

Citizen Science and Environmental Monitoring: Towards a Methodology for Evaluating Opportunities, Costs and Benefits

Final Report on behalf of UK Environmental Observation
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The **UK Environmental Observation Framework** is a partnership of the major public funders of environmental science and was launched in 2008 to address issues of fragmentation, data access and a lack of strategic direction in environmental monitoring.

'Changing the way the UK perceives , values and uses environmental observations'



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Citizen Science and Environmental Monitoring- Final Report

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Contents

1.	Executive Summary	1
2.	Acknowledgments	5
3.	Citation	6
4.	Introduction.....	7
4.1	Reasons for the project	7
4.2	Objectives.....	7
4.3	Outcomes	8
4.4	This report	8
5.	Assessment of current volunteer engagement in agency monitoring	10
5.1	Introduction.....	10
5.2	The survey of government agencies	10
5.3	How embedded is support for citizen science in public bodies?.....	13
5.4	Part 2: What is the current use for citizen science in public bodies?	15
5.5	Part 3: Opportunities and barriers for citizen science	18
5.6	Part 4: Information collected about citizen science (CS) activities	21
5.7	Limitations of the survey	22
5.8	Conclusions and recommendations	23
6.	Review of methodologies for valuing the contribution of citizen science	24
6.1	Introduction.....	24
6.2	Scope	24
6.3	The benefits of citizen science	25
6.4	The costs of citizen science	27
6.5	Financial analysis	29
6.6	Economic analysis.....	31
6.7	Multi-Criteria Analysis (MCA)	34
6.8	Qualitative approaches	34
6.9	Conclusion.....	35
7.	A method for agencies to quantify value	36
7.1	Summary of approaches	36
7.2	Assessment.....	38
8.	The tool	42

8.1	Outline	42
8.2	Testing and refinement	43
8.3	Case studies.....	43
8.4	Observations from the case study assessments	45
9.	Conclusions.....	47
9.1	Findings and observations	47
9.2	Knowledge gaps and recommendations.....	48
	References	51

Appendices

Appendix A	The operational tool.....	56
Appendix B	Initially proposed case studies	66
Appendix C	Case study (final selection) interviews	68

List of Tables

Table 1	Overview of the survey to assess the current use of citizen science in public bodies	11
Table 2	The departments and bodies represented by the 34 respondents in the survey	12
Table 3	The descriptors for respondents to undertake self-assessment of how embedded citizen science is in their organisation. Respondents were asked to select the option that best describes their experience of their organisation. This was adapted with permission from the NCCPE EDGE tool for self-assessment of support for public engagement (http://www.publicengagement.ac.uk/support-it/self-assess-with-edge-tool)	
Table 4	The strengths and weaknesses of the evaluation approaches	36
Table 5	Assessment of performance of the evaluation approaches.....	39

List of Figures

Figure 1	The percent of respondents assessing the degree to which citizen science is embedded in their organisation for each of the eight categories	14
Figure 2	The current use of citizen science to monitor environmental attributes	16
Figure 3	The primary emphasis on using citizen science for each environmental attribute. Attributes are ordered as in Figure 2, i.e. by decreasing proportion of respondents saying use of citizen science to monitoring this attribute was 'embedded' in their organisation. (Responses stating that the environmental state is not applicable to the respondent's organisation have been removed; remaining sample sizes are given to the right of the bars.).....	17
Figure 4	The requirement for monitoring each environmental attribute.....	18
Figure 5	Why citizen science (a) is and (b) is not as suitable for environmental monitoring based on categorisation of text responses. For main categories: N = number of respondents	20
Figure 6	The types of information gathered about citizen science in public bodies. These responses exclude respondents who said they did not know the answer.....	22
Figure 7	Theoretical framework for evaluation of citizen science in environmental monitoring	41
Figure 8	OPM Infestation Map - September 2015	69
Figure 9	Screenshot of Tool (costs sheet) for OPM case study	70
Figure 10	Screenshot of Tool (Benefits sheet) from OPM case study.....	71
Figure 11	Number of volunteers trained/ participated and km ² squares allocated and actually surveyed	72
Figure 12	Mapped river obstacles around York.....	74
Figure 13	Part of the wildlife ID kit for Norfolk volunteers.....	76

1. Executive Summary

The UK has a long history of volunteer involvement in monitoring the environment. This volunteer involvement, i.e citizen science, can complement, augment or even replace monitoring by contracted professionals. The UKEOF Citizen Science Working Group identified a need to understand more fully the potential for citizen science to support environmental monitoring programmes, and how to evaluate the relative costs and benefits of different approaches. Experts from WRc, CEH and Fera were contracted to undertake an analysis of the current and potential use of citizen science in environmental monitoring, and to develop a method for assessing the feasibility and viability of using citizen science. The project was conducted, between September 2015 and March 2016, and involved undertaking a survey to assess current volunteer engagement in governmental agencies and related bodies, a review of methodologies for valuing the contribution of citizen science and the development of an evaluation framework in the form of a spreadsheet tool for employing citizen science in environmental monitoring.

The key findings from the project are summarised as follows:

1. Current approaches to citizen science in UK governmental bodies

Interest in citizen science is increasing, but taking a citizen science approach is not free; its costs can be substantial and it can vary considerably in its cost-effectiveness depending on how it is implemented. Citizen science has the potential to provide a wider range of benefits than simply the data collected, such as increasing public engagement or in helping to detect rare events. We assessed the current state of, and attitudes towards, citizen science in key environmental public bodies in the UK through a targeted staff survey and found that:

- Most organisations' approaches to evaluating citizen science is embryonic (suggesting that there is considerable potential for it to develop).
- Citizen science is already widely-used to monitor some environmental attributes, especially non-marine biodiversity, alien invasive species, weather and climate, and protected sites. For these, some respondents considered that citizen science was already an essential component of their organisation's monitoring activities. Citizen science is less widely-used to monitor other environmental attributes.
- The most important opportunities provided by citizen science included:
 - more/better data (e.g. greater spatial coverage of records),
 - being able to undertake public engagement with science and the environment,
 - increased cost effectiveness (or lower cost) compared to monitoring by professionals.
- The greatest barriers for the use of citizen science were regarded as:
 - concerns about data quality,
 - lack of control in the monitoring (potentially leading to spatial bias, inadequate recording, and loss of authority in the results),
 - activities can be unsuitable for volunteers (e.g. due to access restrictions),
 - lack of funding, resources, skills and experience in the organisation

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- Few respondents considered that lack of interest by potential volunteers was an important barrier. However, it is important to consider volunteer recruitment and retention when planning new activities.
 - Many of the costs and benefits of citizen science are known or can be estimated. However, staff and IT costs, which are direct costs, tend to be better known than other (more indirect) costs. Overall, though, we found that costs are rarely collated or used to evaluate the use of citizen science.

2. Evaluation of citizen science

In the context of resource constraints in the public sector and the need for efficiency and transparency, evaluating citizen science approaches is essential, and can be undertaken in different ways:

- to compare the outcomes from citizen science (for research, monitoring or public engagement) with alternative approaches,
- to make a case for funding the development of citizen science activities,
- to justify continued investment in citizen science,
- However, whilst there is much information on best practice in citizen science, there was no readily-available advice for evaluating the costs and benefits of citizen science. This project sought to fill this gap.

3. Developing a framework to evaluate citizen science

From a long list of economic methodologies, we concluded that four approaches were most suitable to evaluate citizen science approaches for environmental monitoring. No single method was suitable in all circumstances so we devised a framework that employs all four approaches (including evaluating some non-monetised costs and benefits).

The four methods are:

- **Return On Investment (ROI)** which solely considers the financial aspects to assess the value an organisation receives from their investment in volunteers.
- **Cost-Benefit Analysis (CBA)** which considers costs and benefits of an approach (e.g. citizen science, or monitoring by professionals) to society as a whole, rather than just to the organisation, and includes non-monetary costs and benefits where a value can be estimated. The costs and benefits are summed in order to determine whether the costs or benefits predominate.
- **Cost-Effectiveness Analysis (CEA)** which compares the relative costs to the outcomes (effects) of two or more options (e.g. comparing contracted monitoring with a citizen science approach). It is most useful when the outcomes of the option are the same, or where constraints prevent the use of a cost-benefit analysis.
- **Multi-Criteria Analysis (MCA)** which is a structured approach to determine the relative preference for different options based on evaluation indicators. Unlike a cost-benefit analysis, the

measurement of indicators need not be in monetary terms. It relies on expert judgement to evaluate non-monetary costs and benefits.

These can be used to indicate the value of undertaking citizen science (ROI and CBA), or to indicate the value of citizen science compared to an alternative e.g. professional monitoring (CEA), including the use of qualitative indicators, such as raising public awareness (MCA).

Fully qualitative approaches can also be used for evaluation, e.g. to assess outcomes for participants, but are generally used post-implementation rather than for evaluating the potential of a particular approach.

4. A tool for evaluation of the use of citizen science

We developed a framework based on these four evaluation methodologies and implemented it via a freely-available tool, which we tested with several case studies. The tool consists of:

- Initial screening questions to assess the feasibility of using citizen science.
- A decision framework to help users decide which of the four evaluation approaches is most suitable.
- A facility to enter costs and benefits. These can either be calculated or estimated values, or qualitative assessments (for the multi-criteria analysis).
- A presentation of the results from the four different evaluation approaches.

The tool is populated with default values, which can be adjusted by the user, but further research is required to gain a better estimate of such values.

The tool can be used for evaluating citizen science as a new standalone activity, or as an activity to replace or augment existing monitoring and research. It can be applied to activities being run by, or commissioned by, an organisation.

Recommendations

- A repeat of the survey of UKEOF members in the future may help to determine whether organisations have advanced in their support for citizen science.
- Individual citizen science activities should be rigorously evaluated at key points in the life of the activity (including during the inception and planning stages). All such evaluations should be planned in advance. The tool could be used to help undertake these evaluations.
- Those undertaking evaluation of citizen science activities should share their findings with other project organisers (within and between organisations). This includes whether the evaluation in the planning phase of activities supports citizen science or supports it over an alternative, such as monitoring by contracted professionals.
- Organisations should undertake a formal risk assessment for the development of citizen science, particularly where it might replace existing long-term or mandated monitoring by professionals.
- Better evaluation of the 'difficult-to-quantify' benefits of citizen science should be a focus for further research. It would be useful to create a database of citizen science benefit values from existing research.

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- The spreadsheet evaluation tool should be piloted and further refined, but will be made available to others outside of UKEOF as a pilot version, as there is likely to be interest from a number of organisations, including internationally. Any results should be carefully considered before being used to support decision-making. The authors and funders cannot accept any responsibility for decisions made with the results of the spreadsheet evaluation tool.

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3. Citation

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4. Introduction

4.1 Reasons for the project

The UK Environmental Observation Framework (UKEOF) is a partnership of mainly government organisations involved in collecting, managing and using environmental data and information. Some of the partner organisations have a long track record of supporting citizen science to collect data for a variety of purposes; others have started to use citizen science to some extent, or are considering doing so. The partnership has an active Citizen Science Working Group which has published guidance on the topic (see: <http://www.ukeof.org.uk/our-work/citizen-science>).

The UKEOF Citizen Science Working Group has identified a need to better understand the potential for citizen scientists to become more involved in environmental monitoring programmes, and how to identify and calculate the costs and benefits of them doing so. This study originates from a Defra Strategic Network Evidence Group event, which tasked the Citizen Science Working Group with investigating the potential of involving volunteers in a wider range of monitoring activities and assessing any financial efficiency.

The UK has a long history of volunteer monitoring in the environment that has tended to focus on schemes that supplement contracted monitoring effort. More recently, as some monitoring agencies face significant financial pressures, there has been an increasing interest in volunteer involvement across a wider range of monitoring activities, perhaps allowing employed staff to be deployed more flexibly, and citizens to participate more fully in stewarding key aspects of their local environment.

Volunteer involvement can incur significant costs through project design, IT support, recruiting, training and engaging with volunteers, and analysing data. However, in some cases such engagement may be the most cost-effective option and provide a significant increased contribution to UK environmental monitoring. For example, in 2007, a £7 million government investment into volunteer monitoring generated data estimated to contribute time in-kind worth £20 million (Mackechnie et al., 2011). However, despite evidence that volunteer monitoring can represent good value for money, presenting a financial case to secure the resources necessary to support, recruit and engage volunteers can be challenging.

4.2 Objectives

The objectives of this project were to:

- Briefly assess and summarise current volunteer engagement in monitoring programmes led by the UK's environmental protection, monitoring and conservation agencies to understand the current "state of play", and to assess the potential future role of volunteers in meeting the agencies' changing needs and aspirations.

