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A USER-FOCUSED INTEGRATED SYSTEM FOR SUSTAINABLE REFURBISHMENT

Gallo Ormazábal, Izaskun*; González Díaz, María Jesús† and García Navarro, Justo‡

Departamento de Construcción y Vías Rurales, Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid, Ciudad Universitaria s/n, 28040 Madrid, España
* i.gallo@upm.es; † mjgonzalez@arquinex.es; ‡ justo.gnavarro@upm.es

Abstract. *Nowadays, it is urgent to renovate a great number of residential buildings. The necessity of improving energy efficiency must also be considered as an opportunity to improve indoor comfort. To achieve this goal, it is essential to develop tools to be used in the decision-making process, aiming to refurbish buildings in an integrated, efficient and sustainable way.The integrated system developed is based on a set of indicators. Sustainability indicators are useful to synthesize and organize complex information. They can provide data to evaluate a process in different stages: evaluation, diagnosis, comparison and tracing. The set of proposed indicators aims to accomplish the holistic approach pursued by sustainable development. So, these indicators are divided into three groups: environmental, social and economic. However, the main innovation of the system of indicators is the social ones. The sustainable refurbishment system aims to be a user-focused one. Therefore, the starting point is the needs of the user and social indicators are developed around this.The system tackles the sustainable refurbishment of buildings beyond energy problems. It proposes incorporating users in the decision-making process involving them in the refurbishment and so, contributing to the success of the renovation. In order to achieve this target, three social indicators are used, divided into 10 sub-indicators, and a "Questionnaire about Sustainable Refurbishment" is drawn up.This research has been carried out in the framework of "Sustainable Refurbishment" Research and Development Project, an integrated project under the supervision of the Centro para el Desarrollo Tecnológico e Industrial (CDTI) from the Spanish Government, in which University and the Construction Industry collaborate. This research project aims to develop an integrated system for the retrofitting of existing buildings to improve their energy efficiency. Accordingly, an additional objective of the project is to improve quality of life of residents.*

1 INTRODUCTION

Recent research projects on energy renovation highlight that incorporating users in the decision-making process facilitates a successful renovation (DEMOHOUSE 2008). In order to address the task of reducing energy use in buildings architects need to seek ways of integrating user involvement in building performance (Janda 2011). "Sustainable Refurbishment" R&D Project [http://rs.fi.upm.es/] tackles the sustainable refurbishment of residential buildings beyond energy problems. At the same time that energy efficiency is improved is essential to enhance the quality of life of residents in other aspects to involve them in the process. In order to achieve this target, three social indicators are used, divided into 10 sub-indicators, and a "Questionnaire about Sustainable Refurbishment" is drawn up. One global social indicator is calculated from this system of indicators. This social indicator quantifies the social performance of the building. The questionnaire is an important part of the set of indicators to engage the residents in the process. First, asking them about their needs and next, equally important, educating them on sustainability issues.

2 BACKGROUND

Indicators are quantitative, qualitative or descriptive measures, helpful to simplify the information available about an item and/or quality of a process (including development, planning, preparation and operation), in a relatively simple way to use and understand (García Navarro 2009). Indicators have three main functions: to measure, simplify and communicate. They are useful to manage information about complex issues such as sustainability because they try to prioritize in an issue with multiple perspectives. Sustainability must deal with environmental, economic and social indicators.

2.1 Sustainability indicators in European and International standards

The International Standard Organization (ISO) in Technical Specification ISO/TS 21929-1:2006 "Sustainability in building construction –sustainability indicators. Part 1: Framework for the development of indicators for buildings" defines a framework for establishing sustainability indicators for buildings. It provides a guide for developing and selecting sustainability indicators. The norm explains that many aspects of building performance are related at the same time with environmental, economic and social impacts, such as: building location, spatial solutions, services, client needs, technical solutions, service life or functional performance of the building, including indoor conditions that affect the health and the well-being of the users.

