# Risks in urban rooftop agriculture: assessing stakeholders' perceptions to ensure efficient policy-making

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## Abstract

Rooftop agriculture (RA) is an innovative form of urban agriculture that takes advantage of unused urban spaces while promoting local food production. However, the implementation of RA projects is limited due to stakeholders' perceived risks. Such risks should be addressed and minimized in policymaking processes to ensure the sustainable deployment of RA initiatives. This paper evaluates the risks that stakeholders perceive in RA and compares these perceptions with the currently available knowledge, including scientific literature, practices and market trends. Qualitative interviews with 56 stakeholders from Berlin and Barcelona were analyzed for this purpose. The results show that perceived risks can be grouped into five main categories: i) risks associated with urban integration (e.g., conflicts with images of "agriculture"), ii) risks associated with the production system (e.g., gentrification potential), iii) risks associated with food products (e.g., soil-less growing techniques are "unnatural"), iv) environmental risks (e.g., limited organic certification) and v) economic risks (e.g., competition with other rooftop uses). These risks are primarily related to a lack of (scientific) knowledge, insufficient communication and non-integrative policymaking. We offer recommendations for efficient project design and policymaking processes. In particular, demonstration and dissemination activities as well as participatory policymaking can narrow the communication gap between RA developers and citizens.

**Keywords:** *Qualitative research; Rooftop greenhouse; Urban sustainability; Local food production; Urban policy.*

## 1. Introduction

Both the increase in the urban population and growing food demand are stimulating the worldwide expansion of urban agriculture (UA) (Mok et al., 2014; UN-Habitat, 2013). UA seeks a sustainable way to increase local production and thereby reduce the urban "foodprint" (Goldstein et al., 2014) while contributing to the socio-economic development of communities (Mok et al., 2014). UA initiatives include a wide range of stakeholders and project types, from traditional sites (e.g., community gardens) to high-tech integrated building solutions (Cohen et al., 2012; Specht et al., 2014; Thomaier et al., 2015).

Building-related agriculture is growing in European and North American cities in particular. It embraces concepts such as vertical farming (Despommier, 2010), zero-acreage farming (Specht et al., 2014), building-integrated agriculture (Caplow, 2009) and skyfarming (Germer et al., 2011). As the most common type, rooftop agriculture (RA) encompasses open-air RA and rooftop greenhouses (RTGs) (Thomaier et al., 2015). Open-air RA is cultivated on available roofs ranging from non-commercial rooftop gardens to entrepreneurial rooftop farms (e.g., Brooklyn Grange in NYC, USA, http://brooklyngrangefarm.com/). RTGs are greenhouses that commonly employ soil-less techniques (e.g., substrate) (Cerón-Palma et al., 2012). Because of the necessary investments in infrastructure, RTGs are typically commercial businesses. Gotham Greens, for example, runs a 1,400 $m^2$ RTG atop a former warehouse in NYC since 2011 (http://gothamgreens.com/).

### 1.1. Research on rooftop agriculture

The existing literature on RA has addressed its theoretical background, agronomic and food security aspects, and the quantification of its environmental and economic balance. Some authors have reflected on definitions, current practices and potential business models (Despommier, 2010; Goldstein et al., 2014; Thomaier et al., 2015). The associated benefits and limitations have been identified for different European contexts. Cerón-Palma et al. (2012) determined the barriers and benefits that technical focus groups (e.g., architects, engineers) associated with the implementation of RTGs in the Mediterranean region. Specht et al. (2014) summarized opportunities and limitations of building-related agriculture based on the existing literature. Both studies highlighted potential benefits and problems in all three dimensions of sustainability (societal, economic and environmental).

The potential contribution of RA to domestic vegetable production has been assessed for various cases (Astee and Kishnani, 2010; Orsini et al., 2014; Sanyé-Mengual et al., 2015a; Whittinghill et al., 2013). The environmental savings associated with shortening the supply chain through RTGs were quantified as the substitution of imported products by local RTG vegetables (Sanyé-Mengual et al., 2013). The environmental and economic burdens of different types of RA have been quantified for RTGs in Barcelona (Spain) (Sanyé-Mengual et al., 2015b) and for community rooftop gardens in Bologna (Italy) (Sanyé-Mengual et al., 2015c).

Previous studies of policymaking surrounding UA have largely focused on developing countries. These studies have addressed the question of how policy can contribute to improvements in urban land use policy, urban food security and health, and environmental policy (Bakker et al., 2001; Bryld, 2003). Research objectives related to RA policy have also recently emerged for Canada and the US (e.g., Cohen and Reynolds, 2015). For cities in Europe, however, research on RA and RA policy implementation has largely been absent.

### 1.2. Social acceptance and perception of risks around innovations

In general, perceptions of innovative products and technologies are critical for their further implementation. An innovation such as RA depends on its social acceptance, particularly in the initial stages (Specht et al., 2016a). “Acceptance” is defined as “the process or fact of something being received as adequate, valid, or suitable” (Oxford Dictionary, 2014). The predominant field of investigation in acceptance research has focused on exploring social acceptance of technological innovations. Therefore, one particular objective of such research is to analyze people’s attitudes toward certain new technologies, especially those related to risks. The widespread phenomenon of perceived risks and low social acceptance of innovations has already been described in different societal contexts, such as new fields of agricultural production, energy production, GMOs or carbon capture and storage (Renn, 2005; Wüstenhagen et al., 2007). Well-known examples of agricultural production innovations initially facing low social acceptance include precision farming, organic farming and conservation agriculture (Kutter et al., 2011; Padel, 2001; Sattler and Nagel, 2010).

In the RA field, previous studies analyzed stakeholder and public perceptions of RA in Berlin and Barcelona in terms of perceived benefits, problems, risks and future implementation actions (Sanyé-Mengual et al., 2016; Specht et al., 2015, 2016a, 2016b). Although a lack of social acceptance had already been identified as potential limitation of RA implementation, previous studies had broader objectives and did not thoroughly investigate the question of perceived risks. Moreover, existing results have not yet been linked to policy.

### 1.3. Aims and research questions

This study aims to close this gap in research and to analyze and debate the risks of RA that stakeholders perceive and link them to policymaking. Thus, the following research questions are investigated:

- What risks of RA do stakeholders perceive?
- What are the main differences between the stories of Berlin and Barcelona?
- What are the policy and practice recommendations for overcoming barriers related to perceived risks?

## 2. Case study description

Berlin and Barcelona were chosen as case studies because RA is currently growing in both cities. Different climate conditions, UA development and current RA implementation are of great interest for comparative purposes. Table 1 summarizes the main characteristics of the case studies.

