP model:* For the construction of the ANP model the clusters identified were used for the HOQ. Fig. 6 shows the ANP model. Its structure consists of three groups of clusters: the goal, the group of the WHATs, and the group of the HOWs. The customer needs correspond to criteria whereas the product technical requirements correspond to alternatives.

Step 4 and 5. Insert ANP outputs in the HOQ and determine the overall priorities of the product technical requirements using the HOQ approach: Table 4 shows the final result of the application that is ranked with the relative weight of the product technical requirements.

Table 3. HOQ: Relationships matrix between WHATs and HOWs.

HOW \ WHATs	HOW																														
	ECONOMIC ASPECTS	Realization costs (2013)	Restructuring costs (2023)	Maintenance costs	Self-financing capacity	Access to public funds	Reclamation and disposal	ENVIRONMENTAL ASPECTS	Parks and gardens	Sustainable technologies	Reclamation and disposal	Energy content	ACCESSIBILITY ASPECTS	Accessibility to the city	Parking	Pedestrian precincts	Cycle paths	LOGISTIC ASPECTS	Flexibility building site	Lead times	Multifunctional flexible areas	ARCHITECTURAL URBAN	Integration with the context	Industrial heritage	MORPHOLOGICAL ASPECTS	Businesses	Sport/multi purpose areas	Schools, libraries, museums	Studios and workshops	Hotels and restaurants	Residences
PROJECT SUSTAINABILITY																															
Economic sustainability	9	9	9	9	9	9	9		1	3	9	3		1	3	1	1		3	9	9			1		3	1	1	1	3	3
Sustainability	3	9	9	3	3	9		9	9	9	9			3	3	3	3		1	3	9			1			9	1			
Project flexibility	3	3	1	9	1	1		1	1	1	1			1	1	1	1		9	9	9		9	9		3		1	3	3	3
Limited inconvenience during construction	3	3		1	1	1		9		1				3	3	3	1		9	9	3			1							
AREA IMPACTS																															
Sustainable mobility	3	3	3	1	3						1			9	9	9	9		3	9	3		3			3	3	3	3	3	3
Architectural value	9	9	9	3	3	1		3	3	1	3			1	3	3	1		3	3	9		9	9							
Area revitalization	3	3	3	9	9	3		3		3				9	9	9	3		3	9	9		9	9		9	9	9	3	3	3
Creation of favorable conditions to socialize	3	3	3	3	3			9	1					9	9	9	9		9	9	9		9	3		9	9	9	3	3	3
METROPOLITAN IMPACTS																															
Cultural facilities		9	9	9	3	9			3					9	9	9	3		3	9	9		9	9		1	3	9	9	3	1
Job creation		1	1	3	1	3			1												3					9	1	3	3	9	
Services for citizens and businesses		3	3	3		1			3	1		1		9	9	9	3		3	9	9		9	9		9	9	9	3	9	3
Facilities for production and artistic training		3	3	3	1	9			3					9	9	9	3		3	3	9		3	9		1	1	3	9	3	1