The European Norm EN 15643-3:2012 "Sustainability of construction works — Sustainability assessment of buildings — Part 3: Framework for the assessment of social performance", in accordance with ISO, defines social aspect as: "aspect of construction works, assembled system (part of works), processes or services related to their life cycle that can cause change to society or quality of life". This norm concentrates social dimension of sustainability on the assessment of aspects and impacts of a building expressed with quantifiable indicators. Social performance measures will be represented through indicators for the following social performance categories:

- Accessibility
- Health and Comfort
- Loadings on the neighborhood
- Maintenance
- Safety / Security
- Sourcing of Materials and Services
- Stakeholder Involvement

The objectives of the assessment are to determine the social impacts and aspects of the building and its site; and to enable the client, user and designer to make decisions that will help address the need for sustainability of buildings. The whole life cycle of the building must be considered: design, construction, use and end of life.

2.2 Social indicators in environmental evaluation tools

Nowadays, the most thorough methodologies to face the sustainability of new or existent buildings are the methods and environmental evaluation tools based in Life Cycle Assessment. Originally, these methods focused on reducing environmental impacts. Gradually, the social and economic commitment that sustainability requires has broadened indicators and methods to these areas too. Since the late 90, the publications of institutions such as International Initiative for a Sustainable Environment (IISBE), World Green Building Council (WGBC) and Sustainable Building Alliance (SBA) show that these methods are in constant evolution.

Despite the general consensus about the need to deal with social, environmental and economic aspects at the same time, in many of these tools, social aspects require further research (Simón-Rojo and Hernández-Aja 2011). The categories and criteria that include "social aspects" are not clearly defined in some of the methods and tools reviewed such as the *British Building Research Establishment Environmental Assessment Method* (BREEAM), the American GREENGLOBE, the Australian GREENSTAR, the Japanese *Comprehensive Assessment System for Built Environment Efficiency* (CASBEE), the Green Building Tool (GBTOOL) or the Australian *National Australian Built Environment Rating System* (NABERS). Whereas, for example the American *Leadership in Energy & Environmental Design* (LEED) and the Spanish *Valor de Eficiencia de Referencia de Edificios* (VERDE), *Hexálogo ASA* (Asociación sostenibilidad y Arquitectura) or *Guía de edificación sostenible para la vivienda en la Comunidad Autónoma del País Vasco* are more explicit collecting social aspects.

3 METHODOLOGY

The research studies, analyzes and considers the social indicators of international, European and national sustainability evaluation methods, in addition to other investigations summarized in the following list:

- DEMOHOUSE Project: "Design and Management Options for improving the energy performance of Housing", *Eco-buildings. European Commission. Sixth Framework Programme*, 2008.
- SECURE Project. Barriers and possibilities for a more energy efficient construction sector, *Intelligent Energy Europe*, 2009.
- Plan Estratégico 2010. Barrio de San Cristóbal de los Ángeles. Distrito de Villaverde. Madrid, *Empresa Municipal de Vivienda y Suelo (EMVS) y Universidad Carlos III*
- ISO/TS 21929-1:2006 "Sustainability in building construction –sustainability indicators. Part 1: Framework for the development of indicators for buildings".
- EN 15643-3:2012 "Sustainability of construction works. Sustainable assessment of buildings. Part 3: Framework for the assessment of social performance".
- Environmental evaluation tools: BREEAM, LEED, CASBEE, GBTOOL and VERDE.
- "Guía de la edificación sostenible para la vivienda en la Comunidad Autónoma del País Vasco", *Departamento de vivienda, obras públicas y transporte. Gobierno Vasco*.
- Hexálogo ASA (*Asociación Sostenibilidad y Arquitectura*).
- Internationally-recognized experts on sustainability in construction such as Sangter, Newsham, Larsson or the WBCSD (*World Business Council for Sustainable Development*).
- Agenda 21 de Málaga.

3.1 Selection of a set of indicators

There is a need for sustainability indicators in order to assess a progress towards a goal. However, the simplification of complicated issues can be misleading (S. Ghosh et al. 2006). If they are too complex or numerous they will not be understood by the non-expert population.

