




Article

Towards a Circular Economy for the City of Seville: The Method for Developing a Guide for a More Sustainable Architecture and Urbanism (GAUS)

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Abstract: The article outlines the creation of a method for the development of tools to incorporate sustainability criteria in the field of architectural design. The aim of the research is to provide society with scientific knowledge related to sustainability, evaluating the environmental impact of their actions within the building sector, in a simple and direct manner through specific and contextualised tools. A specific tool is experimentally developed for the context of Seville, called Guide for a more Sustainable Architecture and Urbanism (GAUS), in its first document, GAUS-D1. Based on national and international documentary references, the method principles are defined, and an approach is adopted that prioritises communicative actions with the aim of reaching citizens, professionals, and researchers in the building sector. The specific experiment is developed with GAUS-D1, and an initial evaluation is made of its suitability and the validity of the proposed method. The approach followed ensures that the experience of developing this type of tool is internationally transferable to any other place. Further statistical verification of the use of the tool (which implies a defined testing strategy) is necessary so that the method can be consolidated as a national and international reference.

Keywords: sustainability; Seville; guide; circular economy; decarbonisation; construction

1. Introduction

Nowadays, a large volume of documentary reference is available on sustainability and architecture; many researchers are currently developing multiple aspects within this framework that should be studied in depth and, academically, the discourse is clear, concise and increasingly rigorous. However, the transmission of this approach to professionals who have to implement it and/or to society is still scarce [1]. Multiple current tools and directives for the assessment and certification of architecture, from an energy efficiency point of view, as well as environmental and sustainability ones [2–7], are studied and applied in specialised areas such as universities, but their professional practice and social perception, above all, are very scarce. Environmental and sustainability issues related to architecture and urban planning are still a pending challenge [8] whose doctrinal corpus has been considerably strengthened and rigorously defined, but whose professional practice and social perception are still deficient. Many authors [1,9,10] have been demanding for decades the need to incorporate this knowledge into the teaching of architecture [11], and with it, into the profession itself, but it is not clear that this has been put into practice. It may be due, partly, to the difficult relationship between the conceptualisation of sustainability and the physical architecture practice. In this sense, the affirmation

of the academic Albert Cuchí [12], according to which, in the specific field of architecture, sustainability inexorably implies the completion of material cycles in construction [13], could be enlightening.

This approach is directly related to the field of energy efficiency and decarbonisation, which is currently under development and in the process of being transferred from the scientific to the regulatory level and even to professional practice. However, it goes further, as it includes the rationalisation in the use of materials and construction systems according to their complete life cycle. That is to say, considering the energy consumption and the environmental impacts involved in their use (from their extraction process, production, transfer, and installation, as well as their useful life and reuse or recycling as new raw materials), closing the cycle and encouraging a circular economy. On this basis, it is sufficiently clear that methodological access from the environmental point of view, on the one hand, and from the economic, on the other, are essential. This means efficiency from the energy point of view and, at the same time, effectiveness in construction.

As the scale expands, it becomes essential to address architectural design, both on a building and urban level. In this case, while maintaining the implicit requirement of sustainability through the effectiveness and efficiency in the management of materials' life cycle, it is also required in the management of information (understood as one of the three aspects of sustainability, when it is approached from a management perspective: Matter, energy, and information [14]).

On the other hand, the exchange of information reveals the degree of physical and psychological comfort achieved by a certain architecture in relation to its occupants. Therefore, from this approach, it is also necessary to address the effectiveness and efficiency of information management. Thus, the bioclimatic knowledge provides it from the technical environmental area, and the involvement of the user or citizen (in the building or urban level) provides it from the social area. If the scale is again extended, the dimension of urban planning and territorial management appears, but, in addition, other non-architectural disciplinary aspects (from disciplines such as politics, geography, history, sociology, and social work) become more relevant. For this reason, in the context of this research, a contribution is made to the field of urban management, policy, and urban governance by introducing, as far as possible, the connection between resource management in architecture [15] and the concept of circular economy [16] applied at the city scale. This relationship is not only beneficial in terms of environmental sustainability, but also brings economic advantages in terms of revaluation of resources, along with new business opportunities [17] and job creation.

Seville is a city committed to sustainable development and climate change, as demonstrated by its adherence to all actions related to Agenda 21, Agenda 2030, and the achievement of the Sustainable Development Goals (SDG), which makes it a suitable case study for the experiment in question. In order to fulfil this commitment, the interrelationship between research, business, and local government [18] is key, as well as the need to disseminate, educate, and train society in this field, generating a framework of "science-informed decision environment" [17]. Therefore, Academic institutions must be put at the service of institutions to facilitate and guarantee the transfer of knowledge to society in areas of major concern at present, such as circular economy and low-carbon economy [19], among others. Scientific knowledge and experience are particularly important for the development of European environmental policies [20], which, at the same time, have an impact on the social level and transcend it. For this purpose, the development of tools such as the Guide for a more Sustainable Architecture and Urbanism (GAUS) are of great importance, since they can represent a key reference in processes of citizen governance that involve the transmission of knowledge in an adapted form, correctly translated for society. Therefore, the aim of this research is to define a method that will allow the development of reference and transferable tools in terms of structure, approach, systematisation of information, content type, and communication capacity, for the introduction of sustainability requirements in architecture design at local level.

The transmission of specialised knowledge to society requires a significant, complex, and meticulous effort to simplify and clarify the means of dissemination so that it is useful and comprehensible. Based on significant references of working with society in the transfer of

architectural and urban concepts [21], not only the applied methodologies are outlined [22], but also the communication tools are generated for this purpose and the need to connect and involve society in general, as well as the productive sector and public administration [18].

Therefore, this research focuses on the necessary transmission of knowledge to society, starting from the broad existing doctrinal framework, with the aim of summarising and producing an approach to the knowledge required, addressing architectural aspects from sustainability on a local scale, taking Seville as an experimental reference. Thus, the aim is to bring technical knowledge closer to citizens, emphasising, on many occasions, the tacit knowledge that they possess in the management of domestic and urban architecture, transforming one into the other [23].