***Table 1.*** *Population, regional food consumption, UA and RA development in Berlin (compiled from Specht* et al*., 2016, p. 4) and Barcelona case studies.*

| | **Berlin, Germany** | **Barcelona, Spain** |
|---|---|---|
| ***Population*** | - 3.5 million inhabitants<br>- Second most populous city proper (within the city limits) in the EU | - 1.5 million inhabitants<br>- Second most populous city in Spain |
| ***Regional food demand*** | - Regional agricultural products are increasingly requested by urban consumers (BMELV, 2013) | - Approximately 16% of food distributed through MercaBarna (a food distribution center) is regionally produced (MercaBarna, 2014)<br>- Demand for local and sustainable food has recently increased in the region (Generalitat de Catalunya, 2012) |
| ***UA development history*** | - Long historic tradition: During industrialization (19th century), inner-city gardens were established to improve food security and health of low-income inhabitants<br>- During World War I, World War II and shortages, the gardens (Schrebergärten) helped protect the population | - UA activities in Barcelona began in the 1980s, promoted by the municipal administration through the Barcelona Urban Gardens Network program<br>- Previously, UA was limited to individual gardens in squatted vacant lands in peri-urban areas (Ajuntament de Barcelona, 2014). |
| ***Current status of UA*** | - 3,000 ha (3% of the city's area) are covered by family home food gardens and garden plots.<br>- Over 73,000 plots are officially designated urban allotment gardens (Senatsverwaltung Berlin)<br>- Over 100 community gardens have been established | - 4.8 ha in the city center are devoted to 13 municipal gardens, which were created as a leisure option for elderly people (Giacchè and Tóth, 2013)<br>- 315 school gardens (Agenda 21) to promote sustainable development (Ajuntament de Barcelona, 2002) |

| | | |
|---|---|---|
| | - A growing number of UA projects, accompanied by increasing media interest and constantly growing public and political awareness | - Development of squatting community gardens as a form of activism<br>- The Vacant Lands Plan (Pla Buits) awarded some vacant lands to social entities for developing community gardens (La Vanguardia, 2013)<br>- Policy level: “UA in Barcelona: global strategy” (Ajuntament de Barcelona, 2014) |
| ***Current development of urban RA*** | - Development of start-ups and experimental cases<br>- Test stages for research and investigation of new applications or to showcase production in RTG<br>- Examples: “ECF Containerfarm” (urban farm, RA in shipping containers) and “Watergy” (integration of energy and water cycles between urban buildings and greenhouses) | - Pilot projects and planned projects:<br>- Some stakeholders have switched their interest to RA<br>- Research entities, architects and restaurant managers have started planning RTGs in Barcelona, though such planning is still in the research and pilot stage (Sanyé-Mengual et al., 2016)<br>- Example: Fertilecity project |

## 3. Research methods and empirical basis

### 3.1 Expert interviews

Qualitative expert interviews were conducted with stakeholders in Berlin (31 interviewees) and Barcelona (25 interviewees). The interviews were part of independent studies in Berlin and Barcelona (Sanyé-Mengual et al., 2016; Specht et al., 2015, 2016a) that approached the same stakeholder groups with comparable interview questionnaires between 2011 and 2013.

Each interview lasted approximately 60 minutes. Four major parts of the interview guidelines overlapped in the two case studies’ questionnaires: (1) personal experiences, knowledge and associations with UA and specific types of RA; (2) potential associated benefits; (3) potential associated risks and problems; and (4) framing conditions, future challenges and actions.

Stakeholders were classified into five stakeholder groups (Table 2). Some stakeholders were already actively involved in RA activities at the time of the interview. Others were considered important due to their knowledge (e.g., regarding markets or technical issues) or their relevance at a strategic, political or administrative level.

***Table 2.*** *Sample profile: overview of interviewed stakeholder groups in Berlin and Barcelona.*

| **Stakeholder groups** | **Role** | **No. of stakeholders** | | | |
|---|---|---|---|---|---|
| | | **Berlin** | | **Barcelona** | |
| | | **Total** | Involved in RA* | **Total** | Involved in RA* |
| Activists and projects | Planning to or establishing of projects (such as UA initiatives, RTG project groups, NGOs in urban development, social UA enterprises) | **8** | [7] | **5** | [5] |
| Lobby groups and unions | Representatives from associations and unions (e.g., from agricultural or horticultural | **8** | [1] | **3** | [2] |

| | | | | | |
|---|---|---|---|---|---|
| | associations, real estate, landscape architecture) | | | | |
| Design and implementation | Architects, landscape architects or greenhouse experts | **7** | [3] | **5** | [4] |
| Policy and administration | Representatives of different associated departments in policy and administration (e.g., from public departments of the environment, urban development, sustainable development, consumer protection, health, landscape planning) | **4** | [0] | **9** | [5] |
| Sales and distribution | Stakeholders who can potentially grow, sell or distribute products (e.g., food distributors, canteens, university canteens, food co-ops, supermarkets) | **4** | [2] | **3** | [0] |
| **Total** | | **31** | | **25** | |

** Number of stakeholders who were actively involved in RA activities at the time of the interviews*

### 3.2. Analysis

All interviews were recorded, transcribed and analyzed. We applied the principles of qualitative content analysis (Corbin and Strauss, 1990; Kuckartz, 2014), whereby text fragments were assigned codes to classify the large number of textual data units into smaller homogeneous categories. The interview transcripts were examined line by line in search of content specifically related to the goal of each particular question. Due to different original languages, the interviews were independently coded by two researchers (one used MaxQDA software, and the other coded manually). The same codes were used in both case studies. Only the aggregated results were translated and merged for comparison. These results were used to assess the perceived risks of RA in the two case studies. The identified risks were discussed in relation to the current state of knowledge.

## 4. Results and discussion

### 4.1. Overview of the perceived risks of RA

The perceived risks surrounding RA in Berlin and Barcelona are presented in Table 3. Five main categories were revealed: i) risks associated with urban integration, ii) risks associated with the production system, iii) risks of food products, iv) environmental risks and v) economic risks. Regarding the urban environment and the system, stakeholders reported concerns about the integration, use, access, complexity and aesthetics of RA projects. Perceived risks of food products were related to acceptance problems with soil-less growing, the expected low quality of the products and potential health risks associated with urban contamination. Finally, stakeholders questioned the environmental and economic balance.