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- Develop simple high-level criteria with which agencies can assess proposals for volunteer involvement in monitoring programmes.
 - Identify the benefits and costs associated with the use of citizen science.
 - Review current methodologies for valuing the contribution of citizen science to environmental monitoring, assessing their strengths and weaknesses.
 - Recommend a simple method for the UK's environmental protection, monitoring and conservation agencies to use to quantify the value of different options for involving volunteers in monitoring programmes.
 - Develop a tool based on the framework and test it using a number of scenarios.
 - Make an overall assessment of the potential for increased citizen science contributions to the current environmental monitoring schemes and likely future monitoring needs.
 - Make a brief assessment of the significance of remaining gaps in our knowledge, and what further work would be needed to fill priority areas.

4.3 Outcomes

This short study will assist the UK's environmental protection, monitoring and conservation agencies to make decisions which will help them to monitor various environmental parameters using the best mix of approaches involving staff, contractors and volunteers in the most effective, efficient and economical way. The study aims to build understanding about how to identify and measure the costs and benefits of monitoring activities using volunteers, explain the main principles involved, and demystify the issues in a way which will be of practical use to the UKEOF partners and others.

Using a recommended consistent and objective rationale, the agencies will be better able to identify and assess the financial case for volunteers to participate in monitoring programmes. They will understand in principle what types of cost and value, to their own business and to wider society, apply to using volunteers and will know how to quantify those aspects which will be core to their own decision-making. The resulting decisions about monitoring will be transparent, made on the broadest, best available and most relevant evidence; and budgets for monitoring will be spent effectively.

Ultimately, this work will help citizen science to fulfil its full potential to deliver broader societal benefits through raising environmental awareness and promoting environmental learning, building social networks, and improving people's local environments (Pocock et al., 2013).

4.4 This report

The following sections report the outcomes of this project. Section 3 reports on the assessment of current volunteer engagement in agency monitoring. Section 4 contains the literature review and

Section 5 presents an evaluation of alternative methodologies that agencies might use when considering using citizen science. Section 6 reports on the citizen science assessment tool and Section 7 identifies knowledge gaps and provides recommendations.

5. Assessment of current volunteer engagement in agency monitoring

5.1 Introduction

Citizen science is the involvement of volunteers in the process of science. Volunteers are commonly involved in data collection, but can also be involved with interpretation of data, initiating questions, project design and dissemination of results (Bonney et al. 2009; Haklay 2013). Citizen science has a long history, especially in ecology and environmental monitoring (Miller-Rushing et al. 2012), but there has been a recent rise in the prominence of citizen science (Silvertown 2009; Bonney et al. 2014). From a policy perspective, citizen science can enable people to have greater engagement with policies and issues that affect them and can contribute to government reporting requirements (Danielsen et al. 2014) and the production of headline indicators (Department for Environment Food and Rural Affairs 2016).

Government agencies have become increasingly interested in citizen science and participatory monitoring. Citizen science has recently been featured in UK government on environmental monitoring (Parliamentary Office of Science And Technology (POST) 2014), and for specific issues such as pollinator monitoring (Department for Environment, Food & Rural Affairs 2014) and tree health surveillance (Tree Health and Plant Biosecurity Expert Taskforce 2012). In parallel with this, there is growing commitment to citizen science in the USA (<https://crowdsourcing-toolkit.sites.usa.gov/>) and the EU (Science Communication Unit 2013; Societize Consortium 2014). The growth in citizen science has been supported by publically-funded reports addressing when citizen science is relevant and how projects can be run (Roy et al. 2012; Pocock et al. 2013) and establishing a toolbox of support for citizen science developers (<https://crowdsourcing-toolkit.sites.usa.gov/>).

Here we ask how embedded citizen science is in government agencies and how much potential there is for citizen science to support, augment or replace professional environmental monitoring undertaken through government agencies. Our objective was to undertake a targeted survey of employees of UK governmental departments, devolved administrations, agencies and other public bodies (hereafter termed 'public bodies') to assess the degree to which citizen science is embedded within and used by them. This allowed gaps and future opportunities for citizen science to be identified (task 6 in the work programme). Additionally, because cost-efficiency is one reason for considering citizen science, we assessed the availability of information from which cost-efficiency could be assessed, in order to support development of a tool to evaluate cost and benefits.

5.2 The survey of government agencies

We designed a survey which was distributed by email to contacts in 17 UK public bodies that have a remit for monitoring the environment (Table 1). Our objective was to consider citizen science within the UK public sector, so we did not distribute the survey to non-governmental organisations or other interested individuals even if they were undertaking citizen science. We asked respondents to consider

the remit of the whole organisation, so including activities which they commission externally as well as any activities run by the organisation. We noted that citizen science which is well-embedded in the public sector is the *appropriate* use of *suitable* citizen science approaches (Pocock et al. 2014); it is not the uncritical use of citizen science.

The survey was distributed to the project team and the UKEOF project steering group members' contacts. We did not seek to undertake a comprehensive survey of employees but aimed to gain representation from key bodies. The survey was comprised of four main parts and we discuss the methods and results of each part below.

Table 1 Overview of the survey to assess the current use of citizen science in public bodies

Part	Question/topic	Options	Description
1: Embedding of support for citizen science	How embedded is citizen science? (for each of eight topics see Table 2)	Embryonic Initiating Developing Embedding	See appendix for narrative description of each option for each topic
2: Current use of citizen science	How citizen science is currently used (for each of 16 environmental attributes)	Not yet been considered Not suitable Embryonic Developing Embedded – partial Embedded – essential	including ensuring data quality potential for CS is being considered CS is being trialled or just beginning relies on CS for SOME monitoring relies on CS for MOST/ ALL monitoring
	Emphasis for using citizen science (for each of 16 environmental attributes)	Emphasis is primarily about public engagement Emphasis is equally on data collection/ quality and public engagement Emphasis is primarily about data collection -	(including outreach, awareness raising and behaviour change) (including ensuring data quality)
	Requirement for monitoring (for each of 16 environmental attributes) *	Regulatory requirement* Research*	

Part	Question/topic	Options	Description
3. Opportunities and barrier for citizen science	What are the top 3 reasons citizen science is regarded as (a) suitable and (b) not suitable for monitoring?	[free text response]	
4: What information about citizen science activities is gathered?	Is the information gathered?	Not collected (as far as you know) Could be estimated Collected for some activities Collected and collated for some activities Collected, collated and used to justify the use of CS Don't know	(but not routinely collected) (but not collated across the organisation) (could be used to justify the use of CS)

* For this question both options could be selected, whereas only one option could be selected for the other questions.

We received responses from 34 people representing 15 agencies and bodies (listed in Table 2) covering many of the important aspects of monitoring the environment in the UK. In presenting the results below we have not separated them by individual respondent to retain anonymity. We received between 1 and 4 responses from each organisation.

Table 2 The departments and bodies represented by the 34 respondents in the survey

Name of public body	Description of status
Department for Food, Environment and Rural Affairs	Ministerial department
Environment Agency	Agencies and other public bodies
Natural England	Agencies and other public bodies
The Scottish Government	Devolved administration
Scottish Environment Protection Agency (SEPA)	Agencies and other public bodies
Scottish Natural Heritage (SNH)	Agencies and other public bodies
Welsh Government	Devolved administration
Natural Resources Wales (NRW)	Agencies and other public bodies
Northern Ireland Executive (Northern Ireland Environment Agency)	Devolved administration
Forestry Commission/Forest Research	Non ministerial departments
Joint Nature Conservation Committee (JNCC)	Agencies and other public bodies
Animal and Plant Health Agency (APHA)	Agencies and other public bodies
Centre for Environment, Fisheries and Aquaculture Science (Cefas)	Agencies and other public bodies
Met Office	Agencies and other public bodies
Natural Environment Research Council (British Geological Survey and Centre for Ecology & Hydrology)	Agencies and other public bodies

5.3 How embedded is support for citizen science in public bodies?

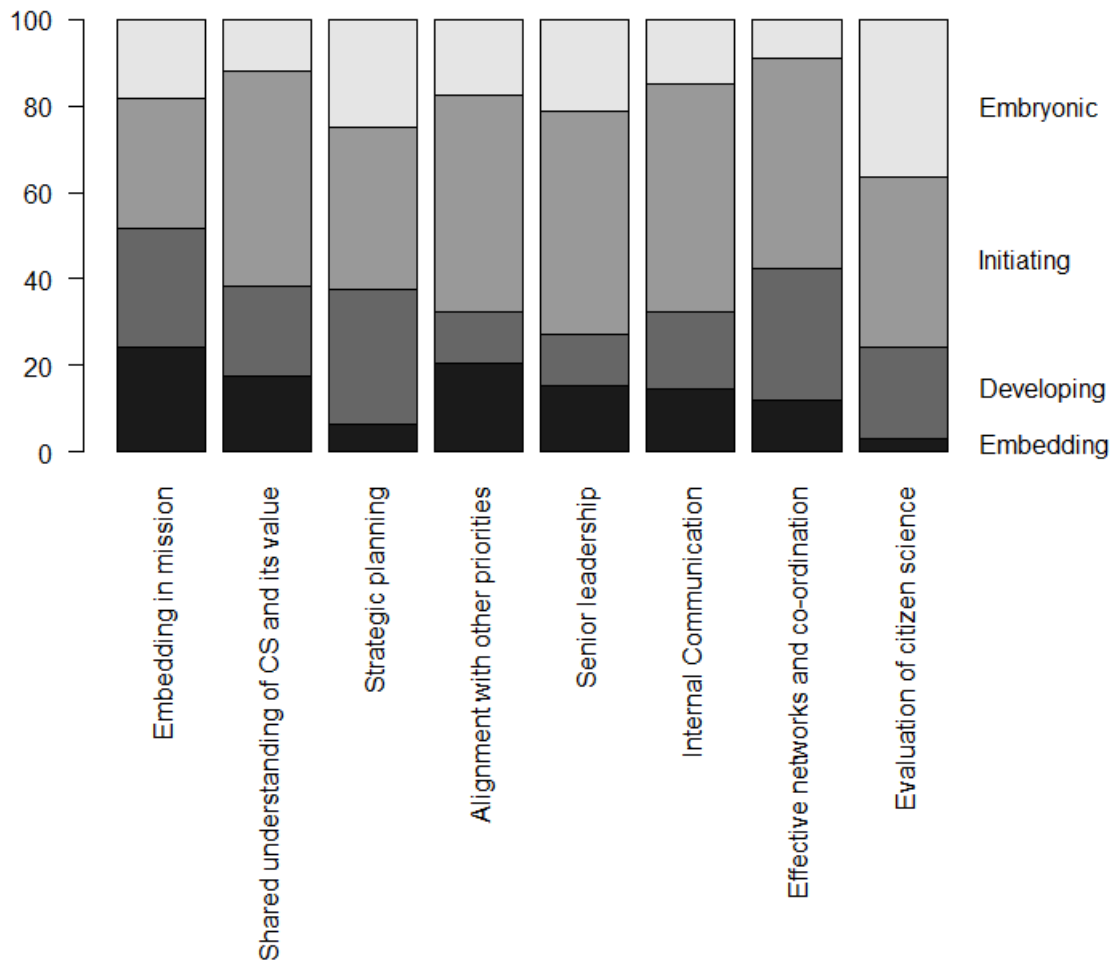
Respondents to the survey were asked to assess their organisation's level of support for citizen science: embryonic, initiating, developing and embedding, each of which was defined with a brief description (Table 3). We explained in the guidance that fully embedding citizen science can be demonstrated by its appropriate use and does not require an all-embracing (i.e. unquestioning and uncritical) use of citizen science by the organisation. The categories and the text for the options were based on the EDGE tool developed by the National Co-ordinating Centre for Public Engagement (NCCPE: <http://www.publicengagement.ac.uk/support-it/self-assess-with-edge-tool>) which was developed in order that "individuals can undertake self-assessment of support for public engagement in organisations". We used and adapted the wording of the EDGE tool with permission from the NCCPE. Respondents were asked to choose the option for each question which, in their experience, best matched their organisation.

The results showed that citizen science is being embedded within public bodies but is yet to be fully embedded (Figure 1), according to the opinion of the respondents.

