PERCEIVING SOCIAL HOUSING THROUGH MATRIX STRUCTURAL ANALYSIS - A THRESHOLD BETWEEN THEORETICAL RESEARCH AND PRACTICAL APPLICATIONS

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ABSTRACT
The current adopted research methods for rehabilitation of social housing projects face lots of challenges to address the complexity of socio-cultural, environmental and economic aspects. Hence, the research discusses matrix structural analysis method that aims at bridging the gap between theoretical and practical approaches for more sustained social housing rehabilitation projects. It acts as a simplified analytical and decision making tool that is capable of structuring the huge range of data, categorized into various scales; starting from urban to architectural solutions, and scopes; discussing building energy performance and management process. The research applies the proposed matrix on a case study project entitled: Interventions in Obsolete Residential Neighbourhoods: Manual of Best Practices (ORRN-MBP) (Promoted by Junta Andalusia, University of Seville, Spain). The project studied eight neighbourhood plans built between the 1950 and 1970 with potential cultural values but suffering incompatibility with contemporary users’ demands. The proposed matrix presents a comprehensive toolkit for decision makers and set a datum for sustainable social housing rehabilitation plans.

Keywords: Matrix structural analysis, decision making process, social housing rehabilitation projects

INTRODUCTION
Rehabilitation of social housing projects is considered among the main challenges that face preserving cultural heritage neighbourhoods especially due to the increasing incompatibility of existing buildings to respond to contemporary users’ needs, demands and life styles. The research presents a review of literature that discusses the definition and evolution of a matrix in urban and architecture research arena. Then, it discusses obsolescence and rehabilitation of social housing projects. The research method cites a case study in Seville, Spain for eight defined neighbourhoods to develop the proposed matrix structural analysis and decision making tool in order to bridge the gap between theoretical approach and practical application for dealing with rehabilitation of social housing projects.

REVIEW OF LITERATURE
Matrix structural analysis has been used as an analytical tool to demonstrate interrelationships and dependencies between elements to provide insights into how to manage complex systems or projects. Then, it has evolved to be used as a decision making tool by weighing up and scoring different factors.
Matrix as an Analytical tool

The research uses two terminologies to describe a matrix as an analytical tool. First; ‘Matrix’ can be perceived as a sort of an ‘Assemblage’ combining together different elements within certain bonds and frameworks, and it could be composed of fragments of different times and scales aiming at interpreting an identified message. It embodies a field of interrelationships concerning dependent and independent variables, explaining connections between them. From this perspective, it has been used on the urban analysis scale by Giovanni Battista Piranesi within his scenography of Campi Martii, Rome, 1762. Also, Aldo Rossi used this method in his Analogous city collage (Venice Biennale in 1976).

Matrix can also be perceived also as a ‘Threshold’, in the sense of acting as a gateway or an interface separating two fixed principals to introduce a new way, direction, principle and idea. Hence, it can be considered as a powerful interpretive tool and analytical method that leads experimental transformations for different scales and scopes of problem solving to increase the capability to build up a critical comparative analysis for the problem and proposals.

Matrix Structural Analysis is not a new methodological technique, where the term was introduced within the scientific discourse in the early 20th century when Werner Heisenberg formulated the theory of Matrix Mechanics. Also, Jean-Nicolas-Louis Durand used the method on the building analysis scale in the late 18th and early 19th century, in order to systematise architectural knowledge, and form a kind of “typological atlas of architecture”.

Matrix as a decision making tool

The transformations of the social structure and the need for mass production for housing after the first and second post-war eras, focused on the production process itself to find a model suitable for social housing, determined by new standards for housing to ensure existence of minimum occupants’ needs in relation to low costs. Hence, this context fostered the use of matrix not only for structural analysis but also as a decision making tool that could rule the housing construction process.  

Alexander Klein, in 1928 used matrix of successive increments to describe an analytical comparison for different typologies of social housing projects, followed by a numerical analysis using the scoring method, then a graphical expression of spaces, relations and connections. Klien’s research was a threshold that introduced afterward a series of experimental applications, e.g. the Gross-Siedlung at Bad Dürenberg housing project in Leipzig in 1930 for 1000 lodgings between Loggia house typology, apartment blocks, and single family houses.

During the 1960’s, new challenges faced social housing projects to plan for the dynamics of growth practiced in the informal slums. This promoted the project of PREVI (Proyecto Experimental de Vivienda in Lima, Latin America) as a pioneering housing project that aimed at creating low-rise, high-density housing of 1,500 dwellings with a view to expansion and adaptation for each residential unit. Later, a research work entitled ‘Time builds’ elaborated by EquipoArquitectura (EqA), Fernando Garcia-Huidoboro, Diego Torres Torriti, Nicolas Tugas, had been concluded with a final matrix charting the lifespans and modifications of 14 housing models over forty years. This frame work had been the main idea of the Chilean practice Elemental’s "half a house" model.

