Preliminary analysis for the urban regeneration of derelict industrial sites through Adaptive Reuse interventions: the former Stanic refinery of Bari

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Abstract

The theme of urban regeneration of underutilized areas and disused historic buildings is increasingly becoming a fundamental intervention to develop smart urban regeneration policies. The city is a dynamic and malleable place according to the needs of the population, where abandoned places are reinvented and converted to generate new opportunities and centralities. Important resources to activate sustainable urban densification policies are abandoned industrial areas, once the engine of nations' economies, today relegated to unused skeletons. Towards revitalizing and generating sustainable recovery actions of these sites, adaptive reuse is adopted as a process of modifying, transforming and reusing obsolete volumes in contemporary architectures with new functions, extending their useful life. The adaptive reuse intervention on industrial heritage sites shouldn't modify their settings and historical relevance. This paper aims to select the best design solution for the former Stanic refinery area in Bari, starting from

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multi-criteria analysis concerning social, physical-morphologic, environmental, and urban aspects. The research methodology is designed starting from a literature review about urban regeneration processes and adaptive reuse interventions and finishing with a weighted checklist of the selected parameters for each scenario. Adaptive reuse strategies contribute to reduce urban sprawl and demolition activities, applying smart conversion activities and technologies on derelict industrial sites of existing heritage.

Keywords

Adaptive reuse; MCDM Analysis; Design strategies; Building adaptation; Decision-making model

Introduction

The regeneration of disused industrial heritage buildings is a topic of fundamental importance in today's social, cultural and architectural debate. Recovering the spaces that have been abandoned by industrial production or conferring new environmental, economic and social qualities on decayed urban sites fit perfectly into the concept of sustainable city. These processes limit urban dispersion and reduce the environmental impacts that are naturally part of the built-up areas. In addition, the redevelopment of decommissioned industrial sites is a central issue for the implementation of Regional policies and for the creation of numerous intersections linked to the promotion and regeneration of marginal abandoned sheds through adaptive reuse procedures (Calderazzi, 2015). In Italy, abandoned industrial areas occupy the 3% of the entre Italian surface (ISTAT, 2012). The theme of disused industrial areas also occupies the Italian urban and architectural scene with the aim to develop conversion strategies for these unused spaces, transforming them in modern multipurpose containers. These urban-scale recovery actions have brought out not only morphological and environmental problems, linked to the intervention dimensions for reducing pollution problems, but also social and economic constraints regarding the ability of the industrial building to meet population needs (Calderazzi, 2012). The possibility of rebuilding the city no longer by expanding its boundaries, but by working within them, in a process of self-regeneration with strong cultural and social motivations, acquires, today, a fundamental value and opens up important reflections on the enhancement of history, architecture, landscape restoration and conservation measures (Piludu, 2017). Reusing decommissioned areas as a result of decentralization, deindustrialization and obsolescence becomes an opportunity to set in motion urban regeneration activities of those places whose specific values in terms of identity and recognisability have been acknowledged. The idea to refurbish abandoned industrial heritage sites is based on the need for its reuse, giving new dignity to these derelict and unused areas. The regeneration of an industrial building goes beyond the idea of conservative restoration and always implies an act of repurposing that can make the building useful to the community and active in the city dynamic system. Old and decommissioned factories become the starting point to set evolution smart processes that can transform the existent and reduce urban sprawl. A derelict industrial site isn’t considered as an empty space but as a potential flexible area to introduce functions useful for the community and attractive services to develop tourism policies in the city periphery. At the same time, all these transformations on industrial heritage buildings should be done with accuracy and taking into consideration the architectural-morphologic aspects of the site. The adaptive reuse models expand the possibility of reusing a building, converting it into a new usable and functional space, without compromising the spatial composition and the architectural features that have characterized its history. In addition, accurate preliminary context analysis, regarding physical-morphologic, social, urban and environmental aspects, can indicate the procedural steps for the definition of these intervention strategies. The paper analyses the four categories mentioned above and identifies through a multi-criteria analysis which of the possible plausible options is the one that best reflects the current needs of the local population and satisfies wider and longer-term expectations to make them attractive and integrate also urban suburbs to the city core.

In particular, the paper firstly focuses the attention on the theme of adaptive reuse and subsequently defines the methodology, applying it to the case study of the former Stanic refinery in Bari, Puglia. The aim is to draw up guidelines to activate urban and ecological regeneration paths of the disused industrial site, considering the iconicity and historical memory of the place and reviving the desire to recreate a reality of landscape and environmental value necessary for the city of Bari. According to Robiglio, adaptive reuse can be an optimal opportunity to convert the existent if social participation, preservation of the building memory and flexibility are taking into account simultaneously (Robiglio, 2017).

Adaptive Reuse

Today, the preservation and transformation of heritage industrial buildings is increasingly becoming one of the main aspects of sustainable urban planning. It could be easily managed if stakeholders analyse accurately all the categories and parameters that affect building adaptation. To achieve this goal, it's important to deepen the theme of adaptive reuse. As stated by the Department of the Environment and Heritage of Australian Government (2004), adaptive reuse is the process that changes a disused or ineffective item into a new item that can be used for a different purpose. This process, if it's applied on an historic building, must not affect the heritage significance of the site and its setting. The most successful examples of built heritage adaptive reuse projects are those that best respect and retain the buildings history, adding contemporary layers that increase site attractiveness. This type of renewal strategy has the potential to bring new life to disused or abandoned assets. In fact, the process increases space attractiveness and social benefit by creating sites that satisfy community needs and re-engage people to use them, hosting new services, sometimes connected with the old ones.

Giving a new identity to abandoned industrial sheds serves to reintegrate and re-functionalise these vast areas in the metropolis system without losing the historical sites memory that have characterized industrial and productive cities. Many underutilized historical buildings are viewed as the starting point for city regeneration and play a crucial role in the social, economic and cultural development of society. In addition, there is a strong awareness in the community that it is cheaper to convert abandoned sites rather than to demolish and rebuild them. This consciousness promotes the vast interest in adaptive reuse strategy and, at the same time, amplify the studies regarding the parameters that should be considered in the refurbishment process or that can affect building conversions (Aigwi et al., 2018; Ball, 2002; Pearce et al., 2004).

Many authors have tried to identify the factors that most influence the stakeholder's choices to activate adaptive reuse strategies, implementing multi-criteria analysis models to evaluate the potential and feasibility of the recovery intervention. The Adaptive Reuse Potential (ARP) Model of Langston (2011; 2012) and the AdaptSTAR Model of Conejos (2013; Conejos et al., 2013) allow to understand the effectiveness of the building reuse intervention and evaluate the weight of each factor affected by the process. The Adaptive Reuse Potential Model examines buildings adaptability in terms of seven categories of obsolescence that are closely related to sustainability. It helps to prioritize existing derelict buildings that have a substantial embedded physical life remaining in them (Yung et al., 2014). The AdaptSTAR Model is a decision-making tool that contributes to underline climate change adaptation strategies for built assets. It provides a weighted checklist of factors that assists in the development of building transformation policies for future reuse interventions (Conejos et al., 2015).