Table 3 The descriptors for respondents to undertake self-assessment of how embedded citizen science is in their organisation. Respondents were asked to select the option that best describes their experience of their organisation. This was adapted with permission from the NCCPE EDGE tool for self-assessment of support for public engagement (<http://www.publicengagement.ac.uk/support-it/self-assess-with-edge-tool>)

<i>Topics</i>	<i>Embryonic</i>	<i>Initiating</i>	<i>Developing</i>	<i>Embedded</i>
Embedding in mission and Strategic planning	Citizen science is not addressed explicitly in the organisational mission or strategies.	Citizen science is referenced sporadically within the organisational mission documents and strategies, but is not considered a priority area.	Work is underway to review the organisation's commitment to citizen science, in order to articulate a set of strategic priorities and embed these in the organisational mission and other relevant strategies.	The relevance of and opportunities for citizen science is identified in the organisation's official mission and in other key organisation-wide strategies, with success indicators identified.
Shared understanding of citizen science and its value	The term 'citizen science' is used inconsistently or infrequently and very few staff have an understanding or appreciation of what it means or its relevance to their work. Opinions about CS tend to be simplistic (overly critical or overly optimistic).	References to 'citizen science' appear in some organisational strategies and plans, but there is no organisation-wide understanding of citizen science.	Consultation is underway with internal and external stakeholders to develop an understanding of citizen science, its relevance and purpose.	The organisation has consulted widely (internally and externally) to develop an understanding of citizen science as relevant for both engagement and data collection. This understanding is used consistently.
Strategic planning	There is no official strategic plan for advancing citizen science.	Although some short- and long-term goals for citizen science have been defined, these have not been formalized into an official strategic plan that will guide their implementation.	Work is underway to develop an official strategic plan to identify where citizen science is relevant and how it can be implemented.	The organisation has developed an official strategic plan for advancing citizen science, which includes viable short-term and long-term goals.
Alignment with other priorities	Citizen science rarely features as a component within wider organisational initiatives.	Citizen science occasionally features within wider organisational initiatives, but in a relatively piecemeal way.	Processes are being developed to ensure that the opportunities for citizen science are routinely considered during strategic planning.	The opportunities for citizen science are routinely considered during strategic planning and organisation-wide developments.
Senior leadership	Few (if any) of the most influential leaders in the organisation serve as champions for citizen science.	Some of the organisation's senior team act as informal champions for citizen science.	Some of the organisation's senior team act as formal champions for citizen science.	The CEO, Director or equivalent champions the appropriate use of citizen science. All senior leaders have an understanding of the importance and value of citizen science to the organisation's agenda.
Internal Communication	The organisation's commitment to citizen science is rarely if ever featured in internal communications.	Citizen science occasionally features in internal communications.	Citizen science frequently features in internal communications, but rarely as a high profile item or with an emphasis on its strategic importance.	Citizen science appears prominently in the organisation's internal communications; its strategic importance is highlighted.
Effective networks and co-ordination	There is no attempt to co-ordinate citizen science activity or to network learning and expertise across the organisation.	There are some informal attempts being made to co-ordinate citizen science activities, but there is no strategic plan for this work. Some self-forming networks exist, but are not supported directly by the organisation.	Oversight and co-ordination of citizen science has been formally allocated (e.g. to a working group or committee) but there is limited support and resource to invest in activity.	The organisation has a strategic plan to focus its co-ordination of citizen science activity and to network learning and expertise.
Evaluation of citizen science	There is no organized, organisation-wide effort underway to evaluate the quantity and quality of citizen science activities taking place, nor any recognition of the value of evaluation in informing future activities.	There are attempts to evaluate the quality of some citizen science activities, but there are no efforts across the organisation. Evaluation is focussed on monitoring (e.g. how many records were collected).	A systematic effort to evaluate the quality of citizen science activities has been initiated. Summative evaluation is common (e.g. considering the overall success of the activity).	An on-going, systematic effort is in place to evaluate the quality of citizen science activities that are taking place throughout the organisation. Evaluation feedback is being used to inform future activity and strategy. Formative evaluation (e.g. considering how to improve citizen science activities) is an expected part of engagement activities.

Figure 1 The percent of respondents assessing the degree to which citizen science is embedded in their organisation for each of the eight categories



Key findings

- At least one quarter of respondents (and up to one half) said that their organisation’s approach to citizen science was ‘developing’ or ‘embedded’.
- For all questions the majority response was that their organisation’s support for citizen science was ‘initiating’. This suggests that there is potential that is not yet fulfilled for government agencies to consider and support citizen science.
- The least embedded aspect of citizen science was the evaluation of citizen science, followed by strategic planning. This shows that there is clear need for tools to evaluate citizen science, including considering its cost-effectiveness, such as that being proposed in the current project. Tools to support evaluation should also support strategic planning because it helps provide an evidence base for decision-making.

5.4 Part 2: What is the current use for citizen science in public bodies?

In the second part of the survey, respondents were asked to consider each of 16 environmental attributes and for each attribute of relevance to their organisation, respondents were asked to describe (1) how citizen science is currently used, (2) what the motivation for using citizen science is, and (3) what the requirement for the monitoring/reporting is (Table 1).

There does not exist a single, comprehensive list of environmental attributes to be monitored, so we assembled a list from existing reviews (UKEOF 2010; The Scottish Government 2011; Natural England 2013; Natural Capital Committee 2014; Natural Resources Wales 2014; JNCC 2015; The Royal Society 2015; UK Environmental Change Network 2015; Department for Environment Food and Rural Affairs 2016). The final list of 16 attributes comprised environmental states (e.g. marine biodiversity) and drivers of environmental change (e.g. nutrient enrichment or alien invasive species), most of which were domain specific (e.g. terrestrial, fresh water, marine or atmosphere).

Key findings

- Across the environmental attributes there is substantial variation in the use of citizen science (Figure 2): it was considered embedded by 60% of respondents for monitoring terrestrial & freshwater biodiversity and alien invasive species, but by <10% for monitoring coastal water quality, river flows and floods and nutrient enrichment.
- There was only one attribute (soil condition)¹ where citizen science had been considered and found to be unsuitable (Figure 2). It is possible that this number will increase as the use of citizen science is considered more in the future.
- Most respondents considered that the aims of data collection and public engagement were about equally important in their organisation's consideration of citizen science (Figure 3). However, there was a significant trend for emphasis on public engagement to be negatively correlated with how embedded citizen science is for monitoring that attribute (correlation coefficient $r = 0.632$, $P = 0.01$; i.e. the black bars in Figure 3 tend to increase down the graph). It is possible that positive experience of using citizen science for monitoring leads to a greater emphasis on data collection compared to primarily public engagement.
- Emphasis on data collection (i.e. white and grey bars in Figure 3; median = 86%) averaged higher than emphasis on public engagement (i.e. grey and black bars in Figure 3; median = 68%). This suggests that data collection is a stronger driver than public engagement for citizen science in the public sector, although there is clearly recognition of the potential for public engagement.

¹ Though citizen scientists have been involved in soil-related projects, such as earthworm surveys for schools.

- Across the attributes, there is a roughly equal spread of regulatory requirement for monitoring (i.e. the monitoring is mandated and has to be undertaken) and monitoring for research, e.g. to inform policy development (Figure 4).

Figure 2 The current use of citizen science to monitor environmental attributes

Attributes are ordered by decreasing proportion of respondents saying use of citizen science to monitor this attribute was 'embedded' (essentially or partially) in their organisation. (Responses stating that the environmental state is not applicable to the respondent's organisation have been removed; remaining sample sizes are given to the right of the bars.)

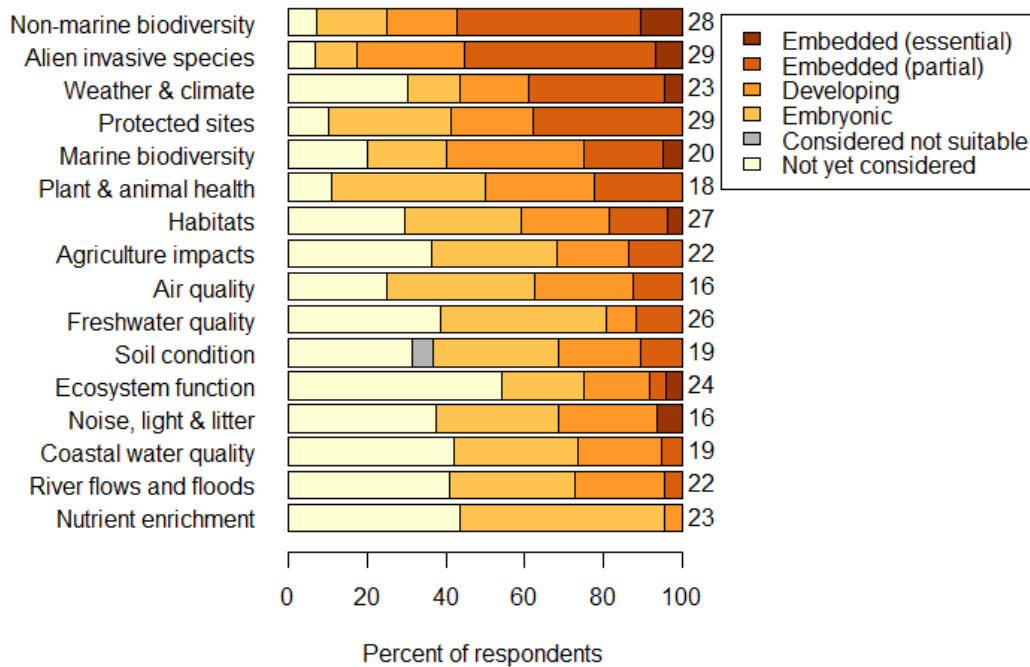


Figure 3 The primary emphasis on using citizen science for each environmental attribute. Attributes are ordered as in Figure 2, i.e. by decreasing proportion of respondents saying use of citizen science to monitoring this attribute was 'embedded' in their organisation. (Responses stating that the environmental state is not applicable to the respondent's organisation have been removed; remaining sample sizes are given to the right of the bars.)

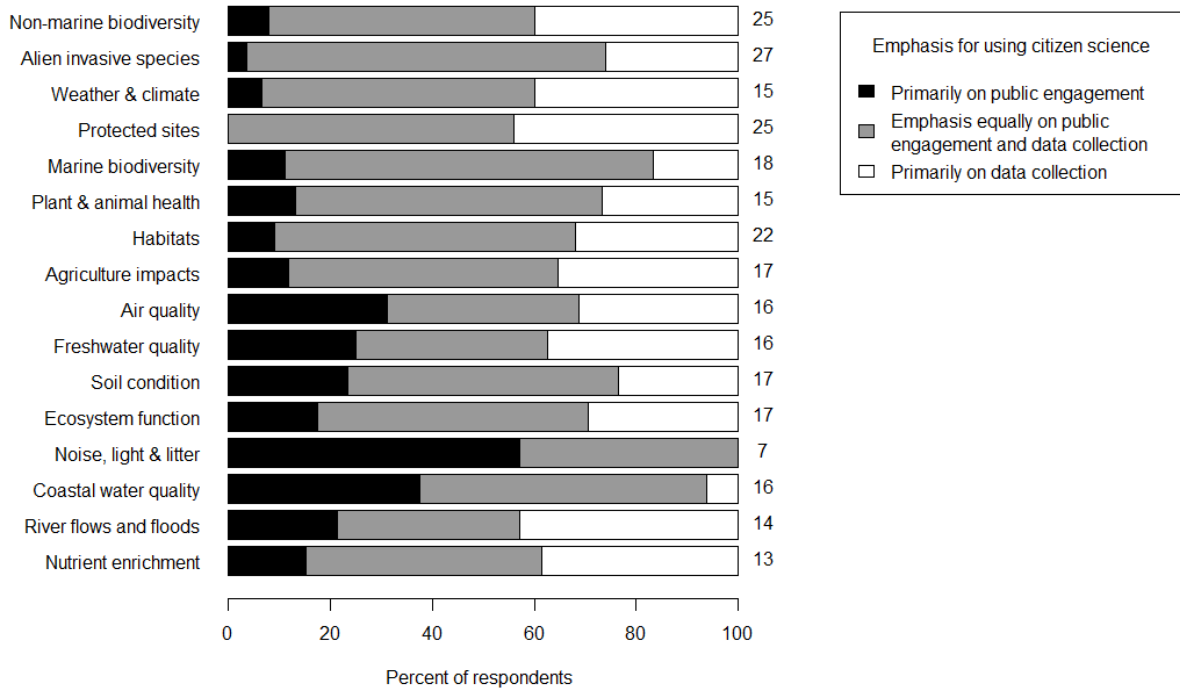
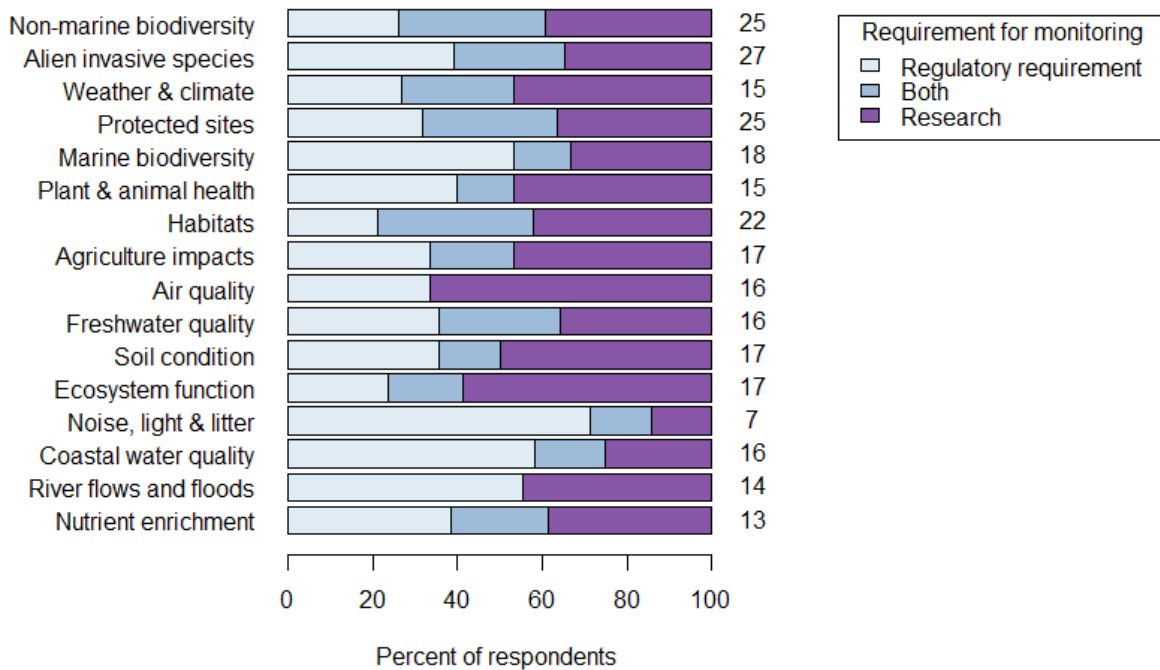


