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Keywords: Community Gardens; Urban Agriculture; Hydroponics; Soil-less Cultivation.

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Abstract: The aim of this paper is to investigate the role that soil-less methods of food production can play in urban agriculture, particularly in projects that are run by community groups. Over the last years, a drive by people to engage in sustainable lifestyles has resulted in a surge in urban agriculture. Typically, on-soil horticulture is greatly appreciated by urban farmers for its invaluable contribution to urban ecology. Yet, some community projects across Europe are experimenting with indoor soil-less methods, which offer an opportunity to reduce the waste of resources such as water and space, including valuable greenspace. Against this backdrop, the paper investigates the drivers and barriers that may facilitate or hinder soil-less methods for urban farmers. We triangulate information from the literature with a small-scale pilot study, based on interviews in a community garden in Portsmouth, UK, in which a small hydroponic unit was utilised by a group of experienced farmers. We subsequently compare results with a previous pilot study, similar in design but with interviewees who have limited experience in growing food. Qualitative results show a general appreciation of the environmental advantages that the hydroponic unit can yield and at the same time diffidence towards a hydroponic produce which is perceived as non-natural in both groups. Quantitative analysis showed that 90% of experienced farmers had prior knowledge of soil-less methods against 42% of the wider sample group. We conclude that, for the participants to the pilots, higher knowledge of soil-less systems does not necessarily lead to higher acceptance. Yet, feedback gathered suggests that there is interest in soil-less methods, which appears to be linked to the propensity of community gardens to test new arrangements and techniques within their projects.

"I like to get my hands stuck in the soil": a pilot study in the acceptance of soil-less methods of cultivation in community gardens.

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Keywords: Community gardens; Urban Agriculture; Hydroponics; Soil-less cultivation.

Graphical abstract:

Highlights:

- Factors preventing use of hydroponics in urban agriculture are poorly understood
- Hindering factors include use of chemicals and hydroponics perceived as non-natural
- Hindering factors are stronger amongst experienced urban gardeners
- Awareness of overall environmental benefits of hydroponics can combat reservations

1. Introduction.

[1]A large body of literature documents the wide range of benefits that, in the global North and beyond, urban agriculture (UA) can generate, which include improvements to the urban biodiversity, to the local economy and to the health and wellbeing of those who practice it (see Table 1 for an overview of selected studies). Productivity as a benefit is discussed to a minor extent, although there are a few studies evaluating its potential; those that exist identify land availability as a major barrier. For example, Garnett (1999) finds that land available in London has the potential of supplying 18% of Londoners' vegetable intake only. Ackerman et al. (2013) estimated that vacant land in New York (about 4,9884 acres) cannot make the city self-sufficient, although when the extended metropolitan areas are considered, UA can support between 58 and 89% of its population. Lee-Smith (2010) concludes that UA plays a significant role in urban food security and economy in Uganda and Kenya, and Badami and Ramankutty (2015) reach different conclusions, stating that, globally, UA's contribution to food security without the provision of sufficient land is unsatisfactory.

Community groups practicing UA have demonstrated great innovation in experimenting with new spatial, economic and horticultural models (Caputo et al., 2016). For example, Community Supported Agriculture has been used as a model enabling economic sustainability while creating new jobs (a case in point is Growing Communities in London - growingcommunities.org). Lack of suitable land is one of the challenges tackled by many community groups, with some experimenting with the use of rooftops and other urban spaces usually overlooked (Orsini et al., 2017). An innovative approach that a few community groups are trialling because of its space and resource efficiency is soilless techniques such as hydroponics and aquaponics. These techniques also have the advantage of circumventing risks related to soil contamination that can be common in cities (Hursthouse and Laitão, 2016). Groups like Bristol Fish Project in the UK, Hemmeodlat in Malmo and Kääntöpöytä in Oslo have constructed their soil-less systems indoor with limited resources while testing the suitability of new techniques to urban farming. However, the environmental efficiency of indoor hydroponics (Romeo et al., 2018) and aquaponics (Forchino et al., 2017) systems still needs to be proved, since they can utilise high levels of energy. Their contribution to urban ecology and enhanced urban biodiversity, which is one of the benefits of UA when practiced on soil, is also unclear.

[1] There are a number of abbreviations used in this article. (1) UA: Urban Agriculture. (2) FBL: Fratton Big Local, one of the field sites used for the study. (3) SG: Southsea Greenhouse, one of the field sites used for the study.

In spite of these drawbacks, soil-less techniques enable the possibility to grow anywhere and in any season. Crops produced in cities can contribute to a more efficient and clean food supply chain, and increase food security, especially in the perspective of climatic changes and their negative impact on global food production (Wheeler and Von Braun, 2013). But in a context in which for the majority of community groups productivity is a lesser objective and the authenticity of the produce matters, what drives or prevents urban farmers to utilise soil-less methods? There is a paucity of studies that explore this question, despite increasing pressure on society to produce more food in a more sustainable manner and the willingness of community groups to experiment with new social and technological structures that may enable this.

The study presented herein addresses such a question by eliciting the perception of soil-less methods from community groups engaging in UA, thus providing leverage points that can be used to overcome barriers to their adoption. In the following section, we present a literature review aimed at demonstrating the propensity to innovation that UA has shown over the last years, which explains the recent interest for soil-less methods. We subsequently illustrate the methodology of this study and its results. In section 4, we compare and discuss the views of a group of experienced urban farmers with inexperienced farmers interviewed in a previous study, aiming to understand prior knowledge of soil-less growing systems and acceptance of hydroponic produce and growing methods.