In this sense, the GAUS guide, in its first document, GAUS-D1, used as an experiment, represents a mediating tool in this process, and its development involves extensive research in both communicative and technical terms. For this purpose, it undertakes an extensive analysis of the state of the art in terms of methodology and then proposes a sustainability approach at the scale of materials and construction systems (with a significant impact on circular economy), proposing other different scales of architecture such as: Bioclimatic design, public space design, and urban design for further experiments.

The doctrinal corpus on the subject under study is very extensive, so an exhaustive reference to it would not be meaningful in this article. Subsequently, documents of all types (articles, theses, research, online platforms, and publications in general) that have been of special interest to this research in terms of content, review of literature itself, documentary organization, and/or transference capacity, given their graphic or textual expressive characteristics, are referenced.

The potential references analysed for the design and development of the guide are local, as well as national and international. Among the local relevant documents analysed, the following may be mentioned: The report 'Estimation of the Ecological Footprint of Andalusia and its application to the Seville Urban Area' [24], the 'White Paper—guide for the application of energy efficiency criteria in urban planning and local public construction, province of Seville' [25], or the guides published by SODEAN, the forerunner of the Andalusian Energy Agency, on the integration of solar collectors in buildings [26] or in the urban environment [27]. It is also necessary to refer to the research work developed by the project 'System of Sustainability Indicators in Residential Buildings for Andalusia' [28], a precursor of this research in terms of contents, and a fundamental technical reference complemented with international reference proposals [29–32], as well as the recent guide published earlier this year on life cycle analysis (Renovation LCA), for renovation [13]. These works, despite being of great interest at a technical level, are nevertheless extremely complex for the general public, which is why, from research, the type of communication this proposal was intended to address has to be redirected.

In addition to the experiences, tools [33], and specific scientific–technical documentation from Seville, other national or international cases have been considered as references [34–36], which could complement what has been locally referred in terms of strategies, tools [37], and methodologies. There are several systems of indicators [38–49], which both at building and urban level have been of significant interest as references. They have been objectively analysed to establish the priority issues, scales, and fundamental references. Some international guides [50] have also served as a reference in terms of content, but above all as a reference for structuring the transmission of knowledge. Additionally, several educational strategies that allow working on sustainability issues in architecture have been studied and experienced by many European universities [1,51]. Finally, other related publications are also considered: Guides on sustainability in other cities and Autonomous Communities [52], doctoral theses [53], national and international conference proceedings on sustainability, and even reports on the adaptation of future European regulations [54] to the situation in Spain.

Finally, it must be admitted that sustainability in absolute terms for buildings, and even on an urban scale, is a utopia: It is impossible to meet the specific requirement of closing all material cycles at the local level. For this reason, this proposal is framed within the objective of improving architecture in terms of sustainability and seeking to move towards promoting a greater circular economy for any city, with Seville initially as a case study. The method proposed for the development

of transference tools such as the present GAUS tool in general, and GAUS-D1 tool in particular, also aims to make it a reference in terms of structure, approach, systematisation of information, content type, and communication capacity. Thus, the method constitutes an opportunity of development of this type of tool that can be transferred—as already indicated—to other local situations at both national and international level.

The full document that will constitute the GAUS guide will cover all scales of action, from the urban environment to the construction area, including architectural design. However, this article only describes the experiment of the development of “Document 1: Guide for a more sustainable construction in Seville”. Starting from this document and checking the results obtained in terms of use and management, the subsequent documents will be developed, and the method will be finally statistically confirmed.

2. Materials and Methods

The specific objective of the research presented in this article is to define a method for the development of tools that are capable of correctly and effectively transmitting scientific knowledge to society in technical, appropriate, and practical terms for its understanding and application in the field of sustainability in architecture. To this end, an experimental case study is developed, GAUS-D1, in the local area of Seville, which, after verification, will consolidate the method for its subsequent use in future complementary documents, both for the experimental case study under consideration and for other similar scenarios that can be extrapolated nationally and/or internationally.

The developed GAUS-D1 tool is therefore part of a set of tools that comprises the potential practical application of scientific knowledge in the field of sustainability to architecture at all scales. This set of tools is defined as GAUS and represents the framework of the experiment.

2.1. Research Methodology

The methodology of the conducted research includes the following phases:

- Definition of the theoretical conceptual framework linking the concept of sustainability in architecture with its technical implications in terms of circular economy and its practical application in terms of scientific transfer to the professional field.
- Study of the scientific literature related to this framework as well as previous national and international experiences in transferring such information to society.
- Study and definition of agents involved in professional technical processes as generators of knowledge and information as well as potential users of the tool to be developed following the method defined by this research.
- Establishment of possible connections between agents, information, scientific knowledge, and knowledge transfer tools.
- Determine what type of tool is more appropriate for the transfer of knowledge on sustainability in architecture to society, and what features should define it.
- Proposal of method for the development of such a tool.
- Experimental development of the tool for a local, specific, and defined case study within the framework of action.
- Identification of the features that define this tool as useful, concise, and rigorous in scientific terms.
- Verification of results from the use of the tool.
- Review of the proposed method based on the results of using the experimental tool and consolidation of the outcomes.

