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ORIGINAL PAPER

Urban socio-ecosystem renewal: an ecosystem services assessment approach

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Abstract
Using a novel approach based on the urban ecosystem services approach, this research explores the relation between socio-economic, architectonic and ecological factors in urban renewal processes. This deductive conceptual approach is based on the definition of an urban diagnosis and intervention model based on the concept of urban socio-ecosystemic services. This conceptual approach is applied to three research cases in Andalusia (Spain) neighbourhoods linked to participatory urban renewal processes. A model is inductively defined from these analysed case studies: the socio-ecosystemic services model, based on the conceptual frame, the development of particular instruments and the definition of a participatory methodological strategy. The results obtained in these urban workshops show that the socio-ecosystem model better integrates the relationships between the architectural, socio-economic and ecological dimensions in addressing the need for urban services and infrastructure and the quality of life in neighbourhoods. Citizens can formulate their needs and perceptions of the neighbourhood beyond traditional quantitative variables (i.e. number of car parks, average size of dwellings, population density, etc.), incorporating aspects such as urban landscape, air quality, urban noise, shaded rest areas and children's spaces. All these perceptions are collected and transformed into proposals for neighbourhood improvement, which are assessed and prioritized by the citizens. Together with participatory processes, this approach can be considered as the key to success in urban renewal strategies in neighbourhoods. However, it is necessary to develop indicators and metrics of the relationships between the socio-economic and ecological dimensions that allow a more integrated study of the model at different urban scales.

Keywords Ecosystem services · Resilience · Urban regeneration · Sustainability · Socio-ecosystemic services · Socio-ecosystem

Introduction

Nowadays, human activity has an unquestionable impact on the planet's resources and the biodiversity of the world's ecosystems, reducing both its resilience and its biocapacity. Nature provides humans with the life support system that allows us to organize our way of life, consumption and production in their current conditions. Without nature, the current social and economic system would have no future viability. In the words of Ramón Folch (2003) "We know that all this urban anatomy (urbs) only makes sense when it responds to the activity and needs of its citizens (civitas),

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and only when it adapts to the greater environmental conditions (oikos) does it serve as a basis for a true city (polis). In this context, the words regain the semantic value which etymologically speaking they always had: 'urban politics' is shown as an 'ecological' exercise loaded with 'civic' meaning". Considering that more than half of the world's population lives currently in cities (Haase et al. 2014), and that by 2050 that figure will rise to 68% (Muñoz-Pacheco and Villaseñor 2022; United Nations Department of Economic and Social Affairs 2019), studying urban ecosystems specifically versus other types of ecosystems is a key issue (Blanco et al. 2021). However, there are few studies of application to the urban environment (Muñoz-Pacheco and Villaseñor 2022). Furthermore, they are mostly partial applications; that is, they do not include the study of all ecosystem services. (Sang et al. 2021; Zaman-Ul-haq et al. 2022).

This means that there is a need for a change in paradigm in line with that proposed by the biologist Margulis (2003) which alters the idea of evolution as a continual competition between individuals and species and shows that life conquered the planet thanks to cooperation. She proposed that "the pact is the symbiosis: there are no winners or losers, but rather a recombination. Something new is built".

This new policy can also address what Serres (2004) calls "the Natural Contract" according to which "it is necessary to stop understanding nature as that enormous collection of things reduced to the status of passively appropriated objects, and convert them into legal subjects". These new non-human agents can therefore be incorporated into the exclusively social contract, establishing a natural contract of symbiosis and reciprocity.

For a better understanding of the territory, it is necessary to consider a complex, non-neutral matrix, in which protected areas, land uses, ecological processes and the socio-economic and cultural reality would be inextricably linked, requiring management methods for networks and not individual elements.

To achieve this, an integrated territorial plan is necessary. This is an ambiguous concept, which will have to be well defined so as to be able to invent and contemplate formulas to balance human needs and the requirements of the ecological networks, understanding the latter as one more infrastructure. This is a great challenge requiring dynamic evaluation criteria and decision-making, which hang between "needs" and "possibilities".

The development of numerous evaluation and decision-making instruments for intervention in the territory and in the city has traditionally been marked by the disciplinary reality of different fields such as architecture, economy and ecology. The three fields are very different from each other and are emphasized often by divergent and contradictory approaches. The integration of the three disciplinary approaches is necessary within this integrated territorial plan framework. Therefore, this research aims to establish both conceptual and instrumental links between them so that the approach to urban analysis and intervention starts from an integrated, innovative and interdisciplinary strategy and instrumentation of study and work in socio-ecosystems (Fovet et al. 2021; Liu and Wu 2022).

This new paradigm places the economic system below the social system and this, below the natural system so that the economy becomes less self-centred and acts in the interests of human well-being, guaranteeing a dignified life and considering nature's resilience and capacity (Morandín-Ahuerma et al. 2019). In other words, human activity should not only appropriate services from nature, but should be responsible and take part in the regeneration and maintenance of ecosystems.

Ecosystem services are "the benefits human populations derive, directly or indirectly, from ecosystem functions" (Costanza et al. 1997), also described as "the benefits people obtain from ecosystems" (Reid et al. 2005).

From this perspective, the ecosystem service economy highlights the value of biodiversity and the services the environment provides. It raises awareness of its importance in the decision-making process of economic actors, be they individuals, homes, for profit or non-profit organizations or in political decision-making at all levels. An ecosystem service is therefore a benefit that humans obtain from nature or from the base of resources that sustain their way of life (Daly and Farley 2011). The objective of this approach is to inform decision-makers whose actions affect the environment about their impact and positive or negative consequences. To this effect, it serves as an appraisal of the current state of these ecosystem services, their evaluation once actions have been implemented, and also offers the possibility to study the consequences of the actions according to assumptions and rigorous projections.

The concept of Ecosystem Services was coined in the 1970s in reference to the benefit or contribution of natural systems to human well-being (Daily 1997; De Groot 1992), incorporating the goods and ecosystem services derived from natural capital (ecosystems and natural resources). This conceptual model has been widely used in ecological, socio-cultural and economic assessment of ecosystems, above all as a result of works such as the assessment carried out by Costanza et al. (1997) and the dissemination of the Millennium Ecosystem Assessment (Alcamo et al. 2003) and the TEEB Work Group (2010). Further to these, it has also been used to reinforce the possible and necessary link between governance, planning and resilience (Folke 2006; McPhearson et al. 2015) to improve urban health and quality of life (Gómez-Baggethun and Barton 2013; Rodríguez-Rodríguez et al. 2015; Shao et al. 2023).

The most widespread classification of ecosystem services (Alcamo et al. 2003) recognizes four categories: Supporting Services, Provisioning Services, Regulating Services and Cultural Services. Subsequently, the Millennium Ecosystem Service Assessment Report (Reid et al. 2005) defines ecosystem services as "the benefits that human beings obtain from ecosystems" and also identifies four categories:

- *Supporting services*: ecosystem services, which are necessary for the production of all the other services in the ecosystem. These are nutrient cycling and dispersal, seed dispersal and primary production.
- *Provisioning services*: products obtained from ecosystems. These are: food, crops, wild food and species, water, minerals, pharmaceuticals, biochemicals and industrial products, energy.
- *Regulating services*: The benefits obtained from the regulation of ecosystem processes. These are: carbon capture and storage, climate regulation, waste decomposition, air and water purification, crop pollination and pest and disease control.
- *Cultural services*: non-material benefits which humans obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences. These are: cultural, intellectual and spiritual inspiration, recreational experiences and scientific discovery.

These four categories are the basis for the definition of urban ecosystem services in this research. They provide an opportunity to link planning, management and urban governance (De Luca et al. 2021) with improved urban resilience and subsequently improved sustainability of cities (McPhearson et al. 2015). Assessing this type of service is a complex task (Heal 2000) if we consider that natural ecosystems interact with socio-economic systems at different levels and scales (Holling 2001; Lapostolle and Challéat 2021).