Table 1 – Summary literature reviewed, demonstrating benefits of UA

REFERENCE	**AREA OF BENEFIT**	**PARTICULAR BENEFIT**
Biel, 2016	Well-being	UA can provide opportunity for people to be in close proximity with nature
Dobernig and Stagl, 2015	Well-being	UA facilitates a re- engagement with nature
Certomà, 2011	Sustainability	UA stimulates environmental awareness
Barthel et al., 2010	Sustainability	Gardening helps sustaining an “ecological memory” that is being lost within an urban context
Travaline and Hunold, 2010	Sustainability	UA promotes participation and learning, leading to enhanced environmental awareness (ecological citizenship)
Grebitus et al., 2015	Health	Perception of improved health thorugh gardening, gathered from an online survey
Saldivar-Tanaka and Krasny, 2004	Community-building	UA stimulated community building in a Latin American neighbourhood in New York
Firth et al., 2011	Community-building	UA stimulated community building in two community gardens in Nottingham
Holland, 2004	Community-building	Community gardens investigated in this study demonstrate a sense of community, with participation and involvement being particularly strong

		features.
Purcell and Tyman, 2015	Political	UA enables an independent, self-managed use of public space
Turner et al., 2011	Political	UA improves food security and a sense of safety
Ghose and Pettygrove, 2014	Political	Community gardens as spaces of alternative food production and community development, challenging neoliberal inequities
Dieleman, 2015	Economic	Most of the urban growers In Mexico City sell their crops to the local market.
Benis and Ferrão, 2017	Environmental	UA can help reduce losses and wastage, and can be used to implement a low impact food supply chain,
Goldstein et al., 2016	Environmental	UA sites with onsite renewable energy production can help mitigate climate change
He et al., 2016	Environmental	Lower environmental impact index for organic tomato urban production compared to industrial production
Beniston et al., 2015	Environmental	Soil amendments from urban yard wastes can improve soil quality at previously degraded sites and increase crop yields.

2. The Socio-Cultural Context of Urban Agriculture

2.1 Recent models of UA

New models to grow food in cities that have been experimented with in community projects can be seen as initiated in reaction to changes in society. For example, the multiplication of places to grow food individually or as part of community projects in Detroit is associated with the shrinking of its economy (Colasanti et al., 2012). The surge in demand for spaces to cultivate edible crops coincides with economic downturns (Acton, 2011), including the latest economic crisis in 2007 (Sanyé-Mengual, 2018). UA has moved from a practice of subsistence in wartime to one of leisure in post-war times (Crouch and Ward, 1988), to one that is currently defined as multifunctional. By framing UA as a practice in evolution and presenting some recurrent themes which recently have been at the centre of UA projects, this section outlines the background against which soil-less methods have recently been tested.

2.1.1 Community - Many of the new projects that were started over the last years across Europe are community-based, as opposed to being predominantly confined to the individual/household level, practiced on allotments (Kitao, 2005). One key to interpret this shift (from individual to collective) is the political and economic crisis society is experiencing, which has contributed to view UA as a practice charged with social, political and environmental contents (Ioannou et al., 2016). This is confirmed by Holland (2004) in her study based on 96 questionnaires completed by UK community gardens and city farms. A case in point is the guerrilla gardening movement (see Reynolds, 2014), which utilises UA as a form of protest, particularly pointing at issues of right of access to and ownership and self-management of public space (Adams and Hardman, 2014) which is becoming increasingly difficult within the neo-liberal city (Schwab et al., 2018). The lack of suitable spaces and the complex procedures that are required to allocate and start new ones can lead to radical action (Hardman et al., 2018). Other authors suggest that this protest can be interpreted as a form of civic activism; a desire to beautify cities through vegetation and therefore a demonstration of attachment to places (Certoma', 2011). Regardless of the underlying agenda, community garden projects are typically started by groups, run with the aid of volunteers and willing to network with the local community and organisations in this sector. Their action has a social purpose, in the belief that food can be catalyst for societal improvements, some of which are typically delivered by local authorities because of public interest (management of green areas, educational activities for schools, healthy diets, activities for the elderly people or ethnic minorities, etc.). This has been interpreted as a positive turn by some authors, in that it opens up new possibilities for communities to form and take ownership of local resources (Eizenberg, 2012) and negative by others who see this phenomenon as an opportunity for municipalities to delegate management of public spaces and, by doing so, reduce local authorities' intervention and pre-empt the subversive edge of local groups' requests (Mc Clintock, 2014). In a study on community gardens in Berlin, Rosol (2012) shows how by helping start a new urban farm for children, local authorities support the outsourcing of responsibility for public infrastructures such as parks. In both instances, the significant element of the emergence of this phenomenon is that UA is perceived as a practice that is socially meaningful and that has a role to play in society, which goes beyond the provision of healthy food and the leisure associated with its production.

2.1.2. Urban space – One of the consequences of a higher demand for cultivable plots, which is generally not matched by the supply (Wiltshire, 2010), is the utilisation of marginal urban spaces that would not be typically considered for cultivation due to being paved or contaminated. This becomes an opportunity to regenerate neglected areas by populating them with - typically - raised beds, and attracting a flow of volunteers and visitors (see for example Edible Eastside – www.edible eastside.org). This can develop into an opportunity to occupy spaces that are only temporarily available, since raised beds can be dismantled and the material recycled. A case in point is the Skip Garden in London, in which commercial skips are used as planters. The garden has relocated three times over a decade, retaining the skips and moving when the site was reclaimed by the owner (Global Generation, n.d.). Municipalities have encouraged the temporary use of sites for a variety of purposes, including gardening, with targeted policies (Németh and Langhorst, 2014). The transient nature of these gardens has conceptual implications; it endows mobility to urban nature (i.e. gardens), which is typically confined to a specific place, hence allowing any place in cities to become part of a green infrastructure that can be reconfigured because it is mobile. It is debatable whether this is a positive or negative feature, with flexibility implying that the future is uncertain for many of these projects whenever owners reclaim land or rooftops that have been temporarily occupied with raised beds (Costa et al., 2016). One advantage of these transient spaces is that the decoupling of the food production from its traditional location (green areas) opens up the possibility of increasing the number of urban gardens without necessarily expanding the surface area of green areas dedicated to gardening. Given that there is a disparity in access to quality green space between communities of different socio-economic status (Rigolon, 2016; Rigolon et al., 2018), mobile agriculture could, at least for short periods of time, reduce this (Mitchell and Popham, 2008). In a survey on existing UA projects in and around buildings, Thomaier et al., 2015 ascertained a widespread use of rooftops and some indoor farms. Just as for the community theme, the novelty here is not only in the forms community gardens take (planters on a roof or in a scrapyard) but also in the avenues this approach opens, with green infrastructure that is reconfigurable and highly integrated with buildings, rather than located only on green areas.