In order to identify the best building recovery strategies and the parameters involved in the building conversion process, it is necessary to develop preliminary analyses in order to fully understand the advantages that this modern intervention solution may entail and the constraints that can emerge. Bullen and Love (2011) in their articles have highlighted and listed the potential of using adaptive reuse processes and the weaknesses associated to them. As stated by the authors Adaptive Reuse is seen as a sustainable and effective alternative to address the "environmental gap" by functionally improving a building's performance while simultaneously reducing its environmental loading. The success of an adaptive reuse intervention depends on the factory adaptability to host new functions. Industrial buildings that incorporate surfaces that are flexible and easily manageable require less frequent and less costly refit and remain sustainable over longer periods. The decision whether to reuse a historic factory entails a complex set of considerations, including location, heritage importance, architectural assets, market trends, quality of the environment and physical site conditions (Bullen & Love, 2011). It is, therefore, essential to analyse all the peculiarities of the considered context before hypothesizing design solutions for its recovery and adaptation. The study of historical, architectural, environmental and social aspects not only provides interesting data regarding the current places conditions and social trends, but they simplify the decisions to be made in the early design stage, ensuring the satisfaction of the population needs and developing a sustainable contemporary city model through urban regeneration. Adaptive Reuse is seen by professionals as an effective strategy that enables a building to suit new conditions, amplifying its useful life and reducing urban sprawl. It's more sustainable and cheaper to reuse the existent disused industrial sites rather than to demolish them.

Methodology

Reusing rather than replacing buildings is the most resource-effective strategy to guarantee city development. The preliminary study of the context and areas covered by intervention simplifies the decision-making process regarding the actions to be taken for their recovery. The present section describes the steps and analyses that can be

carried out in advance to guarantee feasible and sustainable regeneration policies through adaptive reuse policies. This paper focuses on the testing that need to be developed at the preliminary design stage in order to direct intervention decisions and strategies for the preservation of decommissioned industrial sites. In particular, the research consists of six main steps that allow to frame the case study main features and to choose which is the function that, according to social, morphological, environmental and urban settings, is more beneficial to the characteristics of the context and satisfies the needs of the local community.
The steps are listed as follows:

1) Historical and evolutionary analysis of the former Stanic refinery in Bari: a narrative review is made for a comprehensive and detailed description of the site history and evolution. This first part frames the main aspects concerning the historical evolution of the site and district, and highlights all the interventions and transformations that the factory has undergone during its life cycle, up to its decommissioning and dismantling.
2) Environmental analysis of the site: it identifies the landscape characteristics of the area, as well as the presence of places to be safeguarded and with high natural quality. The presence of Lama Lamasinata is an extra point of attraction to consider in the site transformation processes but, at the same time, a constraint if a proper management of rainwater and maintenance activities is not guaranteed.
3) Physical-Morphologic site analysis: this paragraph focuses on the characteristics of the disused industrial site according to the compositional-formal structure and the degree of obsolescence of pre-existences. Each Stanic pre-existence is catalogued with the aim of having an initial database of qualitative and quantitative information

with the aim of activating building recovery processes, trying to maintain the historical memory of the place.

4) Study of urban fabric: this paragraph focuses on road infrastructures, distances of the site from major points of interest and from the city centre, urban existing composition, as well as urban fabrics and services in the area. The vastness of this site also involves the study of the relationships between the context, the natural environment and the refinery with the aim of establishing connections and the relationship between the different types of place.
5) Identifying demographic and social data: qualitative data underline the number of inhabitants in the Stanic district and their subdivision by age groups. In addition, the section describes the needs of the local community. Social analyses allow to frame the possible activities and services to be included in the site regeneration project, trying to understand what are the human and multi-ethnic relationships that can be established in the district to guarantee social inclusion.
6) Application of Multi-Criteria Decision-Making (MCDM) Analysis for the reuse of Stanic refinery area. The implementation of multi-criteria approach considers the following steps:

a) Identification and definition of attributes and sub-attributes. The section frames the preliminary criteria evaluation for choosing the best solution to adopt to the selected case study.
b) Elicitation of the value functions for each parameter affecting building adaptation processes. Three different qualitative functions for factor assessment are identified.
c) Description of different planning solutions. The paragraph focuses on the identification of possible design

and functional scenarios that can be adopted to the case study.

d) Identification of specialized decision makers who can provide significant contributions to the classification of the considered categories and sub-criteria. The composition of a focus group allows the direct comparison between professionals and a pairwise evaluation of the identified parameters with the selected design solutions, taking into account the qualitative data of the value functions.
e) Weighting attributes and sub-attributes to indicate the relative importance of each parameter for the specific case study. Specialized figures in the fields of construction, recovery and environmental protection express their opinions on the selected parameters through interviews, quantifying their importance in the preliminary stages of site analysis.
f) Calculation of the partial and total values of each parameter depending on each considered scenario and selection of the most feasible design solution to adopt for Stanic site. The normalized value of each parameter is multiplied by the coefficient extracted from the value functions and discussed by the focus group for each use target. The sum of the values provides the percentage of feasibility of each intervention.

Preliminary surveys and scenarios identification and description are the starting point to summarise all the obtained data about the case study in cataloguing sheet, inserting all the architectural, social, physical and functional aspects found in the monitoring and characterization of site morphology. All qualitative and quantitative information represent the input data for the definition of adaptive reuse strategies through the Design Criteria System (DCS)

(Vizzarri & Fatiguso, 2019; Vizzarri, 2020; Vizzarri et al., 2020).

Case study

The former Stanic refinery area of Bari has been considered a symbol of Bari industrial past for over fifty years. The conversion of this vast empty area is at the basis of the local debate concerning the recovery of abandoned industrial sites in the city of Bari and their importance for the development of smart and sustainable planning and regeneration policies. This area is grafted between the natural and authentic landscape of the Lama Lamasinata and buildings seriality in the industrial area of Bari - Modugno, many of which have been abandoned. The area of the former refinery covers about 530.000 sqm, approximately 3.7 km perimeter, and is located within the district with the same name (Figure 1).

Figure 1 - Satellite image of the city of Bari with indication of the area of the former Stanic refinery.

Historical analysis

This section traces the salient stages of development and transformation of the Stanic area, up to its abandonment and progressive dismantling. From the information acquired on the architectural evolution of the refinery's time, it emerges that the industrial site has undergone many transformations over time that have gradually changed the composition of its spaces.

Today, after the dismantling and repeated remediation of the site (1999-2010), only a few buildings remain which preserve the historical character of the industrial area. To understand the urban development that the Stanic area has undergone over the years, the evolutionary history of the area is analysed.