Hence, the research develops a synthesis for using matrix as an analytical & decision making tool for building design optimization and rehabilitation of social housing projects as shown in Figure (1).
Obsolescence and rehabilitation of social housing projects

Political strategies for housing renovation policies in European countries are changing to emphasise the following sustainable issues; (1) improvement of physical performance, (2) correspondence to the needs of the elderly, (3) improvement of energy efficiency and, (4) social cohesion and area revitalization, Baek and Park (2012). The study shows that comparing Spain to other European countries, shows that it has relatively low ratio of house renovation investment occupied in total houses (30.4%), while it has a medium ratio of public housing support in percent of state budget.

Obsolescence indicators

Obsolescence results from the factor of time, which implies change and most often degradation of performance, usability, occupant satisfaction and the end of the service life of built facilities, and also due to the mismanagement of the physical assets of social housing over time. Obsolescence presents a serious threat to the built property as it rarely accounts for its societal and cultural significance. Hence, minimizing obsolescence and extending building life cycle by improvement, renovation and renewal is a better and more sustainable solution. This requires a systematic analytical and predictive model for identification, prevention, diagnosis and cure of obsolescence indicators.

Different kinds of obsolescence can be classified, characterized and distinguished according to a variety of theoretical/conceptual models. A study by Thomson and Flier (2011) and GOETZ (2012) classified them into physical factors (related to material processes) and behavioural factors (related to human actions) and the interactions between them. Then, numerical methods can be developed to measure/evaluate degradation in the physical and socioeconomic context. This also calls for developing appropriate life cycle management plans to consider the building’s spatial and structural flexibility to accommodate future changes. Synergy arises from economies of scale when sites are combined to increase their development potential.
Sustainable rehabilitation indicators

Rehabilitation addresses obsolescence of a building in its existing use. Strategic approaches for rehabilitation may include: restructuring, diversification and regeneration. Sustainability and more particularly energy efficiency, is a new (additional) input and has become a growing importance for the market position of the built property. It includes social, economic and physical rehabilitation. Hence, a recent study by Vehbi and Hoskara, (2009) proposed a model for measuring the sustainability level of historic urban quarters and to indicate an appropriate strategy for their rehabilitation. It introduces the characteristics, role, selection process and scaling method of sustainability indicators, which are numerical tools used to measure changes in the physical, economic and social structures of a defined urban area. It also shows an inversely proportional relationship between type and the level of obsolescence (revitalization) and the level of sustainability in the physical, economic and social structures of a particular area.

METHODS

MBP project for Rehabilitation of Social housing neighbourhoods

The research presents the practical application of comparative matrix that took place as a concluding frame work for the IORN-MBP project (Intervencion en Barriadas Residenciales Obsoletas: Manual De Buenas Practicas), Junta Andalusia, University of Seville-Spain. The project aimed at studying the current situation of the social housing neighbourhoods built between 1950 and 1970, which were built following the recommendations of the Athens Charter at the end of the Franco dictatorship, responding to a high demand for housing and addressing issues related more to quantity rather than quality. The project defined eight neighborhoods as shown in Figure (2), and discussed their measures of obsolescence in order to propose strategies for rehabilitation plans in the form of Manual of best Practices.

Figure 2 shows geographical location of the eight neighbourhoods under study

Indicators of obsolescence

The IORN-MBP project defined a set of weighted obsolescence indicators divided into physical indicators (70%), and socio economic indicators (30%). The project defined seven physical indicators for obsolescence and assigned weighting for each to express different ranges of obsolescence from a total 70 points as shown in Table (1). Hence, by comparing the obsolescence indicators for the eight predefined locations as shown in Figure (3), it is...
shown that most neighbourhoods are suffering from problems in building accessibility, while least problems occur due to urban complexity and public transport.

Table 1 - physical obsolescence indicators and their weighting, IORN-MBP project

<table>
<thead>
<tr>
<th>Accessibility of open spaces</th>
<th>Possibility of use of EL</th>
<th>Public transport coverage</th>
<th>Coverage of equipments</th>
<th>Urban complexity</th>
<th>Building condition</th>
<th>Buildings accessibility</th>
<th>Total</th>
</tr>
</thead>
</table>

Figure 3 Comparing the physical obsolescence indicators for the eight neighborhoods.

Also, the IORN-MBP project defined six socio economic indicators of obsolescence with equal weighting, as shown in Table (2). By comparing the eight neighbourhoods as shown in Figure (4), it is shown that most socio economic obsolescence indicators are education level, population age and price of housing unit.

Table 2 Socioeconomic obsolescence indicators and their weighting, IORN-MBP project

<table>
<thead>
<tr>
<th>Empty units</th>
<th>Occupation</th>
<th>Population age</th>
<th>Immigration</th>
<th>Education level</th>
<th>Price of housing unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
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<td>5</td>
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<td>16.7</td>
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</table>

Figure 4 comparing the socio economic obsolescence indicators for the eight neighborhoods.

