LIFE *Lugo+Biodynamic*. Planning a multi-ecological neighbourhood as a model of urban resilience

Sowing Sustainable Cities

BORIS HINOJO[1] SUSANA MARTÍNEZ[1] SUSANA PENEDO[2]

[1]3edata ingeniería Ambiental sl, Lugo, Spain
[2] Concello de Lugo, Lugo, Spain

ABSTRACT: The City Council of Lugo (Galicia, Northwest Spain), started in 2016 a Project under the LIFE Climate Action Program, with demonstrative measures of adaptation and resilience to Climate Change., which designs and plans a multi-ecological neighborhood as a model of urban resilience. The main objective of this project is to provide a reference model for the future design of sustainable and resilient medium-sized cities (<250.000 dwellers). The Project addresses three main aspects: i) Residential Neighborhood Urban Design; ii) Demonstrative actions in green and residential areas; iii) Engaging stakeholders (public and private entities). This LIFE Project shows how the municipal initiative in collaboration with innovative activities undertaken within a scientific context have made possible the implementation of demonstrative mechanisms of adaptation to Climate Change in medium-sized cities.
KEYWORDS: Urban resilience, Sustainable Development Goals SDG, climate change mitigation, climate resilient economy

1. INTRODUCTION

Among the 17 Sustainable Development Goals (SDG) proposed by the UN in September 2015, there is one (SDG11) dedicated to Sustainable Cities and Communities, which highlights that sustainable development challenges will be increasingly concentrated in cities and encourages us to achieve inclusive, supportive, resilient and sustainable urban spaces. The cities of the world occupy only 3% of the Earth's surface, but account for 60 to 80% of energy consumption and 75% of carbon emissions [1]. Consequently, cities play a key role in action on climate change, considering that they also house more than half of the global population, most of the building assets, thereby representing high concentrations of population and consumption [2,3], with urbanization projections of 6 billion dwellings by 2050. [4].

The City Council of Lugo (Galicia, Northwest Spain), started in 2016 a Project under the LIFE Climate Action Program, with demonstrative measures of adaptation and resilience to Climate Change., which designs and plans a multi-ecological neighborhood as a model of urban resilience. The main objective of this project is to provide a reference model for the future design of sustainable and resilient medium-sized cities (<250.000 dwellers).

This paper presents the LIFE *Lugo+Biodynamic* initiative, the implemented measures and the main achieved results.

2. APPROACH

The City Council of Lugo obtained EU funding to develop the LIFE *Lugo+Biodynamic* project and carry out the design of a climate-resilient, sustainable and innovative urban planning model of action against Climate Change. The universities of Santiago de Compostela (USC) and Politécnica de Madrid (UPM) have a key role as project partners, and the County Council of Lugo as co-financier.

The Project addresses three main aspects:

- Residential Neighborhood Urban Design
- Demonstrative actions in green and residential areas
- Engaging stakeholders (public and private entities)

All these aspects have been addressed in the context of making an innovative contribution to the shift towards a low-carbon, climate-resilient economy and supporting better environmental and climate change governance at medium scale.

3. ACTIONS

The Project has been divided into actions that are described following the three aforementioned major project approaches.

3.1 Innovative urban design at residential neighborhood scale

- Multi-ecological neighborhood planning as a sustainable urban design model for medium-sized sustainable cities
- Catalogue of green urban design solutions (*GUD – Lugo*) [5] to be applied to both existing and future neighborhoods, with a web-tool for calculating CO_2 saving indicators (https://www.lugobiodinamico.eu/en/)

3.2 Demonstrative actions in green and residential areas

- Energy crops in urban setting (1ha)
- Restoration of a wetland enclosed by urban industrial areas (6.0ha)
- Arboretum with 65 native and representative species of 8 natural habitats in northwestern Spain (Galicia) (5ha)
- Urban forestry: Plantation of native hardwoods to obtain wood (4,1ha) and cultivation of chestnuts in urban environments (3,6ha)
- Implementation of 1.3 ha of urban orchards
- Construction of the *Green Impulse* NZEB building using local timber, as a demonstrative and innovative benchmark of timber construction

3.3 Engaging stakeholders

- Public awareness on Climate Change regarding cities
- Engagement of companies and entities for the promotion of sustainable urbanism

4. METHODS

Following the scheme of those relevant sections of the project, previously defined, we have applied different methodologies to assess a series of indicators and evaluate the degree of efficiency and sustainability for the different actions to be undertaken.