2.2. Justification of the Case Study for the Experiment

The city of Seville, as a region that is highly committed to sustainable development, climate change, and circular economy, demands such tools to improve governance, bringing together citizens,

government institutions, and private companies, using the academic and scientific network as a mediator between these areas. The case study for the experiment, constituted by GAUS-D1, is developed within the framework of the “Local Regulation for Energy Management, Climate Change and Sustainability” [55], issued in 2012, and reinforced in 2018 by the “Urban Agenda for Andalusia 2030” [56]. This first document is based on the need to achieve the commitments adopted for the city of Seville in three specific areas: Sustainable development (as a result of signing the Aalborg Charter in 1994 and joining the European Sustainable Cities and Towns Campaign [57]), climate emergency (having signed the Covenant of Mayors against Climate Change [58]) and, finally, continuous improvement in energy management at local level, a task that had already been carried out since 1997, but which requires adaptation of standards and regulations [56]. In addition, it is worth noting that Seville is closely committed to Agenda 21, the global programme of action in all areas related to sustainable development of the planet, approved at the United Nations Conference on Environment and Development, held in Rio de Janeiro in June 1992. The Agenda calls for changes in economic development activities, based on a new understanding of the impact of human actions on the environment. Nowadays, these commitments acquire even greater relevance following the appearance of Agenda 2030 (New Urban Agenda of the International Habitat Conference III [59]), approved in September 2015, together with the SDG [60], a roadmap to fight poverty and inequality [61] with a centred approach on people, the planet, prosperity, peace, and partnership [62]. For all this, the city must begin to develop tools for its management and urban transformation.

Similarly, the Local Administration of Seville has signed the “Declaration of Principles on Circular Economy” (Paris 2015) [63], which stresses the importance of Local Governments for its implementation. According to this commitment, the involvement of the scientific community in the awareness and transfer of programmes that promote this cyclical economy and the development of local strategies is of considerable importance. Therefore, this guide has been designed and conceived as a fundamental tool to achieve, among others, the SDG and the principles of circular economy in the local area of Seville.

3. Results

The conceptual theoretical framework has been developed as described in the introduction, connecting the concept of sustainability in its broadest conception with its implications in the field of architecture and the promotion of a circular economy for our cities. Similarly, the suitability of certain tools for the transmission of scientific knowledge to society has been studied, and those that represent a more valuable reference for this research are specified, although the documentary analysis has been much broader than what is specifically mentioned in this article.

A research of agents involved in the processes of construction and architectural and urban design has been undertaken, defining the connections between them and the contributions that they can make in terms of knowledge. The requirements in terms of knowledge transfer have been determined through consultation with managers and representatives of the different groups, including businesspersons, technicians and government officials, gathering and determining the practical focus of the required tool to be developed. Afterwards, the type of tool needed has been defined, which meets the expectations and requirements specified, named in the case study developed as GAUS. The results are explained in the following graph (Figure 1).

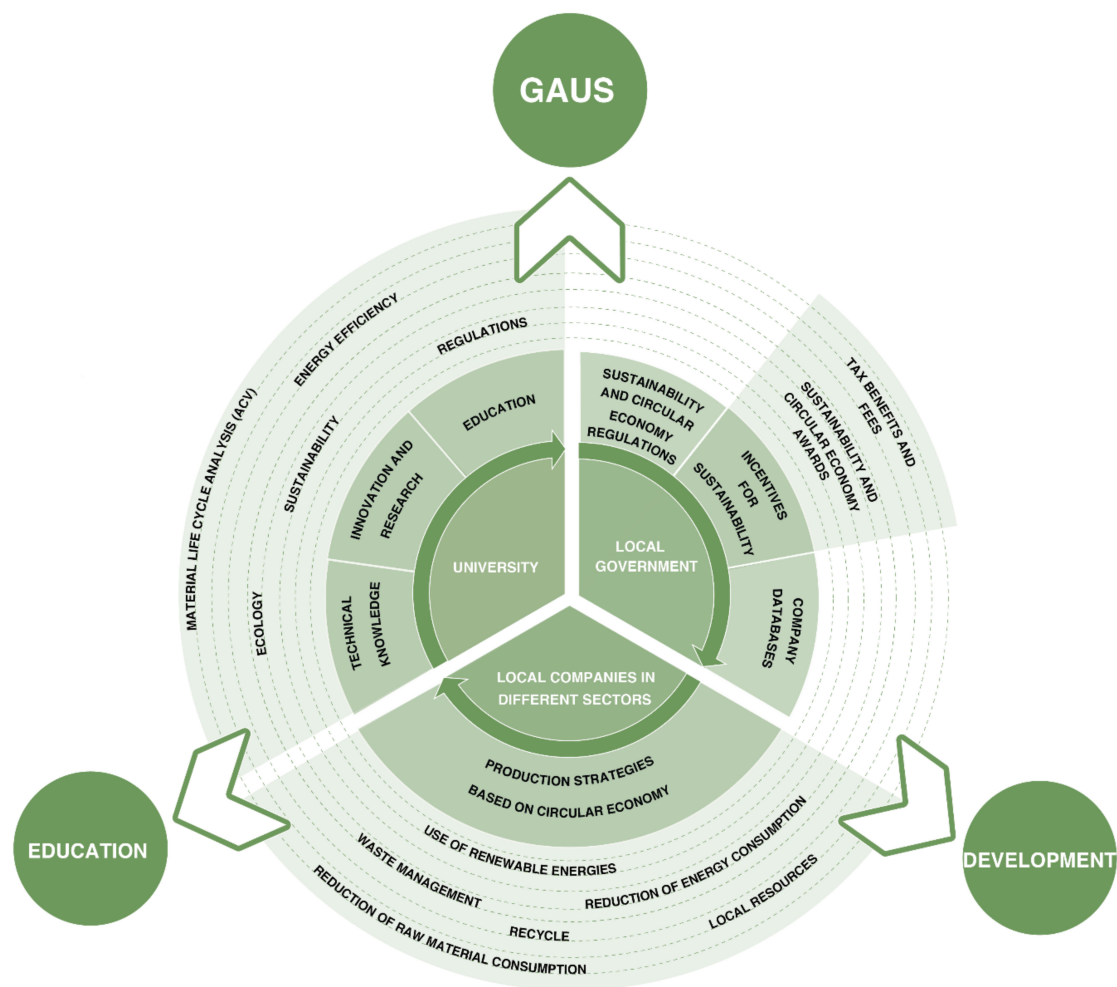


Figure 1. Diagram representing the relationship between agents, knowledge, and technical information in architectural processes. Defining Guide for a more Sustainable Architecture and Urbanism (GAUS) potential contribution in terms of circular economy and sustainability at a local level. Source: The authors.