***Table 3.*** *Perceived risks associated with RA in Berlin and Barcelona. Relevance is specified as high (+++), medium (++), low (+) or not mentioned (n.m.). (Compiled from Specht* et al.*, 2016a and Sanyé-Mengual* et al.*, 2016)*

| | Relevance/Importance | |
|---|---|---|
| | Berlin | Barcelona |
| **I) Risks associated with urban integration** | | |
| Conflicts with images of "agriculture" | +++ | +++ |
| Conflicts with images of "urbanity" | ++ | ++ |
| Conflicts with potential urban animal production | +++ | n.m. |
| Logistics and management constraints for food products | + | + |
| Increase in noise and smell (due to production activity) | ++ | n.m. |
| Little or no perceived aesthetic benefit | + | + |
| **II) Risks associated with the production system** | | |
| Associated technology is perceived as too complex | +++ | +++ |
| Risk that projects are overtaken by large enterprises | ++ | ++ |
| Risk that projects are launched too fast | +++ | n.m. |
| Projects are exclusive and act as a driver of gentrification | ++ | ++ |
| **III) Risk associated with food products** | | |
| Soil-less growing techniques are "unnatural" | +++ | +++ |
| Quality of products expected to be low | ++ | ++ |
| Health risks (due to air pollution) | +++ | +++ |
| Health risks (due to contaminated waste water) | ++ | n.m. |
| **IV) Environmental risks** | | |
| Uncertainty about the overall environmental impact | ++ | ++ |
| Risk of unsustainable management | + | + |
| Soil-less techniques cannot be organic | + | + |
| **V) Economic risks** | | |
| Little or no perceived economic benefit | +++ | +++ |
| Operators are not trained (not professional) enough | ++ | ++ |
| Competition with other rooftop uses | ++ | ++ |
| Competition with peri-urban and rural farmers | + | ++ |

### 4.2. Risks associated with the urban integration of RA

Barriers related to stakeholders' norms and values, particularly their perception of RA being "not real agriculture," were identified as a major challenge for the integration of RA into the urban environment In both cities, RA conflicts with common understandings of food production: several stakeholders believe that agriculture belongs in the countryside, where it can be practiced on large plots. Moreover, high-tech RA has been billed as the *"counter model to cultivate in your own garden"* (Administration representative, Berlin). Stakeholders further perceive a risk of "urban" qualities being disturbed by RA:

> *"We have just managed to achieve a certain level of urbanisation, and now you come along proposing agriculture. We don't want this."* (Urban planner, Berlin)

In the case of Berlin, stakeholders were particularly concerned about re-introducing animals to urban areas, which was perceived as futuristic and unwelcome. Animal production was not addressed by stakeholders in Barcelona, but it was on the minds of stakeholders in Berlin:

> *"Will we see cows or pigs on the roofs? […] I would have a problem with keeping animals in urban areas."* (Landscape planner, Berlin)

In aesthetic terms, stakeholders reported concerns about increased noise and odors. Furthermore, some did not recognize any aesthetic benefits of integrating food production with buildings; hence, they questioned the aesthetic value of RA:

> *"No employee would enjoy having to look on rows and rows of lettuce (…) Something like beauty is an issue after all."* (Real estate representative, Berlin)

These results illustrated that the integration of agricultural production into urban areas is challenged by a number of psychological barriers.

#### *4.2.1 Discussion of the risks associated with urban integration*

The perceived risks and reservations related to the urban integration of RA featured very prominently in our study. Objectively assessing these risks is very difficult, as they are formed on very individual normative levels. These perceptions are essentially linked to personal preferences, attitudes and/or opinions; therefore, determining whether they are either “right” or “wrong” is impossible.

The reservations that we observe here constitute a widespread phenomenon in the field of innovation (Renn, 2005). Typically, nearly every innovation encounters a certain level of rejection in the early stages of its introduction. First, a general rejection of the “unknown” often occurs. In addition, stakeholders can have personal reasons and specific motivations for rejecting RA (e.g., for aesthetic reasons). The two essential ways to address these types of risks are sufficient *communication with the public* and *integrative policymaking.*

Within academic discourses, several theoretical visions and frameworks aim for the conceptual integration of agriculture into cities, which could be a starting point for the development of integrative policy agendas. However, we found that such conceptualizations are not yet compatible with common stakeholder assumptions. Torreggiani et al. (2012) present a wide range of images and contexts related to contemporary forms of the urban–rural interface, discussing the bidirectional trends between rural and urban areas as hybrid interfaces of “rural urbanity.” Integrative concepts such as the “productive city,” the “arable city” (Sartoux, 2008), the “edible city” and “continuous productive urban landscapes (CPUL)” (Bohn and Viljoen, 2011) stand in stark contrast to the strict separation between rural and urban characteristics and functions that the surveyed stakeholders conveyed.

We assume that the concepts surrounding the (re-)integration of agriculture into cities constitute very specific knowledge that is discussed within small academic communities. We conclude that these concepts (such as CPUL) and their underlying ideas have not yet entered into the general public consciousness or policy discourse; they have yet to reach the mainstream or represent a majority view. We hypothesize that deviating norms and conceptions are the most important barriers to wider transformation and system integration—now and in the future.

Successful communication would need to address and integrate all relevant stakeholder groups. In most cities in developing countries, UA has always been an integral part of the cityscape (Orsini et al., 2013). By contrast, in Berlin and Barcelona, food production has historically been set apart and is now increasingly moving “back” from rural or peri-urban areas to the inner city. In the case of urban RA, entirely new actors are confronting the integration of agriculture into cities. They might be stakeholders who never dealt with the issue of agricultural production before (i.e., urban planners, real estate owners or city councils) or stakeholders linked to traditional agriculture (i.e., peri-urban managers and farmers) (Sanyé-Mengual et al., 2016; Specht et al., 2015).

In aesthetic terms, our analysis reveals that several stakeholders do not believe that RA can improve their cities. The results show that some stakeholders can justify their rejection of RA very well. Others simply do not appreciate RA, claiming that they cannot imagine how it could concretely be realized. For the future of RA, communicating and transferring existing images and design concepts of RA to broader target groups is important; people can then make a more grounded judgement on its aesthetic value. The topic of RA has been addressed by architects and design schools around the world (Specht et al., 2014), but visions of how buildings can be aesthetically integrated with agricultural production are still largely unknown.

The issue of animal keeping in European cities is a critical question, which easily results in high levels of resistance, particularly with regard to larger animals (Wilt and Dobbelaar, 2005). At the same time, practical experiences with larger animals are relatively rare. Animal production in current UA practices is limited to bees, chicken and fish rather than larger animals, such as pigs or cows. The differences between Berlin and Barcelona in terms of raising animals might be explained by the different stages of UA development in the two cities. Ongoing practices in Berlin are more advanced, and they include aquaponics (i.e., fish production integrated into hydroponic crops). Thus, animal production is already included in Berlin's UA projects, for example, by the company ECF (http://www.ecf-farmsystems.com). By contrast, RA in Barcelona is still in the initial stages and includes only vegetables. Animal production in current UA practices is limited to bees, chicken and fish rather than large farm animals such as pigs or cows. Besides urban residents' lack of acceptance and fears of urban animal raising practices, legal regulations in Germany and Spain prohibit animals within dense settlements and specify minimum distances between livestock farms and inhabited buildings (e.g., in Spain, 400 m distance for bee keeping and 500 m for pig stables are mandatory).

The integration of UA into policymaking and urban planning (e.g., through its inclusion in acts and programs) and the communication and promotion of positive examples could lead to a process of re-thinking the question of whether a strict separation between "urban" and "rural" functions is really worthwhile. While some people will simply never appreciate the idea of integrating food production into cities, improved communication and integrative policymaking would likely help reduce some of the discussed reservations related to individual norms and conception.