2.1.3. Urban (food) systems – UA is seen as a contributor to the provision of ecosystem services (Langmeyer et al., 2016) and to the utilisation of untapped urban resources such as organic waste and rainwater, and is a critical component of an urban metabolic cycle (Goldstein et al., 2016). Gómez-Baggethun and Barton (2013) show that the monetary value associated to urban ecosystems generally, can be surprisingly high. This leads to the idea that UA can be embedded within an urban system, delivering benefits that are no longer partial (e.g. food for gardeners and benefits for the local biodiversity and climate) but rather absolute (e.g. circular metabolism of urban resources and reduced need for more agricultural land). In this view, UA becomes systemic and the quantification of its benefits goes much beyond the place, neighbourhood or city in which UA projects are established. At a theoretical level, the embeddedness of UA in urban systems and the absolute benefits that it can yield are expressed within the concept developed by Viljoen and Howe (2012) of the city as a continuous urban productive landscape. Another conceptualisation linking UA practices with urban systems is ZFarming, a term coined by Thomaier at el., (2015), portraying an urban food production and supply system composed of zero-mile farming approaches. This idea is in line with a stream of studies highlighting the potential of UA to supply a share of the demand for food in cities. Initiated with a study by Garnett (1999) on London, this stream of quantitative investigation is now well established, as previously discussed. With the idea that production can be scaled up, comes also the idea that alternatives to current food systems are both possible and desirable. Food produced in cities reduces food miles, can more efficiently respond to demand and contribute to mitigate the impact that agricultural production has on land (Kulak et al., 2013). The idea that each individual UA project contributes to a broader objective has strong implications in the way these projects are organised and networked.

2.1.4. Soil-less production - Hydroponics and aquaponics are space-efficient methods and can be installed indoors or, potentially, in any open space. At a point in time in which soil fertility is greatly depleted by industrial agriculture, these systems have already demonstrated that they can lower demand for agricultural land in rural areas (Despommier, 2010). Although the environmental benefits of these systems are debated, community groups adopting them value their efficient use of resources. A case in point is the aquaponic urban farm Bristol Fish Project, which sets as objectives 'the accessibility of hi-tech urban food growing' to local communities and the application of circular economy principles (Bristol Fish Project, n.d.). Other aquaponic micro enterprises such as GrowUp in London (GrowUp, n.d.) have a similar approach in that they organise their high-tech food business with a clear sustainability and social sustainability drive (e.g. electric vehicles to deliver produce and partnership with a local charity assisting young unemployed people, amongst whom employees are selected from).

Examples of soil-less UA in community projects are still rare however, and in order to understand this, the relationship between the two requires critical evaluation. Food grown hydroponically is increasingly produced and consumed but its provenance is generally not communicated to consumers in supermarkets. Would they buy this food if they were made aware of the techniques utilised? And would their views on this production method influence its uptake by community gardens? Secondly, the community projects that currently exist utilise relatively simple technologies which, nevertheless, require knowledge of, and enthusiasm for, engineering and IT. This suggests that the profile of urban farmers involved with these projects is changing to include people who have appropriate technical skills alongside horticultural skills, both of which need to be expanded to apply to specific soil-less methods. Given that the aims of community gardens are often directed on a local scale, reflecting the needs of local urban areas and communities, these skills could be difficult to source. Hemmaodlat, a hydroponic scheme in Sweden is a case in point, aiming to promote hydroponic systems in an area where the lack of green space makes such systems ideal to grow food indoors. After two years of activity, Hemmaodlat had been successful in attracting people from all over Sweden, who were willing to be trained, but has been much less successful in attracting neighbours (Hemmaodlat, pers comm, 2017). More importantly, the typical profile of participants to the group's activities is closer to the young educated and unemployed rather than the low-skilled worker, not necessarily reflecting the area local to the project and the intended recipients of benefits that the project may provide. This raises questions about our capability to manage technologies that although increasingly affordable and easy to use, may be perceived (perhaps mistakenly) as excessively complex or requiring training.

2.2 The need to understand the relationship between UA and soil-less agriculture – Within this literature review we have identified some emerging trends in UA which show how food production is used as a test-bed for alternative models that address broader social and environmental challenges. Urban conditions impeding its diffusion – e.g. lack of suitable space and soil pollution – have been turned into opportunities to utilise neglected spaces such as rooftops and paved areas. Nature and horticulture are also used as a social space to pursue a wider agenda for social inclusion and solidarity, in which experimentation and new methods can be applied. Soil-less growing, which can be a viable and sustainable technique for food growing aligns with similar aims to those which UA aspire to achieve but also has the potential so solve some of the particular challenges UA faces, such as a lack of political and physical space in which to thrive. Yet our review also demonstrates that soil-less cultivation is rarely used in UA and that where it is used, it may have different challenges in terms of engaging as wide a social group as more traditional forms of UA. It is not known which theoretical and actualised barriers to using soil-less methods exist within UA communities in order to resolve this apparent contradiction. We aim to explore these in the following section, presenting the results of a pilot study run in a community garden in Portsmouth, UK. Determining the drivers and barriers to the uptake of soil-less cultivation within UA could enable its use more widely, contributing to cleaner and more efficient UA as well as wider community participation in UA and modern cultivation techniques.

3. Testing the applicability of soil-less methods in urban agriculture: A pilot study

3.1 Methodology

The study is based on two groups of interviews, analysed with a mixed methodology, utilising both qualitative and quantitative methods. Results from the smallest group of interviews (community garden Southsea Greenhouse) are presented here and subsequently compared with the second group of interviews, the results of which were documented in a previous conference paper (Caputo et al., 2017) (see Figure 1).

