Barriers and opportunities for urban agri-green roofs in Mediterranean compact cities

Perla Zambrano-Prado*[a, b 1], David Pons-Gumí[a 1], Susana Toboso-Chavero[a,c], Felipe Parada[a], Alejandro Josa[d], Xavier Gabarrell[a, c], Joan Rieradevall [a,c]

[a] Sostenipra Research Group (Sostenipra 2017 SGR 1683), Institut de Ciència I Tecnologia Ambientals (ICTA-UAB), Universitat Autònoma de Barcelona, 08193 Cerdanyola del Vallès, Barcelona, Spain

[b]Department of Techniques and Construction, Art Architecture and Design University Center, (CUAAD), University of Guadalajara (UdeG), Calzada Independencia Norte 5075, Huentitán El Bajo 44250 Guadalajara, México

[c]Department of Chemical, Biological and Environmental Engineering, Universitat Autònoma de Barcelona (UAB), Campus UAB, 08193 Bellaterra, Barcelona, Spain

[d] Department of Civil and Environmental Engineering (DECA), Civil Engineering School (Escola de Camins), Universitat Politècnica de Catalunya - BarcelonaTech (UPC), Jordi Girona 1-3, Building D2, 08034 Barcelona Spain

[1]These authors have contributed equally to this work

*Corresponding author perla.zambrano@uab.cat

Abstract

The main objective of this study is to analyse the barriers and opportunities with regard to the implementation of urban agri-green roofs (UAGR) in cities. The case study was conducted in Barcelona, a Mediterranean compact city. The World Café methodology and a semi-quantitative analysis were used in this work. Five categories of barriers and opportunities were discussed (social, environmental, legal/administrative, technological/architectural, and economic) by interdisciplinary stakeholders.

In total, 103 barriers and opportunities were identified. The main barriers identified were as follows: the lack of information and social cohesion regarding UAGR projects; the Mediterranean climate; the lack of specific regulations and protocols; and the initial investment, the pre-condition of the roof and its load bearing capacity. The main opportunities identified were as follows: social cohesion, improved life quality, new specific regulations, the profits derived from UAGR projects and aesthetic improvement.

The UAGR's scale of impact results showed a homogeneous distribution between "building" and "city", while the "global" scale remains residual. Regarding the stage of the UAGR life cycle at which barriers and opportunities emerge, the results highlight how most opportunities appear during the "use" stage of the roof, whereas barriers do so during the "project" stage.

Key Words: *Sustainable city, Urban agriculture, Food-Energy-Water Nexus, Multifunctionality, Self-sufficiency, Social perception*

Highlights:

- Urban agri-green roofs can be an ideal tool to improve cities' sustainability.
- The social and legal/administrative fields show the most interest.
- Eighty-four percent of opportunities appear during the "use" stage.
- Governmental support is key to making the population aware of UAGR benefits.

1. Introduction

In recent years, the configuration of the world population has experienced some far-reaching changes. One such change is related to population dynamics, as the global population has increased rapidly since 1950. Today, 55% of the world's population lives in urban areas (United Nations, 2018) in fact, according to the projections, by 2050, 68% of the world's population will live in cities (United Nations, 2018).

In this sense, cities, as spaces where human activity is more concentrated, must develop a key role in the management of the present and future of humankind and in the development of a more sustainable organizational model (European Comission & United Nations Human Settlements Programme, 2016).

Despite their quick growth, cities present a specific vulnerability with regard to managing the food-energy-water (FEW) nexus and its elements, which illustrates the need for efforts to be made in terms of the optimization and use of natural resources (Toboso-Chavero et al., 2018). In this regard, cities have increased the pressure and exploitation levels imposed on the ecosystems, both at local and global scale, as they are responsible, in direct or indirect ways, for nearly 75 % of global energy consumption and 80% of greenhouse gas (GHG) emissions (Ash, Jasny, Roberts, Stone, & Sugden, 2008), exerting high impacts on levels of atmospheric pollution and on the rising demand for natural resources (Cerón-Palma, Sanyé-Mengual, Oliver-Solà, Montero, & Rieradevall, 2012).

Currently, most cities have linear flows regarding inputs and outputs. These are characterized by the import of resources and the export of emissions (Wadel, Avellaneda, & Cuchí, 2010). Therefore, cities demonstrate the need for i) the development of more circular metabolisms, which help to reduce the consumption of resources and energy; and ii) increased opportunities for recycling, reuse and higher degrees of self-sufficiency with respect to the FEW nexus (Corcelli, Fiorentino, Petit-Boix, Rieradevall, & Gabarrell, 2019).

Apart from the abovementioned problems and suggested directions for a better future, cities with high population density, the so-called compact cities, also experience issues related to a lack of space and, more specifically, green spaces. In this sense, real estate speculation and the increase in population density in urban areas have implicitly led to a decrease in the available green space surface per capita and have demonstrated the need for new strategies to compensate for that deficit (Tappert, Klöti, & Drilling, 2018). Thus, given the multiple benefits at the social, economic and environmental levels provided by green spaces and the growing concern with regard to the creation of sustainable cities towards an improved quality of life, there is significant interest as well as a need to enhance such spaces (Taylor & Hochuli, 2017).

Compact cities have problems both in terms of self-sufficiency as well as in the sustainable and efficient management of the resources involved in the FEW link and with regard to the presence of green spaces. Given the spatial limitations and the high competition in relation to space, such problems are relevant and make the transformation of underused spaces a promising way to address them (Toboso-Chavero et al., 2018).

In this respect, roofs can be used in what is referred to as the "Urban Roof Mosaic" or "Urban Rooftop Farming" (URF). This usage consists of using roofs to develop activities

related not only to water collection or food and energy production but also to social and environmental purposes as well as contributing to the self-sufficiency of cities (Benis, Turan, Reinhart, & Ferrão, 2018; Toboso-Chavero et al., 2018). In the present work, the term "urban agri-green roof" (UAGR) will be used to refer to this concept.

1.1. UAGR functionalities and experiences in cities

The existing literature regarding the implementation of UAGR projects in cities with high population densities and/or Mediterranean climates has identified multiple functionalities, specifically linked to urban agriculture (UA); however, such functionalities have been extended to many other fields. UA can be defined as the production of food (including all activities directly or indirectly related to such production, including recycling and waste management or the distribution of the products that result from such projects) in urban, suburban and periurban areas (Dubbeling et al., 2017). UA represents an alternative to the current value chains with regard to meeting the demand for food in urban areas, and it can serve as an ideal tool to cover cities' food needs and, at the same time, develop a fundamental role in other areas of city life (Nadal et al., 2018; Sanyé-Mengual, Anguelovski, Oliver-Solà, Montero, & Rieradevall, 2016).

UA takes into account the nature of some of the above-noted activities, whether public or private, organized communally for self-consumption and leisure, educational purpose, or more broadly in the context of institutions or private enterprises with a focus on production for the purpose of sales (Palmer, Santo, & Brent, 2016).

As many studies have noted (Kim et al., 2018; Nadal et al., 2017; Pons et al., 2015; Sanyé-Mengual et al., 2016), UA can have a huge impact on areas as diverse as public health, social capital construction, economic development or the use of underused space in cities. It can also help to improve a city's self-sufficiency, reducing its dependence on foods that must be shipped in from a distance and the derived costs and contribute to a more circular urban food production system. Further, its benefits can be extended to addressing issues of food safety, psychological and physical health, urban and landscape planning and sustainability (Azunre, Amponsah, Peprah, Takyi, & Braimah, 2019). Also remarkable is UA's ability to generate social cohesion, influence recycling and waste management processes and serve as an educational tool (Cerón-Palma et al., 2012; Sanyé-Mengual et al., 2016; Specht & Sanyé-Mengual, 2017)

URF, which is defined as the practices related to the horticulture in a specific location such as building rooftops (Dubbeling et al., 2017), has emerged as a smart option for generating new agricultural spaces; increasing the green areas of cities and promoting local food production, with its implied reduction in distribution costs (Pons et al., 2015).

This practice can occur in two main ways: rooftop gardens (open-air) and rooftop greenhouses systems (Cerón-Palma et al., 2012; Sanyé-Mengual et al., 2016) The first system, rooftop gardens (open-air), is usually (but not always) based on traditional soil-based cultivation methods, and its implementation tends to be cheaper. The second system, rooftop greenhouses, is focused on intensive production as it offers control of climatic conditions along with the possibility of alternative cultivation techniques such as hydroponics or aquaponics. Despite the benefits provided by this system, the high economic cost and the complexity of its implementation and operation usually limit its

use to buildings with clearly commercial purposes (Ong, 2003; Sanyé-Mengual et al., 2016).

Integrated with UAGR, roofs can incorporate solar thermal and photovoltaic panels in addition to rainwater harvesting systems, contributing to greater building self-sufficiency. Applied at the neighbourhood scale, FEW demand can be optimized (between 7% and 50%) and a global savings of GHG emissions of approximately 111-160 kg/inhabitant per year (Toboso-Chavero et al., 2018).

The installation of photovoltaic panels can contribute to meeting the growing demand for energy in urban areas, generating energy and saving both direct and indirect consumption as well as mitigating the heat island effect, especially in warm and Mediterranean climates (Williams, Rayner, & Raynor, 2010; Wong & Lau, 2013). Therefore, despite the high initial costs and implementation of these facilities (in both economic and emissions terms), the savings of GHG emissions and the reduction of the economic costs derived from energy production and demand are offset in the long-term (Cerón-Palma et al., 2012; Corcelli et al., 2019). In addition, the effects on the air conditioning and thermal insulation of buildings are evident, generating significant savings in terms of these functions and obtaining greater acoustic isolation (Williams et al., 2010).

Regarding water, apart from heating for human consumption, through the use of solar panels, there is evidence of potential savings from tap water through the implementation of rainwater harvesting systems in the context of UAGR. These facilities (UAGR) also have an impact on the mitigation of the negative impacts driven by the typical strong storms and consequent run-off in Mediterranean climates (Corcelli et al., 2019).