It is also important to consider how far they are applicable to the process of change. Furthermore, it is important to take into account the context in which they are going to be used. Following these indications, from the review of the criteria considered as “social” aspects, we chose some of them for the system of indicators established in this research and other new criteria were developed. The general aspects that International and European standards reflect are more developed in national regulations. Some of them were used to elaborate our social indicators, such as:

- Core Documents of Spanish Building Regulations (Código Técnico de la Edificación)
- RD 47/2007 sobre Certificación de Eficiencia Energética de Edificios.
- “Orden sobre la modificación del Plan General de Ordenación Urbana de Valladolid para su adaptación la Ley 5/1999 de Urbanismo de Castilla y León”
- “Ordenanza de Torrejón de Ardoz (Madrid)” and “Ordenanza Bioclimática de Tres Cantos (Madrid)”.
- “Decreto de Ecoeficiencia 21/2006 de Cataluña”.
- UNE 170001-1: 2007 “Accesibilidad universal. Parte 1: Criterios DALCO para facilitar la accesibilidad al entorno” and UNE 170001-2: 2007 “Accesibilidad universal. Parte 2: Sistema de gestión de la accesibilidad”.
- “Orden 1369/2006, de 21 de abril, de la Consejería de Medio Ambiente y Ordenación del Territorio de la Comunidad de Madrid, por la que se aprueban los criterios para obtener la consideración de Vivienda con Protección Pública de carácter sostenible”.

Every social indicator proposed is divided in sub-indicators that deal with more specific aspects in order to facilitate its quantification. This research is developed under the framework of “Sustainable Refurbishment (SR)” Research and Development Project that is an integrated project under the supervision of the *Centro para el Desarrollo Tecnológico e Industrial* (CDTI) from the Spanish Government, in which University and the Construction Industry collaborate. The development of a system of indicators is part of Work Package 8 “Integrated model development”. The Construction Company FCC CO is the leader of the project and the coordinator of this task. Another participant in this task is *Grupo de Termotecnia,* a research group from *Escuela de Ingenieros de Universidad de Sevilla*. The final system of indicators agreed between the participants is shown in Table 1. Our research group *giSCI* was responsible of social indicators. This paper focuses on the development of the set of social indicators.

3.2 Benchmarking for social indicators

Considering the reference methods, standards, regulations and literature, we established an objective, a calculation method and the evaluation parameters for each sub-indicator that comprises every social indicator. In paragraph 4.1 it is shown the final system of social indicators (Table 3).

Environmental Indicators	EN1	Building Use. CO2 emissions	EN1.1	Global emissions	EN1.1.1	Global Energy Efficiency Indicator (EEI)
					EN1.1.2	Class of Energy Efficiency (CEE) A-G
			EN1.2	Heating	EN1.2.1	Heating EEI
					EN1.2.2	CEE (A-G). Heating
			EN1.3	Cooling	EN1.3.1	Cooling EEI
					EN1.3.2	CEE (A-G). Cooling
			EN1.4	Domestic hot water	EN1.4.1	Domestic hot water EEI
					EN1.4.2	CEE (A-G). Domestic hot water
			EN1.5	Lighting and equipment	EN1.5.1	Lighting VEEI
	EN2	Building Use. Final energy	EN2.1	Heating EEI	EN2.1.1	EEI for net energy heating demand
					EN2.1.2	EEI for heating system
					EN2.1.3	Use of renewable energy
			EN2.2	Cooling EEI	EN2.2.1	EEI for net energy cooling demand
					EN2.2.2	EEI for cooling system
					EN2.2.3	Use of renewable energy
			EN2.3	Domestic hot water EEI	EN2.3.1	EEI for domestic hot water system
					EN2.3.2	Use of renewable energy
			EN2.4	Lighting and equipment	EN2.4.1	Lighting VEEI
	EN3	Building Use. Delivered energy (kwh)	EN3.1	Natural gas		
			EN3.2	LPG		
			EN3.3	Diesel fuel		
			EN3.4	Solid mineral fuels		
			EN3.5	Electric power		
			EN3.6	Solar energy		
			EN3.7	Biomass		
			EN3.8	Geothermal		
			EN3.9	Others		
	EN4	Use of water	EN4.1	Supply		
			EN4.2	Evacuation		
			EN4.3	Reuse	EN4.3.1	Rainwater
					EN4.3.2	Greywater
Social Indicators	S1	Users satisfaction	S1.1	Users satisfaction		
	S2	Quality of life	S2.1	Health and comfort	S2.1.1	Hygrothermal comfort
					S2.1.2	Indoor air quality
					S2.1.3	Acoustic comfort
					S2.1.4	Visual comfort and Natural ventilation (*)
					S2.1.5	Cross-ventilation possibilities
					S2.1.6	Use of vegetation
			S2.2	Universal Accesibility and Design for All	S2.2.1	Ambulation
			S2.3	Community services	S2.3.1	Users services
	S3	Participation agreement	S3.1	Information to the users of the building		
Economic Indicators	EC1	Energy and community services costs (Use)	EC1.1	Heating and Hot water		
			EC1.2	Water supply		
			EC1.3	Electric power		
			EC1.4	Community services		
	EC2	Refurbishment costs (Project and Construction)	EC2.1	Pre-Design Stage		
			EC2.2	Design Stage		
			EC2.3	Construction Stage		
			EC2.4	Use Stage		
	EC3	Amortization period	EC3.1	Amortization period		