Built in 1937, the Stanic industrial complex began operating in 1938. Over the years, the area in question has undergone significant expansions, due to the growth in demand, the increase in processing and the subsequent differentiation of processes. In particular, from 1947 to 1967, to obtain the possibility of developing new fuels, new tanks and infrastructures were added in the already rich presence.

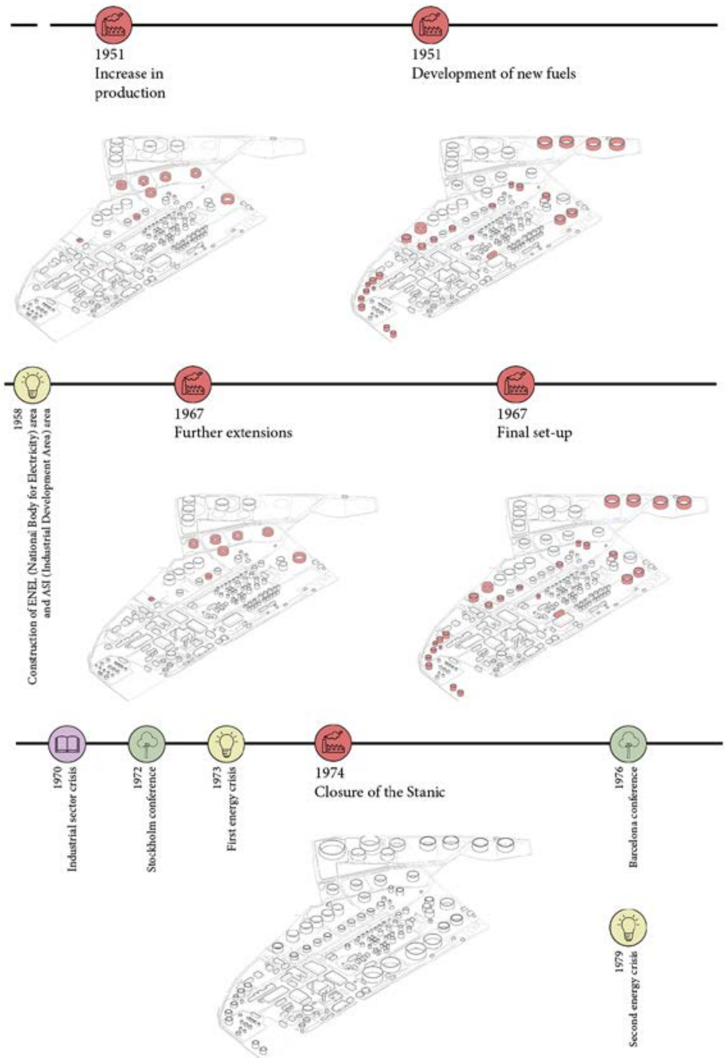
The refinery was active in the area until 1974, and until the 1990s it assumed the function of coastal storage. After the disposal of the cisterns, which took place in 2002, and the subsequent reclamation of the area, which lasted until 2010, the situation has remained unchanged within the area up to the present day.

The high level of degradation of the Lama Lamasinata, the environmental, acoustic and air pollution and the proximity to an industrial area without attraction promoted the growing tendency of the site to remain unused and to make it less prone to be subject to new transformations (Figure 2).

Environmental analysis

The refurbishment of abandoned or disused industrial buildings is a difficult process to manage, since it is characterized, in most cases, by problems related to site pollution and consequences for future generations in terms of health and economic commitment. The remediation of these areas entails a significant increase in costs for the realization of the conversion project. At the same time, it becomes an opportunity to transform the city, create new possibilities and change the quality of the surrounding urban fabric. This concept is strengthened considering the environmental and landscape aspect as another key element to be incorporated into the building design and urban regeneration process. One of the main characteristics that the Apulian territory presents are shallow erosive furrows that convey rainwater to the sea, called "Lama". These canals present a high porosity of the soil with circulation of water in the subsoil. Considering the extreme proximity of the Lama Lamasinata to the site of the former Stanic refinery, the aim is to regenerate, protect and re-naturalize not only the abandoned industrial area, but also to include the surrounding areas, creating an ecological urban system.

The Preliminary Planning Document (DPP) (Comune di Bari, 2008) identifies this natural system as the main feature to develop sustainable regeneration policies, reusing soils as agricultural spaces, managed by the population, keeping in mind the hydraulic characteristics and relative hazards of the rivers.


1951
Increase in production
1951
Development of new fuels
1958
Construction of ENEL (National Body for Electricity) area and ASI (Industrial Development Area) area
1967
Further extensions
1967
Final set-up
1970
Industrial sector crisis
1972
Stockholm conference
1973
First energy crisis
1974
Closure of the Stanic
1976
Barcelona conference
1979
Second energy crisis

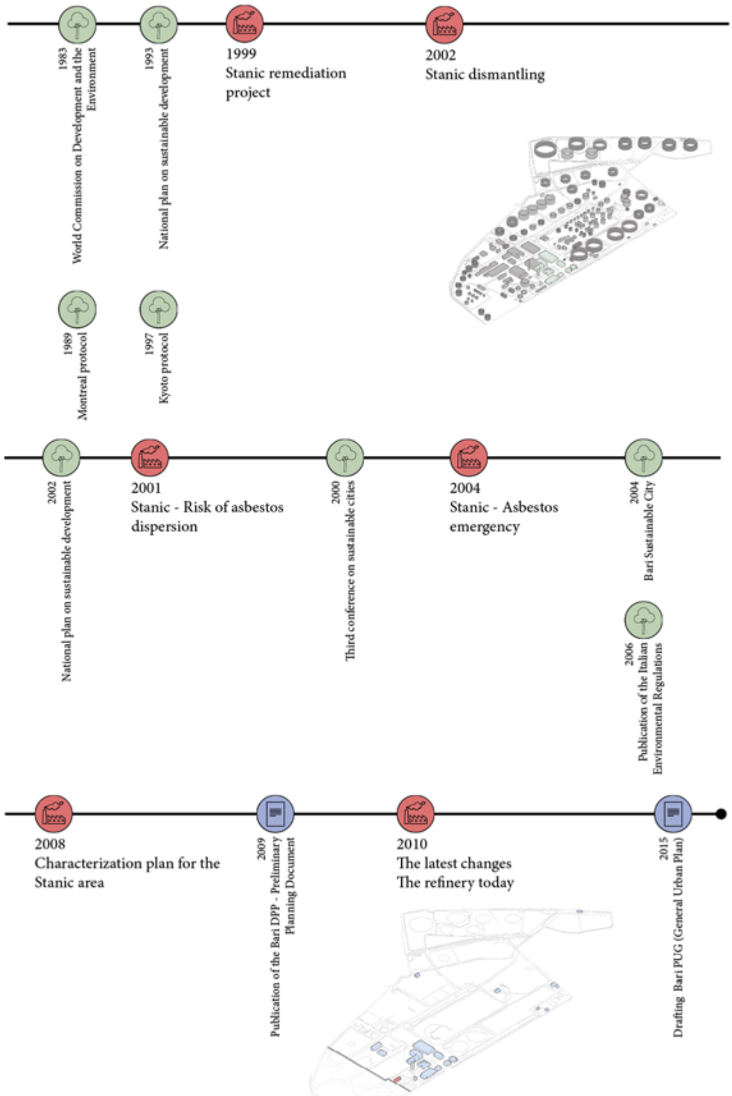


Figure 2 - Representation of the temporal evolution of the Stanic refinery (Piludu, 2017).