Then, the IORN-MBP project used logos to provide recommendations for the studied area as shown in Table (3), and provided interpretations which combine together the previous three phases in a comprehensive diagrammatic design.
Table 3 Using Logos to indicate recommendations, IORN-MBP project

<table>
<thead>
<tr>
<th>Urban scale</th>
<th>Building scale</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Neighbourhoods</td>
<td>Housing accessibility</td>
<td>Instrumental management</td>
</tr>
<tr>
<td>Neighbourhood multifunctionality</td>
<td>Housing flexibility</td>
<td>Flexibility management</td>
</tr>
<tr>
<td>Neighbourhood Connectivity</td>
<td>Recreational housing</td>
<td>Shared management</td>
</tr>
<tr>
<td>Comfortable &amp; efficient Neighbourhood</td>
<td>Community housing</td>
<td>Social management</td>
</tr>
<tr>
<td>Healthy &amp; protected Neighbourhood</td>
<td>Housing diversity</td>
<td>Community management</td>
</tr>
</tbody>
</table>

IORN-MBP matrix representation

The IORN-MBP is represented as shown in Figure (5);
Figure 5 The IORN-MBP matrix for Poligono del Valle-01
Matrix structural analysis

The research develops a structural analysis matrix that demonstrates the composition of elements in a legible and structured manner. The matrix is structured over an orthogonal grid to express the relation regarding scales and scopes of action on the vertical axis, while sequential steps of structural analysis and decision making process are expressed on the horizontal axis. The language used resembles an assemblage of hybrid cultural, social and physical conditions. It varies according to the data composition in the form of maps, photos, numerical charts, written texts, logos and illustrative diagrams. In order to make an in sighted decision, matrix should demonstrate the following points: criteria of assessment, options or alternatives, weights assigned to each criterion based on its importance in the final decision, and scores used to rate each option on a ratio scale.

Matrix Scales of action

Sustainable rehabilitation plans require defining a scale of action which facilitates setting targets and defining appropriate indicators for obsolescence and sustainability. The matrix defines two scales of action which are the ‘Urban scale’ and the ‘Building scale’.

The Urban scale

Urban Analysis takes two steps; documentation and defining obsolescence indicators. Documentation requires gathering general data related to geographical location, urban and housing housing patterns, connectivity, public transportation and land-uses, and then determining the preservation value for the urban context and the development dynamics status and rate. While, obsolescence indicators are defined according to problems of connectivity and accessibility of urban pattern (e.g. Chana and Bami), lack of mixed uses and recreational areas, scarcity of street furniture, and shortage of public transportation.

Decision making process takes two steps; ‘Recommendations’ for sustainable rehabilitation, and ‘Interpretation’ for strategic action plans. Sustainability indicators focus on 7 aspects that include the following; compactness, connectivity, inclusiveness, green, multifunctionality, creativity and safety as shown in Figure (6). Finally, the research uses the classification of strategic approaches found in Vehbi and Hoskara (2009) to define levels of action for the urban scale and accordingly its time plan and output. The shortest interference level is ‘functional restructuring’ with immediate physical output, then promoting ‘functional diversification’, and finally when the neighbour is self-sustained and begins its role as a regeneration agent within its community-‘functional regeneration’- this requires the longest time plan and provides both physical and socio economic outputs as well.

![Figure 6 Functional regeneration plan for Poligono del Valle-01, IORN-MBP project](image-url)
The Building scale

Building analysis takes two steps; documentation and defining obsolescence indicators. Documentation requires gathering general data related to building heights, condition, construction type and year, ownership type, occupants’ density, ages and needs. Obsolescence indicators are related to limited housing typological diversities, incompatibility of housing unit vertical circulation facilities, dimensions and distribution with occupants’ current needs.

Decision making process takes two steps; ‘Recommendations’ for sustainable rehabilitation, and ‘Interpretation’ for strategic action plans. Sustainable indicators focus on 6 aspects; attractiveness of social housing typologies, diversity of mixed land uses, accessibility, flexibility, and safety. The research uses the classification of housing rehabilitation strategies proposed by Baek and Park (2012) into extension type, individual type, combined type and integrated type depending on the rehabilitation objectives and house characteristics as shown in Figure (7). Time plan and economies vary according to the type of adopted strategy with the least budget for the combined and integration plans so as to benefit from the economies of scale, while the most expensive are the individual and extension plans where each building unit is discussed individually.

![Figure 7: Building scale- rehabilitation plan to solve the problem of improving vertical circulation, author’s elaboration after IORN-MBP project](image-url)
Matrix Scopes of action
The matrix defines two scopes of further action related to the ‘Management’ and ‘Energy’. The term management can include variety of scopes. Yet, the IORN-MBP project focused on assessing and improving social, community and shared management process, and on the energy performance of the building envelope.