4.1 Innovative urban design at residential neighborhood scale

The projected multi-ecological neighborhood have been evaluated in terms of potential sustainability by using the Leadership in Energy and Environmental Design for Neighborhood Development standard (LEED-ND) (https://www.usgbc.org/leed/rating-systems/neighborhood-development). LEED-ND is specifically designed to apply to neighborhood contexts. LEED-ND identifies and evaluates three aspects: i) the location and access (SLL: smart location and linkage); ii) internal pattern and design (NPD: neighborhood pattern and design); iii) the use of green technology and building techniques (GIB: green infrastructure and buildings). At this point it is worth pointing out that any similar green neighborhood rating system could have been used to this purpose.

Criteria of the LEED-ND standard (green building rating system) were applied to evaluate three scenarios in terms of sustainability: i) optimum scenario, in which the development of the future neighborhood will follow most of the key LEED-ND criteria; ii) middle scenario; iii) minimum scenario, which defines a very unlikely baseline situation since the projected multi-ecological neighborhood, to be built within the framework of this project LIFE, is intended to meet high sustainability levels and serve as an urban design model for medium-sized sustainable cities.

High levels of walkability, a sense of place, social cohesion and stability, and neighborhood resiliency among flexible and adaptive economic and sociopolitical conditions are some of the requirements which define the most sustainable neighborhoods as LEED-ND standard.

Table 1 summarizes key criteria to consider the level of sustainability of a neighborhood (LEED-ND standard).

Table 1: Criteria for a green neighborhood (LEED-ND standard)

Criteria for a green neighborhood
• A discernible center
• Housing within a five minutes walk of center
• A variety of dwelling types
• A variety of stores and commercial activity
• Flexible backyard “ancillary” buildings for working or living
• A school within walking distance
• Playgrounds near all dwellings
• Connected streets
• Narrow, shaded streets conducive to pedestrian and cyclists
• Buildings close to the street at a pedestrian scale
• Parking or garages placed behind buildings and away from street frontages
• Prominent civic and public buildings
• A community decision process for maintenance, security, and neighborhood development

Furthermore, LEED-ND rating system sets out certain requirements for the consideration of environmental sustainability neighborhood. These conditions have to do with four aspects:

- Smart location is a key parameter since an unsuitable location that wrecks natural areas, forces people to drive long distances, or exposes people to toxics substances could not be balanced with the positive benefits of green building.

- LEED-ND prerequisites exclude development in natural spaces (habitat areas, wetland and water bodies, prime agricultural land, floodplains), accordingly it is a prerequisite avoid these areas within the projected planning and even it could be a relevant strategy include restoring actions of sensitive areas.

- Required parameters are walkable streets with building heights appropriate to street widths or continuous sidewalks, compact development, connected neighborhood streets to each other and adjacent areas.

- Prerequisites require that at least one building within the projected areas to be certified as green under any green building rating system. Also, minimum requirements for building energy and water efficiency are established.

On the other hand, the *Catalogue of sustainable urban solutions* (GUD-Lugo) provides innovative sustainable solutions at different scales (building, street, neighborhood and city) to be implemented both in newly designed neighborhoods and in those already existing in the city of Lugo (accessible in https://www.lugobiodinamico.eu/en/). This inventory of solutions constitutes a core element for the progress towards a sustainable urbanism in the city of Lugo, proposing measures regarding water management, green spaces, bioclimatic urbanism, sustainable mobility as well as public awareness and citizen involvement.

Following this inventory, a simulation was designed for the projected multi-ecological neighborhood area (accessible in https://www.lugobiodinamico.eu/en/).

The projected neighborhood is intended to be developed under sustainability criteria. The buildable area comprises 222.623,5 m^2 inside the Green Lineal Park that surrounds the city and following two river courses Rato and Fervedoria. The design of the multi-ecological neighborhood aims to revitalize this zone, which is characterized by the natural footprint given by the two river basins.