Lama Lamasinata is affected by scarce natural sensitivity and urban decay. Its path is marked by several interruptions, like dams and infrastructures, or artificial elements as terraces that modify in an impressive way the landscape continuity increasing hydraulic risks.
Over the years the Municipality of Bari and local authorities have proceeded to carry out various interventions of mitigation, gradually increasing the degree of artificialisation of the canals and consequently triggering a process of serious alteration of balance relationships between surface and underground hydrology.
The rural landscape is characterized by the dominance of cultivated fields, especially with olive groves and vineyards. The green areas are related to the native tree essences that make up the natural and environmental system of the Lama Lamasinata. This landscape has been defaced, over the years, by the high degradation, the transformations of the urban fabric by human and pollution caused by the presence of illegal landfills. Urban interventions and improper uses have progressively triggered processes of reduction and fragmentation of the herbaceous, shrub and arboreal cover of erosive furrows so much that in some cases spontaneous vegetation is presented in residual form.

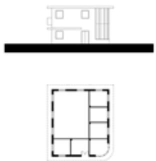
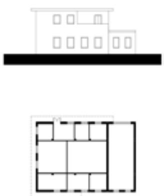
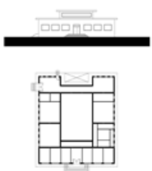
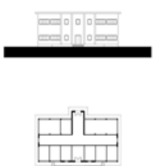
Physical-morphologic analysis

At the time of its construction and expansion, the refinery contained hundreds of structures including buildings, warehouses, service rooms and tanks. Today only a few buildings remain in the refinery site. The research carried out has made it possible to identify 18 buildings: eight are the historic entrance of the refinery, two are tanks and eight are other buildings for storage use scattered in the abandoned area (Figure 3).

Figure 3 - Stanic area buildings and characteristics (Piludu, 2017).

The most relevant buildings, from an architectural point of view, are those facing the main avenue, of which there are still evident traces. The six buildings, described in Table 1, have been surveyed and analysed to understand the possible functional scenarios to insert in these industrial spaces.

All the existing buildings present advanced conditions of physical obsolescence caused by neglect and by the disposal of the refinery.

ID	Plans and sections	Building function	Year	Structure typology	Surface
1		Reception	1936	Concrete, two storey buildings	360 m^2
2		Infirmary	1936	Two volumes joined with a reinforced concrete bearing structure.	459 m^2
3		Chemistry laboratory	1936	Volume of a single mezzanine with load-bearing structure in reinforced concrete.	806 m^2
4		Management and offices	1936	Volume with two floors outside earth with load-bearing structure in reinforced concrete. Load-bearing staircase placed on the back of the building.	714 m^2

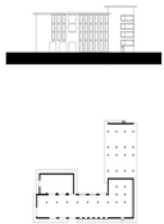
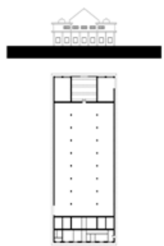
5		Storage	1936	Single volume a double height divided into three naves. Load-bearing structure in concrete reinforced and trusses arranged on the nave central, at the skylight.	2209 m^2
6		Power station	1936	Three volumes with load-bearing structure in reinforced concrete.	4654 m^2

Table 1 - Analysis of pre-existing buildings in Stanic refinery (Piludu, 2017).

Urban analysis

The connection of the area with the city consists mainly of urban roads for transports, while alternative routes of soft mobility are completely absent. The main entrance to the area overlooks the urban road of Via Bruno Buozzi, which connects the area to the F. Crispi Metro station and the F. Crispi railway station, until the waterfront. Via Bruno Buozzi, represents one of the most important crossing axes of the city, and allows the connection of the site to the nearby routes SS96 and SS16. Another important urban street of the quartier is Viale Europa, which runs alongside the ENEL electric power area adjacent to Stanic and which connects the city to the San Paolo district, crossing the Lama Lamasinata (Figure 4).

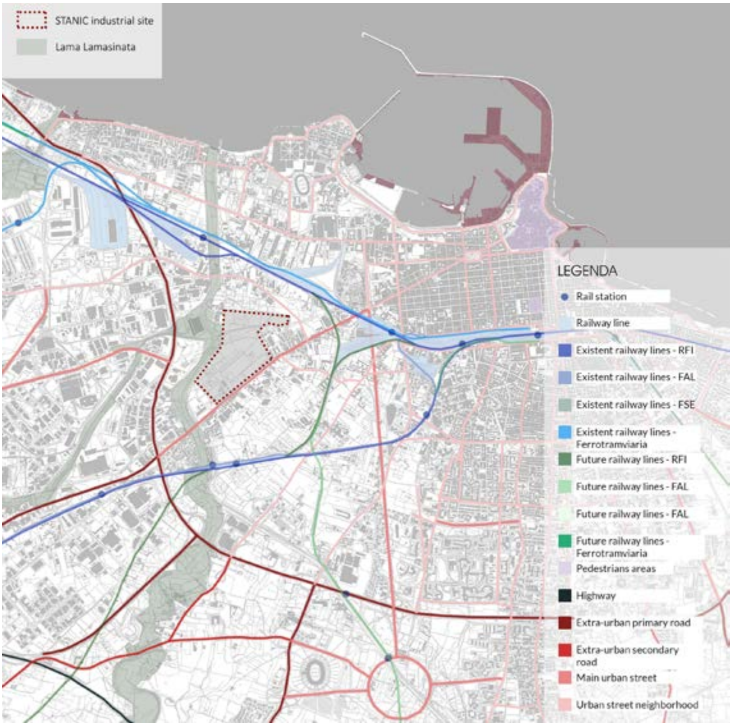


Figure 4 - Urban analysis map (Piludu, 2017).

Inside the former industrial area, it is still possible to see the remains of the internal viability of the refinery, characterized by a cardo-decuman structure and a series of orthogonal paths. The internal infrastructure system identifies strong connections with the city and the presence the old railway path. Analysing some links with the greatest functional polarities of the city immediately highlights the scarcity of direct connections and the high times and distances to reach Stanic district (Figure 5). Public transportation would be optimal in terms of traffic and environmental impact, but the area does not have a strong network of bus connections, so it is cheaper and convenient for people to arrive at the refinery on feet.

