A citizen science approach to obtain quantitative measurements of urban agriculture inputs and outputs in Melbourne

*Please consider this paper for the Peter Harrison Memorial Prize – Open Category

Abstract: There are many advocates and critics of urban agriculture’s role in future food security but little quantitative data, which is potentially due the difficulties in collecting it. Urban food production and practice is an example of a distributed system intrinsically linked to urban farmers and urban lifestyles and therefore cannot be recreated in a lab. Citizen science is identified as a potential method to measure urban agriculture but has potential issues associated with maintaining participation. This paper presents the development of a citizen science methodology combining general CS project design methods with methods for engaging and retaining participants based on motivation for the design of a citizen science project measuring quantitative inputs and outputs of urban agriculture in Melbourne, Australia. It was found that an additional motivation emerged that is not yet documented in existing literature and is particular to citizen science projects. Other conclusions were also drawn related to timeline management, potential cost reductions conflicting with reducing barriers to participation and diversifying recruitment methods to attract participants with more time to be involved.

Keywords: cities, food systems, participatory, urban farming, resources.

1. Introduction

When it comes to food security, cities are vulnerable. By design, cities have a large number of people living in a small space, all of whom need to eat on a daily basis. Over 90% of Australia’s population live in urban areas (UN, 2014), making it one of the most highly urbanised countries in the world. (Sheridan et al., 2016) estimated that over 15,000 tonnes of food is required each day to feed the city of Melbourne based on average Australian diet profiles developed by (Turner et al., 2017).

Large scale centralised food distribution and production systems that currently supply cities are under threat from climate change (UNCTAD, 2013), resource scarcity (FAO, 2011) and urban sprawl (Sheridan et al., 2015; Sinclair, 2015; Wynne et al., 2016). Ryan (2013, 2009) and Biggs (2010) argue that food systems for cities, along with water, energy and waste, have to move to a more distributed model in order to increase resilience in the face of climate change. Cities are key progressive centres for change and sites where there is scope to address future challenges in integrated ways and create better places to live (Resilient Melbourne, 2016).

Urban agriculture (UA) is one example in recent times that has been heralded as a panacea to many of the ills of urban living, in terms of community building but also reducing resource use and improving resilience of the urban food system. Barthel et al (2015) suggest that urban growing maintains collective memory of food production and protects urban green spaces, upholding cities’ capacity to produce food in times of crisis and improving resilience. However, McWilliams (2009) argues that small-scale, fragmented UA may be less efficient in resource use and transport emissions than conventional agriculture. UA often captures the imagination of sustainable city designers, and is frequently lauded by civil society groups as a key component of a sustainable food future. It has been alternately lauded or criticised for its potential to address food security in cities, but – as noted in a recent review of UA’s benefits and limitations – frequently “the enthusiasm is ahead of the evidence” (Santo et al., 2016). In particular, this includes a distinct lack of evidence related to the sustainable performance of urban food gardens to enable comparison with conventional agriculture (Santo et al., 2016) and determining how urban food production might realistically contribute to the wider food system (Ghosh, 2014; van der Schans and Wiskerke, 2012).

Obtaining meaningful data on the performance of urban food gardens requires a different approach to that of rural or peri-urban agriculture. Urban agriculture differs because it is embedded in and defined by its urban context and shaped by the availability and type of urban resources (Mougeot, 2000). UA is intrinsically linked to urban farmers and their lifestyles and has been framed by other researchers as a socio-ecological technical system (Archdeacon, 2015). For this reason, it cannot simply be recreated in a lab experiment and a different method is required to measure inputs and outputs.
Previous studies into the quantitative aspects of urban food production have employed varying methodologies, including largely theoretical approaches such as GIS techniques and estimations of crop yields (Ackerman, Kubi, 2012; Ghosh, 2014), recall surveys (ABS, 1992) and participatory approaches (CoDyre et al., 2015; Zainuddin and Mercer, 2014) such as citizen science. Citizen science (CS) is a method where volunteers are recruited to work in partnership with researchers to answer scientific questions and gather data (Dickinson et al., 2012). It has the combined benefits of making a contribution to ‘real’ science, improving public participation and interest in science and being very cost effective (West and Pateman, 2016). It is considered suitable for measuring urban agriculture because it incorporates urban lifestyle factors and, potentially, seasonal variations in produce.