The General Urban Development Plan now in force includes 1.166 dwellings to be built in this district and an estimation of 3.008 future inhabitants. Under this simulation, two scenarios were proposed: one representing a development following the usual pattern (GUD_Scenario 0) and other in which the inventory actions are implemented (GUD_Scenario 1). In order to perform the simulations, the inventory actions have been structured within six strategic interventions (bioclimatic urbanism; accessibility; urban services; circular economy; water cycle; green spaces). Additionally, some parameters had to be assumed: i) for dwellings, a maximum energy demand of 15 kWh/m^2 and year; ii) a rate of change from car to cycling use of 5.5%; iii) a rate of change from car to bus use of 5%; iv) a rate of change from car use to walking of 10%; v) green surface per inhabitant 30,9 m^2; vi) a rate of trees of 270 trees/ha.

4.2 Demonstrative actions in green and residential areas

The energy efficiency of the Green Impulse NZEB building was evaluated by using the green building standard EDGE ("Excellence in Design for Greater Efficiencies"), which works also as a certification program. EDGE is specifically useful at an early design stage of green buildings to plan the reduction of environmental impact. EDGE is an innovation of the International Finance Corporation (member of the World Bank Group) (https://www.edgebuildings.com/certify/) based on the European CEN and ISO 13790-2008 standards by using a steady-state model .

A building may achieve the EDGE standard if is demonstrated a 20% reduction in three specific issues to compare to average local systems: i) projected operational energy consumption; ii) water use; iii) embodied energy in materials. EDGE standard is based on: i) climatic conditions of the location; ii) building type and occupant use; iii) design and specifications; iv) building orientation.

The so-called *Green Impulse* is a public building which will include spaces for collective use together with spaces for council services, with a surface of 678 m^2 distributed on four floors (Figure 1).

Figure 1: Space distribution within Green Impulse building

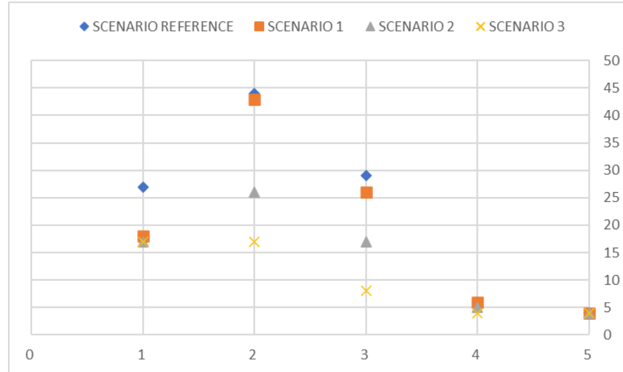

Figure 2: Scenarios rating under LEED-ND criteria (1: Smart Location and linkage (SLL); 2: Neighborhood Pattern and Design (NPD); 3: Green Infrastructure and Buildings (GIB); 4: Innovation and Design Process (ID); 5: Regional Priority Credit (RP); Scenario 1: optimum; Scenario 2: middle; Scenario 3: minimum).

5. RESULTS AND DISCUSSION

5.1 Urban design at residential neighborhood scale

Design of a multi-ecological neighborhood for adaptation to Climate Change covering 294,475 m^2 (both buildable area plus planned general uses), it is intended to be self-sufficient in terms of energy and water, which, compared to the original planning (General Urban Development Plan in force), doubles the surface area of the facilities, and quadruples the green areas while reserves 45% as subsidized housing.

Firstly, results show that the projected neighborhood meets requirements of sustainability regarding: i) smart location; ii) respect for ecologically sensitive areas, since not only they will not be negatively affected but the LIFE project has carried out the restoration of a wetland and natural rainforest with native species and habitats recognized in the European Directive for the protection of natural habitats (Directive 92/43/EU); iii) walkable streets; and iv) building energy efficiency and water efficiency measurements.

Additionally, the project will encourage several particular and valuable measures not specifically considered under this standard like the fostering of the use of green slopes, green fences and especially green building façades and roofs.