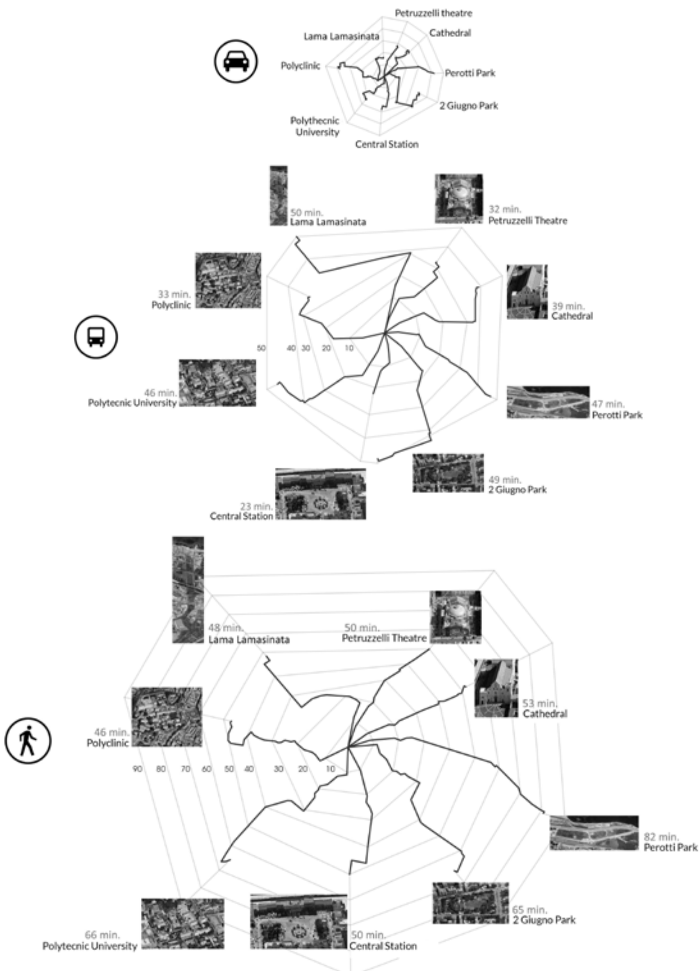


Figure 5 -Isochronous connection between the Stanic area and the functional polarities of Bari. (Piludu, 2017).

Although the area appears distant and difficult to reach, with an adequate connection to the main polarities it can absolutely be integrated with the rest of the polarities, developing a unique landscape scenario. Analysing the area in detail, it is clear how much its vastness makes it challenging to move on foot. The perimeter of the area is just over three kilometers and a half. This means about forty minutes walking. The problem is partially solved walking on the east-west axis, long about two kilometers (Figure 6).

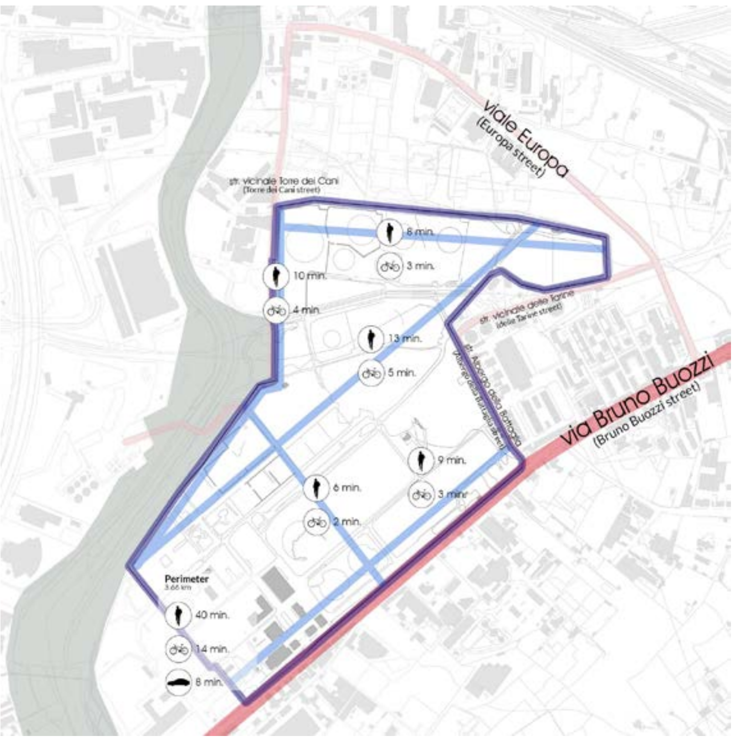


Figure 6 - Travel times inside the Stanic area (Piludu, 2017).

Considering that the site is close to the Lama Lamasinata, the connection of the Stanic refinery with the city, through pedestrians and cycle paths, could be an optimal solution. Slow mobility, especially cycle paths, could become a fundamental resource for the use of this abandoned area.

Social analysis

The Stanic district is part of the Municipio 3 area of Bari, together with San Paolo, Marconi, San Girolamo, Fesca, and Villaggio del Lavoratore neighborhoods. Analysing the context from social, cultural and community perspectives, it is possible to identify the needs of the population and create a project tailored to them.
The area around the Lama Lamasinata appears strongly fragmented and isolated from the rest of the city. Due to the absence of connections and structures capable of catalysing attention in this marginal district, the landscape and the entire periphery of San Girolamo, San Paolo and Stanic districts present high level of degradation and obsolescence. The former services, after the refinery divestment, gradually closed or moved to other parts of the city, bringing the district to the current degraded situation. A few services are located near the social housing residential complex (IACP), where it is possible to find a nursery school, a post office, an elementary school, a pharmacy, and some other small shops for necessities. There are no cultural or sports polarities, in the absence of which the residents are forced to travel by car to reach places in the city with more services.
Considering the urban scale, the main data regarding the structure of the population residing in 2011 in the Stanic district is showed in the Table 2 (Comune di Bari, 2017). By comparing the data from 1991 and 2001 and then from 2001

to 2011, a decrease in the population is shown in Tables 3a and 3b (Comune di Bari, 2017).

<table>
<tr><td rowspan="2">District</td><td colspan="6">People residing on 08/10/2011</td></tr>
<tr><td>Total</td><td>Men</td><td>Women</td><td>Foreign citizens</td><td>Children of 0 - 5 age</td><td>People of 20 - 29 age</td></tr>
<tr><td>Stanic</td><td>3.555</td><td>1.776</td><td>1.779</td><td>92</td><td>227</td><td>467</td></tr>
<tr><td colspan="3">Number of resident families on 08/10/2011</td><td rowspan="2">Surface inhab./sq km</td><td rowspan="2">Density inhab./sq km</td></tr>
<tr><td>Total</td><td>With nominees or citizen foreigner</td><td>Single-component families</td></tr>
<tr><td>1.254</td><td>31</td><td>234</td><td>10,55</td><td>337</td></tr>
</table>

Table 2 - People and families registered as residents on October 8, 2011 in the Stanic district.

	Variations from 1991 to 2001					
	Value			%		
	Men	Women	Total	Men	Women	Total
Stanic	**- 629**	**- 497**	**- 665**	**-20,13**	**-24,21**	**-22,19**

Table 3a - Resident population registered in the Stanic district, divided by sex and former administrative quarters (1991 – 2001).