However, it does have its complications. Success of CS projects relies heavily on recruiting participants and sustaining their involvement (Morais et al., 2013). Although a number of examples of CS projects have been undertaken in the USA and the UK (Bonney et al., 2009; Science Communication Unit, 2013), little has been published in scientific literature about the factors that influence people to take part in CS projects and why participants continue their involvement or not. West and Pateman (2016) developed recommendations for those designing and running CS projects, based on a review of volunteer participation and limited CS literature, however they stated that more research is needed into whether these recommendations are applicable to different types of CS projects.

The aim of this paper is to present a methodology combining general CS project design methods with methods for engaging and retaining participants, based on understanding participant motivations for the design of a UA citizen science project. It forms part of a larger project, Farming Melbourne, measuring both food production and resource use for a range of UA systems in Melbourne to investigate their sustainability performance and potential for integration with other urban systems. Section 2 outlines the justification for a CS approach and Section 3 details the selection and development of methods appropriate for this project. Section 4 presents preliminary results related to recruitment and ongoing involvement. The results are discussed related to the methods employed in Section 5 and conclusions drawn in Section 6.

2. Selection of approach
The aim of Farming Melbourne project is to work with local partners to record food produced and resources required across a range of UA systems and locations in Melbourne over a 12 month period to answer the following questions:

- How much food is produced by urban growers and what resources are required to produce it across different seasons?
- How does this compare with conventional agriculture?
- How could urban agriculture realistically contribute to Melbourne’s food resilience and sustainability?

Data obtained will be incorporated into the Australian Stocks and Flows Framework to explore UA’s potential contribution to urban food security via the development of quantitative ‘what if’ scenarios. Detailed data is required on the relationship between labour, resource use and food production for a select few individual gardens over extended periods to explore different plausible, but not necessarily predictive, urban food system scenarios. This will allow for comparisons to be made with conventional agriculture, determine UA’s potential contribution to the wider urban food system, and provide key information necessary to explore the potential for urban food systems to be integrated with other urban systems such as water and waste management.

Although quantitative measurement of UA has been limited, some examples exist that employ different approaches. In 1992, the Australian Bureau of Statistics conducted a household survey of home production of food (ABS, 1992). Occupants of 34,000 households were asked by trained interviewers to recall production amounts of selected items over the previous 12 months. Although this method provided extensive data, limitations included inaccuracies due to respondents having difficulty recalling what was produced. Aside from lack of resources required to perform such a survey, this method would not be suitable for Farming Melbourne because it would not provide sufficient detail for seasonal variations in food production and associated resource use required for modelling.
Ackerman (2012) investigated the potential for urban agriculture in New York City with an extensive and largely theoretical study employing GIS techniques to identify available sites and estimating crop yields based on generic organic, high yield farming data. Ghosh (2014, 2011) employed a similar approach to spatially compare the local food production potential of home gardens and sustainability performance for urban forms of different densities in nine residential neighbourhood case studies across Australia and New Zealand. Although these approaches are effective in estimating the capacity for or potential of urban agriculture, they are not considered to be suitable for Farming Melbourne because they largely ignore the impact of urban lifestyles on urban food production.

Recent studies by in Melbourne (Zainuddin and Mercer, 2014) and Guelph, Canada (CoDyre et al., 2015), used a participatory approach on a smaller scale where researchers worked in partnership with urban gardeners to measure aspects of UA. Participants recorded food produced (along with certain other aspects such as labour and motivations) which was then analysed by researchers, essentially following a CS methodology. The limitations of this method is that is does not give a representative indication of the extent of urban agriculture production across a city, but it does give good detail about the relationship between urban food production and the urban environment. CoDyre et al. used both a telephone survey and GIS mapping to compliment the measured data and draw conclusions about the potential for UA in Guelph.

A variation of this CS approach is considered suitable for this research project based on the project objectives. Participants will be recruited to measure and record detailed data on their UA practice and motivations over an extended period of time to inform the development of quantitative scenarios. Due to the fact that measurements will also include inputs such as water and fertiliser, this project will extend previous work by allowing the sustainability performance of urban gardens to be explored.