Urban ecosystem services: different approaches according to authors

There is extensive research into ecosystem services and their relationship with and/or application in cities (Chien 2021). Initially, it was developed within the framework of environmental sciences, and they are being increasingly incorporated within the framework of other disciplines. Furthermore, it was initially developed as large-scale research and it changed towards more focused and small-scale studies (Shao et al. 2023). Some authors (Blanco et al. 2021; Folke 2006; Morandín-Ahuerma et al. 2019) address the anthropological urban relationship with the underpinning biotope, referring to a social ecosystem. This enables a connection between the human dimension and its needs within the ecological environment and the necessities of life of all other species. This can be understood in a broader form as: "Living systems are units of interactions that exist within an environment" (Morandín-Ahuerma et al. 2019). Some propose incorporating the concept of ecosystem services into urban design and planning to improve resilience from a social–ecological approach and for the improvement of human well-being (Shao et al. 2023) through the incorporation of its values in urban planning and governance (Elmqvist et al. 2014; Schewenius et al. 2014)). Other authors (Gómez-Baggethun and Barton 2013; Luederitz et al. 2015; McPhearson et al. 2015; Wu 2014) contextualize the term in the city sphere (urban ecosystem services), incorporating aspects linked to urban life related to its biophysical, economic and socio-cultural condition (Bertram and Rehdanz 2015). Similarly, the greatest contribution of these latter authors centres around the unequivocal link they define between urban ecosystem services and human well-being (Lapostolle and Challéat 2021; Wu 2014), as well as increased urban resilience through governance processes which include scientists, professionals, designers and planners (De Luca et al. 2021; McPhearson et al. 2015). Finally, some authors go further, referring to the concept of ecosystem services linked to a specific social ecosystem (Gutiérrez González et al. 2016; Totino et al. 2023) to reflect the nature of this interaction in which natural capital goes hand in hand with other forms of capital (human, technical or social capital, etc.) to produce services.

At the same time, there are two views related to the condition of ecosystem services and their evaluation in reference to the urban environment. The first considers ecosystem services as such solely linked to urban green spaces (Andersson et al. 2014; Elmqvist et al. 2015; Lovell and Taylor 2013; Luederitz et al. 2015; Muñoz-Pacheco and Villaseñor 2022; Paulin et al. 2020; Pukowiec-Kurda 2022; Rodríguez-Rodríguez et al. 2015; Russo and Cirella 2023) either within the city or its immediate surroundings. They are referred to as forming a specific system themselves, different from and complementary to other urban systems, belonging to the city as a whole. A second view considers ecosystem services linked to the whole urban system, including these green spaces, but understanding that the whole city makes up its own supporting ecosystem in which ecosystem services should be assessed as a whole (Chien 2021). In this way, not only humans, but all living beings belonging to the city ecosystem work as a complex and unique ecosystem which takes advantage of mutual synergies and contributions. Ecosystem services are both produced and exploited by and for humans. This research focuses on this second approach, putting it into context and strengthening some aspects.

The socio-ecosystemic services concept

As the interaction between society and ecosystem is more clearly observed at urban scale, so is the generation of natural and anthropogenic ecosystem services given the profound transformation of natural ecosystems that is produced when urban ecosystems are generated. Taking advantage of Lapostolle and Challéat's (2021) approach in "The Integrated Socio-ecosystemic Logic", where they propose a holistic approach that prioritizes neither the anthropocentric nor the ecocentric approaches, this socio-ecosystemic perspective is taken as a starting point. In this research, the conceptual framework of ecosystem services is applied at local scale, where the urban ecosystem (Alberti 1996; Alberti et al. 2003; Nicoletti 1978) is an anthropogenic biome or ecosystem created and maintained by humans and formed by natural and urbanized elements. As a result, urban services are considered the contribution of the urban socio-ecosystem to human well-being out of the interaction between the physical, biological, anthropogenic and urban systems that they are formed from. This research aims to define the concept of socio-ecosystemic services as an integrated approach of the conceptual approaches previously described and commented, going beyond this fundamentally anthropogenic consideration.

This research poses the need to work on the concept of socio-ecosystemic services with the idea that these provide for both human beings and their needs (Max-Neef et al. 1986) and other living things (Morandín-Ahuerma et al. 2019) within the urban framework. We therefore move away from the uniquely anthropogenic approach to adopt a more inclusive approach which incorporates respect for the environment and the need to work in harmony with the ecosystem and existing biotope as a physical support for the city. The city is therefore seen as a community of predominantly human, living things in which a series of services must be provided for its correct functioning. However, beyond the purely quantitative expression of these services, it aims to emphasize the cultural and emotional contribution of human and living beings on the urban environment. The living things which belong to the support ecosystem provide the social–ecological system with a series of emotional and, in general, cultural qualities without which the urban environment would not be the same from a historical, aesthetical, adaptive, bioclimatic or idiosyncratic perspective.

In our case, we apply a conceptual framework to identify the existing neighbourhood socio-ecosystemic services. The neighbourhood is considered the minimum spatial scale for intervention and analysis in which collective socio-ecosystemic services are provided for the citizen and living beings to improve their well-being and quality of life (Hernández 2009) (Shao et al. 2023). This allows us to delimit the analysis of experiences at a specific level, although the neighbourhood is understood as the minimum unit unequivocally linked to the city as a whole.

Evaluating the provision of this type of services allows us to get closer to assessing the efficiency or usefulness of the urban ecosystem when providing the neighbourhood with well-being. In relation to the concept of social metabolism (Infante-Amate et al. 2017; Pauliuk and Hertwich 2015; Toledo 2013) or urban metabolism (Baccini and Brunner 2012; Elliot et al. 2019; Kennedy et al. 2011, 2007; Wolman 1965), it is considered a measurement of the flows of material, energy and hydrological resources necessary to provide a city's population with socio-ecosystemic services. These resources are usually imported from nearby or increasingly further ecosystems. This focus makes it possible to objectify and quantify resources, inputs, outputs and storage of energy, water, nutrients, materials and wastes of urban regions (Pincetl 2012). As a quantification instrument, it can therefore be related directly (translating units of magnitude of each resource service) to the ecosystem services assessment and consequently, with the concept of socio-ecosystemic services defined here.

This approach stems from the evolution of the research into the concept of urban metabolism which, as Wachsmuth (2012) observes, has passed through three stages: human ecology, industrial ecology and finally political ecology where the city is the product of different social–natural fluxes.

Sustainability and urban obsolescence

Within urban design, there is room for numerous disciplines. However, when it comes to decision-making, the relationships between design, economy, sociology and ecology are complex, within a framework defined by the need for sustainable development (Borrallo-Jiménez et al. 2020; Luederitz et al. 2015; Morandín-Ahuerma et al. 2019). The concept of social ecosystem sustainability, coined by Morandín-Ahuerma (2019), can be interpreted as "…the process that defines the relationship between cultures and the biosphere" and proposes an approximation and/or symbiosis between humans and other living beings, shifting urban needs from the merely anthropic to the collective needs of the ecological system itself. Habitability of the urban space as a basic need for humans must go hand in hand with the balance of the ecosystem support and its development. The capacity of the urban system as a provider of socio-ecosystemic services implies that urban metabolism be developed in a framework of equilibrium with the ecosystem, based on an urban bioclimatic design, ecological planning and more sustainable urban management (Karis et al. 2020). In other words, it must control and pursue the closing of energy and

materials cycles (Bai 2016) at local, or at least regional, level (Borrallo-Jimenez and LopezDeAsiain 2020).

Thus, going back to the reflections of some authors who link increased urban resilience to an approach based on urban ecosystem services (McPhearson et al. 2015), we can also establish a relationship between requirements which imply sustainability (environmental, economic and social) with a city's greater capacity for resilience via this approach and assessment of ecosystem services.

Inspired by this approach, this research focuses on the neighbourhood, as it is considered the place where the majority of people's lives are carried out and where certain services are provided for its inhabitants (human and living beings). As a reference point, the neighbourhood also gains certain services from other neighbourhoods and from the city as a whole such as the existing commercial system or the infrastructure system (energy, running water, etc.). In other words, it needs other services produced by other zones in the network.

Neighbourhood urban systems can also be considered in this ecosystem services rationale in which the surroundings contribute to the maintenance of their defining characteristics. Obsolescence (LopezDeAsiain et al. 2020) can be understood as the inability of this urban environment, or neighbourhood, to provide basic socio-ecosystemic services for its inhabitants (humans and other living beings) to build a dignified, happy life for humans which is balanced and resilient (Shao et al. 2023).