3.1. Proposed Method

- The proposed method for the development of transference tools is based on the following actions:
- Definition of the approach, scope, reach and objectives of the tool based on the criteria and needs defined in collaboration and agreement with the different local agents involved in the process of consultation and development of the tool. This phase is key and decisive since it is essential to properly define the scope of the tool in order to guarantee its conciseness as well as its scientific rigor.
- Exhaustive documentary research based on the search for tools, methodologies, and strategies in the field of sustainability in architecture as well as strategies and tools for dissemination and/or transfer to society in different contexts: International, national, and local, applicable to the case study. This will enable well-founded decisions to be made, both in terms of form and substance, for the tool being developed, meaning the suitable format it should have, as well as the simplified but rigorous content required.
- Development of local specific climate characterisation determining the potential bioclimatic strategies to be implemented. Understanding local climate conditions is essential to provide adequate passive solutions for comfort, as well as energy efficiency improvements within the framework of sustainability. This allows us to decide the type of actions in the field of

architectural design, construction, and management to be included in the tool, based on the potential development of bioclimatic strategies in specific passive design systems.

- Historical, cultural, and anthropological analysis, from the field of architecture and limited to the scope of work previously defined according to this method, to determine which architectural cultural references should be considered. In order to do this, a sample of these references is compiled and prioritised according to their traditional use over time, excluding solutions that are unlikely or unusual due to the context, thus simplifying the number of specific proposals to be included in the tool.
- Once the context has been fully defined, the specific architectural references would be identified and their properties studied in terms of sustainability, taking into account their bioclimatic performance, their potential contribution to decarbonisation through their use and the potential improvement of the local circular economy that they could represent. This phase requires an important in-depth study of the architectural references involved and the scale considered. In the experimental case being developed, these would be the traditional materials and construction methods of Seville. Regarding architectural design, it would be required to study the bioclimatic performance of the most common building typologies for Seville and their defining characteristics, as well as the management in their design and construction that would involve the use of local resources and therefore, an improvement in terms of circular economy.
- Selection of cases that are justified and documented as proposals to be promoted by the tool, clearly defining the qualities that they should have, and that guarantee both their best bioclimatic performance and their contribution to the decarbonisation and/or improvement of the circular economy for the city.
- Definition of the most appropriate features and graphic format of the tool for the transmission of information and its dissemination. Finally, all this information must be transferred to the dissemination tool and its content with a well-studied graphic design that is capable of reaching users, in this case both citizens and technicians.
- Development and publication of the tool proposing the appropriate social and technical dissemination of the document with the aim of testing results, developing a specific planning for this purpose that enables it to be addressed to the appropriate and required agents for its verification.
- Adjustment and improvement of the tool after its final verification, and development of a management plan for its update and maintenance that consolidates it as a local reference tool in the long term.

This method has been experimentally developed using GAUS-D1 for Seville, and the results and features of the tool are described in detail in the next section.

The GAUS guide is a tool under development, created by different groups of professionals, each group responsible for the experiment of the method for diverse scales of action in Seville (D1–D5). We have initially applied the method to one of them, document D1, at the scale of building construction, and it will be progressively applied to every scale through the rest of documents once the first one has been completely tested. This article defines the method used for this first document and sets out the results obtained from the experiment.

3.2. Development of GAUS-D1 for Seville

Once the need for a specific tool has been determined for the case of Seville, thanks to the contribution of all parties involved, the approach, scope, and features of this tool are defined in order to meet the goal of being a concise, clear, precise, and objective tool for technicians and citizens when dealing with sustainable construction in our cities.

3.2.1. GAUS Scope

As previously mentioned, the full document that will constitute GAUS will cover a broader scope than the merely material and constructive one and, therefore, will extend to other areas and scales prior to the actual construction of buildings. However, the experiment developed uses this first document “Document 1: Guide for a more sustainable construction in Seville” (GAUS-D1) to experiment the method proposed from the research in order to control accurately the multiple parameters involved.

Therefore, the guide GAUS, once completed by replicating the method proposed by this research, will be comprised of the following documents:

- D1. Guide for a more sustainable construction in Seville (scale at materials and construction methods level): Analysis of the predominant construction techniques in Seville and a protocol for selecting and designing them from a sustainable approach.
- D2. Guide for a more sustainable building design in Seville (scale at place and building level): Protocol for the design of bioclimatic architecture, including water cycle and materials management.
- D3. Guide for a more sustainable urban design in Seville (scale at urban space level): Protocol for the design of urban spaces according to the context of Seville and ensuring their habitability.
- D4. Guide for a more sustainable urban planning in Seville (scale at urban planning level): Urban planning procedures design in terms of sustainability.
- D5. Guidelines for a more sustainable territorial planning of Seville and its surroundings (territorial scale): Guidelines for future territorial plans.

3.2.2. GAUS-D1 Objectives

The tool developed for the experiment presents the following objectives, which have been previously defined together with all the agents involved:

- Promote the culture of sustainable construction, which respects the environment and the ecosystems’ energy cycles, applied at the local level, in the experimental case, Seville, according to its morphology, historical and cultural background, geographical location, and particular climatic parameters; offering a common long-term vision of Seville as a Sustainable City.
- Involve and engage governments, technicians (designers, architects, and builders), and citizens (energy consumers), contributing to the development of awareness and transfer strategies to society in order to “support the generation of more responsible users/consumers/citizens, who can make daily decisions focused on preserving resources throughout the production, consumption and waste process and who are better informed about their own consumption patterns”, in the words of Jordi Segalás [64].
- Be a reference document for technicians, organisations, and citizens, with scientific and technical endorsement, and equivalent to similar actions under development in other European Union countries.
- Contribute to the development of architectural strategies that generate more efficient products and services and promote the reuse of existing ones, providing a scope of implementation for both new build and renovation projects, and contribute to the goal of reducing energy consumption in buildings, including embodied energy in materials, in order to achieve the highest possible decarbonisation.
- Become a recommendation protocol in all stages of the architectural project (design, choice of materials, and construction techniques), construction (waste), and subsequent maintenance of the building. The legislative development, in terms of requirements, should progressively lead to the implementation of these measures, and could even become a subsequent legislative regulation. It must be continuously reviewed in order to be consistent.
- Do not have a prescriptive or regulatory nature, although it does have an incentive value for citizens to be qualified and certified by the competent government agencies (in the case of the

local study, the Energy and Sustainability Agency of Seville [65]). These incentives, such as tax benefits on urban licenses or property-related taxes, are a real claim for their application.