The decision framework developed by Pocock et al (2014) (Figure 1) can be used to verify whether CS is an appropriate approach based on the objectives, but also to highlight key aspects to be incorporated into the project design, methods and budget. It is clear that it will be necessary to provide appropriate sensors (measuring equipment) to allow participants to take measurements. It is also clear that for a longer term project such as this one, a key issue is retention of volunteers. Finally, to improve the prospects of success of this approach from ‘worth considering’ to ‘very good’ instead of ‘not suitable’, it will be necessary to develop the project with input from expert volunteers. These aspects will be addressed in the following section detailing the selection of methods.

Figure 1 - Decision framework assessing suitability of projects for CS (Pocock et al., 2014).
3. Selection of methods / project design

A well known model for developing CS projects is that by (Bonney et al., 2009) (Table 1). Tweddle et al. (2012) added detail to this model and extended it to include delivery and evaluation (Figure 2).

### Table 1 - Model for developing a CS project

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Chose a scientific question</td>
</tr>
<tr>
<td>2.</td>
<td>Form a scientist/ educator/ technologist/ evaluator team.</td>
</tr>
<tr>
<td>3.</td>
<td>Develop, test and refine protocols, data forms, and educational support materials</td>
</tr>
<tr>
<td>4.</td>
<td>Recruit participants</td>
</tr>
<tr>
<td>5.</td>
<td>Train participants</td>
</tr>
<tr>
<td>6.</td>
<td>Accept, edit and display data</td>
</tr>
<tr>
<td>7.</td>
<td>Analyse and interpret data</td>
</tr>
<tr>
<td>8.</td>
<td>Disseminate results</td>
</tr>
<tr>
<td>9.</td>
<td>Measure outcomes</td>
</tr>
</tbody>
</table>

Besides brief mentions about understanding participants and developing support materials, these models don’t include methods to maintain participation, a key area necessary for the success of a longer term CS project such as Farming Melbourne (Figure 1). According to Haklay (2013), CS projects can also have varying levels of participation and engagement required (Table 2).

### Table 2 - Levels of participation and engagement in citizen science projects (Haklay, 2013)

<table>
<thead>
<tr>
<th>Level 4 Extreme citizen science</th>
<th>Collaborative science - problem definition, data collection &amp; analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3 Participatory science</td>
<td>Participation in problem definition and data collection</td>
</tr>
<tr>
<td>Level 2 Distributed Intelligence</td>
<td>Citizens as basic interpreters, volunteered thinking</td>
</tr>
<tr>
<td>Level 1 Crowdsourcing</td>
<td>Citizens as sensors, volunteered computing</td>
</tr>
</tbody>
</table>

Based on the length of involvement, measurements of multiple quantities and the necessity for expert volunteers to be involved with project development (according to the framework in Figure 1), Farming Melbourne can be considered at Level 3. This indicates that the CS project design models in Table 1 and Figure 2 need to be combined with methods dedicated to maintaining participant recruitment to develop a CS approach that is suitable to collect the data required to achieve the project aims. In a study of virtual CS projects, Wald et al (2016) found that increased attention to the motivations of participants may help to sustain the necessary engagement and retention of volunteers.

In response to that lack of research on methods for more in-depth CS projects, West and Pateman (2016) developed recommendations to engage participants and maintain participation for those designing and running CS projects. They are based on a review of general, and extensive, literature related to volunteer
participation and limited literature on CS specifically. The recommendations are listed in Figure 3 (right side), along with the main stages of a participant’s involvement in a volunteer or CS project (left side).

Figure 3 - Checklist for CS project organisers corresponding to each stage in a project (West and Pateman, 2016)

Key aspects of the recommendations centre around understanding the motivations of participants to begin and continue their participation, based on a functional approach to volunteering theory developed by Clary and Snyder (1999). Further studies of environmental volunteering have built upon these motivations (Bruyere and Rappe, 2007; Jacobson et al., 2012) or developed their own categories that can be matched to them (Bell et al., 2008; Hobbs and White, 2012; Measham and Barnett, 2007) making them more relevant to environmental volunteering and CS projects. The six motivations identified by Clary and Snyder are listed in Table 3.