Figure 4 The requirement for monitoring each environmental attribute

The attributes are ordered as in Figure 2, i.e. by decreasing proportion of respondents saying use of citizen science to monitor this attribute was ‘embedded’ in their organisation. (Responses stating that the environmental state is not applicable to the respondent’s organisation have been removed; remaining sample sizes are given to the right of the bars.)



5.5 Part 3: Opportunities and barriers for citizen science

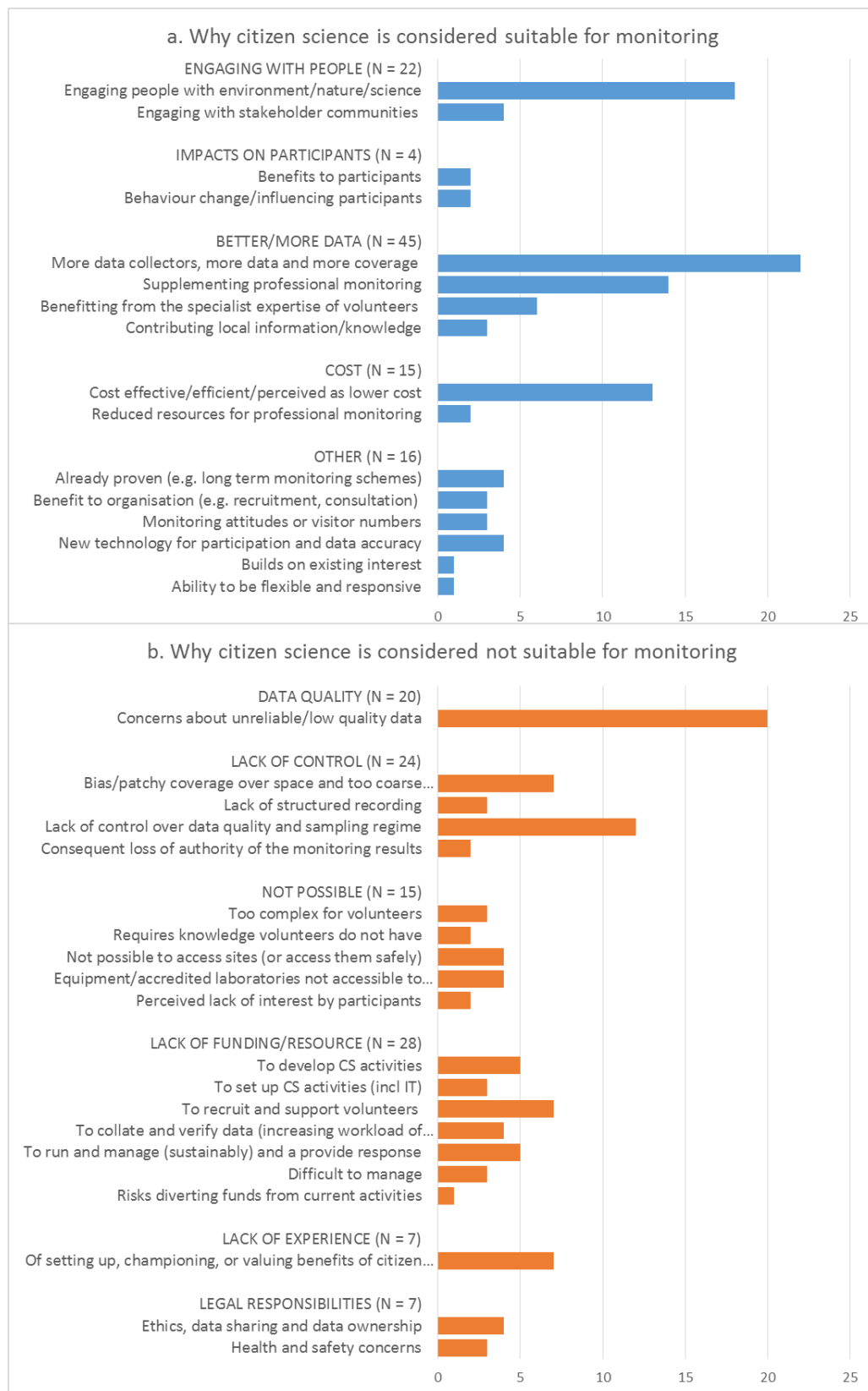
We asked respondents to give the top three reasons that citizen science was considered (a) suitable and (b) not suitable for monitoring in their organisation. This helped us to identify what people considered to be the important opportunities and barriers for using citizen science. Some people’s responses included more than three reasons. We grouped these free text responses into categories for reporting.

Key findings

- The main reasons given for citizen science being suitable for monitoring were typical of those often given in other projects: engaging with people, providing more or better data and reduced cost/increased cost effectiveness (Figure 5).
 - Many respondents noted that citizen science had support for supplementing existing professional monitoring. Therefore the ability of citizen science to provide greater spatial or temporal coverage than professional monitoring can be used to supplement existing monitoring, especially when new statistical techniques are used to effectively combine different data sources.

-
- Respondents commented on both the reduced absolute cost ('cheap') and relative cost ('cheaper' or 'cost effective') of citizen science.
 - The key reasons that citizen science was regarded as not suitable for monitoring were: concerns about data quality, lack of control, being not possible and lack of funding/resource to develop and support citizen science (Figure 5).
 - Concerns about data quality are a criticism of citizen science. Evidence from numerous recent projects has shown that citizen science can provide excellent quality data, but the important issue is that quality is not guaranteed (and so needs to be verified). Also if quality is perceived or assumed to be poorer than professional monitoring then it has a reputational impact on the monitoring results.
 - The lack of control is an important issue where resources are limited and monitoring is mandated. Simply leaving monitoring to citizen science is a high risk, especially where long-term monitoring is concerned, and it may result in spatial bias (e.g. participation being highest near to where people live). These concerns will need to be addressed for citizen science to be trusted by stakeholders and end users of data and so for citizen science to reach its full potential as a way of undertaking environmental monitoring across the different attributes.
 - The third theme that was often raised was the perception that citizen science was not possible; this could be because there is a perceived lack of interest by volunteers or the protocols are too complex or time-consuming, or because of lack of access to sites, equipment or expertise. We suggest that while this may be true in some cases, it may also be that innovation could make citizen science possible in these cases. Innovation would include technological advances, development of new statistical methods to cope with unstructured datasets or missing values (Hill 2012; Isaac et al. 2014; Pagel et al. 2014), and critical appraisal of the overarching needs of the monitoring rather than continuation of existing methods but with volunteers.
 - There was a clear recognition that citizen science is not cost-free and resources are needed to develop citizen science, to run activities and to support volunteers. One respondent noted that resources were more easily obtained to pilot or develop activities than to continue running them, but providing resources to embedded and support on-going citizen science is essential.

Figure 5 Why citizen science (a) is and (b) is not as suitable for environmental monitoring based on categorisation of text responses. For main categories: N = number of respondents



5.6 Part 4: Information collected about citizen science (CS) activities

In the third part of the survey, respondents were asked about the information that their organisation collects on citizen science activities. The topics addressed were:

- Participants: number of participants, time given by participants retention rates;
- Outcomes: use of data, impacts on participants and communities;
- Costs: promotion and recruitment, equipment, participants' expenses;
- The value of participants' own equipment;
- Staff costs: developing a citizen science activity, supporting participants;
- IT costs: setup and development, on-going running costs.

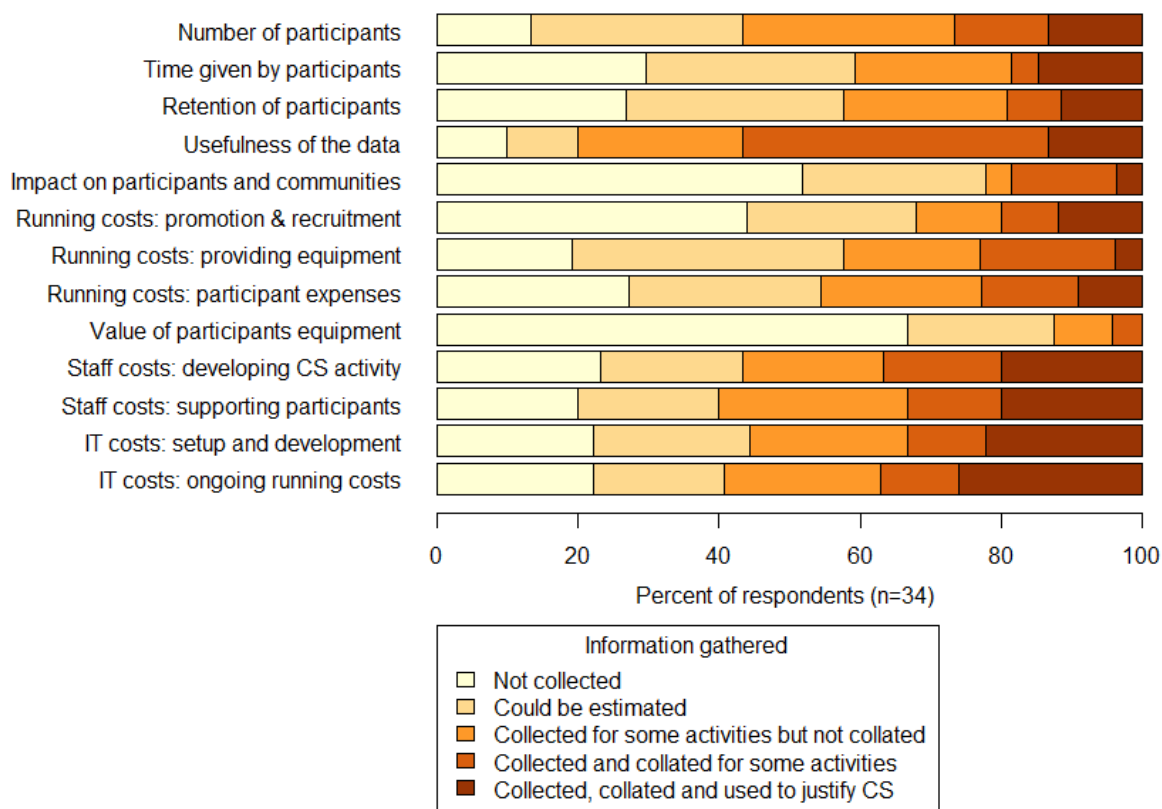
These include costs that can be quantified in monetary terms (such as IT costs, equipment costs or staff time), benefits that can be converted into monetary value (such as volunteers' time) and impacts that are important but difficult to quantify in monetary terms (such as the usefulness of the data, or the impact on participants and their communities). In each case, respondents were also asked to score the extent to which information is collected, collated and used to help justify citizen science within the organisation.