### 4.3. Risks associated with the production system

The second category of perceived risks are those associated with the applied or proposed production system. A major factor in this context is the stakeholders' perception that the technologies applied in RA (namely, soil-less growing and greenhouse techniques) are overly complex.

The results illustrate that risks are associated with production systems, namely, the ease with which one can use, access and understand RA practices. This facility primarily applies to more technologically complex systems, such as RTGs, and to general applications of soil-less growing or practices that exploit synergies between agriculture and buildings (e.g., by coupling heat, water or waste cycles).

As complex technologies are linked to high costs, stakeholders fear that RA could contribute to higher real estate prices and could thus change neighborhoods. The assumed high complexity and high costs of operating RA also lead to the perceived risk that RA will be *adopted by large enterprises* pursuing RA as a profitable but unsustainable business. Stakeholders express concerns that RTGs in particular are managed for profit without integrating social or other functions.

> *"An RTG has to be managed as a company, not as a social project. This type of garden would not be useful for a recreational use. (…) It also misses the part of contacting with nature, working with the soil."* (Local administration, Barcelona)

Only in Berlin were stakeholders afraid that RA projects were being developed too rapidly, leading to a "copy-paste" process from other cities instead of the creation of specific, unique development mechanisms that acknowledged local contexts.

#### *4.3.1 Discussion of the risks associated with the production system*

Comparing the perceived risks regarding the production system with current RA practices and available scientific knowledge, we discovered that some of stakeholders' negative ideas were incongruent with real-life practices and could thus be explained by a *lack of knowledge* of actual implementation. For other perceived risks, the *insufficiency of scientific data* leads to risk perceptions and an inability to generally prove or disprove them.

Two major perceived risks can be traced back to faulty conceptions of RA and only partly justified. First, stakeholders fear the high complexity of RA technology. If we compare the perceived risk of technological complexity with current practices, low-tech open rooftop gardens and farms remain the most common type of RA (Thomaier et al., 2015). Their financial and technological complexity is comparably low. Examples of medium- or large-scale rooftop gardens can be found all over the world. Although open-air rooftop gardening has its own particular challenges (e.g., weather and wind conditions, rainwater collection, load, access) (Specht et al., 2014), it is comparably easy to manage, as their initiators can profit from the well-developed discipline of green roof technologies. Furthermore, the largest share of ongoing projects (even in the case of RTGs) is still soil based (Thomaier et al., 2015). Nevertheless, this issue must be considered because it could become even more relevant in the future, as the use of soil-less growing practices in RA is increasing (Thomaier et al., 2015).

Second, we uncover the perceived risk that large enterprises can take over RA. Given the background of current practices, one may note that essentially two main types of RA initiatives exist, each representing different ownership models. First, for-profit entrepreneurs establish commercial RA projects with RTGs because of their higher efficiency. In this first case, RA may indeed be at risk of takeover by large enterprises. The second type includes socially driven projects, often managed by private initiatives or NGOs. These projects have various ownership models: private ownership, rental agreements or shared ownership among gardeners. These projects typically involve self-production models in which the users benefit from their own gardens, thus avoiding any commercial pathway in which large enterprises could play a role (Thomaier et al., 2015). Therefore, the risk is low for these social projects, as they cannot be exploited from a commercial perspective. In contrast to the stakeholders' perceptions, involvement in UA practices is considered an alternative to the large food sector (when, e.g., multinationals are involved). The individuals involved are aware of topics such as social justice and ecological food production and actively oppose large companies' involvement in UA (Dobernig and Stagl, 2015). Although this risk does not really apply to current practices, large firms could gain more influence in RA in the future.

Regarding the fear of neighborhood transformation, a common assumption is that UA leads to rising real estate values and "green gentrification" (Gould and Lewis, 2012). Furthermore, potential consumers of the products of local food movements are considered to be high-income academics (Guthman, 2003). Stakeholders from Berlin and Barcelona perceived gentrification as a minor risk. Existing studies are ambivalent regarding this "risk" (Opitz et al., 2015). Some see UA as a driver of gentrification, while others interpret developments in UA as improvements for underserved inhabitants. The actual impacts of RA on neighborhood transformation processes have not yet been empirically investigated.

### 4.4. Risks of the food products

The third category of perceived risks affects potential products of RA. Stakeholders in both case studies share the view that producing in soil-less or hydroponic systems is a "too artificial" and "unnatural" way of growing.

> *"Many visitors are shocked when they see how we grow food in hydroponic systems. They say, 'It is impossible to grow tomatoes in such substrate instead of soil.'"* (Urban aquaponics farmer, Berlin)

In addition to normative rejections of soil-less growing, interviewees also expect RA product quality to be lower, less healthy and less tasty compared with products from rural areas.

Compared with “real-soil” produce, hydroponic produce in particular is believed to have lower nutritional value.

Furthermore, consumers’ expect less food safety from urban food products. Stakeholders attach multiple health risks to urban food products related to air, soil and water contamination.

> *“If you consider all the measurements of airborne dust along roadsides (…) that exceed the threshold in each year, people will be very skeptical. Everybody will be critical and suspicious about the quality.”* (Researcher, Berlin)

Finally, Berlin stakeholders were concerned about the potential health risks associated with wastewater use in RA, which is a common practice in aquaponics (Thomaier et al., 2015). Stakeholders in Barcelona were less concerned about this issue (Barcelona pilot projects focus more on harvesting residual heat and rainwater than on reusing wastewater (Sanyé-Mengual et al., 2014)).

Our results demonstrate that major risks of RA are attached to the horticultural products themselves and to perceptions of negative consequences resulting from consuming those products.

#### ***4.4.1 Discussion of the risks of food products***

The perceived risks associated with food products can be partly negated by the results of current scientific analyses. Nevertheless, research investigations of these issues are in the very early stages. The available results are generated on single-case basis, and the further *demonstration and testing of practical cases* are necessary to validate them in other contexts. Once such risks can be refuted, dissemination must combine with *communication* to help reduce risk perceptions, which are built on faulty assumptions.

Existing studies show that, in terms of taste and product quality, soil-less production can even be linked to improved quality for some products (Asaduzzaman et al., 2015; Gruda, 2009). Nonetheless, previous studies have already revealed the generally low acceptance and concerns related to soil-less growing (Sanyé-Mengual et al., 2016; Specht et al., 2014; Specht and Sanyé-Mengual, 2015). In the RA context, “soil-based” growing is the preferred and most accepted type of substrate. In RA practices, substrates are more common than soil-less production (Thomaier et al., 2015). Notably, even if this substrate might look like soil, it is often a lighter material mix of composted green residuals with much greater porosity; it is not “original” soil. In so-called “soil-based” rooftop gardens, the substrate is typically “peat” or “compost.” In fact, RA practitioners employ commercial soil or soil-less techniques (e.g., hydroponics) to avoid one of the main contamination pathways in soil-based UA: the soil itself.