The best conditions, therefore, would be those in which a neighbourhood is completely autonomous (Rodríguez-Rodríguez et al. 2015), producing and offering all those services necessary for the provision of quality of life in the broader trans-disciplinary sense, linked to the concept of sustainability as analysed by Morandín-Ahuerma (2019) and which can be observed from a socio-ecosystemic approach. It would therefore be a neighbourhood which covers all the supporting, provisioning, regulating and cultural services just as in a natural ecosystem, but in this case considering its social dimension below the natural system and incorporating all living things.

In other words, from the urban perspective, a coherent proposal is developed with the necessary change in paradigm that must take place in the way in which we interrelate with our economic, social and natural environment. This conceptual approach allows us to assess and evaluate the state of services at neighbourhood level with a holistic and integrated perspective (McPhearson et al. 2022; Ouyang and Luo 2022; Zaman-Ul-haq et al. 2022) of the city, society, economy and nature, giving decision-makers the means to understand the current state, evaluate projects and proposals and monitor compliance of actions already in progress. Evaluating the sustainability of urban ecosystems and their robustness can be prioritized from this conceptual approach.

In addition, due to the lack of effective applied spatial studies (Chien 2021; Romero-Duque et al. 2020; Sang et al. 2021), the study of specific cases applied to real local situations is considered key to discerning the potential of this conceptual approach. Essentially, as this approach, based on the socio-ecosystemic services concept, is directly linked to the physical support and environmental territory ecosystems, its adoption allows us to ensure the basic requirements of sustainability linked to the equilibrium of this ecosystem and take advantage of its capacity for resilience. Three instruments have been developed during the research processes which are considered field studies. The results achieved from the instruments employed give rise to the development inductively of a model which construction, defines the aim of this article. Thus, this article identifies firstly, the opportunity that the socio-ecosystemic approach and the ecosystem services instrument, provide, defining deductively a new concept and secondly, develops inductively a model, which validity is proved thanks to the instruments and results developed in the analysed cases.

In short, the aims of this research are two. The first aim is to define deductively a new integrating socio-ecosystemic services concept. The second and subsequent aim is to inductively generate and define an approach model known as "The Socio-ecosystemic Services Approach" based on the development and study of successful prior experiences of the application of the aforementioned socio-ecosystemic services concept, which differs from the conceptual models outlined in the introduction due to its broader and more integrating focus.

This research has been developed from 2014 to 2021 at different stages in Andalusia Region, mainly in Málaga, Granada and Sevilla.

Materials and methods

This research proposes the review of three case studies where the socio-ecosystemic model is used to address the intervention in the city from an interdisciplinary perspective, since the city and the urban environment are understood as an environment of great complexity and interaction. To this end, it is initially necessary to develop a theoretical framework that allows us to interrelate three disciplinary fields: architecture, ecology and economics. At the same time, it is necessary to incorporate the social dimension from the methodological approach, through citizen participation, using tools that are suitable for this purpose.

A review is carried out on approaches and tools for action in the city related to a interdisciplinary approach in order to define the theoretical framework concept. Since it was not possible to find a conceptual theoretical framework that

meets this requirement as described and explained in the introduction, it is necessary to deductively define the socio-ecosystemic services concept.

There are numerous tools from the three disciplinary fields for intervention in the city and/or territory; however, these tools are developed from a sectoral or partial approach, not an integral one. According to the analysis of the state of the art carried out in terms of tools for intervention in the city to improve urban resilience and sustainability, it can be seen that these tools have an eminently technical character and are always linked to a single disciplinary field, for example, urban planning, architectural design or circular economy. The tools that work on more specifically ecological aspects, even from an economic point of view, are always applied to certain non-urban or partially urban territorial areas, such as green spaces. There are few experiences of their application in the city, and they are always partial.

For this reason, it is necessary to develop new tools that incorporate the interdisciplinary approach globally, since the city and the urban environment are understood as a great complexity environment where said interdisciplinary approach is absolutely necessary.

Mixed qualitative and quantitative as well as deductive and inductive research methods were used. An initial deductive approach carried out through research undertaken in a number of research articles, and previous developed research, led to a theoretical new concept. In the introduction, an explanation is given as to how and from where the so-called socio-ecosystemic services concept arises, and how it differs from the traditional concepts based either on the assessment of ecosystem services linked to green urban spaces or on the simple contribution of anthropogenic services on an urban socio-ecosystem environment.

Below, the results of different researches in which the aforementioned concept is strategically applied are studied and explained. Instruments used are studied, and it is implemented at different urban scales. All of the case studies are carried out via participatory dynamics, which involve different types of residents, depending on the case. This participatory strategy is considered a key link to the real implementation of the so-called socio-ecosystemic services concept due its relation to social sustainability and resilience through governance (De Luca et al. 2021).

Finally, a conceptual and strategic approach model is defined inductively from this studied practical cases: the socio-ecosystemic services model approach. This approach, using the aforementioned instruments and certain participatory methodological dynamics, leads to urban improvement in terms of capacity building for sustainability.

The research followed the following phases (Fig. 1):

- Conceptualization of socio-ecosystemic services. Deductively, based on the different approaches to the problems of the city in relation to its support ecosystem and how it is approached, valued and evaluated from different disciplines, the need for a new conceptual and theoretical perspective approach arises. This approach should provide greater strength and breadth in its ability to assess the greater or lesser sustainability of cities the "socio-ecosystemic services concept".
- Study of the application of the concept in various case studies at different scales (neighbourhood, city, region), always maintaining the "neighbourhood" study unit as the minimum reference. Development of different useful instruments for each case and participatory work dynamics.

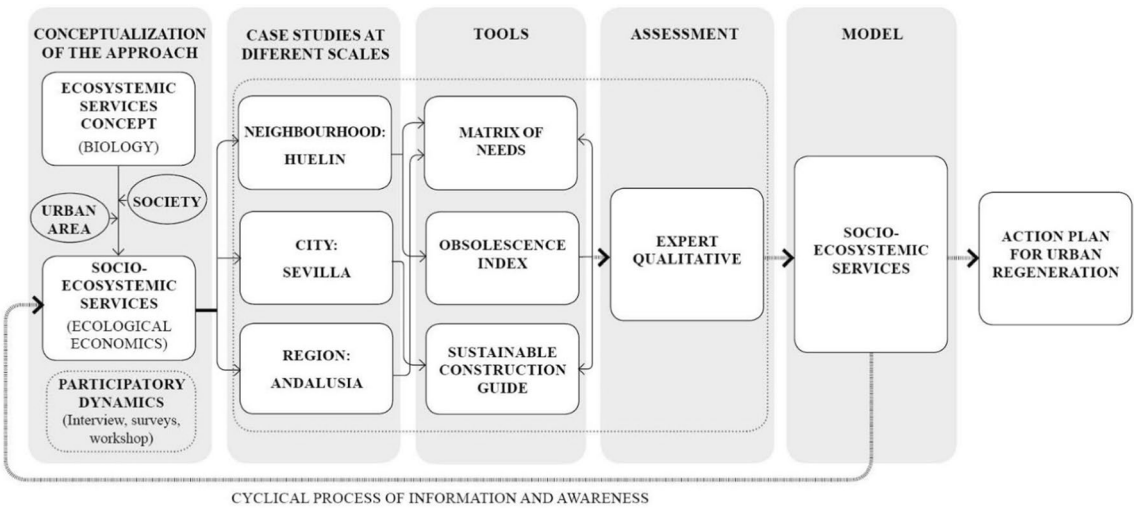

Fig. 1 Research method used. *Source*: the authors

- Verifying the success of the application of the conceptual approach, instruments and participatory methodologies.
- Inductive definition of the model (conceptual approach, instruments, methodology), which implies an action participative regeneration process.

Pilot studies and scales of work

Three case studies were selected from the various studies carried out in different researches based on the new concept defined. These were chosen in view of the qualitative results obtained and the potential effect that the instruments have on these when applied to future research. These were chosen in view of the qualitative results obtained and the potential for future research. The selection of different scales of action is relevant to cover all scales of urban planning work in the city. Nevertheless, the study reference unit is unified in order to adequately develop this research. The reference study unit for the three case studies is the neighbourhood, considered the minimum unit of day-to-day human activity.