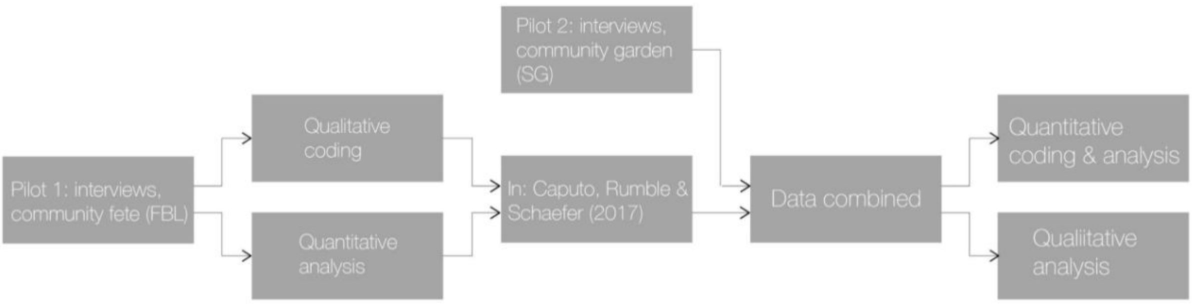


Figure 1 – Flow chart of the analysis of the two pilots.

Due to the limited number of interviewees, the qualitative evaluation is of greater significance. Questions posed to the interviewees were grouped under four themes: 1.) the relevance that each interviewee attributes to UA; 2.) the prior knowledge of hydroponics held by the interviewee; 3.) the positive or negative perception when compared to conventional on-soil horticulture practice and produce; and 4.) the willingness to engage with hydroponic cultivation systems. Interviews were semi-structured: participants were asked to agree, disagree or express uncertainty to each question, and to elaborate further if they wished. Answers and comments were annotated by the study authors and counted for quantitative analysis, with comments analysed qualitatively. Comments were coded under each of the four themes and, when similar comments were expressed by the majority of the interviewees, the number of participants expressing such comments was counted (Table 2).

Table 2 – Recurrent, coded issues emerging during the interviews.

THEMES OF THE INTERVIEW	CODED EMERGENT THEMES
Relevance of UA	• Environmental reasons • Preserving a culture of growing food • Economic advantages
Prior knowledge hydroponics	• Soil-less methods are used for drugs • Prior knowledge that plants can be grown in absence of soil (counted) • Prior knowledge that hydroponic produce is sold in supermarkets (counted)
Perception of hydroponic produce	• Negative perception because of chemicals used for the production • Negative perception because considered as non-natural • Preference of local, organic produce
Willingness to engage with hydroponics	• Lack of space • Preference to get 'hands stuck in the soil'

The community gardens were selected in Portsmouth, because of their availability to engage with a hydroponic unit for at least one growing season, starting from May 2017. This resulted in one group of twenty-four participants (Fratton Big Local: FBL) and one group of eleven (Southsea Greenhouse: SG).

SG data that is not being compared to FBL (section 3.2.1) is expressed in absolute numbers of participants, reflecting the small sample size, with a greater emphasis on qualitative analysis. Data comparing SG and FBL data is expressed in percentage to overcome differences in sample size, though it should be noted that these values, as with raw count data, are illustrative; Statistical analysis was not carried out as the small sample sizes would lead to misleading interpretations of the data.

3.1.1 Study site and groups

In 2017, Portsmouth, UK, was a city of approximately 215,000 inhabitants (Office for National Statistics licensed under the Open Government Licence, 2018), with the second highest density of inhabitants in the UK (Portsmouth City Council, 2011) and only fifteen active community gardens (https://volunteer.portsmouth.gov.uk/events/community-gardens-open-day-getgrowing/). The two community gardens participating in the study rely on groups of volunteers with different socio-cultural profiles.

The first community garden (FBL) is situated within the grounds of an infant school in one of the areas with the highest deprivation levels in Portsmouth (DTZ, 2011). The second community garden, (SG), is within one of the least deprived wards and occupies a small patch of land within the Commons, a green area that borders the southern waterfront of the city. It covers an area of approximately $500m^2$ and includes a small building used as an office and a small greenhouse used as seeding area. Demonstration hydroponic systems were assembled in each of the study sites. At FBL this consisted of a system built by the authors using readily available materials, e.g. PVC tubing, following an open source project (BLT Robotics, n.d.) (Plate 1). At SG, an off-the-shelf flood tray was installed. The two systems were comparable in terms of maintenance load and floorspace, but the FBL system was a vertical frame. Both systems utilised rockwool cubes as a growing media (Grodan Rockwool B.V., Roermond, Netherlands). At FBL rockwool cubes were installed directly into the vertical hydroponic system. At SG rockwool cubes were transplanted into a bed of clay pebbles (Vitalink, Coventry, UK).

Plate 1. Hydroponic frame demonstrated at FBL site, acting as a focal point for interviews that took place at a school fete in July 2017.

At FBL, semi-structured interviews occurred at a school fete held in July 2017. Participants largely consisted of families of the children. Thus, this sample set was broad and did not necessarily have prior experience of gardening. At SG, people with a gardening plot, hence with a clear interest in gardening, were interviewed.

3.2 Results

3.2.1 Interviews at SG

Background of the participants - The majority of the interviewees (eight) either had their own garden outside of the community garden or practice gardening on allotments. Three out of eight stated that they are only interested in growing food, with one saying that 'growing needs to be useful'. Two interviewees declared that they do not garden because they live in flats and one declared that they were only interested in 'helping people', (i.e. gardening was not one of their aims, but rather helping others garden). Two of those who practiced gardening at home grow flowers, with one growing only flowers and one growing flowers in the garden at home and edible plants on an allotment.

Motivations to participate in community gardening - Several participants stated broad environmental reasons for gardening, relating to food waste ("I like wobbly potatoes. The more I buy those the less they are thrown away") and a reduction in pesticide, herbicide and inorganic fertiliser use; several participants were aspiring to grow organically.

Personal satisfaction was another key motivator, with most participants expressing that they achieve something through gardening ("I like the challenge"; "It helped me appreciate food more").

A key theme between participants also placed importance on the community aspect of gardening in this way, emphasising the sense of identity that comes with it ("We share the objective of being self-sufficient.", "We teach this to students, and it builds communities").