UAGR also has an important impact in terms of increasing biodiversity and habitats that are more suited to the life of flora and fauna in cities, creating green spaces and serving as an ideal tool for education and environmental awareness. The impact is also positive with regard to socialization among community members, generating new meeting points and spaces. The fact that such systems facilitate the development of leisure activities must also be taken into account in addition to the possible positive contribution of green roofs to a city's aesthetics (Corcelli et al., 2019; Nadal et al., 2018; Palmer et al., 2016; Williams et al., 2010).

New York City (NYC), Washington DC, Chicago, Toronto, Singapore and Paris initiated pioneer programmes related to food production on building rooftops. Toronto was the first city in North America to adopt a bylaw to require the construction of green roofs (City of Toronto, 2009). A New York City council developed the *FoodWorks A Vision to Improve NYC's Food System* plan, with the main objective of building a better food system and twelve specific objectives, divided into the following issues: agricultural production, processing, distribution, consumption, and post-consumption. Regarding agricultural production, one of the objectives is to *increase urban food production*, and the proposals include the use of rooftops for growing food (The New York City Council, 2010). Through the *Parisculteurs*, the City of Paris supports rooftop urban agriculture projects. Since the first call for projects in 2016, more than 48 projects have been developed (Ville de Paris, 2019).

1.2. Barriers to integrate UAGR

Despite its potential benefits, UAGR also presents barriers regarding its implementation. Examples of such barriers include the availability of suitable space for its development, the competition of water use, the lack of social involvement, legal and administrative obstacles in its planning and execution or complications derived from the impact of pollution on food products in cities (Palmer et al., 2016). Other barriers identified in the literature include the conceptualization and perception of agriculture as UA is not considered by many stakeholders to be "true" agriculture (Sanyé-Mengual et al., 2016; Specht & Sanyé-Mengual, 2017; Specht, Siebert, & Thomaier, 2016).

From a wider perspective on the UA concept, the high economic cost of adapting roofs for the abovementioned uses, the structural load limitations in buildings, the visual/aesthetic impact or the lack of sufficiently qualified technical personnel have also been identified as limitations (Caputo, Iglesias, & Rumble, 2017; Ercilla-Montserrat et al., 2019). Additionally, the limitations prescribed by public administration and corporate lobbies, or the possible environmental impacts of the materials used for the construction of UAGR facilities have also been identified (Cerón-Palma et al., 2012). The lack of economic funds to initiate a project, the perception of high maintenance costs or possible indifference or low acceptance among users also play a key role in developing such projects, as well as the lack of promotion and encouragement by many governments and administrations of this alternative (Sanyé-Mengual et al., 2016; Wong & Lau, 2013).

The aim of this research is to analyse the barriers and opportunities regarding the implementation of UAGR projects in a Mediterranean compact city. In this regard, the specific objectives are as follows:

i) To identify the social, environmental, legal/administrative, technological/architectural and economic barriers and opportunities of UAGR.
ii) To determine the scale, building, city or global aspects of these barriers and opportunities.
iii) To classify the barriers and opportunities within a UAGR project's life cycle stages (from "project" to "use" through "construction").

2. Methods

A mixed method research design was adopted for this work as it can best address our objectives. The qualitative data were gathered through an interdisciplinary focus group technique, the World Café, (Rabiee, 2004), which is suitable for exploring a topic in depth and to focus on interactions among the participants (Bryman, 2012). The extracted data were quantitatively analysed whenever possible. Fig. 1 shows the problem choice and three main stages (study area, data collection, and data analysis and interpretation) of the workflow carried out in this research. The stages are described in detail in the following subsections.

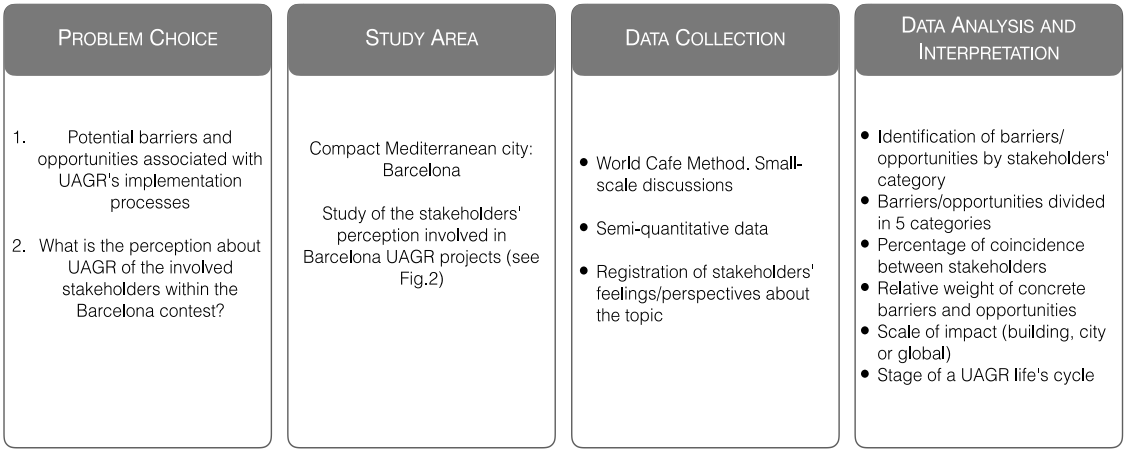

Fig. 1. Workflow to identify barriers and opportunities regarding UAGR implementation

2.1. Study area

The city of Barcelona (Spain) was chosen as a case study based on various criteria. Barcelona is a representative case of a Mediterranean city, identified by sun predominance during most of the year (2,867 hours of sunlight per year) and average temperatures between 12-18°C during the winter and between 20-26°C during the summer (Barcelona City Council, 2018). These climate conditions represent a good environment for agricultural and solar energy production.

Barcelona is described as a compact city, with 1.6 million inhabitants in 101.3 km^2 with 15,747 inhabitants/km^2, while the European average remains at 3,000 inhabitants/km^2 (Barcelona City Council, 2018; European Comission & United Nations Human Settlements Programme, 2016). Some studies have identified an increase of high density urbanized zones of approximately 594 ha between 1977 and 2004 as well as a reduction of 483 ha of unbuilt/vacant lots and 227 ha in “natural-green” spaces (Burriel, Pons, & Terradas, 2000). Therefore, nearly 20% of the city’s surface is occupied by densely built homes, and the city presents 17.6 m^2 of green surface per inhabitant including Collserola Natural Park. Excluding this zone, the green space per inhabitant remains at only near 7 m^2 (Barcelona City Council, 2018).

Additionally, there is increasing institutional and citizen interest in UA. The framework for this study was determined based on the level of interest and on the fact that 2,608 ha of roofs in Barcelona are suitable for urban roof mosaic implementation (Urban Ecology Agency Barcelona, 2010); currently, only the 0.36% of Barcelona’s roofs are green roofs (Urban Ecology Agency Barcelona, 2010).

Green roofs are one of the key elements to achieve a greener and sustainable city as established in government measures such as the Green Plan and Biodiversity of Barcelona 2020. In this context, in June 2017, the Barcelona City Council, through the Municipal Institute of Urban Landscape, and with the support of the "Green/Mosaic Rooftops" working group, promoted the *green mosaic rooftops contest*, an initiative to promote the construction of green roofs. The City Council offered a subsidy (75% of the construction cost) to ten green roof project winners to move forward with projects addressing residential, educational, health and other building uses (Barcelona City Council, 2017).

In addition, the abovementioned contest was the first of its kind begun in Barcelona; thus, the administration in these types of facilities appears to be very recent compared with other areas such as Germany (financial aid since 1987); Japan (duty for a minimum of 20% of green infrastructures in buildings with more than 1000 m^2 of floor surface, since 2001); Linz (Austria, financial aid since 1989) or Portland (building construction incentives; since 1996) (Urban Ecology Agency Barcelona, 2010).

2.1.1. Stakeholders involved in UAGR definition

The participants were selected because of their knowledge of the UAGR projects (Rabiee, 2004). Persons involved in Barcelona's green mosaic rooftops contest were invited to participate. Previously, potential stakeholders were identified who were involved in the different stages (

Fig. 2) of the contest (project design municipal licenses and urban planning, construction, use and tracking implementation) regarding the implementation of UAGR. The selected participants had recent and updated knowledge of the process of implementation of UAGR. In this way, the data analysis of the seminar highlighted the value of the stakeholders and the specific role they play in these projects. To determine the specific role of each stakeholder, they were divided into four basic types: private companies (PC), public administrations (PA), research centres (RC) and owners and users (OU).