Recent studies of contamination in UA highlight potential risks but also outline multiple practices to reduce such risks (e.g., location, crop techniques) (Antisari et al., 2015; Pennissi et al., 2016; Säumel et al., 2012). Among contamination sources, air contamination from road traffic (e.g., fuel preservatives) is one of the main concerns. However, RA potentially has lower exposure to contamination sources because of the height of the gardens. Exposure can be further minimized by analyzing the garden’s location (e.g., distance to main roads), employing preventive methods (e.g., barriers) or using other techniques (Antisari et al., 2015; Säumel et al., 2012). A study by Gelman (2014) demonstrated that among the different RA types, RTGs offer a physical barrier to air contamination that can be further reinforced by using filters in the air exchange systems. Existing projects ensure product safety by performing quality controls. With regard to conventional food, quality certification schemes may reduce the low acceptance and the fear of contaminated food. Thus, administrative bodies might work toward certification standards for urban food, while producers might consider certification in their business plans.

RA and the use of soil-less systems can be a solution to avoid contaminated soils (Meharg, 2016; Pennisi et al., 2016). Studies have revealed the potential for soil contamination depending on location and prior uses (Antisari et al., 2015; McClintock, 2012; Säumel et al., 2012, 2012). Moreover, soil-less production can be useful in the production of certain species through reductions in the uptake of contaminants by accumulator species (e.g., Rosemary) (Antisari et al., 2015). However, people are particularly critical of hydroponic growing techniques in the case of UA (Specht et al., 2016b). Soil-less growing was highly polarizing topic in our interviews, with a large share of stakeholders vehemently rejecting it. Unfortunately, no definite numbers are available regarding the actual share of products from soil-less growing that are sold in Spanish and German supermarkets. However, considering actual horticultural practices, we can assume that some of the offered products are already produced using soil-less techniques. We suspect that several stakeholders and consumers may be unaware of the presence of such products in the market. If soil-less production occurs in closer proximity to consumers, concerns regarding these products might become significant.

### 4.5. Environmental risks

Stakeholders in both cities expressed uncertainties about the overall environmental performance of RA. Given the resources needed for production infrastructure, the environmental impact of RA is expected to be higher than that of conventional production.

> *"If it is more ecological in the end to bring the products from Brandenburg or some other place in Germany, it makes no sense. It would be rather negative then. You invest a lot, where it might be easier to just grow it in the rural areas on normal soil. To conclude, if the energy input is too high, it's useless."* (Landscape architect, Berlin)

In particular, stakeholders perceive that RA is too resource intensive:

> *"You have to consider the external inputs: energy, water, materials. […] What do they do with the waste? What are the materials employed in the design? They do not follow a closed cycle, so they have a great external dependence."* (Peri-urban agricultural park manager, Barcelona)

Furthermore, stakeholders were concerned about the limitations of organic practices in soil-less production, as they considered organic food production to be the only sustainable method. The use of hydroponic and soil-less techniques is thus assumed to increase environmental risks.

Our results reveal that stakeholders generally question whether RA can have a positive environmental impact.

#### *4.5.1 Discussion of environmental risks*

With regard to environmental risks, researchers have worked on preliminary assessments of the environmental performance of RA, finding positive results in relation to the overall environmental balance. Still, these results require *further scientific validation*, and, once proven, they must be *communicated to the public*.

Studies have started assessing the environmental impacts of RA. Using a life cycle assessment, Sanyé-Mengual et al. (2015b) quantified the environmental impacts of a pilot RTG Lab in Spain. As expected, compared with conventional greenhouses, the RTG structure was found to have a larger environmental impact because it used an oversized structure to comply with building laws. However, considering the entire production process (from cradle to farm gate) or the supply chain of products (from cradle to consumer), local tomatoes from an RTG were a more environmentally friendly option than conventional tomatoes.

In contrast to stakeholders' perceptions, particular RTGs promote the re-circulation of water, reaching high levels of water efficiency. Ongoing pilot projects are devoted to closing resource and energy cycles. The projects FertileCity (http://www.fertilecity.com), INFarming (http://www.infarming.de/) and Roof Water-Farm (http://www.roofwaterfarm.com/) are evaluating the metabolic integration of RTGs with existing buildings in Europe. Nadal et al. (2017) demonstrated that the residual energy from buildings can be employed in the rooftop greenhouse thereby reducing the environmental impacts and economic costs of food production in a Mediterranean context. Finally, urban biowastes have been demonstrated to be suitable substrates for RA (Grard et al., 2015).

Regarding organic production in RA, it is indeed impossible to certify RA as organic in the EU, although this occurs in other organic certification schemes, for instance, in the US. However, some scholars have successfully explored the use of organic wastes (including urban wastes) as soil-less production media (e.g., Grard et al., 2015; Li et al., 2002). The use of soluble organic fertilizers in soil-less production (i.e., peat/perlite) has already been tested (Peet et al., 2004), but these tests revealed in low productivity rates related to low levels of N and pH. According to life cycle assessment and life cycle costing (LCC) results (Sanyé-Mengual et al., 2015c), soil production that uses compost as fertilizer has been shown to be the most eco-efficient technique for open-air RA.

## 4.6. Economic risks

In economic terms, stakeholders are generally doubtful regarding the economic benefits and feasibility of RA.

> *"I don't know whether a 200 m² RTG is feasible. It's an issue of scale. […] Economically, I don't even know if one could get a salary […] There is a required investment. The implementation is an issue of economic feasibility.*" (Economic development agency, Barcelona)

Additionally, the lack of "experienced and trained farmers in cities" is perceived as a risk by multiple stakeholders. Finally, RA is perceived as a potential competitor for other economic activities and roofs are preferred as platforms for complementary activities (such as renewable energy, rainwater harvesting or recreational uses):

> *"Generating our own energy for the house has more value than growing vegetables that can also be grown outside."* (Real estate union representative, Berlin)

Second, particularly in Barcelona, stakeholders are afraid that the administration's potential support for UA could reduce interest in and support for agricultural activities in the peri-urban fringe.

### *4.6.1 Discussion of economic risks*

We discovered that most perceived economic risks could be negated by assessing current practices or the literature.

In contrast to stakeholders' perception, an LCC for a pilot-scale RTG in Barcelona demonstrated that local tomato production could be cheaper from a consumer perspective (i.e., considering the entire supply chain) and could even compete with local food products (Sanyé-Mengual et al., 2015b). Furthermore, an LCC study of community RA outlined further positive externalities and socio-economic benefits that should be considered in economic accounting (Sanyé-Mengual et al., 2015c). In Berlin, the large need for vegetable imports suggests that local food supply chains using RTGs could potentially be competitive while avoiding longer conventional distribution pathways (e.g., imports from southern Europe).

Regarding the assumed lack of knowledge and professionalism in RA, current practices show that existing RA companies typically include experts (e.g., agronomist, biologist) on the management team to overcome knowledge barriers (Thomaier et al., 2015). For less commercial projects at the community level, they typically offer educational and training programs (such as workshops, tours or courses) (Thomaier et al., 2015) (Examples of such programs are Brooklyn Grange or Eagle Street Rooftop Farm).