Relevance of UA – All interviewees agreed that growing food in cities is important. Reasons behind this opinion were diverse. Three interviewees brought environmental reasons ('keep cities green'; 'increase biodiversity' and 'connecting with the natural world'). Four had cultural and social motivations (knowing were food comes from, sharing, building a community) or a cultural tradition ("my dad grew vegetables"). Two mentioned health and one specifically mentioned production and the need to produce more. Only one mentioned economy (i.e. saving money from the subsistence budget). Finally, one mentioned efficiency of urban resources (greenspace seems wasteful without food growing in it).

Prior knowledge of hydroponics held by the interviewee - Eight respondents stated that they knew that plants can be grown without soil, one respondent did not know and three had heard the term hydroponics but were not sure what this meant. Five out of the nine respondents who knew that plants can be grown in soil-less media had good or advanced understanding of the functioning of hydroponic systems. Two of these respondents had learnt about hydroponics from the media (radio and television). Three of these respondents associated hydroponics with drug production. In spite of the majority of the interviewees declaring to possess some knowledge about hydroponics, seven respondents did not know that hydroponically grown produce is on sale in many supermarkets and four were aware of it, with only one being enthusiastic about the idea.

Positive or negative perception when compared to conventional on-soil horticulture practice and produce - Some interviewees (four out of eleven) would buy food grown hydroponically, although one would buy it only if nutrients used in the process are not chemically produced. This reflects a notion that is not rooted in reality: to our knowledge, there are no commercial and certified organic nutrients for hydroponic systems currently on the market. Five were not against hydroponically grown food; though three of these participants felt that the method of production was irrelevant and instead prioritised affordability, food miles and flavour, regardless of the agricultural technique used for cultivation. Two interviewees would not buy hydroponic produce because of the chemical nutrients utilised in the process or because of a determination to buy food produced locally.

Willingness to engage with hydroponics - Five out of eleven did not wish to have a hydroponic cabinet installed at home. Four of them had issues with technology per se ("I think that the solution is less technology and more attention to the environment") or with the artificiality of the growing process ("I like to get my hands stuck in the soil – It does not seem real - I would be bothered by chemicals") or with the need for environmental control ("ventilation and temperature would be hard to control at home"). Six wished to have a hydroponic unit at home, three with the caveat of space, one with costs and one with the caveat of energy ("it would depend on how much energy… it requires"). Only one respondent stated, without caveats, that they would consider a hydroponic system at home.

3.2.2. Comparisons between study sites –

46% of the FBL groups thought that growing food in cities was important, while 91% in the SG group thought this. However, there was a high non-response rate in the FBL sample (50%, compared to only 9% in the SG group). Of those that answered the question, 92% of FBL stated that growing food in cities is important and 100% of SG stated this (Fig 2.).

Relevance of UA

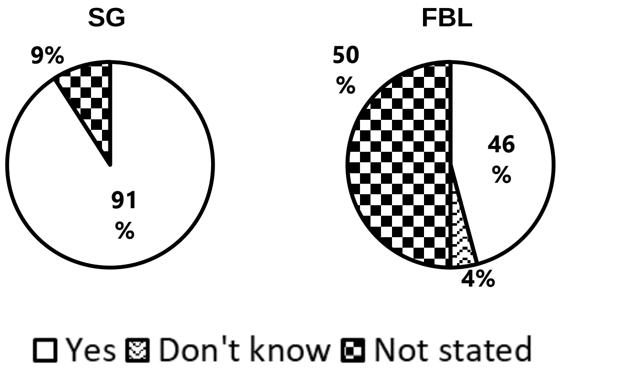
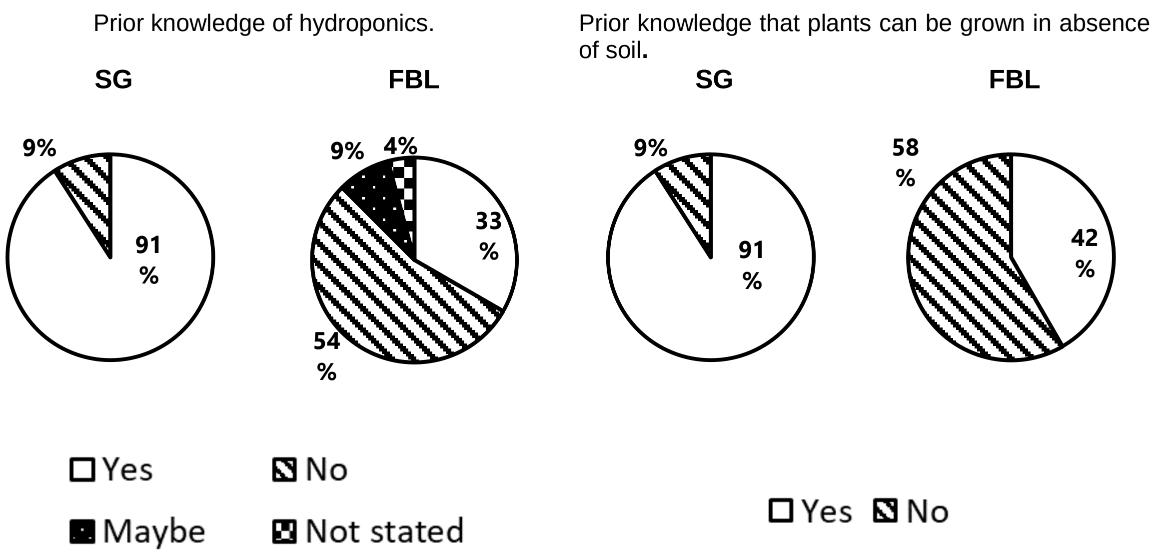


Fig.2. Responses to questions relating to the relevance of UA in cities for Southsea Greenhouse (SG) and Fratton Big Local (FBL).

Prior knowledge of hydroponics was greater within the SG group, with 91% of SG participants stating that they knew about soilless growing and 91% having heard of hydroponics before. This is more than twice the number of participants with this level of knowledge than at FBL where 33% knew what a hydroponic system is. In addition, 45% of the SG participants were aware that supermarket bought fruits and vegetables could be hydroponic, compared with only 25% at FBL (Fig. 3).