- Promote the achievement of SDGs in the local area of Seville, specifically concerning the development of sustainability indicators in relation to circular economy based on those proposed by the European Union, with the capacity to transfer technical knowledge to society.

3.2.3. Documentary Research

An exhaustive study of both local and national or international tools potentially applicable has been conducted: From research documents and reports, decrees, manuals, guides, etc., to relevant projects and experiences. The selection procedure for the analysis of these documents has been based on the following criteria:

- Be a recognised, rigorous, and scientifically referenced document.
- Constitute an administrative document with a legislative character, whether it is mandatory or not.
- Respond to the previously mentioned sustainability aspects from an architectural and urban approach, either from an environmental, economic, or social point of view.

From all these local, national, and international documents analysed, the following contents and/or methodological references of interest for the design of GAUS-D1 are extracted as the main references finally used:

- Contents and local characterisation of architectural references from a cultural, climatic, constructive, and urban point of view [26,27,66].
- Referencing relevant applicable regulations [25,55,67].
- Specific contents related to the framework of sustainability in architecture and decarbonisation [1,13,25,29–32,35,36,39,50,53,67–69].
- Specific contents related to the framework of sustainability for territories, cities, and the circular economy [24,27,35,38,70,71].
- Definition of scales of action for decision making in each construction process [68].
- Methodological references of appropriate graphic representation and written expression for the transmission of knowledge to society [1,26,50].
- References regarding information structure and its summarising, expressive, and communicative capacity [50,52,68].

3.2.4. Climate Characterisation and Potential Bioclimatic Strategies

Understanding local climate conditions, particularly in Seville for this case, is essential to provide adequate passive solutions for comfort, as well as energy efficiency improvements and/or refurbishment within the framework of sustainability.

Passive architecture, defined as an architecture that adapts to surrounding climatic conditions, has existed since antiquity [72]. Based on the experience of traditional architecture, it aims to ensure hygrothermal comfort in buildings based on their own architectural configuration. It is also a close definition related to bioclimatic architecture, which takes into account the environment, health, and well-being of people [73].

Seville is located in southern Spain and Europe, at latitude 37.3881, belonging to the region of Andalusia, with an inland climate classified by Strahler (1951) as “Mediterranean climate”, within the group of “Mid-latitude climates controlled by tropical and polar air masses”. Moderate temperatures and a rainy regime with warm and dry summer periods, presenting significant seasonal variations, define this climate, between the parallels 30°–45° N and 30°–45° S. The annual fluctuation of temperatures is moderate [73]. The “Energy Saving Regulations” applicable in Spain [74] classifies it as climate category B4 (with B being the second in order of increasing severity up to E, corresponding to winter climate severity, and 4, the highest summer climate severity).

It is clear that for centuries, each region has developed unique local passive strategies for comfort and conditioning, which are difficult to standardise, as they depend on many climatic and functional factors [72]. More specifically, in the warm or tempered climate of southern Europe, the use of vegetation and water as shading and cooling strategies for outdoor spaces, seasonal window protection systems against solar gains, natural ventilation at night, or thermal mass as a construction strategy to regulate heat flow, are common local strategies (Figure 2).



Figure 2. Typical interior courtyard building in Seville. Reference for passive strategies to achieve thermal comfort in hot weather considered in GAUS-D1: Awnings, vegetation, and solar control on facades.

Consequently, all of them have been conveniently identified and considered when developing proposals for construction solutions or improvements.

3.2.5. Specification of Local Construction Techniques Related to Building Envelopes

“Local architecture is the architecture of a specific location, defined by the particular use of forms, construction methods and materials” [75], and it is a value in the field of sustainability. Therefore, it is important to identify local construction solutions, of a cultural nature [76], related to the scale of intervention.

In the construction field, technicians can decide which constructive systems to use in order to minimise environmental impact or maximise comfort conditions. However, in the renovation field, it is essential to identify the original state of the building in order to propose improvement solutions based on the existing conditions, with the introduction of new materials and systems. This identification, in the case of major construction works, is guaranteed through compliance with technical requirements imposed by regulations. Furthermore, in the case of minor construction works, without a legal requirement for a competent technician to design the project, the developer lacks objective technical information (not from commercial companies) to adopt effective measures in order to improve energy efficiency within the framework of sustainability. This means improvements such as use of materials with a low environmental and economic impact, produced from local industrial and material resources, and committed to a circular economy.

Some details on the study of the traditional and commonly used construction techniques in Seville are presented below, with the aim of clarifying the level of deepening of the subject undertaken by GAUS-D1.

Concerning the definition of local construction methods in Seville and, more specifically, regarding roof design, there are both flat roofs that can be walked on (typical flat roofs, which recover an elevated free space within a complex urban network in some areas such as the city centre), and sloping roofs with an Arabic tile finish, mixing tradition and innovation (Figure 3).



Figure 3. Seville rooftop landscape. Reference for the characterisation of roofs in terms of local construction methods (flat and sloping roofs with Arabic tiles). Source: The authors.

In terms of predominant façades in the city of Seville, there are several typologies, with one or more layers, and made up of diverse local materials, such as ceramic bricks, wall tiles (or rammed earth walls), stone, or lime plaster. Usually, they lack insulation in their original state, based mainly on thermal mass as a resource of thermal control. In most cases, façades work as supporting structures as well as envelopes (Figure 4).