In contrast to the perceived risk that RA is competing with other uses, current practices actually highlight possibilities for integrating parallel strategies in the design of RTGs. Gotham Greens installed solar photovoltaic panels to supply electricity to its RTG farm. The RTG Lab Fertilecity integrates collected rainwater from the building roof into crop production, reaching 100% water self-sufficiency. Furthermore, the output water flow from the crop can be reused for non-drinking purposes (Sanyé-Mengual et al., 2014). Such combinations increase the multifunctionality of roofs. Furthermore, roofs are essential for additional green activities in urban areas, where real estate development exerts increased pressure on available greenspaces.

Finally, for both investigated cities, RA could be envisioned as complementing rather than competing with rural production, as the demand for local food is growing and the supply remains insufficient to meet this demand (BMELV, 2013; Generalitat de Catalunya, 2012).

## 5. Recommendations for overcoming barriers related to perceived risks

Our results unveiled multiple perceived risks that could slow the deployment of RA projects in Berlin and Barcelona. The discussion of these risks alongside current practices and the existing literature has revealed that RA projects can indeed involve some risks. Furthermore, the discussion has shown that many risks are linked to insufficient communication and do not represent the state of the art of RA as represented by actual current practices and scientific knowledge.

Particular reasons for the rejection of projects must be identified, considered and addressed by those involved in RA development. Therefore, we propose recommendations for the successful development of RA projects and policy. In particular, demonstration and dissemination activities can contribute to addressing the barriers linked to perceived risks. Addressing the perceived risks surrounding RA is the responsibility of different stakeholders, and thus, recommendations are group specific (Table 4).

*Table 4. Recommendations for addressing and minimizing perceived risks of RA by stakeholder group.*

| Stakeholder group | Recommendations |
|---|---|
| Administration and policy | The policymaking process could ensure the following:<br>- Integrative policymaking processes that involve the various relevant stakeholders<br>- Establishment of urban integration standards (e.g., landscape and logistical regulations)<br>- Formation of a quality standard scheme to ensure the food safety of urban products<br>- Implementation of communication and education campaigns on RA and urban food systems to increase citizen awareness |
| RA promoters and producers | The practical project setup can minimize risk perception by designing projects that accomplish the following:<br>- Follow an inclusive, participatory and open planning process that does not primarily target an exclusive or elitist group of consumers |

| | |
|---|---|
| | - Choose unused or abandoned buildings and rooftops, thereby minimizing competition<br>- Use discreet design (the less futuristic the design approach is, the greater the acceptance will be)<br>- Use energy from renewable and local resources, keep energy input low and establish resource cycles within the house or neighborhood (e.g., exploit local organic waste, waste heat and water resources)<br>- Employ soil-based techniques or combine soil-less and soil techniques in the design<br>- Use low-tech growing techniques (or, for other forms, a high level of education would be necessary)<br>- Apply strict quality management and quality control of products (quality must be assured and communicated)<br>- Include educational programs, community building, art and creativity |
| Researchers | Further research is needed to achieve the following:<br>- Generate, communicate and disseminate empirical data on critical issues (such as contamination, gentrification effects, or other potentially negative impacts)<br>- Investigate and demonstrate resource-efficiency models of RA (e.g., metabolic integration between the greenhouse and the building)<br>- Increase citizens' awareness and knowledge through pilot and demonstration projects |

Generally, policy must consider the possibility that perceived risks are linked to different areas and scales and must therefore differentiate among general risks (such as those related to different conceptualizations of farming), risks to large metropolitan and peri-urban areas (e.g., economic competition), risks on the city level (e.g., increases in noise or smell), and risks on the micro level (e.g., particular health risks related to RA products).

## 6. Conclusions

The development of RA is linked to a diverse set of risks according to multiple involved stakeholders in Berlin and Barcelona. Our study presented a comprehensive picture of the perceived risks of RA that might slow its implementation process. Major risks have been associated with the urban integration of RA, the production system, the food products themselves, environmental balance and economic performance. A comparison of the results against the current state of the art, however, demonstrated that many perceived risks are linked to a lack of knowledge, to non-integrative policymaking, to insufficient communication of research concepts to the general public and to the absence of operating demonstration projects. Furthermore, comparing the results against the available literature, we find that current practices and market data have negated several of the perceived risks. Nevertheless, the available literature and practices are insufficient to scientifically evaluate all of the perceived risks. Further research should focus on generating, communicating and disseminating new data to increase awareness and knowledge through pilot and demonstration projects. According to our results, current major research gaps are related to the environmental efficiency models of RA (e.g., metabolic integration between the greenhouse and the building), the use of organic practices in soil-less production and the gentrification effects of RA. Our study revealed few differences in risk perception between the two cities. Thus, we assume that our results are transferable to other cities in the global north as well as to cities with RA at similar stages of implementation.

## 7. References

Ajuntament de Barcelona (2002) Action 21: Guide towards the sustainability of Barcelona [Acción 21: Guía para avanzar hacia la sostenibilidad de Barcelona] www.bcn.cat/agenda21/A21_text/textcastella/AC21.pdf (accessed 25.11.16).

Ajuntament de Barcelona (2014) Urban agriculture in Barcelona: global strategy [L'agricultura urbana a Barcelona: estratègia global]. www.agriculturaurbana.cat/wp-content/uploads/estrategia_globar_agricultura_urbana.pdf (accessed 25.11.16).

Antisari, L.V., Orsini, F., Marchetti, L., Vianello, G., Gianquinto, G.., 2015. Heavy metal accumulation in vegetables grown in urban gardens. Agron. Sustain. Dev. 35, 1139–1147. doi:10.1007/s13593-015-0308-z.

Asaduzzaman, M., Saifullah, M., Reya Mollick, S., A., Hossain, M., M., Halim, G., Asao, T., 2015. Influence of soilless culture substrate on improvement of yield and produce quality of horticultural crops, in: Asaduzzaman, M. (Ed.), Soilless Culture - Use of Substrates for the Production of Quality Horticultural Crops. Rijeka. Intech, pp. 1–32.

Astee, L.Y., Kishnani, N.T., 2010. Building integrated agriculture: utilising rooftops for sustainable food crop cultivation in Singapore. J. Green Build. 5, 105–113.

Bakker, N., Dubbeling, M., Gündel, S., Sabel-Koschella, U., De Zeeuw, H. (Eds.), 2001. Growing cities, growing food - urban agriculture on the policy agenda. Feldafing, DSE / Zentralstelle für Ernährung und Landwirtschaft. www.ruaf.org/publications/growing-cities-growing-food-urban-agriculture-policy-agenda (accessed 25.11.16).

BMELV, 2013. Ökobarometer 2013 (Organic food survey). www.bmel.de/SharedDocs/Downloads/Ernaehrung/Oekobarometer_2013.html (accessed 25.11.16).

Bohn, K., Viljoen, A., 2011. The edible city: envisioning the continuous productive urban landscape (CPUL). FIELD 4, 149–161.