Prior knowledge that hydroponic produce is sold in supermarkets.

SG FBL

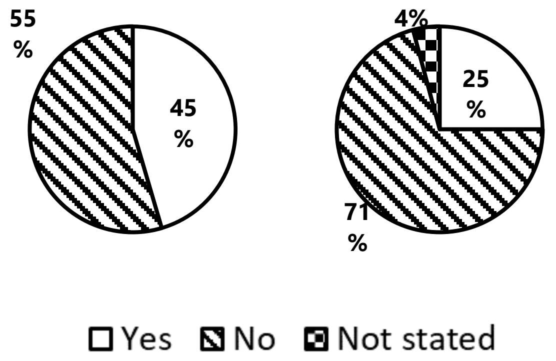


Fig.3. Responses to questions relating to prior awareness of hydroponics for Southsea Greenhouse (SG) and Fratton Big Local (FBL).

More SG participants suggested that knowing food was hydroponic would put them off eating it (8% in FBL and 55% in SG; Fig. 4). However, when taking into account only those that answered the question, results were comparable (13% in FBL and 18% in SG).

Perception of hydroponic produce.

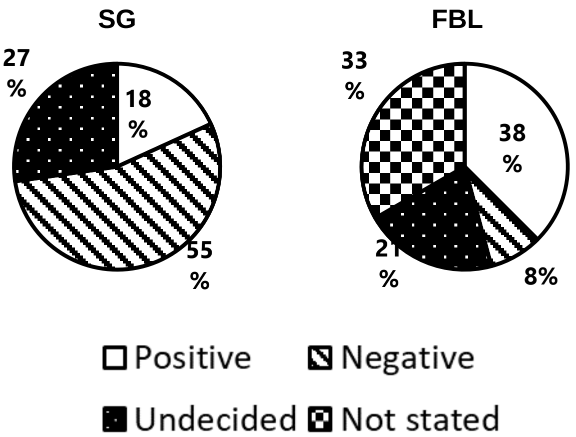


Fig.4. Responses to questions relating to acceptance of hydroponically grown produce for Southsea Greenhouse (SG) and Fratton Big Local (FBL).

In terms of willingness to engage with hydroponics, both groups answered similarly to the question, with 58% of the FBL group and 55% of the SG group saying yes (Fig. 5). The FBL group contained more participants that were unsure, with only 16% stating a flat no, compared 45% of the SG group.

Willingness to engage with hydroponics.

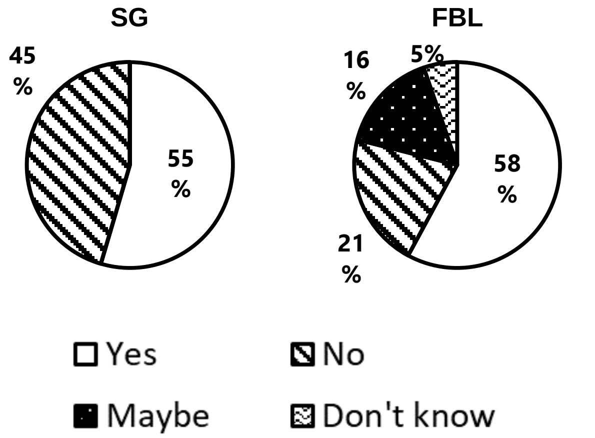


Fig.5. Responses to questions relating to willingness to have hydroponic systems at home for Southsea Greenhouse (SG) and Fratton Big Local (FBL).

Some common themes arose between the two study groups. Chemicals were mentioned frequently, though there was a qualitative difference between the two groups. The FBL group associated hydroponics with the use of chemicals, without attributing chemical use to soil-based methods. The SG group had a higher knowledge base, with most mentions of chemicals revolving around hydroponics only being acceptable if they also enabled a reduction in chemical use. Very few participants in either group specified what type of chemicals were meant (e.g. pesticides, fertiliser, etc.).

Barriers to owning a hydroponic system were common across both groups, though there were some contradictions. The FBL group in particular cited the same benefits of hydroponics (e.g. space, money-saving) as barriers to owning one. The SG group cited time, space and money as barriers to owning a hydro system, but did not state that these could also be beneficial compared to on-soil gardening. Almost all of the SG group had also stated that they did not have room to garden at home and that this was a significant factor in gardening at SG.

At FBL, very few participants stated that hydroponic gardening would not be as fulfilling, or take something away from, their traditional gardening practises. At SG opinion was stronger and more contrasting on this issue. Seven of the ten SG participants discussed similar themes to the keen gardeners at FBL, stating that this could be another way to increase interest in gardening. Three of the SG participants stated that they would not find hydroponic gardening as satisfying as on-soil gardening.

At FBL, several participants discussed that hydroponic gardening was not “natural” and that this was negative. This was not a common theme at SG. There was also less discussion of the use of technology at SG, with a few participants stating that technology was good, but very little interest beyond that. One participant mentioned that the technology used in hydro systems could be a way to engage young people, but another participant contradicted this stating that the young people she works with are only interested in technology when related to gaming.

A theme that came up at SG, but not at FBL, was the suitability of hydroponic systems for other food growers. SG participants were much more inclined to state where they thought hydroponic systems would be more useful than in their own home or the community garden. Examples included for those that don't have gardens, in the developing world and those that are aiming to mass produce food.

Both community groups were keen to install the hydroponic systems not for the benefits in terms of growing, but to increase interest in the community gardens by adding novelty. In addition, the SG group saw having a hydroponic system as a social good, as being part of a study could enable others to be helped, especially those not as fortunate to have enough space to grow. The SG group also saw it as an opportunity to allow them to continue growing salad crops over the winter.