The first is Huelin (LopezDeAsiain et al. 2020), a neighbourhood in the city of Málaga (Spain) with more than 8100 inhabitants. In this case, two operational instruments are developed to support the participatory process: the *matrix of needs* and the *index of obsolescence*. The second case study is Seville (Borrallo-Jiménez et al. 2020), at city scale, maintaining the neighbourhood unit of study as a reference while working at urban design scale as well as at smaller scales such as multifamily buildings, apartments or single-family dwellings. A sustainable construction guide (GAUS) was developed for decision-making related to improving bioclimatic design solutions and more efficient construction systems. The third case study focuses on the region of Andalusia (Osuna-Pérez et al. 2017), using the neighbourhood once again as the unit of study but from different cities and Andalusian towns. The cases studied and assessed can be extrapolated in terms of analysis and proposals for similar improvements for cases with similar characteristics and problems linked to a similar urban obsolescence in Andalusia. The three case studies incorporate participatory strategies which include urban actors.

Urban renewal at neighbourhood scale: Huelin, city of Málaga (Spain)

This research was carried out in the form of a seminar and workshop to which both urban regeneration and neighbourhood improvement experts as well as local residents, associations, local council workers and professionals were invited. A total of thirty-three people participated in the global seminar. A total of eleven experts, seven local professionals, two local council workers, two association representants and six local residents participated in the URBANA-TE Workshop, focused on the Huelin neighbourhood. A survey of local residents (177 surveys) was also carried out and the data subsequently analysed (LopezDeAsiain et al. 2020). This enabled an approach and consolidation of the theme of neighbourhood specifically involving the local residents and neighbourhood associations as well as local council technicians and government bodies.

During the seminar, four educational activities centred on the analysis and work in the Huelin neighbourhood, Malaga were carried out (Table 1). This research also enabled the development of the matrix of needs instrument and the definition of the obsolescence index (LopezDeAsiain et al. 2020).

The process of collaborative work and development of tools during the URBANA-TE workshop follows the scheme of Fig. 2. Researchers carry out a preliminary work of interviews with the social actors and technical detection of deficiencies in the neighbourhood. The workshop is developed in parallel with associations, local council workers, professionals and local residents. It begins with sensitization and information sessions on the socio-ecosystemic services approach, its objective and benefits, collaboratively developing the matrix of needs. Then, an approximation survey of neighbourhood residents' needs is designed. This survey allows to refine and correct the initial matrix of needs and define priorities. These results are collaboratively discussed among all participants, thus extracting the neighbourhood's obsolescence index. Finally, this index, which, together with the matrix of needs, allows to prioritize neighbourhood needs, is used to propose potential improvements in terms of neighbourhood renewal.

The obsolescence index obtained for Huelin (Table 2) shows people's perception of obsolescence and priorities in the neighbourhood. Provision services (economy, water, energy) and regulation services (accessibility, traffic, urban space) are the main areas where people identify deficiencies. In contrast, cultural and recreational services are those with the highest scores.

Urban renewal at city scale: Seville (Spain)

This research focuses specifically on the creation of a "best practices in the framework of sustainability" handbook for the general public. Working in specific contexts is essential for the contemplation of a close and clear approach and for the proposal of solutions or concrete strategies that can be applied by all professionals and understood by the public. For this reason, the city of Seville was chosen. "Delimiting the climate, geographical and territorial parameters makes it possible to produce a simplified document with specific recommendations regarding not only the bioclimatic strategies to implement, but also the specific bioclimatic systems

Table 1 Huelin seminar: main outcomes

Educational activity	Interviews with experts	Introductory meeting	URBANA-TE workshop	Round table
Phases	Search for experts interview approach interviews, editing	Presentation, debate, conclusions	Introduction and diagnosis, Field work Surveys, proposal and presentation	Presentation of experts Critical debate, conclusions
Dynamics	Specialist interviews	Debate among experts	Explanation of the workshop, Analysis information on the Huelin neighbourhood Surveys among local residents Interviews with representatives from local neighbourhood associations Documentation and information on areas of conflict highlighted by local residents Proposals for strategies and potential improvements to be carried out Presentation of results and debate about conclusions	Public debate with experts
Instruments	Video recording	Brainstorming	Diagnosis and SWOT analysis, Development of matrix of needs, Determination of obsolescence index	Exhibitions, moderated debate, open to the public
Results	Documentaries on urban intervention	Confirmation of the Huelin case study and methodology to be carried out	Neighbourhood obsolescence index Prioritized action strategies in the neighbourhood, defined by participatory methods. Definition of a strategic, participatory methodology for the development of future actions in neighbourhoods	Assessment of results obtained Conclusions

Source: The authors

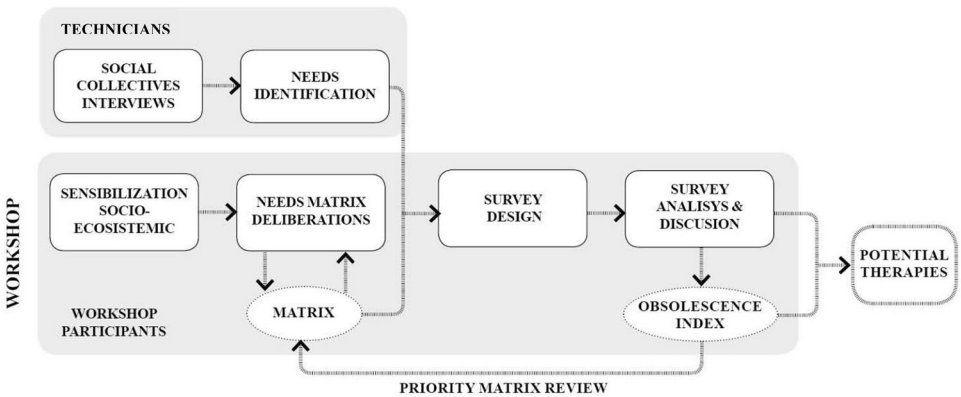

Fig. 2 Huelin URBANA-TE workshop process. *Source*: the authors

recommended for each local situation" (Borrallo-Jiménez et al. 2020).

From this research stemmed the "guide for a more sustainable Architecture and Urbanism in Seville" (GAUS) instrument (Fig. 3). It is divided into several parts according to the scale of action (Table 3).

Table 2 Obsolescence index. Socio-ecosystemic services global assessment at Huelin

Socio-ecosystemic service	Score
Support	
Urban land	3
Public space	3
Buildings	4
Facilities	3
Institutions	4
Housing	4
Mobility	3
Provision	
Materials/water/energy and information	2
Economy	2
Social metabolism	3
Urban land	2
Urban climate	1
Regulation	
Mobility and accessibility	2
Materials/water/energy and information	3
Cultural	
Quality of life	4
Urban landscape	3
Identity and cultural heritage	5
Education	4
Health and security	3
Social relationships and leisure activities	5
Obsolescence index	3

Discrete scorecard index using values from 1 (Bad performance) to 5 (Good performance). Source: The authors

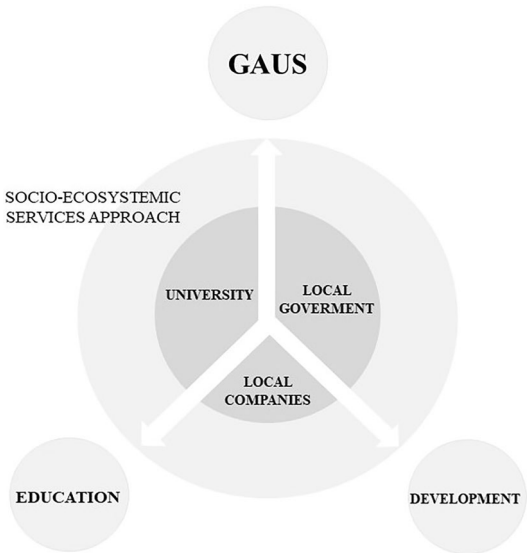

Fig. 3 GAUS approaching conceptual scheme *Source*: the authors

Table 3 Structure of the "Guide for a more Sustainable Architecture and Urbanism" (GAUS) in Seville

Guide for a more Sustainable Architecture and Urbanism in Seville
Improving local resilience
Guide for a more Sustainable Construction in Seville
Guide for a more Sustainable Architecture in Seville
Guide for a more Sustainable Urban Design in Seville
Guide for a more Sustainable Urban Planning in Seville
Guide for a more Sustainable Regional Planning in Seville

Source: The authors

Urban renewal at regional scale: Andalusia (Spain)

This research identifies obsolescence processes in selected Andalusian neighbourhoods (López de Asiain and Cano Ruano 2015). This includes (Fig. 4) the definition of indicators and their intensity rates in relation to social metabolism in those neighbourhoods; measures applicable in relation to such indicators (rehabilitation, regeneration, etc.); choices of location and case studies; and application to a representative case study which can be extrapolated to other situations in Andalusia (López et al. 2015). First of all, a definition of what a neighbourhood is, as a scale reference, was established. The correct approach to include all Andalusian neighbourhoods was defined. This approach has been carried out through the analysis of statistics databases although some nearby case studies were also selected for experimental purposes. This research enables the verification and effectiveness of the matrix of needs as a strategic instrument for the development of surveys to identify deficiencies in different Andalusian neighbourhoods. It is a fundamental initial phase before decision-making related to solutions or strategies for change (Fernández-Valderrama et al. 2016a, 2016b; Rodríguez Estévez et al. 2015).