Key findings

- As with other questions in this survey there was much variation in the responses (Figure 6). Although information on evaluation of citizen science is often collected or can be estimated, it is not often used to justify the use of citizen science.
- The direct costs to the organisation in terms of staff and IT costs tend to be relatively well evaluated (presumably because these are relatively easy to assess) but running costs are less frequently evaluated. It is important to assess running costs because this provides an evidence-base for decision making about citizen science.
- Information on the number of participants is often collected but their contribution of time or retention in the project is less frequently assessed. Knowing this is important to design suitable citizen science projects which provide the data required.
- The usefulness of the data is almost always evaluated, although surprisingly this information is rarely then collated across the organisation and used to justify the use of citizen science.

- The impact of the activity on participants and communities is rarely assessed even though this is an important aspect of citizen science.

Figure 6 The types of information gathered about citizen science in public bodies. These responses exclude respondents who said they did not know the answer



5.7 Limitations of the survey

This is the first national survey of citizen science in the public sector and so provides a unique resource for considering the opportunities and threats to citizen science in the public sector in the future. However, only one or two people responded from most of the organisations and where more people responded from one organisation they provided different responses. This may be because people's knowledge is only partial, or because individuals have different experiences, responsibilities or interests within the organisation.

There may have been bias due to the selection of respondents, i.e. based on their willingness to fill in the survey. It is difficult to predict *a priori* whether this could have influenced the results: the subset of people who took part in the survey may be overly optimistic (because they have enthusiasm for the opportunities of citizen science) or pessimistic (because their hopes for citizen science are not being met). However, they are also likely to be among the best informed about citizen science in their

organisation, so best placed to give an accurate overview. Variation in the responses when considering specific environmental attributes may be due to individual variation, but it may also be due to individuals representing different organisations, and so the variation reflects the remit and practice of different organisations (e.g. commissioning versus carrying out monitoring).

5.8 Conclusions and recommendations

The survey shows, for the first time, how well embedded citizen science is in the UK public sector and how it is used for environmental monitoring. A repeat of this survey in the future may help to determine whether organisations have advanced in their support for citizen science.

We recommend that advocates and senior managers within public organisations involved in environmental monitoring use this framework (Table 2) to undertake periodic self-assessments and explore how citizen science could be supported. An organisation in which citizen science is well supported is likely to result in best, and most appropriate, use of citizen science to achieve the goals of data collection (for environmental monitoring) and for public engagement with the organisation, its goals and its science.

The least embedded aspect of citizen science in this survey was its evaluation. Effective evaluation will inform practice, and so it is important that this is carried out. Evaluation should be at the level of the organisation, as well as at the level of the activity, in order to prioritise resources and provide an evidence-base for strategic support of citizen science. Evaluation can be carried out when developing an activity (formative evaluation) and at key points during the activity (summative evaluation) (Research Councils UK 2011; Tweddle et al. 2012). Evaluation in citizen science requires a multifactorial approach, because both the data and public engagement aspects of the citizen science should be evaluated (see the Multi-Criterion Analysis in Task 3). Currently a tool for formative evaluation of the costs and benefits of citizen science is lacking, hence the relevance of this current project and the production of the Operational Tool (Task 2 and 3, and Appendix A).

One of the most important barriers to using citizen science was the loss of control in the monitoring and potential reduction in data quality. Moving from monitoring entirely by professionals to monitoring via citizen science carries risks and so it is proper to view this as a concern for those within organisations charged with this responsibility. Piloting such citizen science activities and critically evaluating them can provide a stronger evidence base for making decisions about whether and how to implement citizen science within an organisation's monitoring. Running existing monitoring and undertaking pilots can be costly in the short term, even though it can lead to cost-efficiencies in the future. By developing citizen science the organisation relies upon the commitment of volunteers.

Even though some of these environmental attributes do not have a long history of being monitored by volunteers, it was striking that few respondents considered that perceived lack of interest was an important barrier. It is vitally important to consider recruitment and retention of volunteers within the overall evaluation of citizen science for environmental monitoring.

6. Review of methodologies for valuing the contribution of citizen science

6.1 Introduction

As previously noted, the possible use of citizen science for environmental monitoring in the UK has moved beyond supplementing the existing efforts and may now extend into providing core monitoring activities. In order to determine whether a business case can be made for use of citizen science there is a need to objectively assess the benefits of using citizen science in light of the full range of financial costs of doing so (Graff, 2006). There are a number of costs and benefits associated with citizen science which must be captured in the evaluation method. First, these need to be comprehensively identified; then quantified; and then they can be valued (in monetary terms where possible). The costs and benefits can be either direct or indirect, and potentially spread across different stakeholders. A number of methods exist which quantify the benefits and costs to organisations of using volunteers, (such as the Volunteering Impact Assessment Toolkit developed by the Institute for Volunteering Research). However, it is best practice within government departments and agencies to adhere to HM Treasury guidance (i.e. the Green Book) when undertaking evaluations of policies, projects and programmes. Therefore, this section of the report reviews the range of options available for evaluating the use of citizen science for environmental monitoring.

6.2 Scope

This review summarises and categorises existing methodologies, discusses their strengths and weaknesses, and assesses their applicability (usefulness) for evaluating the contribution of citizen science to environmental monitoring. In order to determine the current knowledge base in relation to the methodological options available for evaluating the use of citizen science a comprehensive search of the literature was undertaken. Google and Google Scholar were used with the following search terms:

- methodology for valuing contribution citizen science
- evaluation of citizen science involvement
- citizen science evaluation
- multi criteria analysis / costs benefits citizen science
- economics citizen science
- volunteering valuation methodology
- costs benefits volunteer
- investing volunteering
- economics of volunteering
- crowdsourcing / crowd science value
- costs benefits crowd science
- costs benefits of use amateur scientists
- amateur scientists valuing
- monitoring the environment

-
- evaluation of monitoring

Note that variations on these were also used.

After sifting through around 80 potential sources based on the returns from the literature search, around 20 relevant documents were identified (see Appendix A). The other documents found either contained very similar (or less) material, or looked at valuing volunteering from other perspectives (i.e. national economy or the individual) which did not fit with the requirement for this project. No previous systematic reviews of methodologies for assessing the value of using citizen science for environmental monitoring were found. However, most volunteer assessment reports contain a brief outline of the alternative valuation options available (e.g. Ironmonger, 2011). The following review of methodologies references the documents in the Annex, where appropriate, but also builds on the knowledge of the project team.

The methods are brigaded under the following headings:

- the benefits of citizen science,
- the costs of citizen science,
- financial analysis,
- economic analysis and
- multi-criteria analysis.

It should be noted here that a fully qualitative analysis of the value of citizen science for environmental monitoring would also be possible. However, such an approach would not meet the requirements set out in the project terms of reference (because it is very difficult to compare qualitative values and the financial values would not be quantified), and so an analysis of qualitative methods has not been undertaken here. There are likely to be very few, if any, instances where a purely qualitative analysis would be sufficient for decision-making purposes across the broad spectrum of citizen science activities (i.e. both within and outside of environmental monitoring).

6.3 The benefits of citizen science

For environmental and conservation agencies, citizen science offers a number of benefits, the main one being the opportunity to collect data at a lower cost (freeing up funds for other activities, collecting additional data, or enabling the collection of data to continue into the future under tighter budget constraints). Citizen-based monitoring programmes can also increase public awareness of conservation issues (Gommerman and Monroe, 2012). This can be viewed as a benefit to agencies, firstly through the mandates of some agencies in terms of engaging the public, and secondly since a public educated in environmental issues may be more likely to adopt pro-environmental behaviours and act to prevent illegal environmental activity. Working with volunteers might also improve staff morale (Salamon et al., 2011). An additional, indirect, benefit to agencies is that those engaged in citizen science activity might be expected to support the work of the bodies with which they have volunteered (though as yet there is

no published evidence of this). From the individual volunteer perspective, citizen science offers a number of benefits, such as opportunities to socialize and enjoyment of the activity (these latter being the main benefits from environmental volunteering in England (Ockenden, 2008)). It also allows for a meaningful engagement with scientific research for non-scientists, acquisition of skills (Stepenuck and Green, 2015) and gaining leadership and problem solving skills (Wilson & Hicks, 2010), feelings of doing something worthwhile (i.e. 'giving something back') and a connection with nature or their local environment (Belluci et al., 2014). These well-being benefits can have a significant value (Handy and Srinivasan, 2004). There are also a number of wider societal benefits (Jordan et al. 2012), such as community-building and increased general environmental awareness amongst the population.

The main benefits are listed below, categorised by beneficiary:

Organisation:

Why numbered?

- Better data:
 - wider spatial coverage
 - longer temporal datasets
 - rapid response data
 - 'latent' detection of rare events
 - new datasets to improve policy-making
- Awareness-raising of specific issue (and reporting of illegal activities)
- Meeting agency mandate for engaging the public (where applicable)
- Possible improved agency staff morale
- Increased support amongst the public for work of agencies
- Financial savings from use of citizen science (which could be invested in other research/activities)

Volunteer:

- Opportunity to socialise/connection with local community
- Meaningful engagement with scientific research and increased education and skills (hence job opportunities/social mobility)
- Health benefits (reason/motivation to be physically active)
- Well-being benefits:
 - enjoyment of activity
 - feelings of doing something worthwhile
 - connection with nature or local environment

Wider society:

- Increased general environmental awareness amongst the population (multiplier effect of volunteers' social interactions with colleagues, friends and family)
- Improved scientific knowledge in society (through the volunteers directly, and possibly through publication of data or findings in the media)

-
- Use of data to secure additional funding to do research by other organisations (developing the UK science base)
 - Community-building / social cohesion
 - Improved environment as a result of using the knowledge gained from the monitoring to implement policies that deliver desired outcomes

6.3.1 Measuring the benefits of citizen science

Some of these benefits are relatively simple to measure, such as cost savings to organisations; others are much harder to quantify (e.g. volunteer well-being benefits). Quantification of the benefits could involve collecting evaluation data on:

- Size and quality of citizen science databases
- Numbers of papers published in peer-reviewed journals using these data, numbers of citations of results, numbers of graduate theses completed using citizen science data.

In terms of public engagement metrics could include:

- Number of volunteers
- Numbers of visits to citizen science project web sites
- Number of media items based on citizen science results.

In terms of improved volunteer education/skills/understanding this may require use of a questionnaire:

- Participant survey scores (i.e. improved participant understanding of environmental science and the scientific process, better participant attitudes toward the environment, increased participant interest in environmental science as a career).

Most of the above would not be able to be monetized, and so would only be of use in a multi-criteria analysis (i.e. rather than a cost-benefit analysis) and would be difficult to estimate before the instigation of the citizen science activity. An evaluation of these types of benefit can help to prioritise those of most importance.

6.4 The costs of citizen science

The adoption of citizen science for environmental monitoring is not without costs for the organisation using these volunteers (Graff, 2006). For example, detailed co-ordination and briefing may be required, as well as modification of IT system interfaces in order to accommodate data entry by volunteers (which may be remotely). These additional costs to agencies can partly negate the potential financial savings from adopting citizen science programmes. However, these costs will vary on a case-by-case basis. Therefore, the main additional costs are identified as follows:

Data related costs:

- Validation costs (quality assurance/data verification)
- IT systems for data collection (and feedback of results) in excess of current systems, and/or IT licensing or interface modification costs
- Missing data (both in terms of spatial coverage, when volunteers cannot be recruited in some locations, as well as temporal gaps, when volunteers do not undertake the data collection occasionally, for example due to ill-health, transport difficulties, having other commitments, or an unwillingness to go out in inclement weather)

Staff costs:

- Citizen science project planning
- Volunteer administration and support (including office expenses and meetings)
- Volunteering Coordinator and providing feedback
- Induction and training
- Extra staff costs related to special needs volunteers (e.g. support worker)

Other costs:

- Advertising and recruitment
- Insurance
- Supplies and equipment, including personal safety equipment such as a mobile phone and first aid kit (though some of this may be provided by the participant and some may already be required to be provided for staff/contractors anyway)
- Expenses (reimbursing travel and other actual out of pocket volunteer expenses, though these might be off-set by the existing staff travel expenses related to the monitoring)
- Volunteer uniform/badge

Sometimes allocation of costs will not always be clear-cut. Some costs will not have been separately identified, for example costs of buildings that are partly used by volunteers. However, if no additional costs are incurred and the building would otherwise have not been fully utilised then it is arguable whether any cost should be included in its use for citizen science. Costs should be comparable across both the 'business as usual' (BAU) scenario as well as the 'citizen science monitoring' scenario.

For citizen science projects the recruitment and training costs can be considerable, especially if undertaken repeatedly due to volunteers dropping out or through expanding the project. Start-up costs are normally relatively fixed, i.e. they are similar regardless of the project size (training a class of 25 people will likely cost little more than a class of 5 people, or at least will have a lower additional cost for each extra attendee). Variable costs are often low (at least for projects where volunteers require little supervision or post-monitoring debriefing); this means that few new costs are added whether volunteers go out once or 100 times (apart from any reimbursement of travel expenses), which provides an economy of scale when utilizing citizen scientists (Fauver, 2015).