4. Discussion.

In the discussion section, the result from the pilot studies in SG and FBL are compared. This enables an identification of the perception of soil-less systems within two community groups, with one showing interest (FBL) and the other one having direct experience (SG) in gardening. The group from FBL includes individuals who may have no prior experience in gardening but who have inquired about gardening and hydroponics during a school festival, whereas the sample from SG includes volunteers and leasers of plots within that community garden. It can be assumed that the latter has a higher knowledge of horticultural techniques, including those which are not conventional such as soil-less techniques. This knowledge can influence the way in which hydroponically grown produce is perceived. Prior knowledge of hydroponics was high in SG, higher than the broader sample in FBL and there was a greater understanding of the use of hydroponics in commercial growing. Despite almost all participants knowing what hydroponics were, the majority of the group had no knowledge that a share of produce within conventional supply chains comes from hydroponic cultures. A report on the hydroponic food market states that, in 2014, European output value in this sector totalled USD 9.8 billion and it is set to grow (Market Research Future, 2016). This is a small share when compared to the European agricultural output value which, on that year, was about EURO 200 billion (Eurostat, 2014). Yet, it is sufficiently large to assume that hydroponic produce is sold by many food retailers. Our study group had a lack of knowledge about industrial agricultural systems, despite the fact that they all grew a proportion of their own food. This supports research by Duffy et al., (2005) who found that most people do not actively engage in issues related to food production unless they are prompted to by, for example, the media.

A lower baseline knowledge of hydroponics did not influence participants' reluctance to eat hydroponically produced food. This contradicts evidence in the USA, where Gilmour (2018) found, whilst consumers that have an understanding of hydroponic processes do not need a financial incentive to buy hydroponic produce, those with a lower baseline understanding require a significant discount in order to do so. This was not due to a perceived "risk" with hydroponic foods, as has been identified in similar studies studying consumer attitudes to GM foods (e.g. Klerck and Sweeney, 2007), but rather due to a perceived "unnaturalness" of hydroponics, as was also evident in the current study. Rozin et al., (2004) find that consumer preference for "nature" is particularly strong where food is concerned and that an idealised perception of nature in relation to food production centres around perceived environmental and health risks from "non-natural" food production and a belief that "natural" food tastes better. Siriex et al., (2008) studied this explicitly in relation to greenhouse cultivation vs. open field cultivation and found strong and consistent preferences for open field cultivation, which was perceived as being more "natural".

We found similar reluctance to eat hydroponic produce in both groups, with respondents in SG stating that they did not know if they were less likely to eat hydroponically grown food. Klerck and Sweeney (2007), studying consumer behaviour in relation to knowledge base and the consumption of GM foods, found that higher levels of objective knowledge (i.e. the accurate information on a topic) held by participants could mediate their perceptions of physical risk from consuming a product, but not their psychological risk (i.e. social constructs of risk. See: Frewer et al., 1995), which has a larger impact on consumer behaviours. As the SG participants were a more cohesive group than the FBL participants, we suggest that knowledge base is not the driving factor for this uncertainty, but rather uncertainty around how hydroponics fits in to the social structure and identity of the group. Sparks et al., (1997) list a range of factors influencing food consumption choices that could all produce uncertainty within a group setting, such as peer pressure to avoid certain products or participants feeling a moral obligation to support or avoid certain foods. Future studies should consider testing this explicitly on hydroponics, as most studies to date have been conducted on organic produce or GM foods.

The diffidence in consuming hydroponically grown food was also linked to the use of chemicals. Gardeners in SG demonstrated a higher understanding of the role of synthetic fertilisers in conventional agriculture, not only in relationship to the quality of the food consumed but also in relationship to soil fertility and environmental pollution. Hydroponics have the potential to limit the dispersal of synthetic fertilisers into the environment, so could be considered as a more environmentally friendly to produce food than conventional produce bought in food retailers. Yet, in SG, diffidence persisted in terms of acceptance of hydroponics, perhaps due to the participants not being aware of this potential advantage. It is difficult to surmise how such a diffidence can be overcome although, perhaps, it is necessary that the advantages linked to the consumption of food produced with particular techniques are seen within a more absolute context. In other words, the absolute, rather than local, advantages of producing with hydroponics needs to be perceived as relevant and significant. Gilmour et al., (2018) found that an emphasis on organic production, rather than on hydroponics (where both were used in conjunction) could overcome some of these challenges.

In terms of adopting hydroponics into gardening practise, we found that most people within the gardening group (SG) were amenable. Whilst the same reservations for individually owning a hydro system were expressed as in the broader FBL sample (i.e. lack of space), inclusion in a community gardening project overcame this. Enabling the space to grow food was cited by many participants as a reason to be a part of a community garden. In SG, a motivation for including the hydroponic system within the community garden was on a wider societal level. Participants felt that being a test bed for this technique would create social value beyond the garden itself, helping other community gardens. This was an abstract idea, with little discussion of specific groups that would benefit. Regardless of the reliability of these assumptions, the acceptance to include a new system to grow food in an established community garden is in line with the openness that community groups have demonstrated in experimenting new approaches, which has been discussed in previous sections. That said, in SG, the system was returned after one year on the basis that more space was needed within the poly-tunnel in which it was placed, especially as it was not being actively used by any of the gardeners, but rather was being used as a casual group-gardening activity. Consequently, in this pilot, keenness in experimenting with new methods did not lead to a long-term change and the inclusion of soil-less methods amongst those practiced. Some of the SG gardeners acknowledged that food production may be more efficient using hydroponics, but they also stated that this was not the primary aim of their gardening practise.

All interviewees agreed on the importance of growing food in cities but their enthusiasm was not matched with an awareness of the health risks that this practice can generate. The impact of UA on the local environment is generally positive in terms of mitigation of local microclimate and the urban heat island effect (Qiu et al., 2013), the ecological health of the urban ecosystems at large (Wortman and Lovell, 2013) and even soil quality (Hursthouse and Leitão, 2016). In developed countries, the real impact of this practice is on land use, with urban development competing for land (Zasada, 2011). Air pollution and soil toxicity (Hursthouse and Leitão, 2016) can negatively affect the quality of the vegetables grown and represent a health risk for those who consume the produce. This is all the more valid in cities of the global south (Bell et al. 2011) in which, in addition, the use of contaminated wastewater (Scott et al., 2004) represents a major health hazard. These risks are much reduced in developed countries in which land use is regulated and water is generally available from water networks.