Table 3 - Functions served by or motivations for volunteering (Clary and Snyder, 1999)

<table>
<thead>
<tr>
<th>Function / Motivation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Wanting to learn new things</td>
</tr>
<tr>
<td>Values</td>
<td>Wanting to help others (or help science or the environment)</td>
</tr>
<tr>
<td>Social</td>
<td>Desire to meet new people and strengthen relationships</td>
</tr>
<tr>
<td>Enhancement</td>
<td>Wish to improve themselves personally</td>
</tr>
<tr>
<td>Protective</td>
<td>Reduce negative feelings or address personal problems</td>
</tr>
<tr>
<td>Career</td>
<td>Gain experience that will benefit a future career</td>
</tr>
</tbody>
</table>
For the Farming Melbourne project, the CS project design frameworks from Bonney et al (2009) and Tweddle et al (2012) were combined with recommendations from West and Pateman (2016) to develop CS methods suitable for a project with a high level of participation required. The key aspects of this approach are outlined in the following sections.

3.1 Research and Project planning
After determining the research questions (see Section 2), and necessary CS approach (participatory science), a project team was formed with both researchers and partners from external organisations with interest and expertise in urban food gardening. These included 3000 Acres, Moreland Food Gardens Network, City of Melbourne and Biofilta, a local business involved in developing urban garden technologies. These organisations provided assistance with further developing and refining the project aims, participant tasks and survey questions, providing the expert volunteer input identified as necessary in the CS decision framework (Figure 1). This assisted in a successful application for pilot funding to undertake the project over 12 months. Along with findings from Zainuddin and Mercer (2014) partner organisations also helped researchers to understand what might motivate urban food gardeners to participate in the project and identify potential barriers.

West and Pateman recommended creating meaningful tasks that are applicable to different levels of motivation and ways in which to make it clear what the project is about for potential participants. For this reason, a ‘taster session’ and two different levels of tasks were developed, drawing on the methods employed by CoDyre et al (2015). Participants are initially invited to complete an online questionnaire about their urban garden activities as the taster, which includes the question “are you interested in participating in further research about urban gardening?”. Interested participants are then invited to participate at either Level 1 or Level 2.

Level 1 involves repeating the initial survey on a monthly basis for 12 months, recalling food harvested or swapped, and resources used in the previous week. This is intended to give a snapshot of food garden inputs and outputs across a broader group of participants, that will then be complemented by data from Level 2 participants (i.e. ‘super measurers’). Level 2 involves measuring and recording all garden produce and inputs (water, fertilisers, labour) on a weekly basis for a minimum of three months (or longer if willing). Participants are provided with instructions/training and equipment (weighing scales, hose meters, online form to record data digitally that will then be sent to a central database managed by the research team). The data collection and collation will be coordinated by the research team to get an even spread across 12 months to account for seasonal variations in garden produce. This approach has also been used in other studies measuring urban garden outputs (Zainuddin and Mercer, 2014).

To make it as easy as possible for urban gardeners to record the information about their gardens, the research team decided to use an online survey that will enable urban farmers to immediately record data related to their activities while in-situ in the garden using existing devices they already have – i.e. mobile phones. This method is commonly used in fieldwork applications to record data which is then sent directly to a central database for the research team to analyse. This reduces the time normally required to collate and enter field data into databases. Web apps and online forms have been used with great success in public health research projects (Nery et al., 2015).

The survey design was informed by a review of previous researchers’ efforts to measure urban agriculture harvests (CoDyre et al., 2015; Zainuddin and Mercer, 2014) for measurement techniques and survey design, and West and Pateman’s recommendations around motivations and removing barriers to participation. Additionally, other researchers were contacted with requests for reflections on their research process and what they would change from their survey process. This research guided the decision to allow participants to describe harvest and fertiliser amounts in a number of ways as they saw fit, such as describing harvests by weight, number, or ‘handfuls’ (i.e. volume, expressed in a tangible, commonly used amount).