Variations from 2001 to 2011					
Value			%		
Men	Women	Total	Men	Women	Total
291	**267**	**558**	**16,39**	**15,01**	**15,70**

Table 3b - Resident population registered in the Stanic district, divided by sex and former administrative quarters (2001 – 2011).

Multi-Criteria Decision-Making (MCDM) Analysis

The widespread diffusion of MCDM Analysis in urban planning is connected to the need of justifying feasible policy choices and to the possibility to involve a large number of people in the process (Belton et al., 2002; Huang et al., 2011; Nijkamp et al., 1990; Ksiazek et al., 2015). The identification of qualitative data, using evaluation schemes to solve planning problems, is an important communication tool to facilitate decisions. The decision support system simplifies the selection of adequate strategies of conversion of disused industrial sites. In order to set up a procedure for the selection of the most suitable adaptive reuse solution for the

Stanic site, the first step regards the definition of preliminary design parameters and interventions.
This section applies six macro-phases, already summarized in the previous sections. The three initial parts identify and describe the sub-attributes, the hypothesized uses and the criteria value functions. The fourth part focuses the attention on the selection of decision makers for the creation of focus group to evaluate parameters in relation to each design proposal, considering the quantitative data of each value function. The last two parts implement the MCDM Analysis, multiplying each weighted parameter with the corresponding coefficient obtained by the value function for that specific solution. This methodology identifies the most suitable transformation intervention for the Stanic refinery.

Attributes definition

It has been generally agreed that Multi-Criteria Decision Analysis (MCDM) may simplify decisions, taking into account available technical information and design factors. These methods consider several criteria simultaneously and help decision makers to select the feasible scenario for the conversion of disused sites (Ferretti et al., 2014; Giuliani et al., 2017). As previously mentioned, the first step of this process consists in the structuring of the decision problem, underlining and describing all the sub-attributes that should be considered in the preliminary design survey. In particular, starting from the four main topic analysed, major factors that can influence the choice of the optimal design solution for Stanic area have been identified. The selected criteria are described as follows:

1. *Social analysis parameters (8)*

- Job opportunity: analysis of the quantity and quality of job that the new destination offers.

- Public spaces and green areas: analysis of the quantity and quality of the present public spaces and green areas. Green areas and public spaces are places of aggregation, socialization, and act as catalysts for inhabitants and visitors to the city.
- Pedestrians areas and slow mobility: the presence of sustainable roads makes it possible to improve the socialization and use of public land by visitors and residents. The amount of slow mobility routes and public spaces guarantee the development of society and urban asset.
- Services: the quantity, differentiation and quality of functions that can promote Stanic as a stable, sustainable and self-sufficient city context. It allows to increase the wealth of its inhabitants and thus to improve their living conditions.
- Social activities: increasing of the satisfaction of the inhabitants and quality of life. This parameter evaluates the presence of activities to create neighbourhood relationships and social inclusion.
- Attractiveness: the ability of an area to attract and manage different flows of people due to its activities or structures.
- Connection with the city centre: the analysis of the times and methods of moving not only between the services and places within the project area but also with the rest of the city makes it possible to identify and trace the best connection routes to the various services.
- Gentrification: the insertion of new services and fast public mobility increases the quality of life and re-evaluates district role in the city urban structure.

2. *Physical - Morphologic analysis parameters (4)*

- Recovery of the historic-architectural pre-existences: study of buildings and works of considerable architectural or artistic interest, in order to assess the best strategy for their conservation and restoration.

- Compatibility of the intervention with the context: the analysis of the present context allows to structure feasible intervention strategies without dominating or designing elements in contrast with the pre-existences.
- Introduction of new volumes: the possibility to introduce new volumes in the existent site morphology, considering current regulations in the field of restoration, construction and urban planning.
- Maintainability: this criterion considers the feasibility of maintenance activities on an historical building.

3. *Environmental analysis parameters (5)*

- Landscape quality: it measures the natural potential of the place and its values in terms of greenery and environmental attractiveness.
- Presence of green areas: the amount of green areas is not only important in social or landscape terms. Green areas trigger an increase in biodiversity, a better quality of air and water, having consequences on the quality of life of the inhabitants.
- Safeguard of the natural native species: the ability to enhance and conserve native species and biodiversity, making users aware of the conservation and respect of local species.
- Site renaturation and remediation: the analysis of the level of pollution and degradation of the area.
- Compatibility of the new natural species with the local context: it measures the level of integration of the planned green areas with pre-existing species, without compromising the context morphology and landscape.

4. *Urban analysis parameters (5)*

- Iconicity: the ability of a place to be identified as a reference point for the city.

- Space flexibility: the analysis of space flexibility is a fundamental prerogative for the architecture of reuse. The more flexible a space, the more it can adapt to as many functions as possible.
- Usability: the ability of an object to be used easily and without major hitches by as many people as possible.
- Flow management: it explains how, at urban level, the connections between the place and the nerve points of the city can be integrated and improved.
- Accessibility: includes the characteristics of a place to be reached easily, to be crossed with different transportation systems and by different kinds of people, with specific needs and objectives.

Definition of value functions

The next step consists in the elicitation of the value functions, which represent mathematical graphs based on human judgements. The sub-attributes are described by a value function, which allows to evaluate each criterion to a qualitative range and facilitates pairwise comparison between items. The construction of a value function for the single criterion is a task that can be accomplished through different types of techniques (Von Winterfeldt & Edwards, 1986; Kirkwood, 1997). For the assessment of marginal value function, a range-based technique is used. In particular, for all the identified parameters, only three different qualitative graphs are identified. The first step is the description of the criteria and the identification of score range. The second step is the determination of the qualitative characteristics of the marginal value function with the specification of numerical data. Figure 7 and Table 4 describe the value functions that have been constructed for the sub-criteria considered in the application and the relative scores.