In this case study, different families of neighbourhoods were defined. These families are characterized by their similarity in terms of seven basic themes linked to urban sustainability at neighbourhood scale. As a result of the analysis of the urban sustainability measurement instruments which exist nationally and internationally at this scale, the following themes were chosen: 1. resources, 2. mobility, 3. society, 4. economy, 5. geography, 6. urban design and 7. innovation. Each family of neighbourhoods is represented by a specific neighbourhood on which work is carried out. The results are then extrapolated to the rest of the family. In order to describe each individual neighbourhood, a set of attributes and indicators is designed which draws on three basic sources: data and information

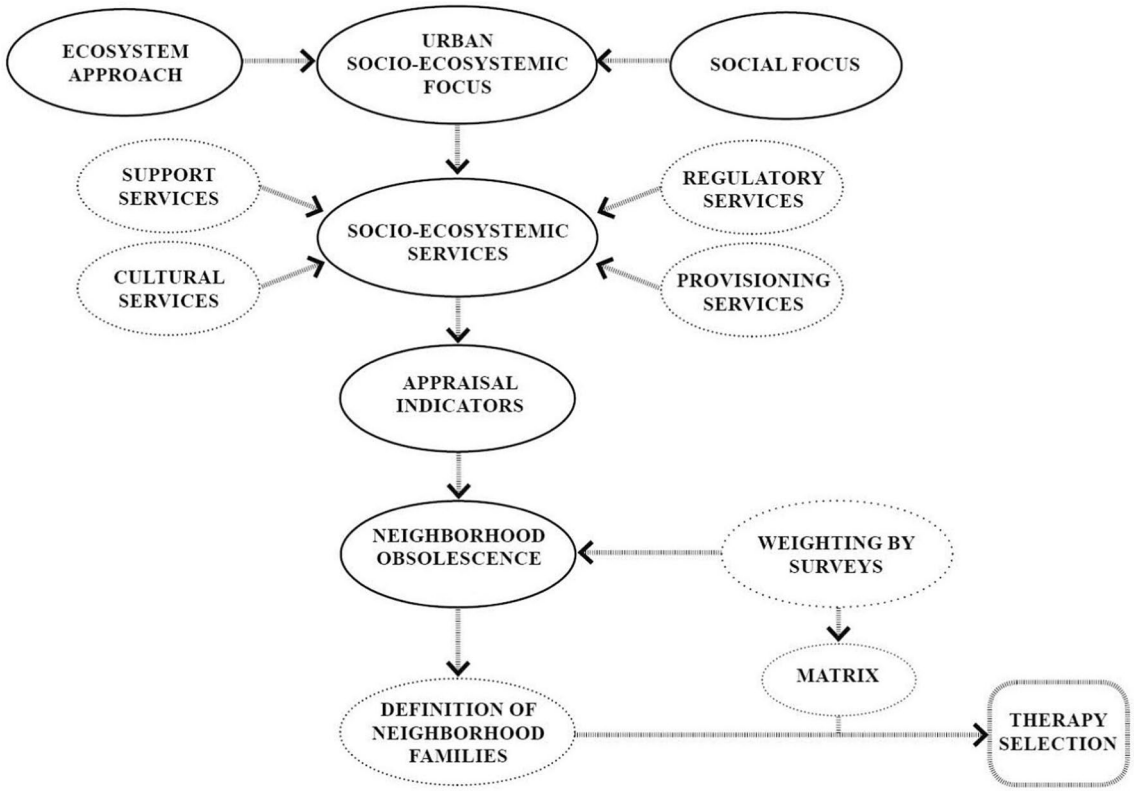

Fig. 4 Urban renewal at regional scale process. *Source*: the authors

contained in official government databases; subjective information obtained from the citizens' perception of the neighbourhood or from social representatives, resulting from the responses to a survey designed to this effect (different from that developed for the specific case of Huelin); and finally, using spatial data obtained from official data infrastructures and similar services to read the city's geometry. The designed methodology is based on the use of relational mapping stemming from statistical calculation of self-organized maps (SOM) which allow us to contemplate the positions that each studied unit occupies, the area to which each one belongs, and the intensity of each of the studied attributes (López de Asiain Alberich et al. 2015). This methodology makes it possible to define the representative case studies for each family of neighbourhoods. Various models with different numbers of families (40, 30, 20, 10) are carried out. The data gathered lead to the conclusion that the 20-family model is the most operational. Solutions to obsolescence issues in the representative cases for each family of neighbourhoods are defined by the "Urban Therapies" (Fernández-Valderrama et al. 2016a, 2016b) defined by the prior EUObs research (López de Asiain and Cano Ruano 2015).

Results and discussion

The conceptual frame

The "socio-ecosystemic services" concept is developed after long debate sessions between experts (architects, economists, ecologists and biologists). A total of forty-nine researchers participate in the debate; however, the final definition of the concept is decided by five specialists: two architects, two economists and a biologist. The definition of the term is agreed upon and then applied to the different lines of research in which the experts are involved.

The three case studies developed within the conceptual theoretical framework of socio-ecosystemic services demonstrate the appropriateness of the application of the concept to the city environment. The need for strategies and instruments that engage the environmental sustainability field, both from the architectural (energy and construction efficiency), and from the ecological perspective (efficiency in urban metabolism and the ecological support system), with the social (efficiency and improvement of urban governance) and economic sustainability fields (economic efficiency considering nature's resilience and capacity), has been developed.

The conceptual theoretical link between architecture, economy and ecology has been established and corresponds to a clear opportunity to develop practical assessment and evaluation tools as well as decision-making. Evaluating the sustainability of urban ecosystems and their robustness can be further developed with a several key instruments and within a specific methodological dimension.

The methodological dimension

Beyond the quantitative evaluation according to socio-ecosystemic services and the qualitative approach which implies the involvement of all living things in the city's ecosystem support, the methodological dimension is key to the success of the urban improvement, rehabilitation or the more commonly known urban regeneration processes (Blanco et al. 2021). Numerous authors (Bednarska-Olejniczak et al. 2019; Bialski et al. 2015; Kochan 2018; López de Asiain and Latapié Sére 2014; Moreno Mata 2018; Squizzato 2019) state the need for a consensus on urban regeneration processes. In other words, citizens should be involved in decision-making. In order to achieve this, participatory processes must be developed as a general methodology dynamic, which also improves urban governance (De Luca et al. 2021).

In the three representative case studies, it is detected that the processes and dynamics which favour citizen participation are relevant in the success and effectiveness of the solutions proposed and defined with the developed instruments. This idea is further reinforced by the approach based on the evaluation of socio-ecosystemic services, which requires the consideration and involvement of all the actors participating in the city. Therefore, it will be necessary to include dynamics and processes which do not merely consult, but involve citizens, technical experts and governmental bodies (Stanganelli et al. 2020; LopezDeAsiain and Díaz-García 2020). The interests and needs of the diverse voiceless, non-human living things in the city should also be considered. In order to do this, it would be useful to involve different non-governmental academic, scientific, recreational or environmental entities, which can represent the interests of the ecosystem to maintain its conservation and equilibrium.