6.5 Financial analysis

The objective of a financial analysis is to assess the financial viability of a proposed plan of action or project (i.e. determine the 'bottom line', the difference between the financial costs and benefits from the perspective of the entity involved). It therefore focuses on the financial benefits and costs to the organisation attributable to the proposed intervention (in this case, implementation of citizen science for environmental monitoring). It should be noted that the results of such an analysis provide only a guide to decision making and should not be used as the sole basis to make operational decisions. There will also need to be consideration of the practicality of the project, risks, and the time distribution of the resources required (e.g. does it have large up-front investment costs which would be difficult to realise).

It is important to start with setting the 'base' or 'reference' case against which to compare the alternative scenario of adoption of citizen science. The base case is a 'do-nothing' or 'business as usual' (BAU) scenario which represents the current state of affairs and provides the benchmark against which the proposed citizen science scenario is measured. Each citizen science scenario will lead to variation in the potential benefits that can be achieved.

6.5.1 Replacement Value

A larger, volunteer, work force can increase the extent and amount of data collected, potentially at a reduced cost per record. Thus, it is the labour cost component that offers the largest potential financial saving. The simplest method adopted to assess this benefit is to use the following formula to calculate the value of volunteers' time (ILO, 2011):

$$\text{Number of volunteers} \times \text{average number of hours} \times \text{average hourly wage}$$

To calculate the hourly wage two different approaches are possible: (a) use the gross average wage (national or local) from the Annual Survey of Hours and Earnings (available on the Office for National Statistics website), or (b) estimate the going wage rate for that work (agency staff or contractors). This generates the simplistic "replacement value".

In the replacement value method, an organisation is estimating their "avoided costs." A more sophisticated approach to the replacement value method applies different hourly wages to individual volunteers, depending on the type of work that is involved (Gaskin and Dobson, 1997) (ONS figures are available for specific professions in the UK; in the US a tool, Economic Impact Of Volunteers Calculator (See: <http://www.handsonnetwork.org/tools/volunteercalculator>), provides a drop-down list of job titles which provide hourly rates, which could be replicated for the UK). In addition, the employer overhead costs (national insurance, pension contributions, as well as adjustments for non-working days, i.e. holidays) can also be included. Although this approach often leads to more accurate estimates of the value of the saving from using volunteers, it may not be practical, since determining individual comparable market value hourly wages and overhead costs for all of the volunteer roles could be time (hence resource) intensive for organisations when citizen science involvement extends beyond one role (such as data collection). Though for monitoring work currently undertaken by staff or contractors, such data should be readily available.

The replacement value method is generally viewed as the easiest way to ascribe value to volunteer efforts. However, an implicit assumption of the replacement value approach is that the output quantity and quality from x hours of a volunteer is equal to the same number of hours from paid employment. In practice this may not be the case (Cordery et al., 2011). Therefore, such an approach has the potential to over-value volunteers' time. On the other hand, it can be argued that the replacement value method only partially estimates the value of volunteer contributions (since it does not attempt to account for the social impact of volunteer activities). In addition, the financial cost to the organisation of using volunteer citizen scientists also needs to be assessed in order to estimate the *net* value of volunteer contributions. Often these costs are ignored in volunteer evaluations that use the replacement value method, giving no indication of whether use of volunteers is cost-effective. Therefore, given the above limitations of the replacement value method, it can be classified as a simple but very limited evaluation methodology (though it could be of use as an initial screening method).

6.5.2 Volunteer Investment and Value Audit (VIVA)

One approach that incorporates both the financial benefits and costs is the Volunteer Investment and Value Audit (VIVA). This is a 'return-on-investment' (ROI) approach to estimating the value organisations receive from their investment in volunteers. The financial value of volunteers to the organisation is estimated using the replacement value outlined above. This value is then divided by the total financial cost to the organisation of supporting these volunteers (i.e. the costs of the citizen science activity). The VIVA ratio thus calculated is seen as the notional ROI, i.e. the value returned on each pound invested in volunteers (Gaskin, 2011). A VIVA toolkit is available for organisations to use: [http://www.ivr.org.uk/images/stories/Institute-of-Volunteering-Research/Migrated-Resources/Documents/V/VIVA-bulletin-\(second-edition\).pdf](http://www.ivr.org.uk/images/stories/Institute-of-Volunteering-Research/Migrated-Resources/Documents/V/VIVA-bulletin-(second-edition).pdf)

A criticism of this method is that the VIVA model does not examine the efficacy of the volunteer, i.e. their ability to accurately collect the data (which will be partly related to the organisational cost). Therefore, a higher VIVA ratio for a proposed citizen science activity can be attained by cutting back on infrastructure, training and support for the volunteers. To address this, the model would need to be extended in order to include an evaluation of the quality of the citizen science monitoring outputs that would result from the different organisational costs (or aspects of these). This might be achieved by benchmarking against professionals, or taking into account the amount of data validation required. If the quality of the output from citizen science can be maintained whilst the VIVA ratio increases, then this reflects real improvements in the efficiency of the citizen science activity.

6.5.3 Limitations of financial analyses

Meaningful comparisons on the basis of finances alone are problematic for a number of reasons. A financial analysis approach does not align well with an outcomes-based evaluation, since it ignores many other important values. Volunteering has impacts on volunteers themselves, on the organisations through which the activity is organised, and also on the quality of life more generally in their communities. Values from a financial analysis only tell part of the story as they do not include the wider economic, social, cultural and environmental costs and benefits. As HM Treasury (2003) Green Book notes: "Costs and benefits that have not been valued should also be appraised; they should not be

ignored simply because they cannot easily be valued. All costs and benefits must therefore be clearly described in an appraisal, and should be quantified where this is possible and meaningful.” This suggests that other, more comprehensive, approaches to valuation are required.

6.6 Economic analysis

There are a number of ways to account for the impact of non-financial outputs on society that are attributable to citizen science. Within an economic analysis a monetary value is assigned to each output. An economic analysis refers to statements of value which are made in monetary terms, but not limited to financial values. Use of monetary terms does not imply that all values can be simplistically reduced to money. It does, however, recognise the universality of money as a medium of exchange, and allows more/most of the costs and benefits to be included. Therefore, in contrast to the replacement value method discussed above, an economic analysis attempts to consider the social impact of volunteer effort in addition to simply calculating their hours worked. As such it can help to indicate the organisation's ROI where a fuller range of outputs is being considered beyond simply the financial gains to the organisation.

6.6.1 Cost-Benefit Analysis (CBA)

The volunteering literature is full of examples of approaches to valuation that consider different aspects of the problem of estimating the true worth of volunteering. The challenge is to integrate the diversity of values into a coherent framework; cost-benefit analysis comes closest to satisfying this criterion. A cost-benefit analysis (CBA) differs from a financial evaluation in that it considers costs and benefits to society as a whole, rather than just to the organisation, as well as non-cash costs and benefits. The costs and benefits are summed in order to determine whether the costs or benefits predominate. ‘Stated preference’ studies can be used when the value to a consumer is not directly observable in the market, so a ‘contingent valuation survey’ (or some other method, such as ‘choice experiments’) can be used to elicit a consumer’s willingness to pay by asking the respondent to state it directly (Bateman et al., 2002).

The well-being benefits that volunteers gain from their volunteering activity can be valued using various approaches, e.g. Well-Being Valuation approach (Foster, 2013). In one study it was estimated that on average volunteers would require £2,400 a year in compensation for forgoing their volunteering activities (i.e. the value of the well-being they get from volunteering) (Haldane, 2014).

If being undertaken by a government department or public sector agency, the approach used should follow the HM Treasury (2003) ‘Green Book’ guidelines for conducting a cost-benefit analysis. A key challenge for such an analysis is often the uncertainty around some benefits as a result of limited data availability. Collection of these data (e.g. through ‘stated preference’ studies) can be expensive. Alternatively, values from the published literature can be used instead, with ranges in the key benefits being adopted in order to gain a sense of the possible magnitude of these benefits in different circumstances. Further analysis to identify the key parameters that affect the net benefits is recommended as part of the cost-benefit analysis process.

In developing a cost-benefit analysis the time horizon and the discount rate are key elements. The values in a cost-benefit analysis are defined as the sum of the costs or benefits over a fixed period of time (e.g. a 10-year evaluation period). The evaluation period adopted in the analysis should reflect the life-span of the citizen science project. Having valued the costs and benefits (given current knowledge and information), the costs and benefits are then aggregated over a defined time period (as mentioned above), and then brought back to a present value using an appropriate discount rate (the Green Book recommends that costs and benefits occurring in the first 30 years of a programme, project or policy be discounted at an annual rate of 3.5%).

The performance indicators most widely used to evaluate the results of a cost-benefit analysis are the Net Present Value (NPV) and the Benefit Cost Ratio (BCR). The NPV of a projected stream of costs and benefits is estimated as the summation of the difference between the annual discounted costs and benefits of a project over the period of analysis. This is calculated as:

$$NPV = \sum_{t=0}^T \frac{1}{(1 + \alpha)^t} (Benefits_t - Costs_t)$$

Where $\frac{1}{(1 + \alpha)^t}$ is the discount factor (and α is the discount rate).

The basic decision criterion is that the NPV of the project should be positive. The BCR attempts to identify the relationship between the costs and benefits of a proposed project. It measures the amount of benefits received for every pound spent. It is estimated as:

$$BCR = \left(\frac{\text{Sum of discounted benefits}}{\text{Sum of discounted costs}} \right)$$

A project is deemed acceptable for investment or implementation if the BCR is greater than or equal to unity (and rejected otherwise). Hence if the ratio is greater than one, the benefits outweigh the costs. The Net Present Value and Benefit Cost Ratio of the citizen science option can then be compared with Business As Usual in order to determine the relative economic gains or losses that adoption of citizen science monitoring would bring. However, it is nearly impossible to ascribe a market value to all of an organisation's social outputs resulting from citizen science, especially as one considers the more intangible benefits (such as building social cohesion) which have no complement in the market place and where stated preference studies or other valuation approaches are not feasible. Thus, as the results of the analysis involve using benefit data that are subject to a degree of uncertainty, it is not appropriate to rely on a single value. Sensitivity analysis can be used to calculate the effect on NPV and BCR of altering the value of key variables. Scenarios can be developed to determine a range of different values for these key variables. Sensitivity analysis can be applied to highlight those input variables for which a change in their value has a significant effect on the overall result (so using this approach the critical variables can be identified).

The main problem associated with use of cost-benefit analysis is that it will favour options where benefits are able to be monetised. Where values have not been monetised they are effectively ignored. A further issue is in relation to distribution of costs and benefits, though this can be overcome by identifying shifts in social value (e.g. from taxpayers on to volunteers if equipment and travel costs are largely borne by the participants). A further criticism of cost-benefit analysis is that it is often based on complex assumptions (e.g. future prices) and hence likely to be inaccurate due to the inherent uncertainties.

6.6.2 Cost-Effectiveness Analysis (CEA)

A key aspect when considering whether to use cost-benefit analysis is determining the counter-factual, i.e. what the citizen science option is being compared against. If the counterfactual is that the monitoring/data collection is mandatory, then the alternative to citizen science engagement is either to use agency staff or to use contractors for this work. Cost-effectiveness analysis (CEA) is an alternative to cost-benefit analysis. It compares the relative costs to the outcomes (effects) of two or more courses of action and is most useful when the outcomes are the same or where there are constraints which prevent the use of a cost-benefit analysis. Therefore, if the organisation has a mandatory requirement to collect data (but no interest in the wider social benefits associated with use of volunteers) then in this situation the alternatives (i.e. agency staff or contractors) must be compared with use of citizen science in order to determine which is the most cost-effective. However, if the counterfactual is that the monitoring/data collection is optional, and there is insufficient budget for agency staff or contractors to undertake the work, then an analysis of the costs and benefits is required (i.e. cost-benefit analysis) in order to determine whether the costs of utilising citizen science are out-weighed by the benefits of the information gathered (and any other benefits deemed of importance to the organisation).

Further, where the outcomes can be quantified but not monetised, cost-effectiveness will be more appropriate (for example, comparing two options that provide the same skills benefits, but for different numbers of volunteers). However, where varying outcomes across multiple factors exist (e.g. different quantities *and qualities* of skills benefits) then a cost-effectiveness analysis will not deliver a single metric that can be used to rank options (i.e. further judgements/qualitative assessments will be required in order to determine the preferable option. This is explored further below).