The survey was piloted with a small number of testers and expert volunteers, in order to ensure there was clarity around what was being asked, and to make sure that what researchers were asking was what respondents were understanding of the questions. This led to changes to the order of questions, expression of questions – such as rephrasing of ‘family’ to household, and additional information being
provided about why questions were being asked and what data would be used for to appeal to different motivations, particularly those around ‘helping the environment’ as environmental concerns were identified in previous studies as motivations for urban gardening (Zainuddin and Mercer 2014).

### 3.2 Participant recruitment and engagement

Participant recruitment occurred mainly via social media and online methods (Facebook, Twitter, email, website), although some also occurred at local food swap events run by project partners and via advertisements on local radio. The ‘boost’ function for Facebook posts was employed to engage participants outside of the researcher’s existing networks in an attempt to get a broader geographical spread of participants.

A research assistant with a background in communications was employed specifically to help develop engagement material, survey content and maintain communication with participants throughout the project. As mentioned previously, a online ‘taster’ session was employed to engage and inform participants, and lead them to higher levels of activity. Online methods were chosen to remove barriers to participation. Limitations of these methods are that they largely exclude participants who are digitally illiterate or who don’t speak english, such as older members of migrant communities who are active in urban gardening. It was initially not considered feasible to include additional measures (leaf-letting, stories in the local paper) to reach these potential participants due to budget restrictions in this pilot study, but would be incorporated if further funding were obtained.

This project used purposive sampling (Morse, 2004), as it is not concerned with the full spread of the population’s food growing habits. Instead it is drawing on data from a range of urban food growers to estimate the productivity of urban food growing across a range of skill levels and gardens. The project is interested in all sorts of gardeners (not just expert), but it did have an interest in those actively engaged in growing food. Because of this, snowball sampling (Morse, 2004) was also used, in order to reach a greater number of participants. Using gatekeeper organisations can also assist with recruitment when there is a population of interest (Unell and Castle, 2012) – such as food gardeners, in this case – so this was another function of the partner organisations, alongside input into survey design and understanding participant motivations.

### 3.3 Initial participation

Throughout their involvement, researchers maintained regular email contact with participants, particularly the super measurers, to answer questions, clarify expectations, remind them to complete their surveys and highlight other options for involvement, however this is the most intense during the first month. This led to the development of an online Frequently Asked Questions (FAQ) page to support participants.

Opportunities for skills and knowledge sharing to appeal to certain motivations were limited due to privacy requirements necessary to obtain ethics clearance for the project. However, a project page was set up on Facebook to try to provide this function without requiring the participants to meet face-to-face, and it’s existence was highlighted to all existing and new participants via email. When contacted with questions about urban gardening practice, researchers addressed the questions but also encouraged participants to post their queries on the page. Newsletters and FAQs were also posted to the page to encourage interaction. Researchers also posted other relevant content that might be considered interesting and educational to participants.

Initial participants were surveyed about their motivations for participation, with questions based on Clary and Snyder’s (1999) identified motivations of volunteers but also from feedback from general email communications with participants. Initial recruitment occurred during autumn when urban garden production was typically minimal. Many participants apologised for their harvest results not being as good as at other times of the year. This led researchers to suspect that an additional motivation for participation in the project was ‘showboating’ or boasting about what they could produce. A carefully worded question was added to the survey that would potentially elicit a positive response within the constraints of cultural sensibilities around ‘showing off’.

### 3.4 Sustained participation

To ensure sustained participation, regular communication with participants was maintained via email, including a weekly or monthly reminder to complete the survey for Level 1 and Level 2 participants.
respectively. In most communications it was emphasised that their contribution was valuable and being used to contribute to the ‘greater good’ to appeal to motivations related to values and ‘helping others’.

Participants can view their own results online and, as mentioned previously, a Facebook page was created to facilitate interaction between participants to appeal to motivations related to learning new skills. Participants are also given the option to ‘opt-in’ to receiving a monthly newsletter documenting the progress of the project so that they can see the results of their contribution and the contribution of others. The newsletter also briefly lets them know about upcoming local food events such as workshops and food or seed swaps being organised by project partners that will be beneficial to them and their gardens.