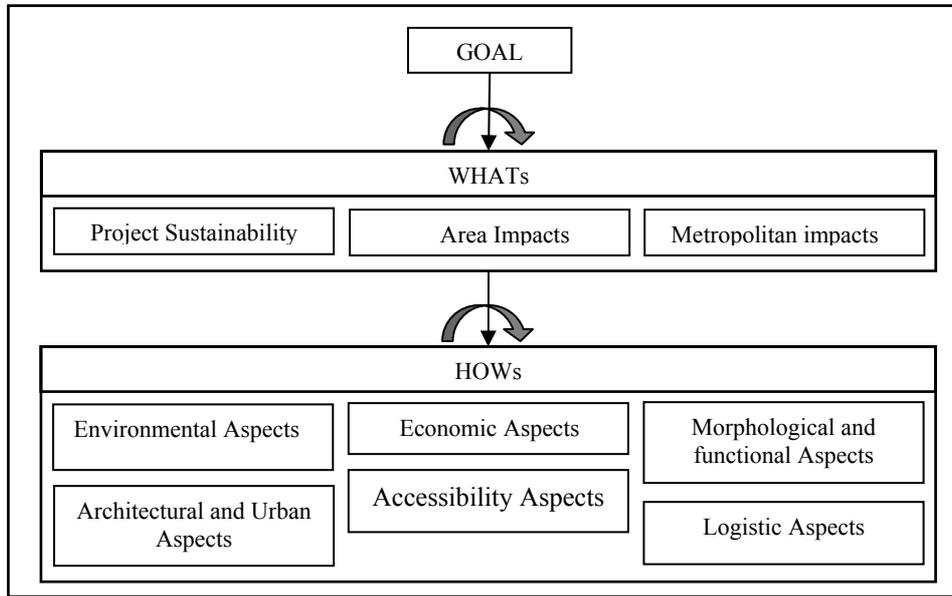


Fig. 5. ANP network

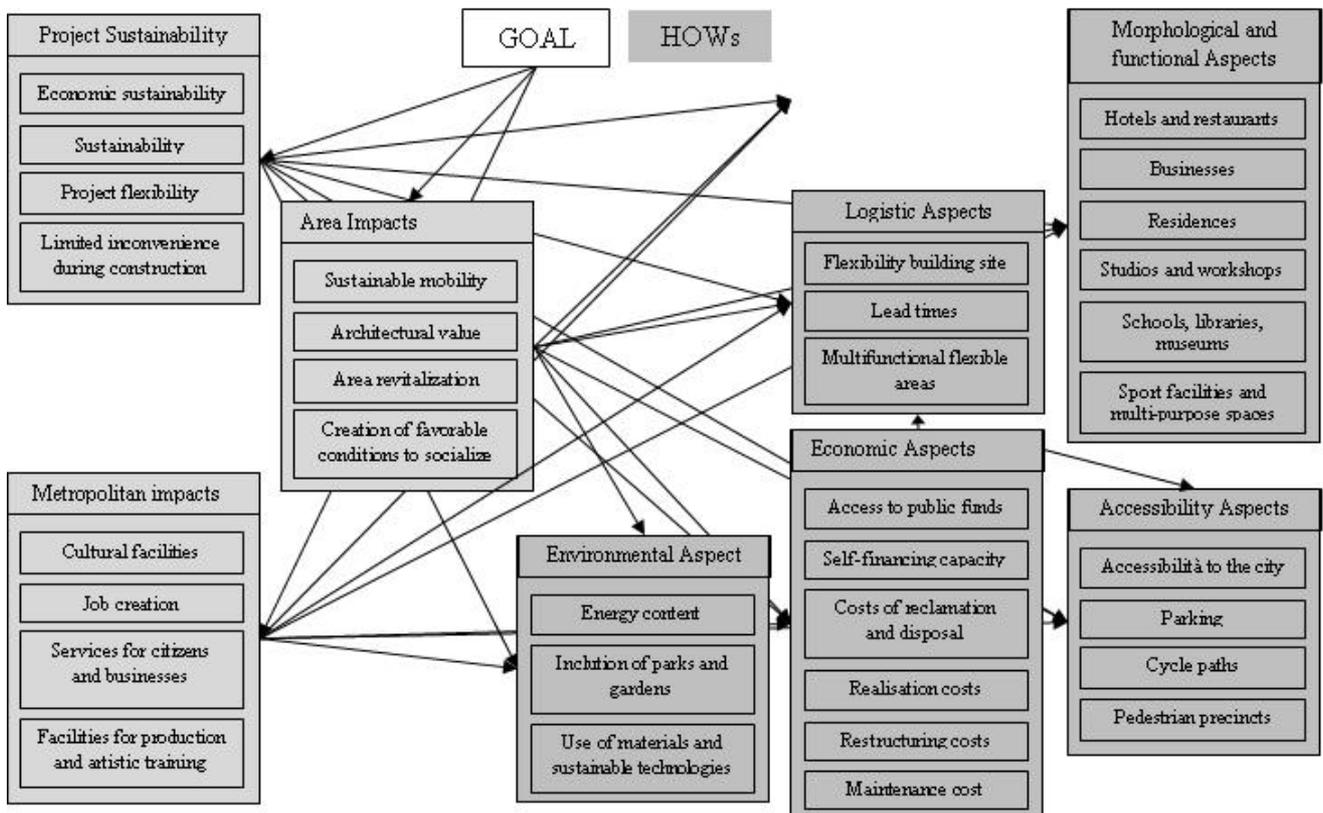


Fig. 6. ANP model

Table 4. HOQ + ANP: final result of the application.

<i>Quality Characteristics</i> (a.k.a. "Functional Requirements" or "Hows")	<i>Minimize (▼), Maximize (▲), or Target (x)</i>	<i>Relative Weight</i> (Relative Importance)
Realization costs (2013)	▼	5,02%
Restructuring costs (2023)	▼	5,31%
Maintenance costs	▼	4,91%
Self-financing capacity	▲	4,88%
Access to public funds	▲	6,06%
Inclusion of parks and gardens	▲	2,57%
Use of materials and sustainable technologies	▲	1,37%
Costs of reclamation and disposal	▼	2,58%
Energy content	▲	1,37%
Accessibility to the city	▲	4,92%
Parking	x	5,37%
Pedestrian precincts	▲	4,98%
Cycle paths	▲	2,14%
Flexibility building site	▲	4,14%
Lead times	▼	6,88%
Multifunctional flexible areas	▲	8,51%
Integration with the contest	▲	4,86%
Industrial heritage	▲	6,44%
Businesses	x	2,70%
Sport facilities and multi-purpose spaces	x	2,26%
Schools, libraries, museums	x	3,34%
Studios and workshops	x	4,44%
Hotels and restaurants	x	3,07%
Residences	x	1,88%

Conclusion

From the application of the combined method ANP and HOQ to the case of “La Friche” in Marseilles it emerges that the most important aspect in defining the transformation process of the area is the project flexibility (tab. 4). This is entirely consistent with the qualities on which “La Friche” was based and on which it continues to evolve, that is, an industry that has spontaneously become a cultural pole and a group of artists that have been able to carry through a cultural development within confines that were not excessively rigid. The element of flexibility is also crucial because the expected recovery in the future phases: in 2013 Marseille will become the capital of culture, and thus “La Friche” will be one of the fulcrums of the activities organized for the event, while for subsequent years other uses the same area have been planned.