Table 1 : Integrated model system of indicators. Breakdown of indicators and sub-indicators

The underlying difficulty of quantifying qualitative rather than quantitative aspects such as social aspects leads to establish a common reference pattern for comparing all the indicators on the same terms. That is, even though the units are in some cases percentages, in others a specific quantity with a magnitude and in others a positive/negative response or a description of a situation, we proceed to assign all these values a number that belongs to a common reference pattern. This way, everything can be compared on the same terms. This normalization process is referred to in Carraro's paper "Aggregation and projection of sustainability indicators" (Carraro et al. 2009). They introduced a new sustainability index: FEEM SI (Fondazione Eni Enrico Mattei Sustainability Index). Normally, the benchmarking procedure assigns only two values, 1 and 0, according to the correspondence to a chosen reference level. In the case of the FEEM SI the purpose was not only to identify best and worst practices, but also to provide a measure of a distance from a given target. This is why five different benchmark levels were identified, and used to attribute different levels of sustainability in FEEM SI.

The research started attributing five levels to every sub-indicator. Finally, because of the difficulty to attribute a value for each level in every social indicator we decided to simplify it to three levels. More research is needed in many of the areas related with social aspects of built environment to identify levels that provide more steps to go from an unsustainable situation to a fully sustainable one. The common reference pattern used for this research is:

0.00	Unsustainable
0.50	Admissible. A discreet level of sustainability, but still far from target
1.00	Appropriate. Target level, fully sustainable

Table 2: Normalization benchmark levels

3.3 Establishing rules for calculating and weighting social indicators

Weighting rules of social indicators meet the following criteria:

- The relative weight of the indicators *S1 User Satisfaction* and *S3 Participation Agreement* is lower than *S2 Quality of Life* because *S2* indicator reflects the matters directly related to the physical characteristics of the building. (See equation (1))
- The relative weight of the sub-indicator *S2.1 Health and Comfort* is higher than *S2.2 Universal Accessibility and Design for All* and *S2.3 Community Services* because it captures those features of the building more directly related to improving energy efficiency, the main priority of "*Sustainable Refurbishment*" project. (See equation (2))
- The relative weight of sub-indicator *S2.1.2 Visual Comfort and Natural Ventilation* is higher than the rest of sub-indicators of the *S2.1 Health and Comfort* sub-indicator because it is considered a *sine qua non* requirement, a prerequisite. It is an essential requirement to ensure the health and hygiene of housing and so, to improve the living conditions in the case of non-compliant. Therefore, the breach of this condition implies that the overall social indicator (*SI*) is 0.00 (Unsustainable). The others sub-indicators of *S2.1* have been considered with equal importance and their relative weight have been distributed among them. (See equation (3))

$$SI = (0.05 \times S1) + (0.85 \times S2) + (0.10 \times S3) \tag{1}$$

$$S1 = S1$$
$$S2 = (0.90 \times S2.1) + (0.06 \times S2.2) + (0.04 \times S2.3) \tag{2}$$
$$S2.1 = (0.7 \times S2.1.2) + [0.06 \times (S2.1.1 + S2.1.3 + S2.1.4 + S2.1.5 + S2.1.6)] \tag{3}$$
$$S2.2 = S2.2$$
$$S2.3 = S2.3$$
$$S3 = S3$$