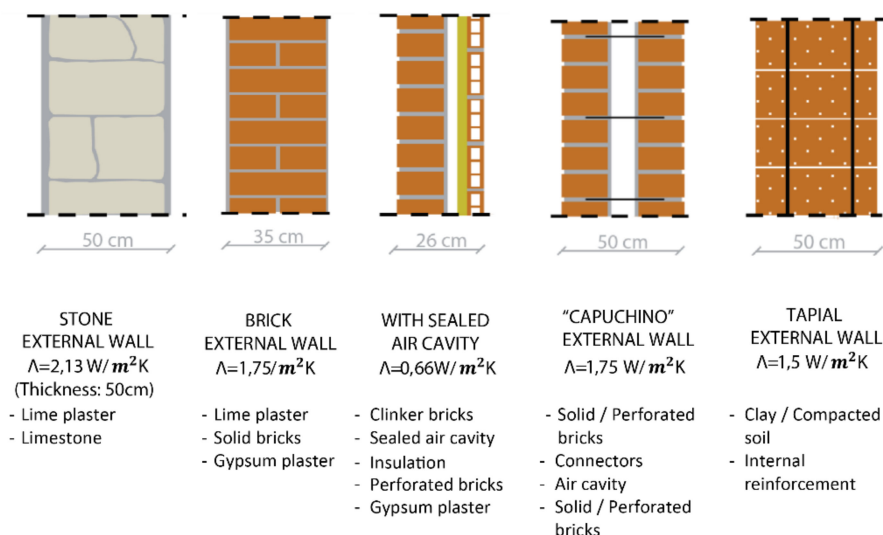


Figure 4. Traditional external wall build-ups in Seville. Example of façade characterisation in terms of local construction methods (GAUS-D1). Source: The authors.

GAUS-D1 includes the most common types of roofs (Figure 5) and façades in the local area of Seville, with all their layers and approximate thermal transmittance values, in order to propose

solutions for improving energy efficiency, mainly by incorporating insulation, through new façade cladding, waterproofing, etc. Hence, initial construction solutions of the properties to be renovated are recognised by users and developers as their own, and their improvement proposals are also recognised as adjusted to a technical reality.

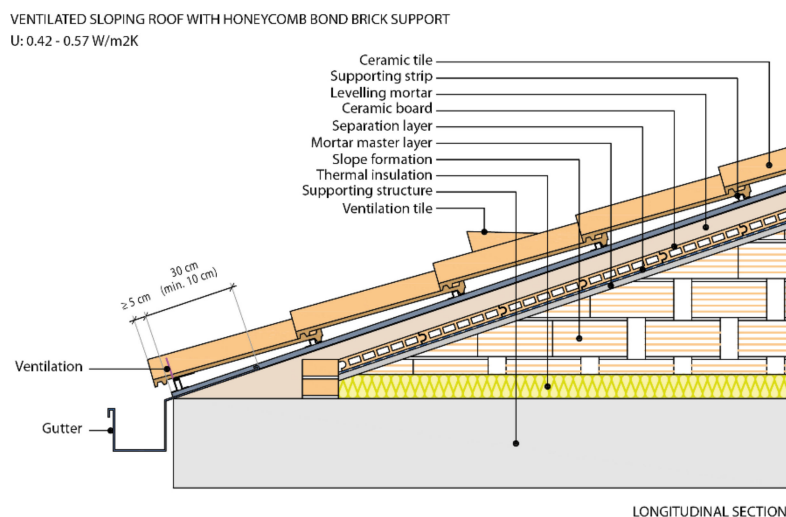


Figure 5. Traditional sloping roof build-up in Seville. Example of roof characterisation in terms of local construction methods (GAUS-D1). Source: The authors and www.hispalyt.es.

3.2.6. Proposal of Actions for Improvement

Given that the building envelope is a key element in the passive conditioning and energy saving of buildings, the proposed actions are mainly focused on façades, with special emphasis on windows, roofs, natural lighting, ventilation, and air quality. It also proposes solutions for water and waste management and the integration of renewable energy systems into architecture (e.g., thermal and photovoltaic solar collectors).

It is assumed that buildings that require renovation are of a certain age, especially in historical cities such as Seville, where useful life of buildings ranges from 50 to 100 years. Some of them were built according to proper construction standards, but lacking the protection of any recognised legal regulation. As a result of this, and the lack of maintenance, the state of conservation is often deficient, with problems of water filtration, air, humidity, deterioration, etc. In this sense, the choice of new materials and products to implement solutions requires specific advice in the field of sustainability. We are referring to ecological and low environmental impact values through Environmental Product Declarations (EPD) in all phases of their life cycle, fundamentally, which can be obtained from prestigious databases such as those of the International EPD[®] System [33] or the Institut Bauen und Umwelt (IBU) [77], among others.

The most sustainable construction solutions are offered based on quantifiable data obtained from specific bibliographical sources. This facilitates decisions on the choice of a particular paint, for example, justifying in this case the advantages of a mineral or natural product over a synthetic one, for its application on façades. Another example can be related to the advantages of certain insulation materials from renewable sources (cork, hemp, or cellulose), which may be less commercially advertised compared to others of a polymeric nature or based on foams, which are responsible for damaging the ozone layer and global warming. It also offers access to local business databases committed to circular economy that may provide some of these resources.

Therefore, GAUS-D1 tool offers a database of construction solutions and proposals for improvement adapted to local climate, materials, and construction methods. It makes it easily recognisable and useful

for local users and building developers who are willing to contribute to environmental preservation and sustainability through their construction activities.

3.2.7. Graphic Design and Structure

GAUS-D1 is structured with “Consultation Cards” focused on both the non-specialised user and the trained technician. It is a tool that, at the same time, can be consulted by the owner of a property to be renovated, as well as by the technician who is going to implement such improvements. That is, it can be used both by the citizen or developer who wants to invest in a new property construction, and by the designer, not an expert in sustainability, who wants to implement it in their project, beyond the exclusive energy efficiency.