Sustainable Management indicators
Management analysis takes two steps; documentation and defining obsolescence indicators for both urban and building scales. The scarcity of street furniture, lack of accessibility of the streets and buildings and the decline in business activities represent the most serious physical obsolescence indicators, while, number of uneducated, unemployed, and/or high percentage of old aged occupants represent the socio-economic indicators, like that in Valle and San Pablo or even cases of high percentage of immigration like that of La Chana.

Decision making process takes two steps; ‘Recommendations’ for sustainable rehabilitation, and ‘Interpretation’ for strategic action plans. Recommendations focus on 9 aspects underlining the main management approaches that include; political, financial, structural, instrumental, digital, shared, social, and community management, which aim at enhancing the neighbourhoods with better social actions improving the training of the inhabitance in collective social work in order to stimulate social cohesion and responsibility. This shall lead to improvement of the housing quality and the image of the neighbourhood within the city which would enhance the real estate market.

Sustainable Energy performance indicators
Energy Analysis takes two steps; documentation and defining obsolescence indicators for energy use on both urban and building scales. Documentation requires gathering general data on the urban scale for; climatic zones and weather files, annual average temperature and humidity range, prevailing wind direction and speed, as well as solar radiation range. While for the building scale, the type of data should cover the monthly energy consumption, type of fuel used for energy production, type of artificial lighting and HVAC mechanical systems used, occupants’ operational schedule, as well as the type of building insulation. Discussing energy obsolescence indicators on the urban scale indicates increased energy consumption due to the increasing demands of occupants’ comfort. While for the building scale, shows a significant deficiency in the building energy performance of the thermal envelope and building facilities, as a result of the high thermal transmittance of building envelope.

Decision making process takes two steps; ‘Recommendations’ for sustainable rehabilitation, and ‘Interpretation’ for strategic action plans. Sustainability indicators can be retrieved by using green rating systems. The addressed recommendations for sustainable rehabilitation plan aim at obtaining comfortable, efficient, healthy, and protected indoor environment. This is by improving the thermal and acoustic insulations of the building envelope, including the facades, external windows, and roof. Finally, interpretations provide detailed building plans and sections for improving building envelope as shown in Figure (8).
The research further develops the following decision making matrix using weighted indicators for obsolescence and sustainable rehabilitation as shown in Table (4). The value of (Y) should be equal to or exceed the value of (X) to achieve a successful sustainable rehabilitation plan.

**Figure 8 MBP Interpretations for improving building energy performance for Polígono del Valle-01, IORN-MBP project**

**Matrix representation**

The research further develops the following decision making matrix using weighted indicators for obsolescence and sustainable rehabilitation as shown in Table (4). The value of (Y) should be equal to or exceed the value of (X) to achieve a successful sustainable rehabilitation plan.

![Matrix representation](image)

**Table 4 Proposed MBP matrix representation**

A: is the total sum of scores for physical obsolescence indicators

B: is the total sum of scores for socioeconomic obsolescence indicators
X=A+B: is the total sum of scores for obsolescence indicators
C: is the total sum of scores for physical sustainability indicators
D: is the total sum of scores for socioeconomic sustainability indicators
Y= C+D: is the total sum of scores for sustainability indicators
The value of (Y) should be equal to or exceed the value of (X)

DISCUSSION & CONCLUSIONS

The research develops a matrix structural analysis and decision making tool to present various sets of alternatives for sustainable rehabilitation of social housing projects. The main aim of the matrix is to build up a critical comparative perception of the problem and research phases, presented through a process of selection, abstraction, prioritisation and interpretation of data processing. The matrix is structured to adjust the relation regarding different scales and scopes of action. It acts as a simplified interpretive tool that is capable of structuring the huge range of data obtained.

The research applies the research method on a case study project entitled: Interventions in Obsolete Residential Neighbourhoods: Manual of Best Practices (MBP) (Promoted by Junta Andalusia, University of Seville, Spain). The project studied eight neighbourhood plans with potential cultural values but suffering incompatibility with contemporary users’ demands. The proposed method presents a comprehensive toolkit that acts as an analytical and decision making tool for sustainable rehabilitated plans using weighting and scoring of defined indicators. This shall set a datum for sustainable social housing rehabilitation plans that would be considered as minimum requirements asked from professionals where they are free to extend their creativity in design beyond these guiding scores.

The structure of the matrix is flexible to respond to different contexts according to the selected obsolescence and sustainability indicators, and also to add more scales and scopes of action depending on the required research. It is also more readable; pointing out levels of strategic plans and timeline of action, and achieves better communication with different decision makers to enable evaluation and comparability for sustainable rehabilitation strategies.

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