Concisely, in a single equation, would be as follows:

$$SI = (0.05 \times S1) + (0.0459 \times S2.1.1) + (0.5355 \times S2.1.2) + (0.0459 \times S2.1.3) + (0.0459 \times S2.1.4) + (0.0459 \times S2.1.5) + (0.0459 \times S2.1.6) + (0.051 \times S2.2) + (0.034 \times S2.3) + (0.10 \times S3) \tag{4}$$

The global social indicator SI that is obtained is interpreted as follows:

SI = 0.00 Unsustainable

The refurbishment process has not considered the basic social aspects.

SI = 0.50 Admissible

The refurbishment process has considered the basic social aspects and puts the building in a better position to deal with other improvements in the future.

SI = 1.00 Appropriate

The refurbishment process has managed to fully incorporate into the building basic social aspects. It has also allowed to establish criteria for tracking them over time and to compare it with other buildings.

3.4 Case Study: residential building in Jacinto Benavente Av, Málaga (Spain)

The theoretical application of these indicators on a pilot building of “Sustainable Refurbishment” R&D project enabled to analyze them in order to reduce the group of indicators. This way, the set of social indicators is adapted to the specific needs of the project: to obtain a system for a fast and convenient evaluation to be used by the Construction Company FCC CO. The pilot building is a residential building of 140 public housing units for rent for people with low income and educational level in Málaga (Andalucía).

In particular, the theoretical application of *S2 Quality of Life* was helpful to guide the direction of the refurbishment beyond energy efficiency problems. Selected social indicators facilitate prioritizing between different requirements in the building. Therefore, they allow planning the refurbishment in progressive stages over time.

4 RESULTS

The most significant results of the research are two tools: a list of social indicators for a quick evaluation and a questionnaire about sustainable refurbishment. The first one synthesizes basic social aspects of a sustainable refurbishment. Meanwhile, the second one facilitates a participative decision-making process and it is part of the system of indicators as its use is obligatory to obtain the maximum punctuation.

4.1 List of social indicators for a quick evaluation

Initially, 4 social indicators were proposed. They were composed of 50 sub-indicators. Finally, they were reduced to 3 composed of 10 sub-indicators to adjust the system to the targets of the project, as it is shown in Table 3.

Two criteria of the system of indicators are considered essential. Both criteria are grouped in the social sub-indicator *S2.1.4 Visual comfort and Natural ventilation.* This sub-indicator deals with two basic conditions for the habitability of dwellings. Those criteria are ratio of glazing and ratio of operable window to room area, in order to achieve enough day lighting and to provide adequate natural ventilation. This requirement is considered *sine qua non*, and it is marked with an asterisk (*) to emphasize its importance. As it was explained in paragraph 3.3, if the building gets 0.00 point at this sub-indicator, then the global punctuation would be

0.00 Unsustainable for the whole building. In the residential building in Málaga, analyzed as Case Study, this sub-indicator enabled detecting that the standard flat (Type A) suffers a lack of healthiness because of the enclosure of the flat open terrace by the residents. So, the global punctuation of this building at its current state is *0.00 Unsustainable*.