Closely linked to the flexibility of the project is the importance attributed to the timing of the operation, which is crucial both from an economic point of view, and for the effectiveness of the intervention at urban and social level.

The third, most important element, is the economic development of the industrial heritage: the economic needs of the recovery of the area did not deny the past and the character of the zone, now closely integrated with the life of the artists. Of particular note, finally, the importance given to access to funds, in line with all other operations led by Euroméditerranée. In general, some reflections can be made on the combined use of two techniques for the evaluation of urban regeneration projects:

- In the case of projects of this size and complexity it seems that the use of both techniques can be justified by their contribution to the understanding of the problem. The dependencies inherent in the QFD process are taken into account using the ANP approach. The use of ANP weights provides feasible and more consistent solutions. The proposed framework adds quantitative precision to an otherwise judgmental decision process;
- For problems of lower complexity of the transformation within the urban zones it seems to us that the use of this tool is excessive;

- The issue of language: in the paper we have maintained the terminology of traditional HOQ, although here we don't analyze a product serial but the use and conversion of a former industrial area. For a more extensive use of both methodologies in a single tool should be reformulated in a more appropriate terminology.

Further applications of the combined ANP and HOQ method to real case study concerning decisions about urban and territorial transformation have to be done in order to verify and improve the general reflections resulting from this application.

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