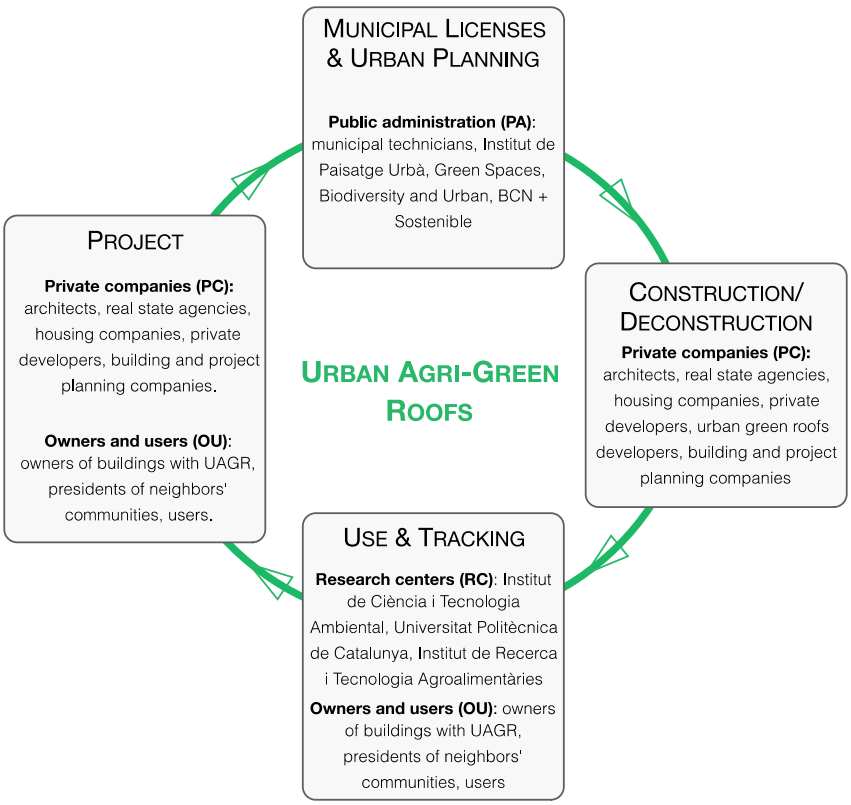

Fig. 2. Stakeholders involved in the stages of a UAGR

2.1.2. Barriers and opportunities definition

Five categories of barriers and opportunities were defined based on the previous literature related to urban agriculture project perceptions (Cerón-Palma et al., 2012; Sanyé-Mengual et al., 2016; Specht & Sanyé-Mengual, 2017): i) social, ii) environmental, iii) legal/administrative, vi) technological/architectural and v) economic.

2.1.3. Data collection

The data collection was carried out using *World Café*, a focus group methodology (Rabiee, 2004; Wilkinson, 1998). Focus groups can generate large amounts of data in a relatively short time, and the findings may be used in qualitative and quantitative procedures (Rabiee, 2004).

The World Café is based on informal relaxed conversations about questions that matter to the participants (The World Café Community Foundation, 2015). The method is based on the principle that the best ideas and solutions often occur outside of formal structures, World Café conversations aim to recreate a living network of collaborative dialogue (The World Café Community Foundation, 2015). This methodology centres attention on creating a living network of collaborative dialogue around specific questions (Prewitt, 2011) based on small-scale discussions, generating an atmosphere of trust and tranquillity that encourages a critical and enriching debate, where each participant can freely express their perceptions, points of view and concerns about the topic in question (Johnson et al., 2018).

2.1.3.1. Discussion tables

The World Café uses group discussion and rotation to promote brainstorming to tap into collective wisdom (Chang & Chen, 2015; MacFarlane et al., 2017).
As a first step, the session began with a registration and welcome to the participants followed by an explanation of the purpose of the conversation and the way in which the event would proceed.
The seminar was comprised of two general rounds of discussion. The first focused on the barriers to UAGR, and the second focused on the opportunities of UAGR, with a pause between each round.
The room was set up with five discussion tables, and each table focused on one of five particular themes (social, environmental, legal/administrative, technological/architectural and economic). The participants were organized into five thematic tables of discussions, and each group was made up of between 4 and 5 people and one host.
The discussion session begun with an open question to the group, allowing the participants to explore the related areas. Each topic was discussed for fifteen minutes. Once the designated time expired, the participants moved to another table trying not to retain the same discussion groups and going through all the proposed topics. If during the discussions, no contributions were made, a list of barriers and/or opportunities and based on the literature was prepared in advance, which was offered to those attending, to boost the discussion (See appendices A and B) (Fouché & Light, 2011; Johnson et al., 2018; Prewitt, 2011; The World Café Community Foundation, 2015).

2.1.3.2. Generation of insights and data capture

To facilitate dialogue, the primary job of the table host was not to focus on asking questions but rather to welcome the participants, introduce them to the topic being discussed at their table and to inform new participants of the on-going conversation when they joined the table. The methods used to capture the participants' views and insights had to be as non-disruptive as possible while simultaneously helping to maintain the informality and café-like atmosphere in the room. The host at each table recorded the responses and added notes of the narratives generated from the participants to a scrapbook.

2.1.4. Data analysis and interpretation

For the data analysis, the stakeholders were classified according to their scope of action in the UAGR projects. Then, for the extraction and analysis of semi-quantitative data, a focus group based on the World Café methodology (The World Café Community Foundation, 2015) was performed.

The answers were transcribed from the scrapbooks recorded by the hosts. This made it possible to preserve the essence and nuances of each contribution while synthesizing the ideas under the same barrier or opportunity. The representation of these data was carried out following five criteria:

i) Identification of the same barrier or opportunity by various members of each stakeholder category.

ii) Percentage of coincidence among the actors when identifying barriers or opportunities. That is, how many stakeholders compared to the total number of participants (n) identified each barrier or opportunity.

iii) Relative weight of the barrier or opportunity of the total answers regarding each specific category, e.g., how many interventions regarding the total enacted for each category; (m) refers to the barrier or opportunity in concrete terms.

iv) Scale of impact, which refers to the specific area that affects each barrier or opportunity. For this criterion, three main scales are distinguished: Building (B), City (C) and Global (G).

v) Stages of Urban Roof Mosaic's life cycle, defined according to the contest stages to define at what specific stage of the whole implementation of UAGR process each barrier and opportunity appears. In this criterion, three main stages are distinguished: Project (P) if the barrier or opportunity appears during the planning, Construction/Deconstruction (C) if they appear during the process of mounting or disassembling the UAGR and Use (U) if they appear once the UAGR has been built and has a relationship with its operation.

3. Results and Discussion

3.1. Identification of barriers and opportunities

The seminar was attended by 70% of the invited actors (24 out of 34). As mentioned above (2.1.1), the segments of the participation were divided according to the role played by the stakeholders in the UAGR projects. Thus, of the 24 participants, 11 who belonged to private companies (PC), 5 who were involved in public administration (PA), 4 who were members of research centres (RC) and 4 who attended as owners and users (OU).

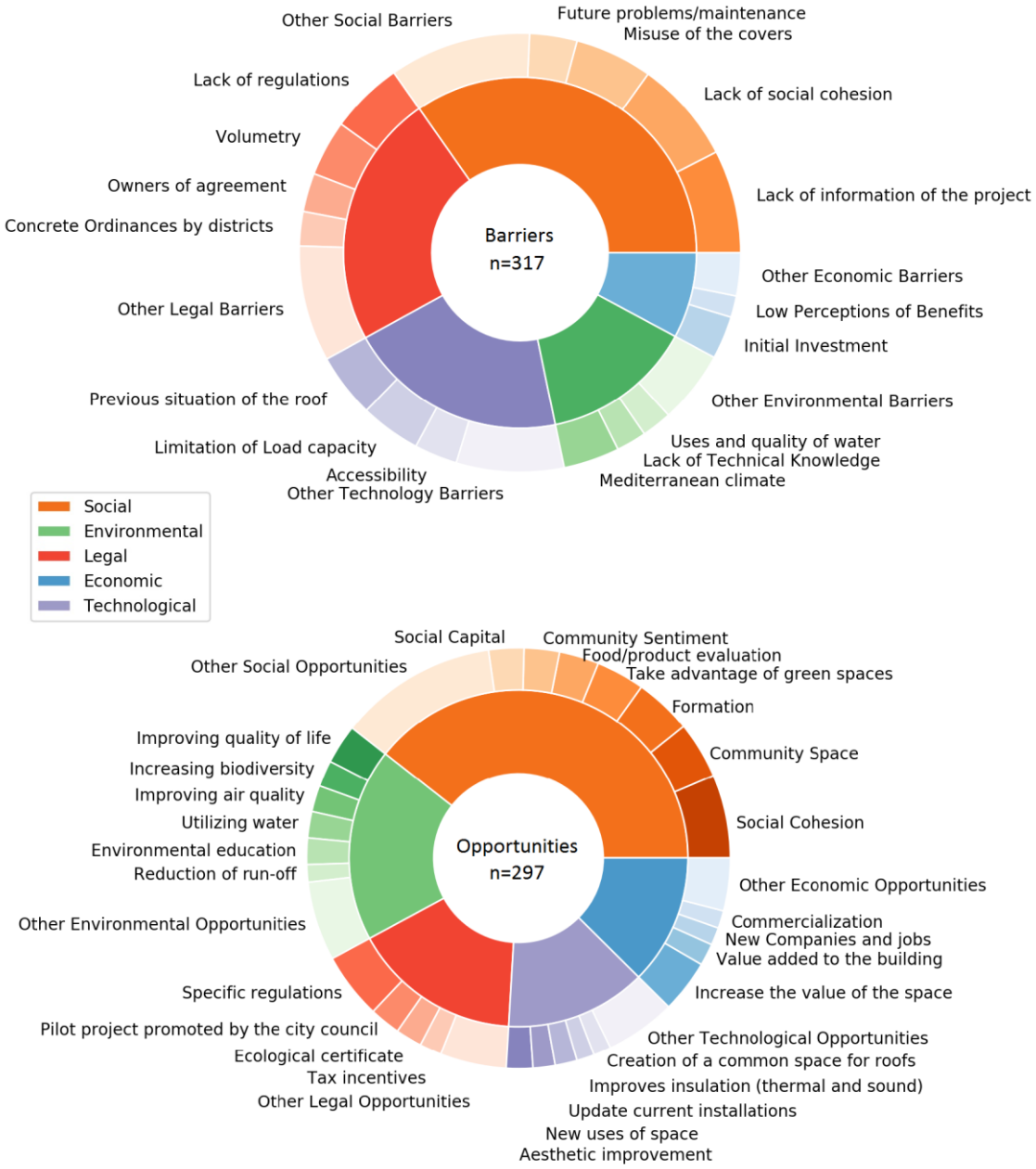

Fig. 3 shows a summary (all the data details are available in the supplementary information) of the data extracted from the transcripts of the notes taken by the hosts of the discussion groups, the relative weight of the principal topics, and the main subcategories related to the barriers and opportunities. Here, the information displayed corresponds to the main barriers and opportunities identified in each category. Table 1 and Table 2 show barriers and opportunities until 70% of the relative weight for each

category is reached. In addition, no barrier with less than 10% of the relative weight is shown.