Bryld, E., 2003. Potentials, problems, and policy implications for urban agriculture in developing countries. Agric. Hum. Values 20, 79–86.

Caplow, T., 2009. Building integrated agriculture: philosophy and practice, in: Urban Futures 2030: Urban Development and Urban Lifestyles of the Future. Heinrich-Böll-Stiftung, Berlin, pp. 48 – 51.

Cerón-Palma, I., Sanyé-Mengual, E., Oliver-Solà, J., Montero, J., Rieradevall, J., 2012. Barriers and opportunities regarding the implementation of rooftop eco. Greenhouses (RTEG) in Mediterranean cities of Europe. J. Urban Technol. 19, 87–103. doi:10.1080/10630732.2012.717685.

Cohen, N., Reynolds, K., 2015. Resource needs for a socially just and sustainable urban agriculture system: lessons from New York City. Renew. Agric. Food Syst. 30, 103–114. doi:10.1017/S1742170514000210.

Cohen, N., Reynolds, K., Sanghvi, R., 2012. Five Borough Farm: Seeding the Future of Urban Agriculture in New York City. Design Trust for Public Space, New York.

Corbin, J.M., Strauss, A., 1990. Grounded theory research: procedures, canons, and evaluative criteria. Qual. Sociol. 13, 3–21. doi:10.1007/BF00988593.

Despommier, D., 2010. The Vertical Farm: Feeding the World in the 21st Century. Thomas Dunne Books, New York.

Dobernig, K., Stagl, S., 2015. Growing a lifestyle movement? Exploring identity-work and lifestyle politics in urban food cultivation? Int. J. Con. Stud. 39, 452–458. doi: 10.1111/ijcs.12222.

Gelman, V.L., 2014. Rooftop Vegetables and Urban Contamination: Trace Elements and Polycyclic Aromatic Hydrocarbons in Crops from Helsinki Rooftops. MSc Thesis. University of Helsinki.

Generalitat de Catalunya, 2012. 2012 Barometer of perception and consumption of environmentally friendly food. http://premsa.gencat.cat/pres_fsvp/docs/2013/04/17/10/33/c0465bc9-41d4-4035-a5de-09239ed91db7.pdf (accessed 25.11.16).

Germer, J., Sauerborn, J., Asch, F., de Boer, J., Schreiber, J., Weber, G., Müller, J., 2011. Skyfarming an ecological innovation to enhance global food security. J. Verbr. Lebensm. 6, 237–251. doi:10.1007/s00003-011-0691-6.
Giacchè, G., Tóth, A., 2013. COST Action Urban Agriculture Europe: UA in Barcelona Metropolitan Region Short Term Scientific Mission Report. www.urbanagricultureeurope.la.rwth-aachen.de/files/130319_stsmreport_barcelona.pdf (accessed 25.11.16).
Goldstein, B., Birkved, M., Hauschild, M., Fernandez, J., 2014. Urban agricultural typologies and the need to quantify their potential to reduce a city' s environmental "foodprint", in: World SB14, Barcelona, 28/30th October 2014, pp. 24–31.
Gould, K.A., Lewis., T.L., 2012. The Environmental Injustice of Green Gentrification, In: the World in Brooklyn: Gentrification, Immigration, and Ethnic Politics in a Global City. Lexington Books, Plymouth, pp. 113–146.
Grard, B.J.-P., Bel, N., Marchal, N., Madre, F., Castell, J.-F., Cambier, P., Aubry, C., 2015. Recycling urban waste as possible use for rooftop vegetable garden. Future of Food: Journal on Food, Agriculture and Society 3, 21-34.
Gruda, N., 2009. Do soilless culture systems have an influence on product quality of vegetables? J. Appl. Bot. Food Qual. 82, 141–147.
Guthman, J., 2003. Fast food/organic food: reflexive tastes and the making of 'yuppie chow'. Soc. Cult. Geogr. 4, 45–58. doi:10.1080/1464936032000049306.
Kuckartz, U., 2014. Qualitative Text Analysis. A Guide to Methods, Practice and Using Software. Sage Publications, Thousand Oaks, CA.
Kutter, T., Tiemann, S., Siebert, R., Fountas, S., 2011. The role of communication and co-operation in the adoption of precision farming. Precision Agric. 12, 2–17. doi:10.1007/s11119-009-9150-0.
La Vanguardia, 2013. El "Pla buits" cedeix 14 emplaçaments a diverses entitats [the "Vacant lands plan" gives 14 spaces to various entities]. www.lavanguardia.com/local/barcelona/20130429/54372976246/el-pla-buits-cedeix-14-emplacaments.html (accessed 25.11.16).
Li, Q.S., Guo, S.R., Li, S.J., 2002. Utilization of organic wastes for manufacturing soilless media. J. Nat. Resour. 4, 515–519.
Local Action on Food, 2012. A Growing Trade. A Guide for Community Groups That Want to Grow and Sell Food in Our Towns and Cities. Sustain: the Alliance for Better Food and Farming, London.
McClintock, N., 2012. Assessing soil lead contamination at multiple scales in Oakland, California: implications for urban agriculture and environmental justice. Appl. Geogr. 35, 460–473. doi:10.1016/j.apgeog.2012.10.001.
Meharg, A.A., 2016. Perspective: city farming needs monitoring. Nature 531, S60. doi:10.1038/531S60a.
MercaBarna, 2014. Mercabarna stats: vegetables - commercialized tonnes – 2013. www.mercabarna.es/serveis/estadistiques-productes/ (accessed 25.11.16).
Mok, H., Williamson, V.G., Grove, J.R., Burry, K., Barker, S.F., Hamilton, A.J., 2014. Strawberry fields forever? Urban agriculture in developed countries: a review. Agron. Sustain. Dev. 34, 21–43. doi:10.1007/s13593-013-0156-7.
Nadal, A., Llorach-Masana, P., Cuerva, E., López-Capel, E., Montero, J.I., Josa, A., Rieradevall, J., Royapoor, M., 2017, Building-integrated rooftop greenhouses: An energy and environmental assessment in the mediterranean context. Appl. Energy 187, 338-351. doi: 10.1016/j.apenergy.2016.11.051
Opitz, I., Berges, R., Piorr, A., Krikser, T., 2016. Contributing to food security in urban areas: differences between urban agriculture and peri-urban agriculture in the Global North. Agric. Hum. Values 33, 341–358. doi:10.1007/s10460-015-9610-2.
Orsini, F., Gasperi, D., Marchetti, L., Piovene, C., Draghetti, S., Ramazzotti, S., Bazzocchi, G., Gianquinto, G., 2014. Exploring the production capacity of rooftop gardens (RTGs) in

urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna. Food Sec. 6, 781–792. doi:10.1007/s12571-014-0389-6.

Orsini, F., Kahane, R., Nono-Womdim, R., Gianquinto, G., 2013. Urban agriculture in the developing world: a review. Agron. Sustain. Dev. 33, 695–720. doi:10.1007/s13593-013-0143-z.