Furthermore, the dynamic and participatory processes are a very important instrument to decide which technical architectural solutions are directly suitable in each situation and neighbourhood and which should be discarded. Thanks to the instruments such as the matrix of needs or the obsolescence index developed in order to apply some solutions to the problems detected by means of the sustainability indicators, a wide structure of potential strategies to develop has been constructed. From this point, the technical analysis of situations and strategies to implement has been developed but it is completely necessary to include inhabitants' perception of the situation and potential possibilities for improvement. Some experiments have been carried out, mainly through surveys at different scales in Huelin and in the Region of Andalusia with the aim of getting residents involved in the renewal process of their neighbourhoods. It is therefore absolutely necessary to have the informed opinions of the residents in a neighbourhood in order to make decisions about improvements as well as determining its potential deficiencies. This can only be achieved through participatory processes which directly involve residents gathering credible information about their day-to-day needs and above all gather information about which priorities residents see as satisfying their daily needs.

For this, the instruments studied have been highly useful. The indicators of needs matrix highlight all the aspects to study from a technical perspective and enable the definition of potential application solutions, which are subsequently explained and discussed. The index of obsolescence instrument, used in participatory dynamics (LopezDeAsiain et al. 2020), enables actions to be prioritized, specific solutions with little appeal for residents to be discarded and decisions made during the participatory process to be strengthened.

Table 4 Strategies used for the different participation approaches

Case study	Region: Andalusia	City: Seville	Neighbourhood: Huelin
Engagement instrument	Videos of interviews with experts Direct contact with representatives from neighbourhood associations	Distribution to professional bodies and through the city hall	Round tables Direct contact with representatives from neighbourhood associations Fieldwork in the streets
Data collection	Individual interviews surveys	Satisfaction survey after use	Individual interviews Surveys Group discussions
Frames of engagement	Website / Communication Channel	Informative guides (GAUS)	Workshop URBANA-TE Open academic seminars

Source: The authors

It is important that the participatory dynamics and instruments are adjusted for each specific case study (Table 4). This should be carried out in an informed manner to ensure the participation of everyone. The instruments used should be clear, dynamic and flexible to ensure citizen involvement.

The strategies to capture the public's attention and subsequently involve them in particular participatory actions have varied in each case. Those directly related to mass data collection focused on surveys (Huelin, Andalusia). In the first case, these surveys were carried out at different times on the street by a team of researchers and actors involved in the neighbourhood over a three-day period until a significant sample was gathered. In the second case, a survey was carried out on relevant actors and representatives of the different reference neighbourhoods. This survey has a different focus, with more specific questions requiring greater prior knowledge of local residents' concerns. To attract the representatives to whom this survey was aimed, a personalized appeal was made through specialists in citizen involvement and surveys, who had had prior contact with each individual on several occasions. These contacts are enticed via the initiative's website which includes previously edited videos of debates and interviews with national and international experts such as Albert Cuchí, Salvador Rueda and Ramón Folch concerning the neighbourhood improvement strategies. In the case of Huelin, other capture and involvement strategies are used: an appeal is made through institutions (principally, the town hall) via the citizen participation area and other actors known to the research team are involved in participatory dynamics with different focuses in the city of Málaga. To attract the public in general, a number of group visits are made to the neighbourhood with the aim of raising awareness of the actions that will later be carried out. Two academic seminars complement these dissemination and involvement actions. The first is held before the workshop and survey completion and the second, after. Both seminars are open to the public.

The GAUS instrument is, in this case, focused on independent citizen involvement and participation. This is possible due to its specificness for a particular city for which bioclimatic as well as historical and modern architectural design solutions have been defined. These solutions have been perfectly adapted to the technical requirements in line with sustainability requirements and guarantee the provision of certain socio-ecosystemic services, above all supporting. In this case, citizen involvement relies on the ability of the Town Hall to disseminate information though its Energy Agency and dissemination among professional colleges linked to the construction sector.

Approach instruments

The three instruments developed in the case studies and analysed for the development of the model share the conceptual basis of the same approach (as proposed in this research). This is based on an understanding of socio-ecosystemic services as all those necessary to provide an adequate quality of life for all living beings in cities, in equilibrium with the surrounding ecosystem (Shao et al. 2023).

The matrix of needs

The matrix of needs is originally developed in de Huelin case study. The differential value of this instrument is to enable citizens to decide the order of priority for each problem or deficiency in their neighbourhood. These are detected previously thanks to the obsolescence indicators applied.

The instrument developed consists of a matrix which assesses and detects needs in a specific neighbourhood as well as potentially necessary improvements defined from a technical perspective. This instrument is verified with a survey that enables participatory verification of these needs and more importantly, their priority according to local residents (LopezDeAsiain et al. 2020). In this way, the matrix of needs defines first and foremost these needs (human and ecosystem) while linking them to specific improvements that can be carried out.

This matrix is developed for any case study from an initial basic needs table (Max-Neef et al. 1986) which is used to link socio-ecosystemic services. We set out from these needs to be covered, as defined by the citizen in their day-to day life (LopezDeAsiain et al. 2020). When the indicators are related to citizens' needs, we can detect a series of generic or tactical problem-solving improvements which can become necessary in neighbourhoods. These can be linked to different areas:

- Social–cultural improvements
- Urban metabolism improvements
- Improvements in facilities
- Improvements in the diversity of activities
- Improvements in mobility and accessibility
- Conservation improvements—equilibrium in the supporting ecosystem
- Improvements in fomenting local production
- Improvements in bioclimatic design of buildings and urban spaces.

These improvements are related to defined levels of management which involve to a lesser or greater extent different stakeholders: social management, management of metabolic equilibrium (energy, materials, water) and

urban management. These stakeholders determine whether the neighbourhood is providing the predetermined socio-ecosystemic services or not. This instrument, developed for the Huelin neighbourhood case study and subsequently used for its extrapolation to neighbourhoods in the region of Andalusia (Osuna-Pérez et al. 2017), is shown to be highly useful from the moment it enables the registration of all the deficiencies in neighbourhoods while linking them to possible improvements in terms of socio-ecosystemic services. In this way, the socio-ecosystemic services are defined in equilibrium with the surrounding ecological system, maintaining sustainable environmental requirements throughout.

Verification of this instrument matrix is carried out with the fieldwork in the Huelin case study (LopezDeAsiain et al. 2020) by several means. In the first stage, some interviews with relevant neighbourhood actors were carried out to gain an overview of the situation. In the second stage, a workshop took place where different actors from the neighbourhood and the city (government, academic, and citizen actors) participated in the construction of the matrix and the development of the survey. Finally, the results of the action were discussed during the workshop, highlighting the prioritization of actions defined by the instruments.

The obsolescence index

The obsolescence index is originally developed in de Huelin case study. A service provision unit (SPU) was used to define the ecosystem services. This can help to quantify and therefore construct subsequent variables and indicators (Haase et al. 2014). Therefore, in the first place, the ecosystem service must be quantifiable. This is also applicable to the urban area of socio-ecosystemic services. The research develops a method to link conditions in an urban context (also those related to natural resource metabolism) with the basic needs of the population in a particular urban environment.

After technically analysing existing sustainability system indicators and the real day-to day needs of local residents in a neighbourhood, an obsolescence index is defined. This is used to determine and define existing problems in Andalusian neighbourhoods such as the inability to provide certain socio-ecosystemic services with the aim of posing possible urban regeneration processes (Blanco et al. 2021) to improve citizens' quality of life (Hernández 2009; Shao et al. 2023). To define this index (LopezDeAsiain et al. 2020), the most opportune indicators according to areas of work predefined by the approach based on residents' needs were selected by researchers. These allow for future improvements based on corresponding strategies.

A preliminary "state of the art" study was conducted in order to define the most suitable sustainability indicators for consideration. Several national and international indicator systems have been studied. The selection criteria for these systems are as follows (LopezDeAsiain et al. 2020):

- They are indicators in urban sustainability
- They are systems that allow an objective self-evaluation of progress in terms of sustainability for each urban situation, in comparison with those systems based on competition between study subjects through rankings or other similar methods.
- These are indicator systems not developed for commercial purposes
- They define a broad organization structure that covers all urban aspects and their complexity.
- They define indicators in a specific way and develop them by using tables and sheets for calculation or data collection

All systems have been analysed in terms of developer organization, authors, objective, scale, approach, strengths and limitations. The selected indicators were defined according to their quality; therefore, they present the following properties (LopezDeAsiain et al. 2020):

- They have scientific validity
- They are easy to interpret
- They are sensitive to identified changes
- They are simple and easy to understand
- They are based on information that is available or accessible at a reasonable cost
- They are included within an organization model or framework that explains the objectives and goals
- They are based, preferably, on intelligible units
- They can be revised over time

These properties are not all mandatory, but most of them can be observed.