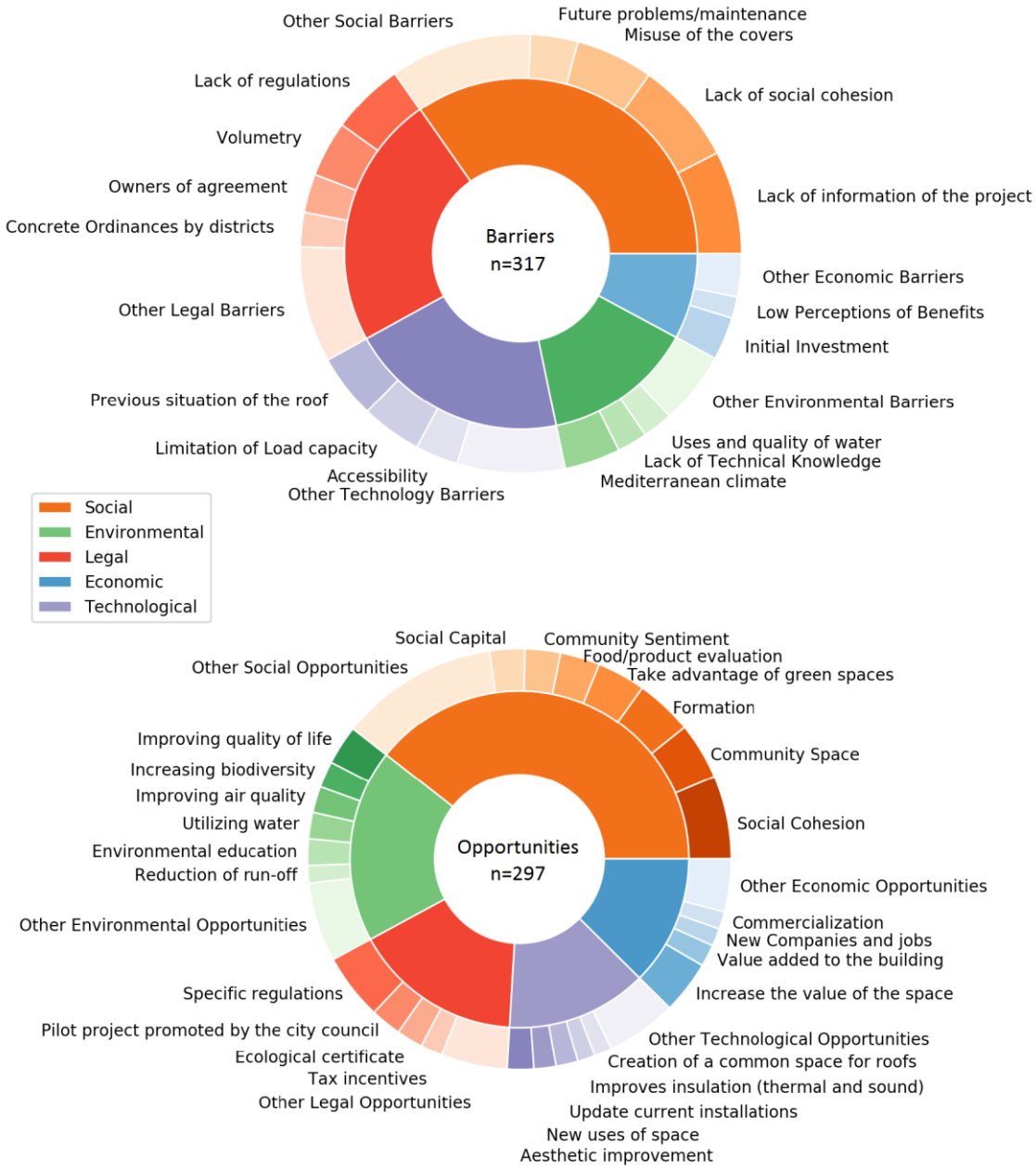

Fig. 3. Relative weight of principal topics and the main subcategories related to barriers and opportunities regarding UAGR Barcelona case study

The percentage of coincidence among the stakeholders was calculated as n=24 for the barriers and n=19 for the opportunities[1].

[1] With regard to the economic barriers, two participants (public administration and research center) left before the break; with regard to the economic opportunities, one from public administration also did so. For this reason, in this field, n=22 (opportunities) and n=18 (barriers).

Barriers: social m=110, legal and administrative m=74, technological and architectural m=64, environmental m=44, and economic m=25.

Opportunities: social m=117, environmental m=55, legal and administrative m=48, technological and architectural m=40, and economic m=37.

According to the number of responses, not all barriers and opportunities had the same number of contributions. Social issues are those that have generated more interventions, with a total of 227. However, the area that generated fewer interactions was economics, with just 62 registered answers.

Table 1. Barriers regarding UAGRs implementation in the city of Barcelona. If the identification of a barrier was unanimously perceived among all the stakeholders of the same type, it has been represented in dark grey; if they were identified by some stakeholder, but not-all, light grey; and blank if no stakeholder identified it.

Stakeholders	All	Not-all	Nobody

Scale	Building	City	Global
	B	C	G

Stage	Project	Construction	Use
	P	C	U

Category	Barrier	Relative weight on the total of answers (%)	Coincidence among stakeholders (%)	Public administration (PA)	Private companies (PC)	Research centres (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Social	Lack of information and scope regarding UAGR	22	100					C	P
	Lack of social cohesion	22	100					B	P
	Use of UAGR by communities	16	75,0					B	U
	Maintenance or unforeseen issues	10	46					B	U
Environmental	Mediterranean climate	30	54					G	U
	Technical or/and environmental lack of training	16	29					B	P
	Uses and quality of water	16	29					C	U
Legal	Lack of specific regulations and protocols	23	71					C	P
	Volumetric limitations	18	54					B	P
	Vertical property regulations	12	38					B	P
	Commercialization of the obtained products	11	33					C	P
Economic	Initial investment	40	46					B	P
	Small benefit perception	20	23					B	P

	Maintenance costs	20	23					B	U
Technological	Pre-condition of the roof and its elements	23	63					B	P
	Structural load limitations	22	58					B	P
	UAGR accessibility	16	42					B	P

Table 2. Opportunities regarding UAGRs implementation in the city of Barcelona. If the identification of opportunity was unanimously perceived among all the stakeholders of the same type, it has been represented in dark grey; if they were identified by some stakeholder, but not-all, light grey; and blank if no stakeholder identified it.

Stakeholders	All	Not-all	Nobody

Scale	Building	City	Global
	B	C	G

Stage	Project	Construction	Use
	P	C	U

Category	Opportunity	Relative weight on the total of answers (%)	Coincidence among stakeholders (%)	Public administration (PA)	Private companies (PC)	Research centres (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Social	Social cohesion	16	100					B	U
	Generate common spaces	11	68					B	U
	Education tool	11	68					C	U
	Generate “green + sociability” spaces	9	58					B	U
	Food and local products appreciation	8	47					G	U
	Community feeling	7	42					B	U
	Social capital	7	42					G	U
Environmental	Improved life quality	16	47					B	U
	Biodiversity increase/improvement	11	32					C	U
	Improved air quality	11	32					C	U
	Better water uses	11	32					B	U
	Environmental education	11	32					C	U
Legal	New specific regulations	31	79					C	P

	Pilot projects promoted by the city council	15	37					C	P
	Creation of a UAGR ecological certificate	13	32					C	P
	Tax incentives	10	26					C	P
Economic	Profits derived from the UAGR	32	67					B	U
	Added value to building	15	28					B	U
	New jobs and business	11	22					C	U
	Sales of local products	11	22					C	U
Technological	Aesthetic improvement	15	32					B	U
	New space's uses	13	26					B	U
	Update current facilities	13	26					B	U
	Improvement in thermal and acoustic insulation	10	21					B	U
	Creation of a common space to share experiences related with UAGR	10	21					C	U

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3.1.1. Social barriers and opportunities

The notable social barriers perceived by the stakeholders, with consensus among all the actors, include the lack of information and scope of UAGR projects such as prejudices, scepticism, lack of running examples and sensibility, little or non-support by the administration or the feeling that agri-green roofs will bring more problems than benefits and the lack of social cohesion, that is, the low involvement of the community members in the implementation of these types of projects. Both barriers represent 44% of the total contributions in this area.

The lack of information about the real scope of UAGR projects includes the fact that fears and prejudices against such a project can influence more than the potential benefits such as the fact of performing major work, water, and humidity or the influence of pollution on agricultural products. Additionally, the lack of spirit and social cohesion affects the "project" stage insofar as the lack of predisposition by users and owners of buildings makes it difficult to carry out UAGR projects. According to the registered opinions, such lack of spirit is not considered to be due to scepticism but rather that concepts such as "social good" or "citizen awareness", that is, the priority of collective interest against the individual, are not well-integrated in city communities.

Another barrier is the doubt whether these spaces will be used. This issue is not unanimously perceived by any type of actor; however, in each category, someone identifies it. Future maintenance problems (46% of coincidence among stakeholders) are also an important concern.

Consumers' lack of trust in the quality and health risks of producing food on rooftops represents the principal social barrier in many cities including Barcelona (Cerón-Palma et al., 2012), Bologna (Sanyé-Mengual, Orsini, & Gianquinto, 2018) and Berlin (Specht, Siebert, et al., 2016; Specht, Weith, Swoboda, & Siebert, 2016) as it is a new model of food production, and there is a lack of information about how it performs in relation to the air pollution in cities. This perception is related to prejudices and scepticism, which is one of the principal social barriers found in this study. A recent study related to air pollution in rooftop crops shows that heavy metals concentration in lettuce is below the EU-legislated level, even when the lettuce crops were located in high-traffic areas of Barcelona (Ercilla-Montserrat, Muñoz, Montero, Gabarrell, & Rieradevall, 2018).