As part of the initial recruitment stage, prizes were advertised to participants based on the length of their involvement. Participants who complete the initial questionnaire will go into the draw to win a prize to a gardening store of $30. Those who go on to complete the survey for a number of months will go in a draw to win prizes such as garden store vouchers, garden club memberships, seeds, or discounts to interesting events. There will be a prize draw for those who complete 3/12 surveys, 6/12 surveys, and 12/12 surveys, with the prizes increasing in value for greater participation. Those who undertake phase 2 and complete the three-month online diary will go in a draw to win a $100 voucher for a garden supplies shop.

3.5 End participation
In the event of inactivity for a prolonged period from a participant, researchers initiated contact via a friendly email emphasising the value of their contribution and asking if they still wanted to continue and reminded of other options for participation, such as monthly measuring or starting measurements at a later date when it was more convenient. If the participant confirmed that they no longer wanted to participate, they were sent a follow up email thanking them for their participation and asking if they would share their reasons, although in most cases reasons were volunteered. This data was collected and used to inform materials and communications employed to sustain participation of other participants. They were also given the option to remain on the mailing list to stay informed about project progress and results.

4. Results
Dear Reviewer, please note: these results are from an ongoing project. By the time the final paper is submitted in October, there will be a further three months of data on participation and motivations.

For the purposes of this paper, the results section is focused on figures related to participant engagement and participation, rather than quantitative measurements from urban food gardens. The latter figures will be presented in a subsequent paper once the 12 month data collection period is complete.

After the first three months of data collection, 141 people had taken the initial ‘taster’ survey. From this, just under 50% were engaged to continue their involvement - 37 as monthly measurers (Level 1) and 25 as super measurers (Level 2). After the post including the survey was ‘boosted’ on Facebook, double the amount of new participants signed up compared to the weekly average so far for the project. Out of all participants, most are in their 30s or 40s. The average age is 42, with the oldest and youngest participants at 73 and 25 years old respectively. The average age for super measurers is slightly higher at 44, with the oldest and youngest participants at 65 and 27 years old respectively.

Most participants are located in the north of Melbourne. Most common suburbs are Coburg (7 measurers), Footscray, Brunswick, Fitzroy North/Clifton Hill, Reservoir and Kew (4 measurers each), Thornbury, Northcote and Brunswick East (3 measurers each). There are also participants from areas outside of greater Melbourne such as Bendigo (1) and Ballarat (3), then Sydney (1) and even Perth (1). Super measurers are clustered even further north. Most common suburbs are Coburg (3), Preston, Fawkner and Brunswick (2 each). Figure 4 shows the spread of participants within the inner suburbs of Melbourne and Figure 5 shows the geographical spread of participants across Melbourne and surrounding locations. The information could only be presented by postcode for privacy reasons, so there may be multiple participants in each location.
Figure 4 - Geographical locations of participants within inner suburbs of Melbourne.

Figure 5 - Geographical locations of participants in Melbourne and surrounding locations.
In terms of ongoing participation, 50% of super measurers and 55% of monthly measurers have completed all of their required measurements (in some cases participants have exceeded the requirements because they choose to complete their surveys weekly rather than monthly). A small number participants expressed a preference to record their data in spreadsheets and send it to researchers regularly rather than entering it into the online survey. They were sent a template to assist with this process.

No super measurers have commenced frequent measuring and then ceased. In most cases, participants complete the initial survey and agree to be a super measurer, but then change their mind when contacted, or simply did not respond to emails. Two measurers initially agreed to be super measurers, then change their minds once provided with the next steps due to time constraints. One is quoted as saying “Sorry, this sounds too onerous for me to do on top of what is already a handful. Sounds like something I could do in retirement!”, which agrees with our demographic data results that a show an older average age for super measurers. One participant did not continue due to health reasons and another because they moved house and no longer have a garden. They all chose to remain on the mailing list to be informed about project update, progress and results.

The questions and results from the survey of participant motivations to take part in the project are shown in Table 4 (note: participants could select more than one option that applies to them). The majority stated that they are involved because they want to share knowledge or learn new things. It also showed that the third most popular reason for involvement was to showcase what they produce in their garden, the motivation that was included in addition to existing volunteer motivations documented in existing studies.