Once the existing sustainability indicator systems have been analysed, as well as the real and daily needs of residents in a neighbourhood, an obsolescence index is defined. In defining this index, the most suitable indicators have been selected according to the areas of work predefined by the neighbourhood needs-based approach (subsequently verified by surveys and interviews), and which provide an opportunity to work on future improvements based on the corresponding strategies.

Thanks to the experiment carried out in the Huelin neighbourhood (Table 2, Fig. 2), the validity and usefulness of the selected obsolescence indicators which determine deficiencies within neighbourhoods from a technical perspective are confirmed. Nevertheless, the relative importance of these deficiencies does not always correspond to the perception of local residents, according to the verifications through

surveys and interviews, so it is necessary to work with specific participatory dynamics which do.

The sustainable building guide (GAUS)

This instrument was developed in the Framework Agreement for Collaboration between the University and the Seville City Council's Energy and Sustainability Agency. It covers the improvement in local resilience from the moment that citizens are implied as the target community for improvement in the decision-making process, linking it to improved urban governance fomenting to a greater extent participatory city design processes (Fig. 3). Its aim is on the one hand educational and on the other instrumental. In other words, the design chosen is proximity with the user, both technical in the architectural and profane in the material, through easily understood, clear, structured graphics with technically appropriate and thorough content. Practical and statistical assessment of the instrument is still being carried out although qualitative evaluations carried out by experts up until now confirm its validity as both an educational and participatory instrument for improvement in terms of sustainability (Borrallo-Jiménez et al. 2020).

The model: the socio-ecosystemic services approach

The model: The socio-ecosystemic services approach, is finally defined by various strategies, instruments and approaches. Firstly, it is necessary to raise awareness among the actors participating in any type of intervention in the city and the territory, regarding the new concept of socio-ecosystemic services. The acting technicians must understand and embrace the model, but they must also carry out awareness-raising work among the different participating actors in the urban and/or territorial area they are working on. In order to do this, they can use simple and direct communication strategies similar to those used in the development of the guide GAUS (Borrallo-Jiménez et al. 2020).

Secondly, considering the technical field, both, the matrix of needs and the obsolescence index tools developed should be used. Nevertheless, they should be used from a strategic participatory approach, which has been called and defined as the socio-ecosystemic protocol. This socio-ecosystemic protocol has participatory dynamics and strategies adapted to each specific situation, following a logic of processes linked to the field of citizen participation.

To define the model (Fig. 5), preselected case studies and instruments defined in their development are analysed and presented and qualitatively valued by experts. The needs matrix is key to relating needs with possible improvements in certain socio-ecosystemic services. These services make up the model which enables a complex anthropogenic system such as is a city to comply with environmental, social and economic sustainability requirements. For this, we define these requirements out of the need for local maximization of the closing of energy and materials cycles in an urban environment (Borrallo-Jiménez et al. 2020), alongside the need to do so in consensus with the local community (Bednarska-Olejniczak et al. 2019; Bialski et al. 2015; Kochan 2018; López de Asiain and Latapié Sére 2014; Moreno Mata 2018; Squizzato 2019).

Neighbourhood socio-ecosystemic services are supporting, provisioning, regulating and cultural services. Each of these is composed of different areas which allow us to approach the needs and requirements which must be obtained to provide an inclusive (human and other living things) quality of life in equilibrium with the environment.

Selected socio-ecosystemic services defined by the research

Supporting services These are necessary for the production of the other ecosystem services and neighbourhood sustainability.

- Urban land support, biotope.
- Balanced ecosystem, rich in biodiversity, biocenosis.
- Geology, terrain, hydrology, microclimate integrated into public spaces and buildings.
- Balanced urban structure which gives rise to an appropriate urban public space-building relationship linked to the supporting ecosystem.
- Functional urban diversity. Organization and balance between land uses.
- Adequate, well-maintained public spaces and streets.
- Adequate, well-maintained buildings.

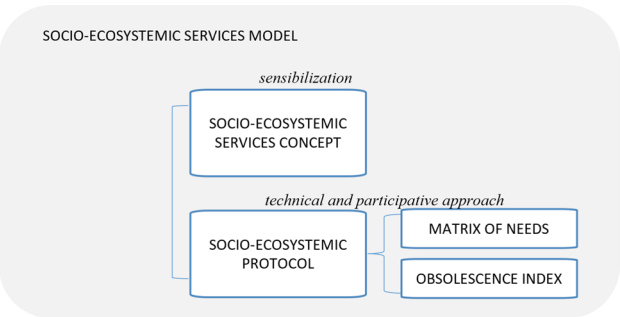

Fig. 5 The socio-ecosystemic services model. *Source*: The authors

- Adequate, well-maintained infrastructures.
- Adequate institutions for social, environmental and economic management.

Provisioning services These are the direct products and services obtained from the socio-ecosystem neighbourhood.

- Housing, health centres, schools and social–cultural centres.
- Qualified public space.
- Shops, offices, small-scale industry (Exchange of goods and services).
- Supply of materials (food, goods, supporting maintenance materials), water, energy and information (telecommunications).
- Assessment of materials, water and energy.
- Accessibility mobility.
- Social exchange situations.

Regulating services These are the benefits obtained from the regulation of socio-economic cycles.

- Regulation of urban land. Management of the balance between uses. Management of urban green spaces.
- Management and control of microclimate.
- Regulation of accessibility and mobility.
- Management and control of energy.
- Management of material flows. Collection and treatment of MSW.
- Management and control of the water cycle.
- Management of information. Rules, organization.

Cultural services These are the intangible benefits obtained from social ecosystems.

- Habitability, physical and psychological comfort
- Urban landscape
- Neighbourhood identity
- Belonging to the community
- Education
- Health and safety
- Cultural heritage and identity
- Social, leisure and recreational relations
- Access to information

Specific quantification of the categories is always relative to the context of the neighbourhood studied. This point is essential for the correct dimensioning of the problem to be solved. A unique dimensioning for every neighbourhood would imply a merely technical and not citizen-based vision of the problem. To facilitate the translation of this quantification, the Huelin survey worked with a discrete scorecard index using values from 1 (Bad performance) to 5 (Good performance). This strategy has been extrapolated to the rest of the cases. What varies, depending on the neighbourhood, is the specific meaning of each of these five levels. They should be determined together with the local residents taking their perceptions into consideration. To do this, the rest of the participatory instruments such as debates with experts and citizens and interviews with key neighbourhood actor are used.

Discussion

The defined concept, the "socio-ecosystemic services concept", applied to the city, allows us to transfer from an eminently ecological economy approach and tools field, towards an urban planning and architectural design one. This transfer, studied in the analysed cases in practical terms and tools, allows us to develop a model that brings together the three disciplines we need to work with: economics, ecology, and architecture. Studied cases develop specific tools that integrate variables specifically linked to one or more of these three disciplines (Zaman-Ul-haq et al. 2022).

In the matrix of needs tool, aspects of the daily life of the inhabitants of the city are incorporated. In addition, specific needs of other living beings are incorporated through work, debate and discussion with specialized teams of biologists and ecologists.

The defined obsolescence index also incorporates aspects and variables clearly of anthropological origin, traditionally worked as indicators of sustainability in cities, but it also incorporates variables derived from the valuation of ecosystem services linked to the ecological support system of the city.

The list of socio-ecosystem services, which is part of the developed model, includes variables traditionally assumed from an ecosystem services biological model but it also incorporates some variables usually considered in urban sustainability indicator systems.