6.6.3 Social Return on Investment (SROI)

Another approach is the social return on investment (SROI) methodology, which extends ROI to include social impacts. It has also been used to assess volunteering (Belluci et al., 2014), and SROI ratios can be used to evaluate alternative options. Although social return on investment draws from cost-benefit analysis it was developed from an accounting perspective and requires stakeholder involvement and verification. As such it is not deemed particularly useful for this project. Note that by accepting the relevance of economic value, this does not mean that the organisation is disqualifying other forms of valuation, quantitative or qualitative. Economic analyses can be used alongside other evaluation approaches, one of which is multi-criteria analysis.

6.6.4 Other economic approaches

When looking more widely at approaches for valuing alternative actions, the analytical methods used within the private sector largely fall within the cost-benefit analysis approach outlined above (specifically discounted cash flows). These have been adapted to varying degrees in order to help evaluate investment choices, and include: the fuzzy pay-off method for real option valuation (FPOM) and related Datar–Mathews method, both of which are methods for valuing real options; as well as applied information economics (AIE), which is a decision analysis method. However, adoption of them for assessing the value of utilising citizen science in this project is deemed unsuitable because of their mathematical complexity. This would create a ‘black box’ approach rather than the transparent framework requested.

6.7 Multi-Criteria Analysis (MCA)

Multi-criteria analysis (MCA) describes any structured approach used to determine overall preferences among alternative options, where each of the options results in outcomes with multiple objectives or attributes (DTLR, 2001). Multi-criteria analysis requires that a number of evaluation indicators are identified. Unlike a cost-benefit analysis, the measurement of indicators need not be in monetary terms (i.e. recognition is given to the fact that a variety of both monetary and non-monetary objectives may influence policy decisions), but they are often based on quantitative analysis (ETR, 1999). Thus different environmental and social indicators may be developed alongside costs and benefits (DTLR, 2001). Even though a variety of indicators are used, MCA provides techniques for comparing and ranking different outcomes. It is particularly applicable to cases where a single-criterion approach (such as cost-benefit analysis) cannot be used, especially where significant environmental and social impacts cannot be assigned monetary values.

Multi-criteria analysis can be relatively easy to use, depending on the particular multi-criteria tool employed (DEFRA, 2003), and does not require specialist knowledge (e.g. economic skills to undertake a cost-benefit analysis). The choice of appropriate multi-criteria technique will require some expertise, but this can be acquired fairly easily. However, the final evaluation of a multi-criteria analysis output will rely on the exercise of some expert judgment. There do not currently appear to be any examples of MCA being used as a decision-making tool for evaluating use of volunteers.

6.8 Qualitative approaches

The above analysis has been limited to a small number of approaches which are largely quantitative in nature. This is not to say that qualitative discourses of the value of volunteering are irrelevant, indeed the volunteering literature generally prefers qualitative analyses to the language of economics (Studer and Schnurbein, 2013), claiming the latter is inadequate in describing the value of their activities. A number of evaluation toolkits for assessing volunteering exist (e.g. the Volunteering Impact Assessment Toolkit and the Cornell Lab of Ornithology toolkit of resources for helping project leaders measure participant outcomes), whose strength is the combination of quantitative and qualitative findings. They help organisations to assess the impact of volunteering on all key stakeholders (volunteers, the organisation, the beneficiaries and the broader community). However, they are designed for post-implementation evaluation, rather than assessing the option to use volunteers.

6.9 Conclusion

Based on this review of the literature, none of the valuation methods previously discussed on volunteering should be rejected outright. They will be applicable in differing circumstances. The main benefits and constraints of the valuation methods are summarized in the next section, when a framework is proposed for organisations to evaluate the value of citizen science for environmental monitoring purposes.

7. A method for agencies to quantify value

7.1 Summary of approaches

The main strengths and weaknesses of the evaluation approaches identified in the previous section are summarized in Table 4 in order to assess their suitability for evaluating the use of citizen science for environmental monitoring from a financial or wider economic perspective². The table lists each approach, identifying the associated strengths and weaknesses, and indicates where formal guidance in implementing the approach exists.

Table 4 The strengths and weaknesses of the evaluation approaches

Approach to evaluation (and metric)	Strengths	Weaknesses	General formal guidance
Financial Analysis			
Replacement value (i) (£, gross average wage)	Simplest approach (i.e. just looks at payment for time) requiring no specialist knowledge & quick to undertake; Limited data requirements; Gives indication of gross savings that may be broadly correct on average.	Inaccurate results where roles are significantly different to average wage levels; Does not consider overheads; Does not consider costs of using volunteers; Does not consider wider benefits (e.g. improved volunteer skills or well-being). Assumes the quantity of outputs per person (work rate) will be the same as paid staff. Does not take account of quality of outputs.	http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_167639.pdf
Replacement value (ii) (£, specific going rate including employer overheads)	Gives a much more accurate indication than simple replacement value of gross savings from using volunteers; Not much more difficult to undertake, as still simple approach.	Requires wage data relating to specific jobs/work; Does not consider costs of using volunteers; Does not consider wider benefits (e.g. improved volunteer skills or well-being); Assumes the quantity of outputs per person (work rate) will be the same as paid staff. Does not take account of quality of outputs.	
Return On Investment (i) (VIVA ratio, £ per £)	Still a simple conceptual approach; Can use specific going rate for work including overheads; Also considers costs so that the net savings from the use of volunteers can be estimated;	Requires additional data on costs (which may not be fully known so have to be estimated); Assumes the quantity of outputs (work rate) will be the same as paid staff.	

² A financial analysis uses market prices as they relate to the organisation, whilst an economic perspective includes values which do not have market prices and draws the boundary of analysis beyond just the organisation.

Approach to evaluation (and metric)	Strengths	Weaknesses	General formal guidance
		Does not take account of quality of outputs; Does not consider wider benefits (e.g. improved volunteer skills or well-being).	http://www.ivr.org.uk/images/stories/institute-of-Volunteering-Research/Migrate-d-Resources/Documents/V/VIVA-bulletin-(second-edition).pdf
Return On Investment (ii) <i>(Adjusted VIVA ratio, £ per £)</i>	Improves accuracy over the simple Return On Investment approach; Makes adjustments for the quantity of outputs (work rate); Can also factor in the quality of work outputs from volunteers.	Requires data on average volunteer work rate where performing the same task (or assumptions on how the quantity of output per volunteer differs from staff); Where there are quality differences these are reported in qualitative terms as it is difficult to adjust the ratio thus making comparisons difficult; Does not consider wider benefits (e.g. improved volunteer skills or well-being).	
Economic Analysis			
Cost-Benefit Analysis <i>(NPV £, Benefit:Cost Ratio)</i>	Consistent for all options; Single, quantitative aggregate measure; Measures all differences in costs and benefits (in theory); Factors in time value (via 'discounting'); Transparent framework, the theory of which is relatively simple to understand; Recommended by HM Treasury for project assessment (as contrasted with cost-effectiveness analysis).	Discount rates (see previous chapter) used can give very different results; The difficult to quantify factors are excluded from valuations; Even though the framework is transparent the analysis can still contain 'hidden' assumptions (or value judgements), e.g. equity; Complex and costly procedures used to obtain some valuations (can introduce inaccuracy); Potential to misinterpret the results (over-reliance on a single value).	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf
Cost-Effectiveness Analysis <i>(PV £)</i>	Can include both quantitative and qualitative aspects within the measures of effectiveness; Identifies most efficient option where benefits are difficult / impossible to value; Requires less data than CBA and is simpler to undertake.	Only as valid as its underlying measures of effectiveness; Primarily an approach to evaluating competing similar options; Does not value benefits so cannot provide a measure of the net gain (i.e. benefits minus costs); Cannot be used where options have different scopes (i.e. incomparable outputs).	Mainly used in health care where most formal guidance exists. Example of non-clinical use: http://eprints.white.rose.ac.uk/3529/1/Hulme2006using_cost_eff.pdf
Social Return On Investment <i>(social ratio, £ per £, as well as a narrative)</i>	Includes all economic values where possible; Systematic way of also incorporating wider values; Accepts there will be non-linear processes and multifaceted background situations; Can gain greater buy-in for decisions (from stakeholders); Increasing use in relation to volunteering.	Quantitative output should not be used for decision-making on its own; Can be difficult to assess the narrative output element; Requires Theory of Change to identify all stakeholders; Additional costs of engaging stakeholders in the evaluation process.	https://www.bond.org.uk/data/files/Cabinet_office_A_guide_to_Social_Return_on_Investment.pdf

Approach to evaluation (and metric)	Strengths	Weaknesses	General formal guidance
Real Options Analysis (<i>option value £</i>)	Includes the value of flexibility (or delay) that a course of action provides; Allows for better analysis where there is great uncertainty; Helps differentiate between options where the net present value is marginal.	Additional analysis steps involved; Complex mathematics create a 'black box'; Not required where there are low levels of uncertainty; Very limited previous use in the public sector.	https://www.ofgem.gov.uk/sites/default/files/docs/2012/03/real_options_investment_decision_making.pdf
Multi-Criteria Analysis			
Multi-Criteria Analysis (<i>weighted score</i>)	Can include economic values as well as other quantitative and qualitative data, so more comprehensive; Can engage stakeholders in the process; No technical skills required for undertaking the basic process.	Has numerous criteria and indicators and so requires application of a weighting to derive a single metric; Potential subjectivity and inconsistency as requires use of judgement; Risk of double counting impacts.	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7612/1132618.pdf
Qualitative Analysis			
Qualitative Approaches (<i>descriptive</i>)	Does not rely on quantifying impacts / reducing impacts to a single value; Can recognise, record and assess the full diversity of values.	Works better for post implementation evaluation; More subjective potentially leading to inconsistent evaluations; Collation of qualitative data and its analysis can be time-consuming and requires expertise.	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/67427/design-method-impact-eval.pdf

7.2 Assessment

It is assumed that the end users, i.e. those who will have to undertake the evaluation, are not experts in economics and have no experience of carrying out the analyses listed above. Criteria can be used to assess the above approaches. An assessment of these approaches is made based on the following criteria, where each of the criteria is given equal weighting:

- expenditure coverage (i.e. the extent to which all costs are included in the analysis);
- cost of implementation (i.e. how much resource would have to be devoted to producing an evaluation using the approach);
- recognition (i.e. validity based on how widely the approach is already used across public sector organisations for evaluation in general, not just in relation to volunteering);
- simplicity (i.e. how easy it is to undertake by a non-expert in the approach);
- transparency (i.e. how easy it is to understand the processes in the approach or the converse to which the process is a 'black box').

For each approach the performance against the above criteria is assessed and assigned a colour coding (red, yellow, or green) to reflect relatively poor, moderate, or good performance. The results are presented in Table 5 below.

Table 5 Assessment of performance of the evaluation approaches

Approach to evaluation	Expenditure coverage	Cost of implementation	Recognition	Simplicity	Transparency	Notes
Replacement Value	Red	Green	Red	Green	Green	Does not include the costs of using volunteers
Return On Investment	Green	Green	Yellow	Green	Green	Only suitable for financial values for organisation
Cost-Benefit Analysis	Green	Yellow	Green	Yellow	Yellow	Requires additional data (value of benefits)
Cost-Effectiveness Analysis	Green	Green	Green	Yellow	Green	Easiest approach that looks at wider benefits
Social Return On Investment	Green	Red	Green	Yellow	Green	Suited to evaluation not as a decision-making tool
Multi-Criteria Analysis	Green	Yellow	Green	Yellow	Yellow	Requires weightings, increasing subjectivity
Real Options Analysis	Green	Red	Red	Red	Red	Complex analytical approach for minimal gain
Qualitative Approaches	Yellow	Red	Yellow	Red	Yellow	No firm metrics, and time-consuming to implement

Note: green indicates where the evaluation approach would be expected to perform well and red indicates where it would be expected to perform badly; yellow indicates where the evaluation approach can perform well or badly depending upon the specific circumstances.

From this assessment the simplest and cheapest approaches with minimal data requirements are the Replacement Value and Return On Investment approaches. However, the former has very limited coverage (it does not consider the costs of using volunteers) and therefore does not meet the requirements specified for use in evaluating citizen science. Return On Investment may be adequate, but only where financial values are required (though if it is to be used then the more advanced version, (ii), is recommended).

Where coverage of the wider social benefits from using citizen science is required then one of the other approaches should be used. Of these, Cost-Effectiveness Analysis is the easiest to undertake. Cost-Benefit Analysis and the Social Return On Investment approach both produce an estimate of the net

gain (net benefit), but require additional data. Since the Social Return On Investment approach requires stakeholder engagement it can be more costly to implement than Cost-Benefit Analysis, which, although it can utilise surveys to gather data, can use existing benefit figures from previous studies instead. Social Return On Investment is better suited as an evaluation tool rather than a decision tool.