Each card responds to an action type, easily located through an exhaustive index. Thus, a clear division into fundamental parts of the building’s envelope and into aspects of usability and energy, provides an easy location for the card that describes the intended improvement action.

This method ensures, on one hand, that scientific knowledge, research, and innovation benefit the entire scientific and professional community and, on the other, that citizens are nourished by its results and can use them to improve their quality of life [41]. This means improving the impact on the environment in a simple and direct way and causing a clear action of knowledge transfer.

It is particularly relevant to be concise in order to be accessible to the local citizen, who is committed to the environment, climate change, and sustainability, compared to the conception of an excessively technical document, which is only aimed at professionals in the sector.

The intention of the design chosen for this guide is to approach the user, both technical and non-technical, through explicit, clear, and structured graphics that are intuitive and easy to understand. It is intended that both the graphics and the language used are close, although precise and rigorous; the structure, clear and organised; and the design, chromatic, attractive, and amusing.

This double user-technician approach is directly reflected in the structure and design of each card, where a first more visual part, with adequately defined initial concepts and the fundamental support of the use of representative iconography, is complemented by a second part of a more technical and specific language where the given prescriptions are completed. The guide has a double qualitative and formative reading of concepts related to sustainability. In addition, the local approach allows for specific solutions for particular strategies determined by the climate.

The guide provides referenced data and results of Life Cycle Assessment (LCA) from Environmental Product Declarations (EPD) within the more technical part, which enable professionals in the construction sector as well as citizens and users committed to sustainability, to make decisions related to environmental impact of products. It also incorporates a database of local companies involved in the circular economy and related to products and materials recommended in the construction solutions provided.

Each card is identified by an acronym and a colour corresponding to the block of the table of contents to which it belongs. A simple 3D scheme allows us to locate, within the building, the specified construction element/system; creating a visual explanation that helps us to understand the action that is going to be described. This 3D model is developed using the BIM (Building Information Modelling) methodology, applied to relevant existing examples of sustainable architecture in Seville, functioning as a laboratory or a virtual model of the aspects studied and developed for this guide.

The following approach to the content of each Action Card is developed using simple yet meaningful graphics that highlight the impact on sustainability, in terms of energy, materials, health, or pollution (Figure 6).

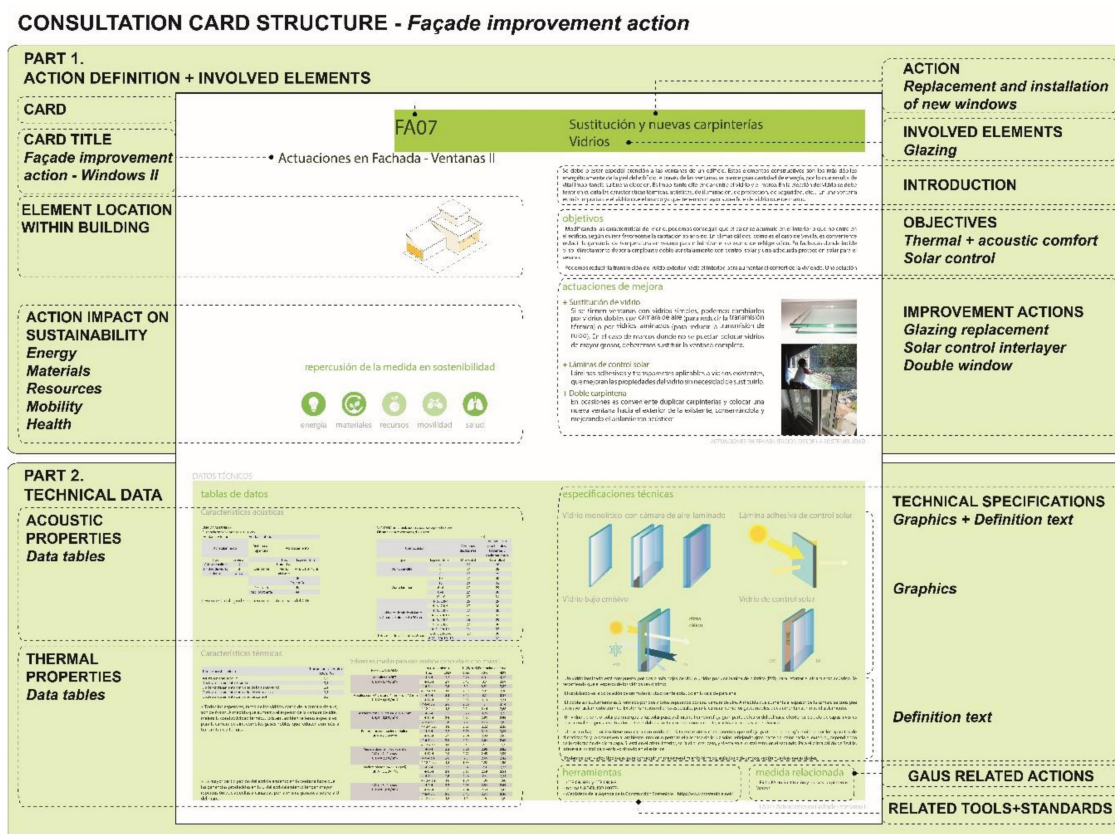


Figure 6. Example of Action Card contained in GAUS-D1. Definition of its graphic design and content structure. In this case, the card explains potential actions to improve building façades. Source: The authors.

The main content of the first part of each Action Card is focused on its definition and objectives. These objectives directly propose a series of improvement actions that are briefly described together with photographs to easily identify the element or system on which a construction, design, or usability proposal is presented.