A “non-production” attitude towards growing was shared by the majority of the group we studied, with cultural or environmental motivations placing higher. Only one participant spoke of their gardening practises as a subsistence activity, but again this was mixed with other motivations, expressing their gardening activities in terms of demonstrating the benefits of alternative farming methods (i.e. protest against convention) in reducing energy and plastic use, both barriers to this person accepting hydroponics as a sustainable gardening practise. Tornaghi and Van Dyck (2014) suggest that a growing number of gardening initiatives fit with this observation; undertaken as an attempt to show alternative farming practises or engage in “political gardening”. Yet our evidence suggests that while hydroponics has the potential to increase yields in community gardening projects and demonstrate alternative farming practises to the community, this was unlikely to be a strong motivator for embracing this technique, with some participants feeling that this could be achieved via other methods. However, most participants acknowledged that this could be a good technique for other growers, who valued yield more. This highlighted that the community gardeners believed that other community gardens may have different motivations to theirs.

A key motivation for community gardening that did not fit with the hydroponic system was social interaction. A number of participants had expressed social interaction as a strong motivator for participating in community gardening and Draper and Freedman (2010) support this, with two-thirds of studies expressing this as a motivation. Personal observations by the authors suggest that in SG, social interaction was gained, in the main, via two mechanisms; casual interaction while gardeners tended to their personal plots and more sustained interaction at garden tidy-ups. Garden tidy-ups were usually focussed around an upcoming showcase event, once again supporting a strong theme in motivations for gardening in this group; a need to be seen to be helping gardeners outside of the community garden. This finding suggests that hydroponics could be more successfully integrated into community gardens like this one, with a strong moral, external focus, if external publicity of it is easier. However, evidently there are a number of additional barriers to enabling this. The use of the hydroponic system at SG was implemented in a socially-focused way, i.e. with the whole group responsible for its maintenance and upkeep, but this resulted in low use of the technology and, ultimately, a low level of engagement. We hypothesise that this was due to a lack of confidence in using the technology. This could be a major barrier because of the many factors that need to be considered in order to lower the environmental impact of hydroponic systems, one of which is the material used as a growing media. Much research has been developed in this direction over the last decades (Barrett et al. 2016). For example, coconut fibre can be used as a substrate rather than rockwool (Di Lorenzo, 2005), the production of which requires high levels of energy (Rainbow, 2010). This is relevant because locally sourced and sustainable materials are likely to be preferred by environmentally motivated urban farmers. A study suggests that the use of communal tools by community gardening groups can produce challenges that can only be resolved through tracking tool usage and ensuring gardeners are aware of what is happening to those tools when they are absent (Wang et al., 2015). In line with this finding, potential barriers could be overcome with at least one gardener who is better trained in the use of the technology and more involved in promoting the use of the hydroponic system to gardeners involved in the community project. Essentially acting as a technical advisor and ambassador.

5. Conclusions.

In the face of an interest in the utilisation of soil-less methods of food production from urban gardeners, this article investigates through a pilot study what drives or prevents urban farmers to utilise such methods. There are two main conclusions. The first one is that, in the pilot, higher knowledge of soil-less systems does not necessarily lead to higher acceptance. This can be explained with the predominant focus on social and environmental benefits, rather than productivity, which prevails amongst farmers in the global north. Particular attachment to gardening practice as one that enables a closer contact with nature can also hinder an understanding of the absolute benefits of soil-less food production. Potentially, this production does not impact on the ecosystem of green spaces as much as horticulture, which requires selectivity (of plants and pests), soil enhancement and ecological modifications. We conclude that in order to embrace soil-less methods, the perception of UA as a practice necessary to contribute to a more sustainable food chain generally (rather to the wellbeing of the gardeners and the local environmental amelioration only) must be stronger. The second one is that interest in hydroponic systems can be linked to the propensity of community gardens to test new solutions/arrangements. This propensity is volatile and needs to be connected to higher motivations in order to become rooted within the gardeners' practices. Again, this necessitates a stronger understanding of the wider impact of such practices and the priorities that the search for a more sustainable food production requires. We conclude that a topic that will need in depth research and further evidence is the absolute contribution of hydroponics to the mitigation of the impact of food production on the environment, which, if confirmed positive, can drive its uptake in community garden projects.

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RESPONSE TO REVIEWERS AND EDITOR – January 2020

We are grateful for the comment received from Reviewer#4, who is happy with the amendments of the draft that was submitted. No other comments from reviewers requiring revisions to the last draft submitted were included in the communication received by the Editor.

Comments from the Editor were helpful and they have been addressed in the new draft submitted. A summary of our responses to such comments can be found below.

Comments from the Editor	Responses of the authors
Highlight should underscore the major outcomes of the study. Each point should be written concisely and specific to reflect the novelty of the study; each point should be less than 85 characters including the spaces. Avoid abbreviation terms.	Highlights have been reduced to four, summarising the main findings of the study. Each highlight is no longer than 85 characters.
Please revise the Conclusions to be more concise and show only the high impact outcomes and avoid discussions.	The Conclusion section is now shorter. We have slightly modified the language which may have suggested that issues were discussed rather than summarised. We believe that now this ambiguity is resolved.
Please consult the journal's reference style for the exact appearance of these elements, unnecessary italic font, and use of punctuation and capitalisation. *Bibliography style is not always consistent, please check the reference section carefully and correct the inconsistency.*	The bibliography section has been revised and we hope that all inconsistencies addressed.
Avoid using footnote style for referencing.	The only foot note is on page 1 of the article. It is not used for referencing but to provide the list of abbreviations. The Guide for Authors (p. 9) reads: ‘Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article’. Please advise whether abbreviations must be provided elsewhere in the paper and in which format.

***Author Contributions Section**

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Heather Rumble: Conceptualization; Methodology; Formal analysis; Investigation; Writing - Original Draft; Writing - Review & Editing; Visualization; Project administration; Funding acquisition.

Martin Schaefer: Conceptualization; Methodology; Investigation; Writing - Original Draft; Writing - Review & Editing.

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DECLARATION OF INTEREST

The authors of this article declare that there are no financial or personal relationships with other people or organizations that could inappropriately influence the work presented here.