The previous studies identify low acceptance and concerns related to rooftop food production using soilless growing systems, which is perceived as "artificial, unnatural, and not real" (Sanyé-Mengual et al., 2016; Specht & Sanyé-Mengual, 2017). However, this barrier was not mentioned in the results of the seminar. In this sense, it is important to develop and to disseminate appropriate information about UAGR crop systems and the quality of the products to the stakeholders, which could be reflected in the gradual decrease of this shared social barrier in various European cities.

In Berlin, a social perception was identified that this kind of project is exclusive and acts as a driver for gentrification (Specht, Siebert, et al., 2016). This perception was not mentioned in the World Café conducted in Barcelona. However, this study revealed a

new concern about the lack of social cohesion; this social barrier, was not found in the previous studies where the social cohesion was perceived only as an opportunity.

Regarding social opportunities, several proposals were observed as well as numerous nuances when discussing the perceptions described under one opportunity topic. The only social opportunity that generates an absolute consensus in its perception among all the stakeholders was "social cohesion", although the relative weight of the responses was lower than in the barriers (16% of the total opinions versus 22%). In this sense, under the umbrella of the opportunity mentioned, the actors perceive that UAGR could offer the possibility to generate new rules and attitudes as well as the possibility of benefiting specific groups of users and offering new spaces for citizen participation at all levels (for example, geriatrics, schools, individuals or families).

Another widely perceived opportunity (68% of stakeholders) corresponds to the possibility of creating community garden spaces, which was accepted by all participants related to the fields of research (RC) and private companies (PC). Educational opportunity emerges with the same percentage of perception, although with a slight variation in the distribution among stakeholders. In this category, the richness and variety of references that we could classify as the same barrier was remarkable. It should also be noted that social cohesion was also perceived as a barrier (as lacking) and as an opportunity (as UAGR can offer new spaces and ways to generate it). Another important detail corresponds to the fact that many of the mentioned social barriers and opportunities are not "purely" social, but they are very interrelated among other categories (socio-economic, legal, administrative, environmental).

Regarding social opportunities, this study and previous studies from Barcelona, Bologna and Berlin identified social cohesion and education as major benefits of the integration of UAGR projects (Cerón-Palma et al., 2012; Sanyé-Mengual et al., 2016; Specht, Siebert, et al., 2016). In this sense, UAGR emerged as a catalyst for community improvement and social interaction as well as the strengthening of social ties and serving as an educational tool and a major means of appreciating local products (Cerón-Palma et al., 2012). In discussing barriers and limitations, we find connections with the possibility of low user acceptance and social indifference; however, the lack of qualified personnel to take advantage of the educational potential, the incompatibility of UAGR with city activities, the loss of rural jobs or social disparities with regard to the accessibility to the production systems were not perceived as barriers in the seminar. Otherwise, the lack of information and scope regarding UAGR, which appears as the most important barrier in this study, does not find correspondence in the literature.

3.1.2. Environmental barriers and opportunities

In the environmental field, less concordance is found among stakeholders than in the social one. Thus, only one barrier, the Mediterranean climate, exceeds 50% of the coincidence among them; and only two (also Mediterranean climate and the uses and quality of water) are capable of generating consensus among all stakeholder typologies.

Thus, Mediterranean climate obtains the specific weight of 30% with respect to total responses in this category, and it is identified by all actor types, although none of them identify it unanimously. Mediterranean climate is identified as a barrier with regard to the

form and frequency of precipitation, which occurs in sporadic but intense events (storms), with sun effects and wind. The uses and quality of water were also perceived as a barrier for all stakeholders, although with a much smaller coincidence and relative weight (29% and 16%). With the same percentage as the uses and quality of water, the barrier of technical or/and environmental lack of environmental training, referring to the lack of knowledge by the stakeholders involved in UAGR projects with, for example, bird migration, how to choose vegetation or which species should be introduced to avoid harming ecosystem equilibrium. However, this barrier was not identified by any of the actors corresponding to the owners and users (OU) category.

The major environmental barrier identified in the seminar was Barcelona's climate conditions. This result has no relationship between the environmental barriers reported in the previous works (e.g., Cerón-Palma et al., 2012; Sanyé-Mengual et al., 2016; Specht et al., 2014), which could be due the participants in this study, who interpreted the environmental concept in relation to the climate and natural resource conditions for growing food rather than environmental impacts. The major environmental concerns in the previous research were related to the environmental impact of construction materials (Sanyé-Mengual et al., 2016; Specht & Sanyé-Mengual, 2017; Specht, Siebert, et al., 2016). Health risks due to air pollution, low expected quality products (Specht, Siebert, et al., 2016), problems regarding organic waste management (Cerón-Palma et al., 2012) were not even mentioned in the seminar.

With respect to opportunities, the heterogeneous tendency remains: no clear opportunity is perceived by the four types of actors, and the one with the most percentage of acceptance (improved life quality) does not reach the 50%, and it has 16% of relative weight, while the next ones remain at 11% of relative weight and 32% of coincidence. "Environmental education" was only perceived by stakeholders from public administration and private companies.

It should be noted that opportunities regarding climate change mitigation, the reduction of the heat island effect, energy savings and improvements in thermal and acoustic insulation were very residual (none of them exceeds 7% of relative weight).

In addition, carbon footprint reduction and decrease in GHG emissions (Cerón-Palma et al., 2012) were identified under the improved air quality opportunity, as does biodiversity improvement (Williams et al., 2010). This is in keeping with the general perception that there is a clear lack of information about the scope and effects of UAGR within the population. Health risks due to air pollution, low expected quality products (Specht, Siebert, et al., 2016) or problems regarding organic waste management (Cerón-Palma et al., 2012) and uncertainty about the overall environment impact or the possibility of unsustainable management (Specht & Sanyé-Mengual, 2017) were not even mentioned in the seminar.

3.1.3. Legal/administrative barriers and opportunities

In terms of legal and administrative barriers and opportunities, more consensus was found among the stakeholders than in the environmental field. Within the barriers, the lack of specific regulations and protocols regarding UAGR was remarkable, with 71% of coincidence among actors, 23% of relative weight and unanimously identified by the four

types of stakeholders, although it was only identified by all the individuals in the public administration group. Some interventions recorded during the seminar referred to criteria disparity, differences in legislation interpretation or lack of stability.

Another barrier that stands out is building volume limitation in the implementation of UAGR (54% of coincidence and 17% of relative weight) as specific legislation is limiting in terms of structural reinforcement, shadow or greenhouses facilities. It is also important to mention two more barriers as they are also identified by all types of stakeholders, although at a reduced percentage. First is the percentage of acceptance of the owners when implementing a UAGR in a community of owners. This is an important limiting factor since, for a UAGR to prosper, an approval of at least 80% of owners is required, while for other modifications (such as the installation of an elevator, for example), 50% is sufficient. The second refers to the difficulties of the legal commercialization of agricultural products grown on roofs or regarding urban agriculture.

There is a clear identification of regulatory barriers for UAGR projects that is shared with several cities. Some cities around the world (e.g., New York City (NYC), Washington DC, Chicago, Toronto, Singapore or Paris) are promoting and supporting pioneer programmes related to food production in buildings. Some of these cities offer tax incentives and subsidies to encourage green rooftops (Brin et al., 2016). Toronto was the first city in North America to adopt a bylaw to require and govern the construction of green roofs. The law establishes a graduated green roof requirement for new buildings greater than 2,000 m² (City of Toronto, 2009). In the case of Paris, a city council has been initiated on urban regulations to allow for farming on rooftops in excess of building heights, and it has also launched the Parisculteurs (2016) initiative (Brin et al., 2016). The NYC Council launched the Food Works plan (2010) for increasing urban food production by various strategies including supporting rooftop agriculture. However, rooftop greenhouses encounter a barrier to development as some buildings are at or exceed their floor-to-area ratio (FAR) allowance, preventing an addition to the building. The solution in that case was a policy change to facilitate their development. The NYC Departments of Buildings and City Planning developed a waiver programme for greenhouses seeking space on buildings that have met or exceeded their FAR (The New York City Council, 2010). They have also adopted regulation changes on industrial, commercial and school buildings for the integration of rooftop greenhouses (Brin et al., 2016).

In the case of Barcelona, its General Metropolitan Plan does not allow agriculture activities inside the city, which makes the commercialization of these types of products unlawful. There are also height and volume limitations regarding the installation of greenhouses or other roof elements (photovoltaic panels, water tanks) due to the Spanish Technical Building Code, which sets forth basic requirements for the resistance and stability of buildings during construction and use, and it establishes limitations regarding energy and water self-consumption (Royal Decree 900/2015), leading to the obligation of self-consumption facilities to contribute to the general energy system distribution at the same rate as the rest of consumers (Bruzual, 2018).

Regarding opportunities, the feedback dynamics that are present in the previous categories are repeated. That is, barriers are identified at the same time as opportunities. This does not mean that the barriers and opportunities coincide but that the actions to be taken to overcome theme are focused on the same field as well as the opportunities that

they present. In this sense, the possibility emerges of developing specific regulations for UAGR (79% of coincidence and 31% of specific weight) as the most widely identified opportunity. Therefore, UAGR projects open the door to a deep analysis to elaborate upon their own regulations and to unify the administration criteria as well as facilitate changes in the normative and legal procedures. It must be emphasized that all the stakeholders in the public administration group identified this opportunity while no one in the research centres did.

Few city administrations (i.e., NYC, Paris, Toronto) have realized that some policy changes can lead to a better food system for cities, providing advantages in the local economy, social benefits, and the mitigation of environmental impacts. Policy changes represent opportunities on the local level food system to create positive outcomes.