<table>
<thead>
<tr>
<th>Function served*</th>
<th>Reason</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>Because you want to share existing knowledge with others (eg. you feel it is important to help researchers/ other participants)</td>
<td>90.90%</td>
</tr>
<tr>
<td>Understanding</td>
<td>Wanting to learn new things about your garden, or about urban agriculture and research (eg. participating in this project lets you learn through direct experience)</td>
<td>72.70%</td>
</tr>
<tr>
<td>Showcasing</td>
<td>Being able to showcase how much you can grow in your garden (eg. demonstrating your proficiency as an urban gardener)</td>
<td>40.90%</td>
</tr>
<tr>
<td>Protective</td>
<td>Providing an additional sense of purpose to your gardening (eg. volunteering with this project provides an escape/ therapeutic help)</td>
<td>31.80%</td>
</tr>
<tr>
<td>Social</td>
<td>The potential to interact and build relationships with new or like-minded people (eg. via our facebook page)</td>
<td>27.30%</td>
</tr>
<tr>
<td>Enhancement</td>
<td>Being able to contribute to your personal development through participating in this project (eg. volunteering time makes you feel better about yourself)</td>
<td>27.30%</td>
</tr>
<tr>
<td>Career</td>
<td>Benefit your career (eg. you can mention your involvement in this project on your CV, this project provides work experience)</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>13.50%</td>
</tr>
</tbody>
</table>

5. Discussion
In this section reflections on applying citizen science to a project that requires high levels of participation will be discussed. The main areas covered will include understanding participant motivations, project timelines, potential cost savings and participant recruitment.
A key finding from this research was the emergence of a potential additional motivation that may be particular to CS projects compared to general volunteering motivations. This is the ‘showcasing’ motivation, where participants are motivated to participate because it gives them an opportunity to showcase their abilities. It will be necessary to monitor motivations through the remaining duration of the project to confirm if this motivation is important not just for recruitment and engagement but also for ongoing participation.

In the project planning stage, a significant amount of time was required to develop and refine the survey tools and engagement materials because it involved worked closely with external partners. Although the results of the process were better than what could have been achieved by the researchers alone, it put the project behind schedule from the start. This means that further funding may be required to complete data collection for the full 12 month period to account for seasonal variations. It is recommended that any other researchers looking to co-develop questions or materials with expert volunteers or stakeholders to allow for extra time outside of what is required for data collection.

The potential to reduce research costs by employing a CS approach is in conflict with reducing barriers to and maintaining participation. Although citizen science can potentially reduce project costs by outsourcing data collection, allowing participants to describe their measurements in varying units that they find most suitable significant increases the time and resources required for data collection. This could possibly be ameliorated by developing pictorial guides based on common interpretations of harvest amounts with an associated weight as a reference guide. Maintaining participation takes up significant time in terms of the initial and ongoing communication required. Improving survey design to incorporate greater automation, such as automatic welcome, equipment request and monthly reminder emails, would reduce this and improve the potential for reducing project costs. Developing and maintaining an FAQ page is also recommended to reduce research costs.

Due to the tendency for participants, particularly super measurers, to be older than average, it suggests that online methods for recruitment and engagement should be extended to include leaf-letting or stories in the local paper. This is not considered to only apply to this project, but many other CS projects as participants with more time to be involved are likely to be retired, therefore older and less digitally literate.

6. Conclusion
This paper documents the development and application of methodology combining traditional frameworks for citizen science project design with methods to increase engagement and participation based on understanding motivations from literature on volunteering. It was found that an additional motivation emerged that was particular to citizen science projects - showcasing, where participants are motivated to participate because it gives them an opportunity to showcase their abilities.

It was also found that using a citizen science approach didn’t necessarily result in reduced research costs due to greater time and resources being required to develop the project with external input, analyse data from surveys designed to reduce barriers to participation, and for participant engagement. Strategies involving greater automation and development of additional support resources were suggested to streamline the data collection and engagement process. It was also found that it may be necessary to employ more than just online methods to recruit and engagement participants because those with more time to participate may be retired and potentially older and less digitally literate.

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