Figure 2 summarizes the results attained after evaluating the LEED-ND criteria, according to the three envisaged scenarios. The *reference scenario* refers to the maximum score position within the LEED-ND rating, which is 110 points distributed as follows: 27 for SLL; 44 for NPD, 29 for GIB, 6 for ID and 4 for RP.

Results prove that any of the envisaged scenarios would achieve the certification of environmental sustainability, with 50, 69 and 97 credits respectively for the minimum, middle and maximum scenario. Sections regarding ID and RP are quite similar among scenarios, since the project will indeed include urban landscaping measures (urban orchards, green façades, green roofs, ….) and social equity measures. Regarding SLL section, in all cases similar results were found since conditions of the location are the same, with the only difference of potential cycling facilities. For NPD section optimum scenario is quite similar to the reference one (the ideal situation), but middle and minimum shows worse conditions related to the quality of walkable streets, the number of accessible uses (facilities), characteristics of housing types, parking and transportation demand and parks and recreation. Concerning GIB section, main differences among scenarios were found in energy efficiency and production (from minimum thresholds of energy efficiency to relevant improvement; from 5 to 20% of energy cost produced under renewable energy), just as the management of heat islands and light pollution (Figure 2).

As scalable results it is worth pointing that NPD accounts for 40% of the results, so addressing walkable streets, compact development, neighborhood connections, affordable and diverse housing and accessible parks and schools are effective measures in achieving the goals. On the other hand, GIB accounts for 26% of the results, meaning that other aspects to be kept in mind are those related to energy efficiency and energy production.

Additionally, the Catalogue of Green Urban Design Solutions includes 51 practical solutions at different scales (building, street, neighborhood and city), with measurable indicators for the set of solutions and a linked assessment web-tool. From the simulated application in a town sector results a reduction in energy consumption of 788 MWh/year, with 90% energy self-sufficiency**,** a reduction in GHG emissions of 12,515 tons of CO_2/year (with transport being the activity that most significantly contributes to this reduction) and a rate NOx/year degradation of 47,28 tons (Figure 3).

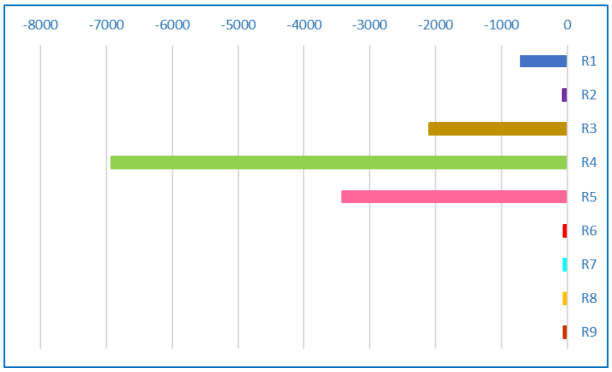

Figure 3. Simulated application of the Catalogue of Green Urban Design Solutions (Regarding GUD_Scenario0 and GUD-Scenario1).
(R1: Reduction by building density, typology and orientation (mWh/year); R2: reduction by infiltration structures (mWh/year); R3: reduction by integral management of public transport (tCO$_2$/year); R4: reduction by pedestrian paths (tCO$_2$/year); R5: Reduction by cycling paths (tCO$_2$/year); R6: Reduction by urban forests (tCO$_2$/year); R7: Reduction by tree-lined street (tCO$_2$/year); R8: Reduction by green roofs (tCO$_2$/year); R9: Reduction by Green façades (tCO$_2$/year)).

5.2 Demonstrative actions in green and residential areas

Green Impulse building is a crucial component of the project that involves promoting multi-storey and innovative construction with locally sourced structural timber as well as nearly zero-energy buildings, also contributing to the promotion and use of water and electricity saving measures. Furthermore, renewable energies (solar photovoltaic and biomass) will be used to reduce emissions and increase resilience.