As we have shown, regulatory barriers are potential opportunities to create laws and programmes to promote and increase UAGR projects. The experience of cities that have changed policies concerning the integration of UAGR projects show the potential that Barcelona now has to change the law towards regulations that are more *friendly* to UAGR projects. In this way, some legal initiatives have emerged in Barcelona. Beginning (Bruzual, 2018) in 1999, the Ordinance of Urban Landscape of Barcelona authorized planters and pots on rooftops as long as they are mobile. Later, in 2013, the Barcelona Green Infrastructure and Biodiversity Plan advocated for the promotion of urban green zones on rooftops; and in 2017, the Stimulus Programme for the City's Urban Green Infrastructures proposed an increase of 1 m^2 of urban green areas per inhabitant by 2030, taking rooftops into account. In 2018, within the framework of the Climate Plan 2018-2030 for Barcelona (the research of this paper is, in fact, part of this green infrastructure promotion plan by the city council), several proposals were introduced such as laws to promote productive rooftops, to boost the energy generation on rooftops and to promote water collection and use in buildings. There is a need to assess the regulatory barriers of UAGR projects to encourage food production on rooftops within each city and to explore the use of incentives to encourage these projects.

3.1.4. Economic barriers and opportunities

In the discussions of economic barriers, it should be noted that it is one of the sections in which there was less participation. Only 25 of the answers were registered (for 117 in social barriers or 74 in legal ones), and no barrier reached 50% of coincidence among stakeholders (Table 1).

Taking this lack of engagement into account, the most widely perceived barrier corresponds to the initial capital investment, with 46% of coincidence among stakeholders but a relative weight of 40% and identification by all the typologies of actors. This barrier refers to the installation and facilities costs, work and materials, as well as economic disproportion between the necessary structural reinforcement and the cost of the UAGR elements. There is also the fact that the rehabilitation of a roof under a UAGR project can be much more expensive than a conventional rehabilitation

Other significant barriers include maintenance costs (not identified by owners and users) and the low perception of UAGR's benefits and advantages, in the sense that they are perceived as "extra expenses" and there is a little predisposition to investing in it. Regarding this fact, the relationships between this barrier and the social one of lack of

information and prejudices regarding UAGR emerged since users are not aware of the potential benefits that the implementation of such a project can bring, including economic benefits, in the form of savings, for example, in energy bills or the development of activities and services on the roofs.

The difficulty of commercializing the products obtained from UAGR appeared in a residual way during the seminar (4% of relative weight).

The previous studies from Barcelona, Berlin or Bologna (Cerón-Palma et al., 2012; Sanyé-Mengual et al., 2016, 2018; Specht & Sanyé-Mengual, 2017) have also identified the initial investment cost along with rehabilitation costs, the elevated price of UAGR systems and the little or no perceived economic benefits as a strong barrier, together with the fact that it is difficult to develop a rooftop business (connected with legal issues), which some authors (Palmer et al., 2016; Specht & Sanyé-Mengual, 2017) have also identified as a prominent economic barrier, together with the competition of UAGR with other rooftop uses.

In terms of opportunities, the profits derived from the new uses of the roofs clearly stands out, that is, to profit economically from a space that was previously not associated with any pecuniary use. This opportunity stands out above the others with a 67% of coincidence among stakeholders, 32% of relative weight and identification by all types of actors. Within a "direct profit" perspective, a multitude of business opportunities is found for the community and/or construction companies that incorporate UAGR, with possibilities such as renting the space, guided tours or holding events, among others, along with the possibility of FEW self-consumption or the production and possible sale of resources. In an indirect way, the reduction of costs related to FEW production, consumption and distribution, along with the savings in energy bills and the switch of the production chain to a more local scale, which can be derived for the opportunities identified in the seminar.

Other highlighted opportunities in terms of the percentage of coincidence and relative weight are the added value for the building (revaluation), the possibility of creation of new companies and jobs or the commercialization of local products and/or services. However, in all these opportunities, the perception among the stakeholders is very heterogeneous, with the participants in the field of public administration (PA) and private companies (PC) being very receptive but less so in the research centres (RC) or owners and users (OU).

When discussing economic opportunities, it is important to note the double-stranded character presented by the participants. In this sense, employment opportunities cannot imply a significant number of liveable wage jobs, and they even require additional expertise formation. Furthermore, the increased value added to the buildings can lead to the displacement of low-income residents.

Short-term business opportunities may imply unproven profitability in the long-term along with the indispensable financial and political support, which is not always assured (Palmer et al., 2016). The economic feasibility of these projects must be assessed on a case-by-case basis (Berlin Urban Development and the Environment, 2015).

3.1.5. Technological and architectural barriers and opportunities

There are two architectural and technological barriers above the rest. First, the previous situation of the elements on the roof, with 62% of coincidence among stakeholders and 23% of relative weight. This barrier refers to the current uses and pre-existing elements in the roof that constrain adaptation for new UAGR uses such as air conditioning facilities, TV aerials, photovoltaic panels or gardening elements. The second barrier, interrelated with the legal field, is the building's load limitation, with 58% of coincidence and 22% of relative weight. Both barriers are identified by all the typologies of the stakeholders, although none of them do so unanimously.

The complexity of incorporating FEW flows in buildings, the transportation of inputs and outputs of UAGR systems, the complications in terms of rehabilitating existing roofs or the use of polluting construction materials are barely mentioned in the seminar, and together they do not reach 10% of relative weight.

Load resistance was identified in this and previous studies from Barcelona (Cerón-Palma et al., 2012). While the previous literature has referred to large barriers and opportunities for social, economic, and environmental issues, there is a clear lack in the identification of architectural barriers and opportunities. In this sense, this study may make an important contribution to this specific issue.

The third perceived barrier (UAGR accessibility) does not find many correspondences in the literature, although they are extensively studied in the literature regarding this issue (Cerón-Palma et al., 2012; Nadal et al., 2018; Sanyé-Mengual et al., 2016). Along with them, the risks associated with urban integration, which include conflicts with the "urbanity" and "agriculture" concepts, animal production, noise and/or smell problems or visual/aesthetic image conflicts (Specht & Sanyé-Mengual, 2017; Specht, Siebert, et al., 2016), were not mentioned in the seminar, although the possibility of aesthetic city improvement was perceived as an opportunity. The load resistance and rooftop access are critical issues that must be addressed. Discussions with the stakeholders related to both load resistance and waterproofing indicate that technical solutions exist unless the load bearing of the building is dramatically different from the requirements of the project (Brin et al., 2016).

Regarding opportunities, it is remarkable that none are identified by all types of stakeholders. This is reflected in the low percentages of coincidence among actors; thus, no opportunity reaches 50% of coincidence, and the highest percentage stands at 31%. Thus, the most perceived opportunity (with 32% of coincidence and 15% of relative weight) corresponds to the possibilities of aesthetic improvement offered by UAGR project implementation, including the development of architects' creativity, developing new "beauty" and "urbanity" concepts within the city or the possibility of "hiding" pre-existing facilities/machinery on the roofs. However, this opportunity was only identified by the actors belonging to public administration and private companies.

New space uses and the possibility to update current installations were perceived with similar coincidence and relative weight (26% and 12%, respectively). In addition, although the numbers are lower than in the first mentioned opportunity, their acceptance among the types of actors is extensive as only those belonging to research centres do not identify them. The new uses of space include the possibility of creating quality and comfortable areas, the use of underutilized spaces or responding to new spatial needs.

Further, the possibility of updating current installations includes the detection and amendment of hidden deficiencies as well as the improvement the current state of the roofs.

The relationship between architectural/technological and environmental opportunities is also noteworthy as many proposals in the architectural field have a direct impact on the environment. In this sense, for example, the opportunity to generate cities and buildings that are more sustainable, improvements to thermal and energy insulation or the possibility of creating green corridors were identified in both categories. Special mention should be given to the "construction" stage, which only presents four technological/architectural barriers and one regarding legal/administrative issues, along with no opportunities of any kind identified.

3.2. Building, city or global scale of barriers and opportunities

Fig. 4 illustrates the results related to scale. The overall results showed that the barriers and opportunities identified by stakeholders during the seminar were mainly distributed between "city" (47%) and "building" (44%), while "global" remains at 9%. Regarding the barriers, the data from the seminar reflect that 45% belong to "city", 46% to "building" and 9% to "global".

In terms of categories, "city" is the predominant scale in the legal and administrative barriers (approximately 70% of relative weight), while in the architectural and technological barriers, the emphasis is on "building" scale (75% of relative weight). The rest present a more homogenous distribution, with percentages of approximately 50% between "city" and "building". The "global" scale has little impact on the barriers, reaching only 8% of relative weight.

With regard to opportunities, the "building" scale is still outstanding (close to 70% of relative weight) in the technological and architectural field, while the "city" scale stands out with 63% of relative weight in the legal and administration area. In the economic field, the distribution is homogenous, with approximately 45% of opportunities pertaining to the "city" scale and 36% to the "building" scale. In the environmental field, the opportunities are distributed homogenously between the "building" and "city" scales (with relative weights of 46%, respectively).

Finally, in the social sphere, the scale where more opportunities appear is the "city" scale, with nearly 55%, followed by the "building" (35%) and "global" (10%) scales. However, the "global" scale barely represents 10% of the total perceived opportunities. Additionally, the "city" scale encompasses 49% of opportunities, while the "building" scale occupies the remaining 41%.