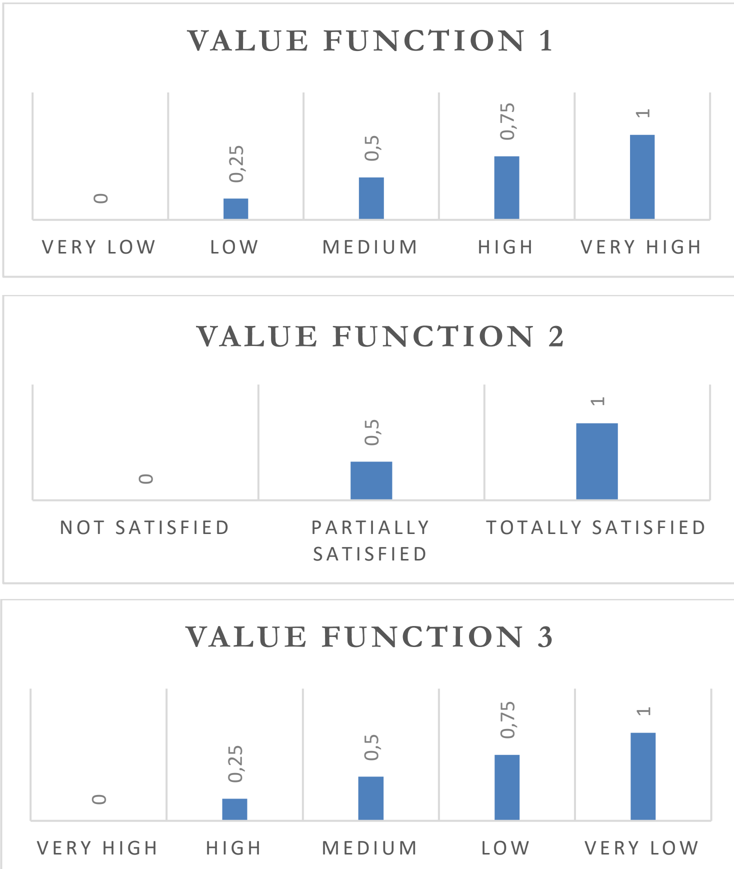


Figure 7 - Value functions graphs.

Attributes	Sub-attributes	Parameters of value functions											
Social analysis parameters	Job opportunity	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Insertion of public spaces and green areas	NS	0	PS	0.5	TS	1						
	Insertion of pedestrians areas and slow mobility	NS	0	PS	0.5	TS	1						
	Introduction of new services	NS	0	PS	0.5	TS	1						
	Social activities	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Attractiveness	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Connection with the city centre	NS	0	PS	0.5	TS	1						
	Gentrification	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
Physical - Morphologic analysis parameters	Recovery of the historic and architectural pre-existences	NS	0	PS	0.5	TS	1						
	Compatibility of the intervention with the context	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Introduction of new volumes	VH	0	H	0.25	M	0.5	L	0.75	VL	1		
	Maintainability	VH	0	H	0.25	M	0.5	L	0.75	VL	1		
Environmental analysis parameters	Landscape quality	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Presence of green areas	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Safeguard of the natural native species	NS	0	PS	0.5	TS	1						
	Site renaturation and remediation	VH	0	H	0.25	M	0.5	L	0.75	VL	1		
	Compatibility of the new natural species with the natural context	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
Urban analysis parameters	Iconicity	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Space flexibility	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Usability	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Flow management	VL	0	L	0.25	M	0.5	H	0.75	VH	1		
	Accessibility	VL	0	L	0.25	M	0.5	H	0.75	VH	1		

Table 4 - Value coefficient scale for each parameter.

Design proposals

Considering the previous analysis, three design proposals are defined. The interventions differ not only in the relationship between built and natural landscape, but also in the type of use (public, semi-public and private). Each solution includes functions strictly related to the population needs and to the urban shape.

The three scenarios are listed as follow:

a) *Environmental and thematic park:* the proposal focuses on recycling the buildings, production structures, machinery, and even the grounds themselves. Through bio-phytoremediation techniques, the soil and water would be "cleaned and greened". The preservation and adaptive reuse of existing structures allow to safeguard the historical memory of the place. The recovered buildings are used as incubators of recreational functions and community services that frame the park not only as a large green walking lung, but also as a place to perform outdoor activities, sports, creative and educational workshops.
b) *Technological, cultural and education park:* the concept is to create a large urban park, which in part tends to reconnect to the existing urban fabric through a series of ecological corridors, in order to stimulate the creation of sustainable urban mobility, supported by the presence of an interchange hub. The role and naturalness of the Lama Lamasinata is restored, making it an integral part of the new system. Remediation and bio-phytoremediation activities are two techniques that become even more fundamental today in an environmentally damaged area. Laboratories, offices, areas for the study of plant species, educational and hemp production laboratories, archives, areas for the transformation and packaging of products and zero-km commercial areas compose the functional program.
c) *Manufacturing and industrial park:* this functional typology restores the pre-existences and increases the density of the buildings with the aim of introducing functions relating to the manufacturing and craft field. It is conceived as an innovation accelerator for all companies that aim to enlarge their market with eco-efficient solutions. The naturalistic-environmental aspect is always present in order not to damage the landscape quality of

the place, prevailing a purely private use of the site . Start-ups, incubators, spin-offs, warehouses, smart offices and design, production and assembly laboratories occupy most of the area of the former Stanic refinery area.

Stakeholders analysis and interviews

The stakeholders analysis allows to define the main actors of the process under investigation. At the same time, very often, decision makers have conflicting ideas and interests on the possible conversion interventions of abandoned industrial sites. Decision problems, relating to the design and implementation of urban transformation and regeneration process, involve multiple actors with different views, design solutions and objectives. In this context, the valuation of alternative scenarios is a complex process, because various items need to be compared. Through focus groups, twenty-one people, specialized in the construction, recovery and environmental-historical-architectural values preservation fields, discuss the theme of the recovery of the Stanic area, trying to quantify the importance of each parameter in relation to the different proposed design solutions. This involves the selection of the numerical data of each criterion from the value functions, according to the considered possible solutions. In addition, a questionnaire is submitted to the same actors to quantify the weight of the attributes and sub-attributes. Table 5 lists the values of the parameters with respect to the building adaptation interventions that emerged from the focus group.

Attributes	Sub-attributes	Environmental and thematic park	Technological, cultural and education park	Manufacturing and industrial park
Social analysis parameters	Job opportunity	0.25	1	1
	Insertion of public spaces and green areas	1	1	0.5
	Insertion of pedestrians areas and slow mobility	1	1	0.5
	Introduction of new services	0.5	1	1
	Social activities	0.75	1	0.5
	Attractiveness	0.75	1	0.5
	Connection with the city centre	0.5	1	1
	Gentrification	0.5	0.75	0.75
Physical - Morphologic analysis parameters	Recovery of the historic and architectural pre-existences	1	1	1
	Compatibility of the intervention with the context	0.75	0.75	0.75
	Introduction of new volumes	1	0.75	0.5
	Maintainability	0.75	0.5	0.5
Environmental analysis parameters	Landscape quality	1	1	0.5
	Presence of green areas	1	0.75	0.5
	Safeguard of the natural native species	1	1	0.5
	Site renaturation and remediation	0.5	0.5	0.25
	Compatibility of the new natural species with the natural context	1	0.75	0.25
Urban analysis parameters	Iconicity	0.5	0.75	1
	Space flexibility	1	1	1
	Usability	1	1	1
	Flow management	0.75	0.75	0.75
	Accessibility	1	1	1

Table 5 – Parameters values extracted from the value functions.