The obsolescence index thus defined makes it possible to relate the matrix of needs with said selected socio-ecosystem services. Through participatory strategies previously mentioned in this research, such as the "socio-ecosystemic protocol", and with these tools, it is possible to instrumentalize city obsolescence analysis processes and proposals for intervention and sustainability and therefore resilience improvement at neighbourhood scale (De Luca et al. 2021). This innovative socio-ecosystem protocol (Liu and Wu 2022), based on participatory dynamics, more typically used in

sociological frameworks than specifically architectural ones, and widely studied, has been initially enunciated. However, it is not detailed since is does not concern this article. In addition, this protocol should be further evaluated regarding its possible extrapolation to other situations, since this investigation has not been able to demonstrate its validity yet.

Going deeper specifically regarding the variables selected y/o included by the model, we can make the following reflection. The model based on a socio-ecosystemic approach defined by this research enables the incorporation of anthropogenic and natural aspects into the analysis of services which can provision a city from the neighbourhood to the residents and other living beings within it, increasing even further the doctrine (Chien 2021) on social ecosystem services applied to the urban environment. There is, therefore, a coherence in the developed approach in relation to the need to broaden the concept of ecosystem services. Up until now, this had been linked by numerous authors solely to the existing natural environment of cities, in isolation, and constituted by their green spaces (Andersson et al. 2014; Elmqvist et al. 2015; Lovell and Taylor 2013; Luederitz et al. 2015; Paulin et al. 2020; Pukowiec-Kurda 2022; Rodríguez-Rodríguez et al. 2015), and socio-ecosystems (Folke 2006; Morandín-Ahuerma et al. 2019) with the implication of both human and other living beings (Chien 2021) defining the concept of socio-ecosystemic services. In this way, the model enables the effective incorporation of the inclusive approach which recognizes the needs in terms of services of all the living beings in a city and in order to improve their quality of life (Shao et al. 2023).

Furthermore, the model defined responds to the social and/or urban metabolism needs of cities, following the evolution of the three-stage concept according to Wachsmuth (2012), guaranteeing the incorporation of necessary services for urban life in the framework of the requirements of the concept of sustainability (Shao et al. 2023) linked to the correct management of the flow of material and energy resources and closing their cycles (Bai et al. 2016; Borrallo-Jiménez et al. 2020). It also supports the rapprochement between disciplines that must be similar in their relationship with the intervention in the city and the territory and until now are divergent in many cases: architecture, economy and ecology.

The model allows the use of tools and instruments from the three disciplines in an integrated way (McPhearson et al. 2022; Ouyang and Luo 2022; Zaman-Ul-haq et al. 2022), with the aim of achieving the well-being of living beings defined by the concept of sustainable development (Shao et al. 2023).

The defined model selected variables are based on the most widespread classification of ecosystem services (Alcamo et al. 2003) and its later materialization as four categories in the Millennium Ecosystem Services Assessment

Table 5 Scheme of analysis of cases in terms of scope, achievements and limits

Case study Scale	Instruments	Scope	Achievements	Limits
Region: Andalusia	Matrix of needs	Definition of the grade of obsolescence of different types of neighbourhoods in Andalusia and study of the possible improvements to carry out regarding sustainability	Development of a robust analysis instrument to assess sustainability obsolescence in all types of neighbourhoods and its link to potential urban improvement therapies	Need to define participatory processes in addition to the analysis carried out for each neighbourhood, including actors involved in each specific case in order to prioritize the improvement actions that will be carried out
City: Seville	Sustainable construction guide (GAUS)	Awareness and training for citizen autonomy in environment and sustainability for urban and building design	Development of an informative and educational instrument. Validity of the instrument and its development method	Partial local environment of the developed instrument. Its usefulness will depend on its dissemination, and it has not been verified statistically
Neighbourhood: Huelin	Matrix of needs and obsolescence index	Definition of sustainability indicators which make up the obsolescence index through the application of the matrix of needs. Development of participatory dynamic with local actors	Verification of the validity of the two instruments in each case study through the carrying out of surveys on citizens and local residents and associations. Posterior statistical analysis for the consolidation of the obsolescence index	Necessity to generate participatory dynamics with greater implication of all local actors. Lack of representation of some collectives such as women, children and youths as well as surrounding ecosystem validators

Source: The authors

report (Reid et al. 2005) and add to it with those items necessary, according to the focus of the research and thus consolidating the inclusive capacity as an instrument for the analysis and intervention in the improvement of cities and urban or natural environment in general.

The case studies have shown that the methodological dimension proposed from the socio-ecosystemic approach and in relation to the defined model, which is based on participatory dynamics, is adequate for its effective use in practical terms. This strategy, named el "protocolo socio-ecosistemico", allows a direct relation to be established between the urban ecosystems and their governance, called for by some authors (Elmqvist et al. 2014; McPhearson et al. 2015; Schewenius et al. 2014), exploiting links between planning, urban design, governance and citizen involvement with concrete instruments and contributing to the improvement of natural and urban resilience and well-being (De Luca et al. 2021; Shao et al. 2023).

In relation to the analysed case studies and the experiences at different scales, we can extract the following conclusions relative to the scope of the research, achievements and limits of the practical cases. The cases are presented from region to neighbourhood trying to frame how specific community-based decisions are made at different scales (Table 5).

Since the model has been extracted inductively from the three cases analysed, it can be said that in terms of scope, the model responds adequately to the strategy developed for the instruments employed in the different cases. It also gives rise to the definition of sustainability indicators to analyse the obsolescence of different neighbourhoods, by the obsolescence index, defining possible improvements to carry out. Furthermore, in its participatory approach, "the socio-ecosystemic protocol", the model foments citizen awareness and information regarding sustainability of urban ecosystems (Shao et al. 2023). This is done in a potentially independent manner, which leads to robust advances in citizens' assimilation of sustainability, beyond the involvement of technicians or government bodies.

Furthermore, the research has made it possible to check and subsequently validate the instruments developed in each case study for the definition of the model. The case studies themselves validate these instruments and confirm the link with the developed model. This way, a rapprochement is produced from research to practice and vice versa, which makes it possible to reduce the gap between both (Shao et al. 2023). The scientific validation of the different instruments has been carried out through the systematic qualitative analysis of the results in relation to the objectives proposed for each case study. In order to do this, a group of experts made up of architects, economists, biologists and ecologists has systematically reviewed these results according to previously established criteria. These criteria evaluate the achievements obtained from 1 to 5, with 1 being defined as an objective not met and 5 as an objective achieved according to the priorities of the citizens.

Nevertheless, it is necessary to determine the limits of the present research in regard to the case studies and the analysed instruments. The need has been defined to use strategies based on citizen participation (De Luca et al. 2021; Stanganelli et al. 2020) for the approach of the city in the framework of the socio-ecosystemic model developed. This implies a further need for the study of possible participatory strategies which help determine greater success, in practical terms, of the models' application. This gives rise to a robust and permanent, inclusive involvement of different social collectives, including those which could represent non-human living things in the ecosystem. Similarly, it would be necessary to extrapolate the model to other situations and confirm its usefulness at the different work scales (Shao et al. 2023) carried out in other experiences and thus guarantee its capacity for adaptation and real usefulness as an instrument for urban regeneration (Blanco et al. 2021).

Conclusion

The socio-ecosystemic services concept and approach allows a dimension of environmental, economic and social sustainability to be introduced into the study and improve the urban environment for a perspective based on the metabolism of cities and not solely on the management of urban green spaces. At the same time, an integrated model of socio-ecosystemic services can be defined, with all its theoretical and practical apparatus, and whose practical application in the analysis of the city detects urban obsolescence via indicators, sets out and develops processes for participatory approximation in decision-making for urban improvement and defines potential solutions for improvements establishing priorities in each case study, agreed by citizens for their management and application.

The approach poses, and also nurtures, the development of certain instruments and methods for urban intervention in line with the concept of sustainability of urban ecosystems and their robustness by fomenting urban governance through participatory dynamics. These instruments and methods could be extrapolated, adapting to very diverse situations through the development of city analysis processes. The practical case studies carried out and analysed make up the reference cases to follow in order to check the potential extrapolation of the socio-ecosystemic services model to other situations, which must be checked further. In addition, it is necessary to test the "socio-ecosystemic protocol" proposal for the citizen participatory processes

which complements the socio-ecosystemic services model in its application dynamics for the different cases and action scales. Moreover, it is necessary to develop indicators which permit a wider study of the model's behaviour at different urban scales, as well as develop other instruments which allow its scope to be assessed.

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Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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