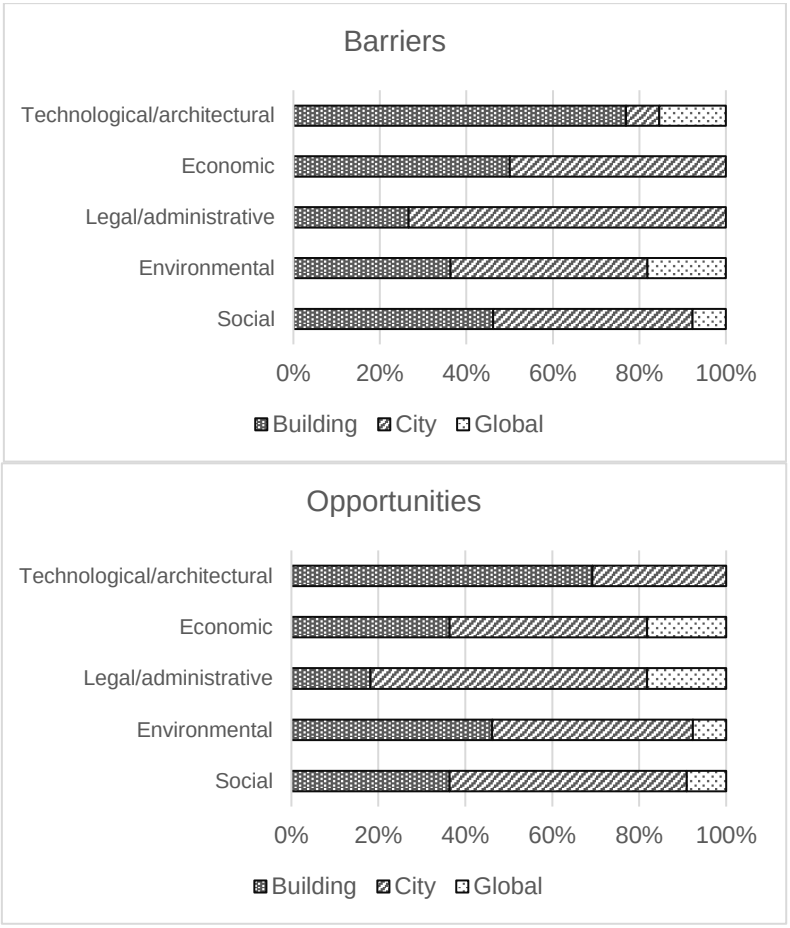

Fig. 4. Scale of impact of potential barriers and opportunities regarding UAGRs in the city of Barcelona

3.3. Barriers and opportunities within UAGR projects life cycle stages

Regarding the stages of a UAGR life cycle, it is essential to highlight the clear division between barriers and opportunities (Fig. 5). Referring to the barriers, the "project" stage stands out compared with the rest (62% of relative weight). Next, we find the "use" stage (29%), followed by the "construction" stage (9%). Thus, only the environmental category presents a predominance of the "use" stage in the discussions of the barriers, while the other categories' (technological/architectural, legal, economic and social) barriers are clearly project-based.

Within the opportunities, the distribution changes radically, and a very clear predominance of the "use" stage emerges, with 84% of relative weight on the total of opportunities. The "project" stage presents 16% of relative weight, while no opportunity is identified at the "construction" stage.

Thus, until UAGRs are in operation, most opportunities are not perceived (or they simply do not appear until the UAGR is fully operational). This leads us to consider why it is difficult to perceive UAGRs' benefits since, without any or fewer UAGR projects in operation, the population will never be aware of its implications and advantages.

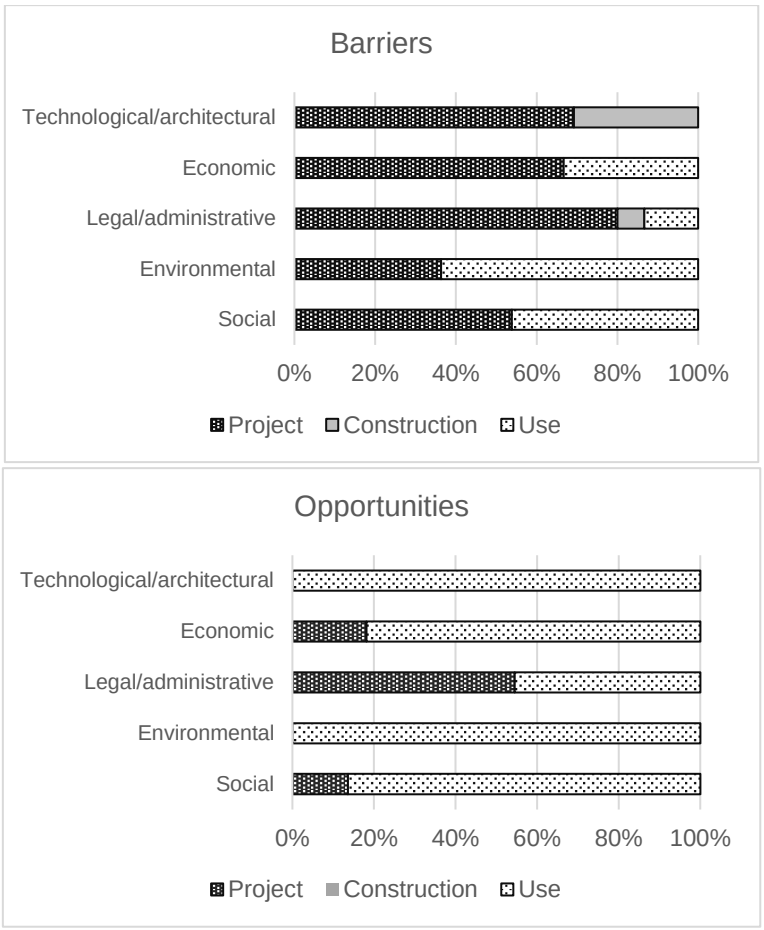

Fig. 5. Stage of UAGRs life cycle where potential barriers and opportunities emerge regarding UAGRs in the city of Barcelona

4. Conclusions

This study has allowed for the attainment of a highly instructive picture of the reality and perception of UAGR projects in the city of Barcelona.

Regarding the barriers, the social and legal administrative categories emerged as those that generate more consensus and interest among the stakeholders. Thus, the lack of information and scope regarding UAGR and the absence of social cohesion are perceived as the main barriers, along with the lack of specific regulations and protocols. In the other categories, the most widely identified barriers involve 50% of coincidence among the actors and refer to the Mediterranean climate (environmental), initial investment (economic) and pre-condition of the roof and its elements (technological/architectural).

Within the opportunities, the social field again appears as the highlighted opportunity, with "social cohesion" generating a total consensus among actors. "New specific regulations" (legal/administrative) and "profits derived from UAGR" (economic) are other important opportunities that are highly perceived.

Another important conclusion is that some items appear as a barrier and as opportunity (social cohesion or lack of specific regulation, for example).

In the stakeholders' distribution view of the barriers, no major differences were observed since all the main barriers were identified by at least one member of all actors' typologies

except for three ("technical or/and lack of formation", "maintenance costs" and "UAGR accessibility). The group that demonstrated more consensus was public administration, with three barriers identified by all members.

From a scale of impact perspective, the barriers appear to be mostly distributed between "city" and "building", while global scale shows a residual relevance, which may imply a closed-system perception regarding cities. In an analysis by areas, it is noted that the economic, environmental and social categories are distributed in a quite homogenous way. Additionally, the technological/architectural categories clearly stand out in terms of the "building" scale, while in the legal/administrative field, the key scale corresponds to "city". Within the opportunities, the mainstream homogeneous distribution is maintained, although it moves towards the "city" scale. This scale maintains a key role in the legal/administrative category, while the "building" scale does so in the technological/architectural category.

Focusing on the stages of the UAGR projects' life cycles, there are clear differences between the barriers and opportunities. The barriers mainly appear during the project stage (62%), while the opportunities do so almost exclusively within the "use" stage (84%).

Because most barriers are perceived in the project stage, and opportunities are not perceived until the use phase, an effort by the administration is needed to implement UAGR projects so that the population can perceive the benefits they generate in all areas of society in an accurate way. In the effort to elaborate a clear, specific regulation regarding UAGR, generating more social consensus and cohesion, along with economic support for those projects, will be key in facilitating its implementation. Moreover, despite the extensive list of barriers and opportunities, their relative weight is concentrated in a relatively small number, showing little dispersion. This would facilitate a policy approach in Barcelona and, by extension, in other Mediterranean compact cities aiming to boost agri-green roofs in their cities. Therefore, this research is a valuable asset towards helping cities to predict and overcome plausible limitations and promoting the opportunities yielded by these projects.

Considering the focus for future research, it would be appropriate to investigate the development of indicators to monitor the impact of UAGRs to verify how they match to the stakeholders' perception. It would also be appropriate to investigate how to generate more consensus and social cohesion. One essential means of contributing to this purpose would be to deepen the dissemination work about the UAGR's opportunities and to respond to the main prejudices of potential users. The key points that should be evaluated in future work include the following: how to introduce UAGR within current legal frameworks and expand on the interest in the impact and sustainability of the used materials and the disequilibrium that can be generated in local ecosystems.