Results show that the implementation of energy efficiency measures in the *Green Impulse* building will lead to an estimated reduction in energy use of 82,43% compared to a conventional building (base case), primarily due to the quality of the insulation of the building and the generation of energy for self-consumption (solar and biomass). Also, a reduction in water use of 25,34% could be achieved, with estimated savings in the use of embodied energy (energy used in the making of the construction materials) of 74,44%. Additionally, emissions are estimated to be 6,30 tCO_2/year with an operational emission reduction of up to 32,74 tCO_2/year (Figures 4 and 5).

Although these statistics are preliminary to some extent, as the building is not yet under construction, they do unequivocally demonstrate the sustainable dimension of the building, which is also intended to serve as a reference in the new urban development of the city.

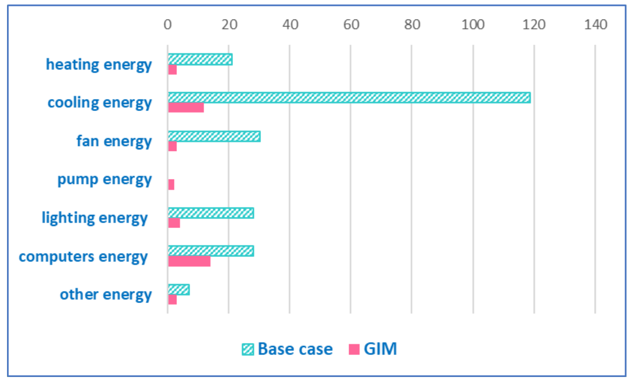

Figure 4. Estimated reduction in the use of energy for the Green Impulse building (kWh/m^2 year)

On the other hand, sustainability of urban green infrastructures (UGI) has been analyzed by estimating their ecological balance in a previous study [6]. This concept evaluates the balance between the biocapacity [7] of the new areas dedicated to forestry plantations and urban agriculture and the quantification of the ecological footprint [8], measured as global hectares (Gha), caused by implementation and management activities. The applied methodology can be seen in depth in De la Sota et al (2019). It is foreseeable a positive ecological balance that will arise when the biocapacity (productive capacity) of the new areas exceeds their ecological footprint.

Demonstrative actions included in this analysis were: i) forestry of native hardwoods (4.5 ha); ii) energy crops in urban settings (1 ha); iii) Chestnut forests (3.9 ha); iv) Arboretum (5 ha); v) Urban orchards (0.4 ha). Results showed that, apart from energy crops, demonstrative actions had a positive ecological balance. Energy crops were characterized by a neutral position since the uptake and emission of CO_2 are almost equivalent due to their use in biomass burning.

UGI globally showed an ecological footprint of 0.088Gha with an estimated total biocapacity of 1.93 Gha, what proves that UGI within Life project positively contribute in offsetting annual CO2 emissions. The study also showed that 0.26 tC ha-1 and year is the average value of uptaken C when all the actions were taken under evaluation.

Figure 5. Estimated reduction by embodied energy for the Green Impulse building (MJ/m^2)

5.3 Engaging stakeholders

More than 60 awareness-raising and communication activities have been carried out, reaching 3,200 people in the academic environment, NGOs and the general population, as well as regular publications to reach the largest part of the municipality's population through local media (press) and the Internet.

The project has also succeeded in the involvement of private entities from the forestry and building sectors what was carried out through interviews and surveys.

Additionally, the publication of a municipal regulation prioritizing building and urban planning licenses that plan to integrate sustainable development and climate change adaptation measures, is achieving results in 65 building projects so far (which represents around 200 dwellings) while becoming a highly positive indicator of the involved stakeholders commitment.

6. CONCLUSIONS

This LIFE Project shows how the municipal initiative in collaboration with innovative activities undertaken within a scientific context and EU environmental funds (LIFE Program: https://ec.europa.eu/easme/en/life) have made possible the implementation of demonstrative mechanisms of adaptation to Climate Change, which enable and will facilitate: i) the meaningful uptake of CO_2; ii) more efficient management of economic and environmental resources at municipal level; iii) the awareness of the population and private entities regarding Climate Change; iv) the promotion of new perspectives in the constructive dynamics of private initiative; v) the design of sustainable cities based on ecology, well-being, resilience and equality with a present and future impact. The Project has also the great potential to become a benchmark for other medium-sized cities, featuring highly replicable and therefore transferable tools and materials.

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