Weighting criteria

Once the alternatives have been evaluated, it is necessary to define the weights of the different attributes of the decision problem. Twenty-one different experts in the context of urban planning, history of architecture, cultural heritage and refurbishment fill out a structured questionnaire to estimate the parameters that most affect the composition and design choices of building conversion in the preliminary design stage. The survey, therefore, is based on the evaluation, in a range from 1 (very unimportant) to 5 (very important), of

the categories and sub-parameters identified in the previous sections. The results show that most of the criteria are fundamental for the activation of urban regeneration policies for abandoned industrial sites.
However, especially for sites with architectural importance, a parameter to be considered is the recovery of pre-existences with the aim of safeguarding the historical memory of the place. Even the environmental aspects are not to be overlooked, especially when intervening on polluted industrial areas which therefore require soil remediation. The parameters, relating to site attractiveness, flexibility of spaces and usability features, are also relevant.
Table 6 contains all the weights related to each parameter and normalized according to the category they belong to. These considerations are reflected in the weight of the four main categories, where the most important attribute is the urban analysis (25,59%), followed respectively by the environmental analysis (25,29%), social analysis (25%) and physical - morphological analysis (24,12%).

Aggregation and discussion of results

In the last methodology phase, each attribute score extrapolated by the value functions is compared with the corresponding weight, arisings by the focus group survey. In addition, the estimation and normalization of parameters percentages allow to calculate the total feasibility score of the three alternatives. MCDM Analysis includes different aggregation models, but the simplest and most used one is the additive model and, in particular, the following equation:

$$V(a)=\sum wi \times vi(ai)$$

Where V(a) is the overall value of alternative a, vi(ai) is the single attribute value function reflecting alternative a´s performance of attribute i, and wi is the weight assigned to reflect the importance of attribute ì. On the right side of Table 6 the partial and overall values and the ranking of the design solutions are calculated. For each analysis category, the partial average values of each individual design option are outlined. This multicriteria evaluation methodology shows that the technological, cultural and education park obtained the highest ranking in the section containing the social parameters. This means that the considered design solution better meets the needs of the community and attracts more users. The second option, regarding the environmental and thematic park, is the best scenario in the categories of environmental and physical-morphologic parameters. The hypothesis of creating an urban park with multiple activities for each age group incorporates an intervention aimed at recovering the native landscape and the union of multiple functions related to the naturalistic aspect of the site. The question that this solution, from the physical-morphologic aspects, has obtained a high score lies in the ease of maintenance of the site, in the low insertion of new volumes and in the non-invasiveness of the intervention. The manufacturing and industrial park does not achieve high values in the first three categories of criteria most likely linked to the strictly private function of the new intervention and the need to introduce new volumes on the site. At the same time, it has the best evaluation in the section concerning urban analyses, as it converts the primitive function of the site in a modern key, preserving the historical memory of a productive and manufacturing area. From the total values obtained, the technological, cultural and education park solution (total score: 86,05/100) is the best alternative according to the four considered preliminary analysis categories.

Attributes	Sub-attributes	Values	Environmental and thematic park	Technological, cultural and education park	Manufacturing and industrial park
Social analysis parameters	Job opportunity	2,82	0,70	2,82	2,82
	Insertion of public spaces and green areas	3,31	3,31	3,31	1,66
	Insertion of pedestrians areas and slow mobility	3,08	3,08	3,08	1,54
	Introduction of new services	3,35	1,67	3,35	3,35
	Social activities	3,20	2,40	3,20	1,60
	Attractiveness	3,42	2,57	3,42	1,71
	Connection with the city centre	3,01	1,50	3,01	3,01
	Gentrification	2,82	1,41	2,11	2,11
25,00			16,65	24,30	17,79
Physical - Morphologic analysis parameters	Recovery of the historic and architectural pre-existences	6,63	6,63	6,63	6,63
	Compatibility of the intervention with the context	6,87	5,15	5,15	5,15
	Introduction of new volumes	4,21	4,21	3,16	2,11
	Maintainability	6,40	4,80	3,20	3,20
24,12			20,80	18,15	17,09
Environmental analysis parameters	Landscape quality	4,95	4,95	4,95	2,48
	Presence of green areas	5,25	5,25	3,94	2,62
	Safeguard of the natural native species	5,13	5,13	5,13	2,57
	Site renaturation and remediation	4,95	2,48	2,48	1,24
	Compatibility of the new natural species with the natural context	5,01	5,01	3,76	1,25
25,29			22,82	20,25	10,16
Urban analysis parameters	Iconicity	4,18	2,09	3,14	4,18
	Space flexibility	5,45	5,45	5,45	5,45
	Usability	5,45	5,45	5,45	5,45
	Flow management	4,75	3,56	3,56	3,56
	Accessibility	5,76	5,76	5,76	5,76
25,59			22,31	23,36	24,40
FINAL SCORE			82,58	86,05	69,44

Table 6 – Partial and overall attributes and sub-attributes values.

Considering the landscape aspect, the insertion of new social, cultural and educational functions not only allows to activate policies of urban regeneration and sustainable development of the neighborhood, but, through bio-phyto-remediation activities for soil reclamation, it increases the feasibility and maintainability of the intervention.

Conclusions and future developments

The work focuses on sustainable regeneration of disused industrial heritage site in Bari. This building typology is increasingly used for adaptive reuse interventions, due to its significant historical memory and space flexibility. At the same time, it is characterized by environmental constraints, strong decay and marginal urban location. Starting from the identification of building typology values, based on the formal and historical background, the possibilities to reuse have been investigated through literature review. In particular, the case of Stanic refinery is carried out under Multi-Criteria Decision-Making (MCDM) Analysis. This method has been applied on three detailed design solutions and a great number of attributes relating to social, physical-morphologic, urban and environmental aspects. These four main categories have been accurately analysed during the preliminary stage of activities for the development of refurbishment strategies.

Thanks to its versatility and adaptability to different problems, MCDM Analysis is an interesting tool to rank the satisfactory, efficient and sustainable uses for Stanic refinery area. The adaptation of industrial derelict warehouses to different uses plays an important role in ensuring the continued efficient use of the building stock, extending its useful life. Adaptive reuse interventions not only increase the site attractiveness, but also develop modern and feasible strategies to reuse dismissed or abandoned structures, reducing urban sprawl.

Future research developments will focus on the cataloguing and synthesis of data obtained from preliminary analyses in a summary table of the case study. Starting from these input data, it will be possible to define, through the Design Criteria System (DCS), the best strategy to be adopted with the

selection of the attributes and sub-attributes to be considered in the building transformation process. The sum of the weights of each parameter will allow to obtain the feasibility coefficient of the adaptive reuse process. To complete the analysis, it will quantify and evaluate intervention costs and the potential building score to undergo sustainable site conversions, through the use of the ARP model (Langston, 2012) and the AdaptSTAR Model (Conejos et al., 2013; Conejos et al., 2015).
Multi-criteria models, decision support systems and virtual analysis platforms aim at simplifying the procedures for the recovery of existing abandoned sheds, framing the steps that characterize the adaptive reuse activities and quantifying the incidence of parameters that can influence design stakeholders' choices.

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