S1 Users satisfaction					5%
Did you fulfill the questionnaire about sustainable refurbishment?					
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, at pre-design stage		Yes, at pre-design and use stages	
S2 Quality of life					85%
S2.1 Health and comfort					90%
S2.1.1 Hygrothermal comfort Has the building the energy efficiency certificate?					6%
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, the rating of the building is worst than C and users are informed about it		Yes, the rating is better than C and users are informed about it	
S2.1.2 Indoor air quality Has the building the ventilation system required to provide the necessary indoor air quality?					6%
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, the dwellings have the required admission and extraction openings		Yes, the dwelllings fulfilled CTE DB HS3	
S2.1.3 Acoustic comfort Has the building any indoor or outdoor acoustic problems?					6%
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
Yes, there is acoustic discomfort but the reason of the problem is not identified		Yes, the satisfaction questionnaire has been fulfilled and the reason of the acoustic problem is identified		No, there is no acoustic discomfort in the building	
S2.1.4 Visual comfort and natural ventilation (*) Is there daylighting and natural ventilation in 100% of bedrooms, living rooms, dining rooms and kitchens? (*) *Sine qua non* requirement					70%
0.00	Unsustainable		1.00	Appropriate	
No			Yes, the glazing area is bigger than 1/10 of room area and the operable part of the window is bigger than 1/20 of room area in every bedroom, living room, dining room and kitchen		
S2.1.5 Cross-ventilation possibilities Is there cross-ventilation in the dwellings to improve indoor air quality and thermal comfort?					6%
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, at least 50% of dwellings had that possibility		Yes, more than 75% of dwellings had that possibility	

Table 3: List of social indicators for a quick evaluation - Summary of calculation method, evaluation parameters and weighting of social indicators

S2.1.6 Use of vegetation Has the building and its plot any possibilities to be used as CO_2 sink?					6%
0.00	Unsustainable	0.50	Admissible	1.00	Appropiate
No		Yes, there is some vegetation but not enough		Yes, the vegetation has been improved adding new elements	
S2.2 Universal Accesibility and Design for All					6%
Are the common areas of the building and the plot accessible?					
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, at least one way is accessible		Yes, indoor and outdoor common areas of the building are fully accessible	
S2.3 Community services					4%
Has the building instructions of use, a management plan or any common service for the users?					
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, there is a cleaning and maintenance service in the building		Yes, there are cleaning and maintenance service, instructions of use and at least another common service	
S3 Participation Agreement					10%
Are the users of the building well-informed about the construction work that is going to be carried out?					
0.00	Unsustainable	0.50	Admissible	1.00	Appropriate
No		Yes, the constructor has convened briefings series with the neighborhood to inform them about the work in progress		Yes, the “Participation Agreement” has been written and all the stakeholders has signed it to establish a participating decision-making process	

Table 3: List of social indicators for a quick evaluation - Summary of calculation method, evaluation parameters and weighting of social indicators (continue)

4.2 Questionnaire about sustainable refurbishment

The questionnaire is organized in five areas: Energy, Water, Waste, Building Conservation, and Level of Satisfaction and Comfort. The main objectives are collecting information, as well as, informing the residents about different issues related to sustainable refurbishment of the building. The questionnaire must be used before and after the refurbishment process to obtain the maximum punctuation in indicator *S1 Users satisfaction*. It also contains useful information to calculate *S2 Quality of life* and *S3 Participation agreement*.

Questions are formulated in such a way that the affirmative answer is also the better in terms of sustainability. So, somehow, the user is being educated at the same time that is being informed and that information is being collected. Furthermore, all the affirmative answers are in the same column therefore, the questionnaire quickly provides a global vision of the building current condition before the refurbishment or later, after it has been undertaken.

Replying the questionnaire promotes a participating decision-making process. The information obtained would be useful for a preliminary evaluation of the condition of the building and to detect action priorities. Additionally, the delivery of the surveys and the questionnaire itself would be helpful to inform about the refurbishment and about essential aspects of sustainability. It would contribute to reduce social barriers of the refurbishment process because it would promote residents participation, it would be helpful to explain the refurbishment to them and it would facilitate the higher degree of social implication that is necessary to achieve a successful refurbishment.

5 CONCLUSIONS

- The questionnaire together with the group of social indicators provides a user-friendly tool to quantify if the refurbishment process has managed to incorporate basic social aspects in the building. They also allow to track the intervention and to compare with other buildings.
- The questionnaire on sustainable rehabilitation promotes a controlled participatory decision-making process, in order to reduce the inherent difficulties of this short of processes.
- The simplification effort undertaken to address social issues without requiring excessively laborious calculations allowed synthesizing a group of indicators for obtaining and managing crucial social aspects in the building.

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