3.2.8. Social and Technical Dissemination of the Tool

GAUS-D1 is conceived as an open database on sustainability (construction scale) and within the reach of society (tool). Although the design originally proposed is graphic in paper format, the need for continuous updating of databases, regulations, and other sources raises a complementary required development in web or digital format.

4. Discussion

The partial conclusions reached following the development of GAUS-D1, and in accordance with the objectives set for it, are as follows:

- The need for this type of document is currently unquestionable in Spain. The multiplicity of tools compiled in continuous development by numerous professional and educational entities of international scope corroborates this and also shows the need for transference to society.
- It is a relevant contribution that promotes the perception and commitment of Seville as a sustainable city.
- It becomes a reference document and tool for technicians, organisations, and citizens, with scientific and technical endorsement, comparable to similar initiatives being developed in other European Union countries.

- Given the specific measures it provides to reduce environmental impacts and energy consumption, including the energy embedded in materials, it represents an important contribution to the goal of near-zero-energy buildings to achieve the highest possible decarbonisation.
- It is a practical and concise guide that allows both organisations and users to evaluate and quantify renovation and construction activities within the framework of sustainability, in order to apply incentives and subsidies.
- It represents an important progress in terms of transfer to society from the field of architecture to sustainable development and the circular economy. The methodology and development criteria allow the tool to be transferred to another local context of similar scope.
- GAUS-D1 can be considered a basic and solid tool that brings together the technical knowledge needed to achieve the SDG and the transmission of that knowledge to society, getting involved in the daily actions defined by lifestyles.

4.1. Defining Successful GAUS-D1 Features

A subsequent analysis of GAUS-D1 allows us to identify the features that make it a useful, direct, and concise tool, as well as rigorous in scientific terms, which is the objective of this research. These characteristics have been defined during the methodological process of development of the proposed method and will allow us to corroborate its initial validity. They can be summarised as follows:

- Definition and contextualisation of a large part of the parameters due to the selection of a specific local case study, which makes it possible to limit the range of possible construction situations and avoid unjustified simplifications that would make the tool less rigorous.
- Detailed definition of the local context under consideration and all its physical (climate, orography, topography, urban form, etc.) and cultural (traditional building systems, traditional and/or common materials, historical and patrimonial chromaticism, etc.) conditions from the architectural point of view, in order to develop an accurate local analysis.
- Adaptation to the requirements in form and content, either practical, educational, or technical, defined by the local government, social, or business agents according to the analysis of the parties involved.
- Adaptation to the European developments regarding qualification of the construction industry in terms of sustainability, gathering updated regulations, recommendations, and/or methodological proposals, being a reference recommended as an action protocol by the local authorities. Its monitoring can be used to objectively justify the achievement of incentives.
- Contribution and promotion of building improvement strategies that use more efficient methods from an energy and material point of view.
- Conceived as a tool that allows the approach and practical translation of some of the SDG to specific construction design decisions that improve the environmental impact of cities, their habitability, and their local management; contributing to the improvement, at the same time, of the circular economy.
- The exhaustive documentary research on tools, methodologies, and strategies in the field of sustainability and their transfer to society in different contexts provides a database and important background for other studies to be developed along the same path.

All these features, which achieve the objectives initially set by the tool itself, demonstrate the initial validity of the method for the development of practical, precise, and rigorous tools that allow the promotion and incorporation of sustainability principles in architectural construction design for specific local contexts.

4.2. Results Verification and Method Review

The initial theoretical–conceptual verification performed is not sufficient to establish the validity of the proposed method. It is therefore necessary to conduct practical checks on the results of the actual use of the tool by its potential users, both citizens in general, and government technicians and/or professionals in the construction sector. Currently, a campaign is being undertaken to disseminate the tool, from its presentation at congresses and technical meetings to the promotion of its use among professional technical associations and local public authorities. However, relevant statistical data on its use and results will not be available for several years so, despite its initial validity, it will be necessary to perform a subsequent study of its practical relevance in terms of use and results obtained. The terms and indicators of this future study are currently being developed in collaboration with the agents and groups involved.

Once the proposed future study has been completed, it will be required to review the method in depth in order to determine potential changes and adjustments that will guarantee the development of tools that are even better suited to local needs regarding the incorporation of sustainability aspects in architectural construction. However, the method, theoretically proven, although not statistically, can be used for the development of parallel documents related to different architectural scales. This would allow a greater possibility of later statistical verification of the method and thus, its potential transfer to other local contexts that require it for the development of their own specific tools.

The current need for this type of document is unquestionable. The variety of certification and regulation tools [2–6,15,16,29–36,50,54,68], in continuous development by many professional and educational entities corroborates this, and also highlights the need for transfer to society [18,19] in terms of improving the empowerment of citizens and ultimately local resilience and global social sustainability.

5. Conclusions

The presented tool-guide, developed as an experiment by this research, is an important advance in this sense, since it addresses all the required conceptual and technical issues, and it adapts to the user profile and constitutes a major step in terms of knowledge transfer from the field of architecture and circular economy to society.

On the other hand, and here perhaps lies its relevance, it constitutes a validation guarantee of the method proposed by this research and its objective, promoting the use of the proposed method in other similar studies, both for the Seville case study and for other local contexts, while its rigorous statistical validation is being developed.

In this sense, the method defined and developed by this research is useful for the development of reference and transferable tools in terms of structure, approach, systematisation of information, content type, and communication capacity; for the introduction of sustainability requirements in architecture design at local level. Moreover, this method is valid for its extrapolation to other situations, although it can be improved and adjusted, as previously indicated, after a subsequent detailed study that is desirable but not currently scientifically feasible.

The fundamental contribution of the proposed method implies its capacity to develop precise tools useful for citizens and/or technicians that are at the same time scientifically rigorous for the incorporation of sustainability aspects in architectural design, becoming a tool itself for the development and transfer of scientific knowledge to citizens, in a transparent, simple, direct, and rigorous manner.

This contribution is key to the specific development of urban improvement actions based on architectural sustainability principles that result in the improvement of the circular economy in our cities and their resilience.

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