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Appendix A: barriers support list for the World Café by categories

Category	Barriers
Economic	Project cost
Economic	Previous structural inform cost
Economic	Waterproofing cost
Economic	Maintenance cost
Technological/architectural	UAGR are not well identified in material banks or BIM energy-type calculation programs
Technological/architectural	Need to expand sanitation network
Technological/architectural	Lack of database regarding constructive components of UAGR
Technological/architectural	Difficulties regarding water use: collection and storage
Technological/architectural	Urban limitation to perimeter adjustment
Technological/architectural	Some buildings need structural reinforcement
Technological/architectural	Difficulties of access and insulation of roofs
Technological/architectural	Possible pathologies due to poor execution (humidity/structure)
Social	Need for a community leader
Social	Self-management problems regarding long-term maintenance
Social	Perception of technical problems associated with UAGR
Social	Perception of inequality of benefits
Social	Lack of community implication
Social	Low solidarity among neighbors, difficult consensus
Social	Stakeholders complexity when projecting (tenants, owners)
Social	Skepticism regarding community benefits of UAGR)
Legal/administrative	Lack of specific normative regarding UAGR
Legal/administrative	Need to modify the statutes of neighboring communities

Legal/administrative	Limitation of pergolas/greenhouses by volume issues
Legal/administrative	You cannot sell agricultural products
Legal/administrative	Current legislation focuses more on UAGR promotion rather than agricultural production
Legal/administrative	A majority of 50% is necessary to carry out UAGR project, and more in case of reinforcement needs.
Legal/administrative	Lack of unified criteria by the public administrations
Legal/administrative	Financial aids require to suspend rental agreements
Environmental	Limitation of water resources during drought periods
Environmental	Environmental impacts of the construction of greenhouses, solar panels…

Appendix B: opportunities support list for the World Café by categories

Category	Opportunities
Economic	Recovery of underused spaces
Economic	Energy savings due to better insulation
Economic	Complement the "shopping lists" with self-produced products
Economic	Reduction of sewerage tax
Economic	New jobs creation
Economic	Product consumption cooperatives
Technological/architectural	Urban landscape improvement
Technological/architectural	Integration of the UAGR in the building design
Technological/architectural	Buildings more isolated (thermic and acoustic)
Technological/architectural	Fluxes synergy (heat, ventilation, water and organic matter)
Technological/architectural	Possibility of obtaining environmental, energetic and food indicators.
Technological/architectural	Reuse of nutrients from the residual water flows of the crops (circular fluxes).
Technological/architectural	Incorporation of ICT (information and communication technologies) to the management of UAGR
Technological/architectural	Smart buildings

Social	Boost health spaces
Social	Improve corporate social responsibility by introducing UAGR in corporate buildings
Social	Promotion of nature-related activities
Social	Most self-sufficient cities
Social	Facilitates social inclusion
Social	Urban farming (collective inclusion)
Social	Variety of fresh seasonal products
Legal/administrative	Improvement and/or update of existing regulations
Legal/administrative	New metabolic vision of the city
Legal/administrative	Meet the city's international agreements on food and climate change
Environmental	Biodiversity boost. Naturalization of the city.
Environmental	Heat island effect reduction.
Environmental	Take advantages of local endogenous resources (rainwater, sunlight, etc.)
Environmental	Reduction in CO2 emissions (or equivalents)
Environmental	Reduction of sewer network flows
Environmental	Minimization of food waste in collection, transport and storage.

Appendix C: complete barriers and opportunities data extracted from the UAGR seminar

Stakeholders	All	Not-all	Nobody

Scale	Building	City	Global
	B	C	G

Stage	Project	Construction	Use
	P	C	U

Social Barriers	Relative weight on the total of answers (%) (m=110)	Coincidence among stakeholders (%) (n=24)	Public administration (PA)	Private companies (PC)	Research centers (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Lack of information and scope regarding UAGR	22	100					C	P
Lack of social cohesion	22	100					B	P
Use of UAGR by communities	16	75					B	U
Maintenance or unforeseen issues	10	46					B	U
Difficulties regarding decision-making	8	38					B	P
Lack of examples by municipalities and administrations	6	29					C	P
Age bands of interest regarding UAGR	5	20					C	U
Administrators role	5	25					B	U
Compensation for the made efforts	2	8					G	U
Lack of technical reference for the communities	1	4					B	P
Administrative barriers that appear once the social ones have been overcome	1	4					C	P
Lack of tracking	1	4					C	P
Robbery	1	4					C	U

Social opportunities	Relative weight on the total of answers (%) (m=117)	Coincidence among stakeholders (%) (n=19)	Public administration (PA)	Private companies (PC)	Research centers (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Social cohesion	16	100					B	U
Generate common spaces	11	68					B	U
Education tool	11	68					C	U
Generate “green + sociability” spaces	9	58					B	U
Food and local products appreciation	8	47					G	U
Community feeling	7	42					B	U
Social capital	7	42					G	U
Users’ life quality	6	37					B	U
Therapeutic and pedagogic value (schools, geriatrics)	5	32					B	U
Dissemination of UAGR contest and projects	4	26					C	P
Facilitation of UAGR projects	3	16					C	P
Job creation	3	16					C	U
Out-of-market services	2	11					C	U
Opportunity for the elderly or mobility problems	2	11					C	U
Technicians tracking	1	5					C	P
City concept (landscape view)	1	5					C	U
Bring agricultural activities to the urban areas	1	5					C	U
Social slit reduction	1	5					C	U
Park “at your home"	1	5					B	U
Network of cameras to monitor UAGR	1	5					B	U
New business fields/market niches by administrators	1	5					C	U
“inhabit future”	1	5					C	U

Environmental barriers	Relative weight on the total of answers (%) (m=44)	Coincidence among stakeholders (%) (n=24)	Public administration (PA)	Private companies (PC)	Research centers (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Mediterranean clime	30	54	■	■	■	■	G	U
Technical or/and environmental lack of formation	16	29	■	■	■		B	P
Uses and quality of water	16	29	■	■	■	■	C	U
Water uses and quality	16	29	■	■	■	■	B	P
Materials used	11	21	■	■			B	U
Prejudices/problems regarding flora and fauna	11	21	■	■		■	B	U
Limitations of rainwater collections tanks	5	8		■		■	C	P
Lack of guidelines to carry out UAGR projects	2	4		■			G	P
Lack of an environmental/transdisciplinary concrete focus	2	4		■			C	U
Heat island effect	2	4		■			C	U
City pollution affecting productive crops	2	4		■	■		C	U
Conflicts of trees with height regulations	2	4				■	B	P

Environmental opportunities	Relative weight on the total of answers (%) (m=55)	Coincidence among stakeholders (%) (n=19)	Public administration (PA)	Private companies (PC)	Research centers (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Improved life quality	16	47					B	U
Biodiversity increase/improvement	11	32					C	U
Improved air quality	11	32					C	U
Better water uses	11	32					B	U
Environmental education	11	32					C	U
Run-off reduction	7	21					E	U
Decreasing in heat island effect	7	21					C	U
Improves in thermal insulation	7	21					E	U
Energy savings	6	16					E	U
Green corridors	6	16					C	U
Food sovereignty and proximity products	4	11					C	U
Climate change mitigation	2	5					G	U
Improves in acoustic insulation	2	5					E	U

Legal/administrative opportunities	Relative weight on the total of answers (%) (m=48)	Coincidence among stakeholders (%) (n=19)	Public administration (PA)	Private companies (PC)	Research centers (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
New specific regulations	31	79					C	P
Pilot projects promoted by the city council	15	37					C	P
Creation of an UAGR ecological certificate	13	32					C	P
Tax incentives	10	26					C	P
Contact other European cities/councils	8	21					G	P
Decriminalization/facilitation of marketing urban agricultural products	6	16					C	U

Subjects in architectural schools	4	11					G	P
New community agreements	4	11					B	P
“rain + green”	4	11					B	U
Prioritize certain social groups for UAGR projects	2	5					C	U
Allow economic activities on the roofs	2	5					C	U

Economic barriers	**Relative weight on the total of answers (%) (m=25)**	**Coincidence among stakeholders (%) (n=22)**	**Public administration (PA)**	**Private companies (PC)**	**Research centers (RC)**	**Owners and users (OU)**	**Scale**	**Stage of UAGR life cycle**
Initial investment	40	46					B	P
Small benefit perception	20	23					B	P
Maintenance costs	20	23					B	U
Lack of financial aids	12	14					C	P
Very expensive for public administrations	4	5					C	P
Difficulties on marketing the product	4	5					C	U

Economic opportunities	**Relative weight on the total of answers (%) (m=37)**	**Coincidence among stakeholders (%) (n=18)**	**Public administration (PA)**	**Private companies (PC)**	**Research centers (RC)**	**Owners and users (OU)**	**Scale**	**Stage of UAGR life cycle**
Profits derived from the UAGR	32	67					B	U
Added value to building	15	28					B	U
New jobs and business	11	22					C	U
Sales of local products	11	22					C	U
Tax incentives	11	22					C	P

Energetic and economic opportunity	5	11					B	U
Prevention in public health	5	11					C	U
Consumer-housing-office cooperatives	3	6					G	U
Indirect economic profits derived from social benefits	3	6					B	U
Changes in legal frameworks	3	6					C	P
Environmental regulations on a business level	3	6					G	U

Technological/architectural barriers	**Relative weight on the total of answers (%) (m=64)**	**Coincidence among stakeholders (%) (n=24)**	**Public administration (PA)**	**Private companies (PC)**	**Research centers (RC)**	**Owners and users (OU)**	**Scale**	**Stage of UAGR life cycle**
Pre-condition of the roof and its elements	23	63					B	P
Structural load limitations	22	58					B	P
UAGR accessibility	16	42					B	P
Safety on the roofs	9	25					B	P
Priority of aesthetic criteria versus sustainable practices	8	21					B	P
Material limitations	5	13					C	P
Installation of electricity and water network	5	13					B	C
Waterproof materials guarantee	3	8					G	C
Cost of waterproofing	3	8					B	P
Difficulty on place water tanks	2	4					B	C
Heritage limitations	2	4					B	P
Old buildings	2	4					B	P
Lack of specific materials for UAGR construction	2	4					G	C

Technological/architectural opportunities	Relative weight on the total of answers (%) (m=40)	Coincidence among stakeholders (%) (n=19)	Public administration (PA)	Private companies (PC)	Research centers (RC)	Owners and users (OU)	Scale	Stage of UAGR life cycle
Aesthetic improvement	15	32					B	U
New space's uses	13	26					B	U
Update current facilities	13	26					B	U
Improvement in thermal and acoustic insulation	10	21					B	U
Creation of a common space to share experiences related with UAGR	10	21					C	U
Redistribution of roof elements	8	16					B	U
More sustainable cities and buildings	8	16					B	U
Opportunity for smart buildings	8	16					B	U
Network of technicians between different cities	5	11					C	U
Analyze climatic and environmental data	5	11					B	U
Waterproof improvement	3	5					B	U
Better city drainage	3	5					C	U
Opportunity to build green corridors	3	5					C	U