Oxford Dictionary, 2014. Acceptance. www.oxforddictionaries.com/de/definition/englisch/acceptance (accessed 25.11.16).

Padel, S., 2001. Conversion to organic farming: a typical example of the diffusion of an innovation? Sociol. Ruralis 41, 40–61. doi:10.1111/1467-9523.00169.

Peet, M.M., Rippy, J.M., Nelson, P.V., Catignani, G.L., 2004. Organic production of greenhouse tomatoes utilizing the bag system and soluble organic fertilizers. Acta Hortic. 659, 707–719.

Pennisi, G., Orsini, F., Gasperi, D., Mancarella, S., Sanoubar, R., Antisari, L.V., Vianello, G., Gianquinto, G., 2016. Soilless system on peat reduce trace metals in urban-grown food: unexpected evidence for a soil origin of plant contamination. Agron. Sustain. Dev. 36, 56.

Renn, O., 2005. Technikakzeptanz: Lehren und Rückschlüsse der Akzeptanzforschung für die Bewältigung des technischen Wandels. Technikfolgenabschätzung – Theor. Praxis. 3, 29–37. www.tatup-journal.de/downloads/2005/tatup053_renn05a.pdf (accessed 25.11.16).

Sanyé-Mengual, E., Anguelovski, I., Oliver-Solà, J., Montero, J.I., Rieradevall, J., 2016. Resolving differing stakeholder perceptions of urban rooftop farming in Mediterranean cities: promoting food production as a driver for innovative forms of urban agriculture. Agric. Hum. Values 33, 101-120. doi:10.1007/s10460-015-9594-y.

Sanyé-Mengual, E., Cerón-Palma, I., Oliver-Solà, J., Montero, J.I., Rieradevall, J., 2013. Environmental analysis of the logistics of agricultural products from roof top greenhouses in Mediterranean urban areas. J. Sci. Food Agric. 93, 100–109. doi:10.1002/jsfa.5736.

Sanyé-Mengual, E., Cerón-Palma, I., Oliver-Solà, J., Montero, J.I., Rieradevall, J., 2015a. Integrating horticulture into cities: a guide for assessing the implementation potential of rooftop greenhouses (RTGs) in industrial and logistics parks. J. Urban Technol. 22, 87-111.

Sanyé-Mengual, E., Llorach-Massana, P., Sanjuan-Delmás, D., Oliver-Solà, J., Josa, A., Montero, J.I., Rieradevall, J., 2014. The ICTA-ICP Rooftop Greenhouse Lab (RTG-Lab): closing metabolic flows (energy, water, CO2) through integrated rooftop greenhouses, in: Roggema, R., & Keefer, G. (Eds.), Finding Spaces for Productive Spaces. 6th AESOP Sustainable Food Planning Conference. VHL University of Applied Sciences, pp. 692–701.

Sanyé-Mengual, E., Oliver-Solà, J., Montero, J.I., Rieradevall, J., 2015b. An environmental and economic life cycle assessment of rooftop Greenhouse (RTG) implementation in Barcelona, Spain. Assessing new forms of urban agriculture from the greenhouse structure to the final product level. Int. J. Life Cycle Assess. 20, 350-366.

Sanyé-Mengual, E., Orsini, F., Oliver-Solà, J., Rieradevall, J., Montero, J.I., Gianquinto, G., 2015c. Techniques and crops for efficient rooftop gardens in Bologna, Italy. Agron. Sustain. Dev. 35, 1477–1488.

Sartoux, P., 2008. The arable city. Space (Magazine) 488, 123.

Sattler, C., Nagel, U.J., 2010. Factors affecting farmers' acceptance of conservation measures—a case study from north-eastern Germany. Land Use Policy 27, 70–77. doi:10.1016/j.landusepol.2008.02.002.

Säumel, I., Kotsyuk, I., Hölscher, M., Lenkereit, C., Weber, F., Kowarik, I., 2012. How healthy is urban horticulture in high traffic areas? Trace metal concentrations in vegetable crops

from plantings within inner city neighbourhoods in Berlin, Germany. Environ. Pollut. 165, 124–132.
Specht, K., Sanyé-Mengual, E., 2015. Urban rooftop farming in Berlin and Barcelona: what risks and uncertainties do key stakeholders perceive?, in: Cinà, G., & Dansero, E. (Eds.), Localizing urban food strategies. Farming cities and performing rurality. 7th International Aesop Sustainable Food Planning Conference Proceedings, Politecnico di Torino, Torino, pp. 307–313
Specht, K., Siebert, R., Hartmann, I., Freisinger, U.B., Sawicka, M., Werner, A., Thomaier, S., Henckel, D., Walk, H., Dierich, A., 2014. Urban agriculture of the future: an overview of sustainability aspects of food production in and on buildings. Agric. Hum. Values 31, 33–51. doi:10.1007/s10460-013-9448-4.
Specht, K., Siebert, R., Thomaier, S., 2016a. Perception and acceptance of agricultural production in and on urban buildings (ZFarming): a qualitative study from Berlin, Germany. Agric. Hum. Values 33, 753–769. doi:10.1007/s10460-015-9658-z.
Specht, K., Siebert, R., Thomaier, S., Freisinger, U., Sawicka, M., Dierich, A., Henckel, D., Busse, M., 2015. Zero-acreage farming in the city of Berlin: an aggregated stakeholder perspective on potential benefits and challenges. Sustainability 7, 4511–4523. doi:10.3390/su7044511.
Specht, K., Weith, T., Swoboda, K., Siebert, R., 2016b. Socially acceptable urban agriculture businesses. Agron. Sustain. Dev. 36, 1-14. doi:10.1007/s13593-016-0355-0.
Thomaier, S., Specht, K., Henckel, D., Dierich, A., Siebert, R., Freisinger, U.B., Sawicka, M., 2015. Farming in and on urban buildings: present practice and specific novelties of zero-acreage farming (ZFarming). Renew. Agric. Food Syst. 30, 43–54. doi:10.1017/S1742170514000143.
Torreggiani, D., Dall’Ara, E., Tassinari, P., 2012. The urban nature of agriculture: bidirectional trends between city and countryside. Cities 29, 412–416. doi:/10.
UN-Habitat, 2013. State of the World’s cities 2012/2013 - Prosperity of cities. United Nations Human Settlements Programme (UN-Habitat), Nairobi.
Whittinghill, L.J., Rowe, D.B., Cregg, B.M., 2013. Evaluation of vegetable production on extensive Green roofs. Agroecol. Sustain. Food Syst. 37, 465–484. doi:10.1080/21683565.2012.756847.
Wilt, J. de, Dobbelaar, T., 2005. Agroparks: the Concept, the Response, the Practice. Innovation Network, Utrecht.
Wüstenhagen, R., Wolsink, M., Bürer, M.J., 2007. Social acceptance of renewable energy innovation: an introduction to the concept. Energy Policy 35, 2683–2691. doi:/10.