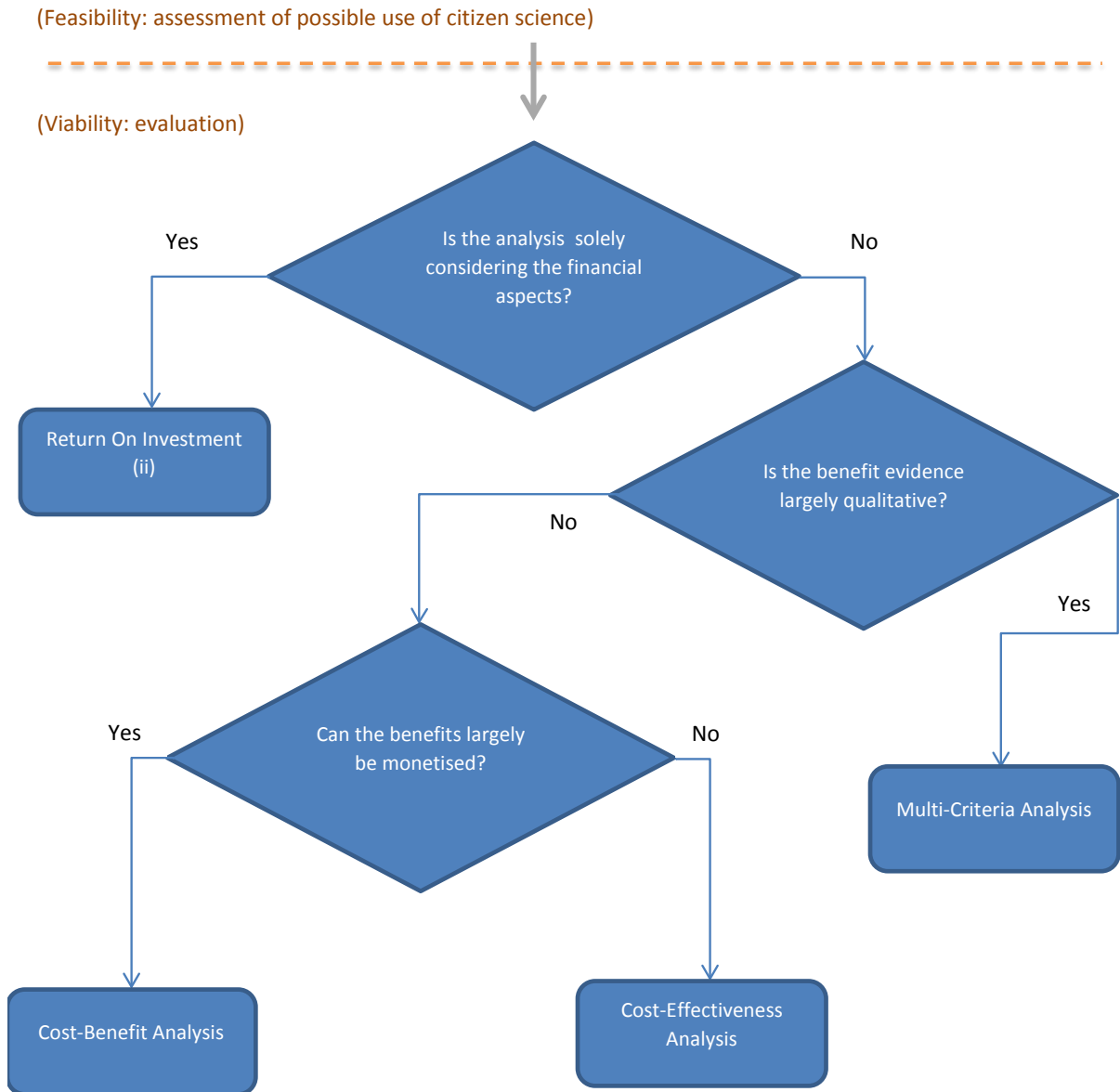
Real Options Analysis offers a marginal improvement in completeness over Cost-Benefit Analysis in some circumstances but is much more difficult and time-consuming to implement, so is not considered useful in this context. Likewise Qualitative Approaches also under-perform in a number of areas for application in the envisaged role.

Based on this analysis, the short-listed approaches for evaluation of the use of citizen science in environmental monitoring are:

- Return On Investment
- Cost-Benefit Analysis
- Cost-Effectiveness Analysis
- Multi-Criteria Analysis

Each of these provides a different type of analysis that may be suitable for specific circumstances, all of which may arise when evaluating the use of citizen science in environmental monitoring. Therefore, there is not a single methodology that will allow UKEOF partners to undertake a simple and proportionate assessment of the viability of citizen monitoring; rather, a framework can be devised that utilises all four approaches. This framework is outlined diagrammatically below:

Figure 7 Theoretical framework for evaluation of citizen science in environmental monitoring



Note that the above represents the evaluation approaches that are recommended for different situations. However, more than one evaluation approach could be adopted in order to obtain a fuller picture of the viability of using citizen science.

8. The tool

8.1 Outline

Whilst presented in the section 5 as separate methodologies, the theoretical framework can also be realised in terms of a single operational tool. As part of this project such an example tool has been developed in a spread-sheet format (detail of the tool along with screen shots of it can be found in Appendix A). The tool follows the theoretical framework but also includes some initial high-level screening questions (as requested in the requirements for this project). These are the screening questions, which are for assessing the feasibility of using citizen science:

1. Is the activity initiated in collaboration with potential participants?
2. Have you piloted the methodology with your target audience? Have you evaluated the results of the pilot and concluded that citizen science is a suitable approach?
3. Have you referred to best practice guides and existing citizen science expertise?
4. Have you defined your scientific aims? (e.g. a question to be addressed, or an environmental state to monitor)
5. Have you defined the number of records and coverage (over space and time) necessary for the activity to be successful?
6. Have you considered how you will assess the accuracy of the records?
7. Have you defined a target audience (with the required skills) and considered their motivations for taking part?
8. Have you defined the message/s that will be communicated through the activity? Have you concluded that a citizen science approach is more suitable than a communication campaign?
9. Can you commit resources for the life of the activity?
10. Do you have resources to evaluate the project: the quality and amount of data and the participants' experience?

The two main calculation worksheets, which follow the screening questions and set-up sheet, are the costs sheet and the benefits sheet. In the costs worksheet the user is required to enter information about the costs of using citizen science in the environmental monitoring project being assessed. The benefits worksheet is used to assess the different benefits from using citizen science. The financial aspects of these build upon the VIVA toolkit (Gaskin, 2011). The outputs summary worksheet contains

all of the results for each evaluation approach (where completed), namely Return On Investment, Cost-Effectiveness Analysis, Cost-Benefit Analysis and Multi-Criteria Analysis. The financial and economic analyses use relatively simple calculations to sum total costs and benefits and derive net figures (as required for the specific analysis). The MCA calculations are based on scores and weightings assigned to the different levels of benefits (see Appendix A).

8.2 Testing and refinement

The tool was developed within the project team and then tested with a number of potential end users. Initially this was viewed as a means of illustrating the tool with real examples. However, given the amount of time available and the need to explain certain elements of the tool with the end users, providing fully costed examples was not possible. The process with the end users instead focussed upon their understanding of what they were being asked to do and the clarity and layout of the tool. To this end the testing helped improve the clarity of the tool to make it more user-friendly. Comments were also received from the project steering group. Most of the comments from both the external organisations as well as the project steering group related to the wording used (and presentational aspects such as colour coding). Therefore, changes were made to try to make cell headings, questions, and explanatory notes in the tool clearer, as requested, along with the presentational aspects.

However, it should be noted that the tool is only in pilot form at this stage and requires further testing by the agencies to determine which analysis functions are of most use and where further refinements may be required. In addition the tool is currently in a simple MS Excel spread-sheet format to facilitate understanding of the calculation processes. In order to improve ease of use it would be beneficial to produce a more developed, interactive version of the tool (if resources allow).

Finally, it should be noted that the tool is not a 'black box' that is not intended to provide a single answer to the user. Instead, it allows (and encourages) the user to investigate different approaches to evaluation.

8.3 Case studies

A number of scenarios / case studies for testing the tool were suggested in the Interim Progress Report (January, 2016) that was subsequently discussed with the Steering Group. The suggested scenarios are reproduced in Appendix B. The discussion highlighted the need for case studies with good data sources but also in situations where only "rough and ready" information was available. Where possible the case studies should reflect the priorities of UKEOF partners and be completed in the time available – this led to Proposal 3 (Earth Observation Data Integration Pilot) being dropped as a potential case study. Initial approval from the steering group was forthcoming for Proposal 1 on monitoring the spread of oak processionary moth. Proposals 2 (non-native species initiative) and 5 (species surveillance) proceeded largely because of the willingness of key individuals to participate in the time available. A separate case study involving volunteers recording barriers in river courses was identified subsequently.

Each case study is briefly outlined below and the interview responses detailed in Appendix C.

8.3.1 Case study 1: Oak Processionary Moth outbreak management – monitoring spread

Oak processionary moth (*Thaumetopoea processionea*) is a major defoliator of oak in Europe. The larvae (caterpillars) feed on the foliage of many species of oak trees. They may pose a human irritant because of their poisonous hairs, which may cause skin irritation and asthma. A Defra funded oak processionary moth (OPM) control plan is currently being implemented. The main policy objective is to limit the rate of spread of OPM from existing known areas of infestation, and to suppress population levels within infested areas to limit the impact of OPM. Citizen science was included in the oak processionary moth 2016 control plan.

Activity plans include visual surveillance and pheromone trapping both of which could include an element of citizen science. The 2016 plan was to conduct a visual survey of trees known to be infested in 2014 and 2015, as well any within 100 metres of those trees. A visual survey of trees is planned for areas within 250 metres of pheromone traps in which more than five moths were caught in 2015. The visual surveys are planned to be collaborative exercises with others conducting their own surveys, and encourage wider surveys by others, such as Observatree, Woodland Trust and Tree Wardens, to look out for 'satellite' infestations.

8.3.2 Case study 2: Lowland heathland species surveillance – pilot study

Natural England has been exploring the feasibility of establishing and operating a national species surveillance network for lowland heathlands across England that could co-ordinate and support recording activity. This was motivated by the cultural and conservation value of lowland heath and that its quality is ultimately largely a function of the different kinds of species found there. Many species typically associated with this habitat are rare or rapidly declining. Effective national monitoring and surveillance programmes are necessary to understand their population status and trends. It was recognised that structured surveillance with volunteer recording communities was one potential approach to this.

Existing monitoring with volunteers has focussed upon species taxon-groups and also provided some multi-taxa sampling at the same locations. The research needed to go beyond this relatively narrow approach in order to enable reporting on the quality of habitats and to broaden the taxonomic scope beyond groups with a large pool of volunteers. Co-locating habitat and species surveillance offers the possibility of networks, with multi-taxa surveillance, using existing volunteers. It also has other potential advantages, such as the ability to relate habitat structure and quality to species changes, and to help understand the impacts of a series of environmental drivers.

8.3.3 Case Study 3: River Obstacles – smartphone app

The River Obstacles project is a joint endeavour by the Scottish Environment Protection Agency (SEPA), the Rivers and Fisheries Trust for Scotland (RAFTS), the Environment Agency (EA) and the Nature Locator team. River obstacles include both man-made and natural objects which hinder the flow of water bodies. Many of the thousands of man-made obstacles perform important functions e.g. dams, sluices, weirs and road culverts. However, they can also cause problems such as restricting the

movement of fish, damaging river banks and beds, and posing a hazard to people using boats, canoes and kayaks.

The location of many of these obstacles is known, and the kind of impacts that they can cause. It is suspected, however, that there are many more obstacles not known about, particularly in the more remote, upland areas of the UK. For this, a new, free to use mobile app for iPhone and Android devices has been developed for people to send in photos and details of obstacles that they see when out and about either on, in, or by the UK's rivers. The information received will be used by public bodies, groups of river users, local authorities and private companies to identify redundant man made obstacles that can be removed from rivers, and prioritise improvements to other obstacles that will yield the biggest environmental improvements. Information on natural obstacles will also be used to determine the natural limits to movement for different species of fish.

8.3.4 Case study 4: Non-native species Initiative

Invasive non-native species pose one of the most serious threats to biodiversity worldwide. The Norfolk Non-native Species Initiative was launched in 2008 to promote the prevention, control and eradication of invasive, alien species. The remit includes collating and monitoring data on the distribution and spread of non-native species in the county. The monitoring work also includes surveying of related native species. The Initiative has been established under the umbrella of the Norfolk Biodiversity Partnership and works through a stakeholders' forum comprised of representatives from over 20 organisations. It is financially supported by the Broads Authority, the Environment Agency, Natural England, Norfolk County Council and the Water Management Alliance. Volunteers have the potential to make significant contributions but require the support and coordination of project officers to be effective. Improved access to and ability to submit up-to-date monitoring information records could improve the effectiveness and coordination of actions for control and eradication of new non-native species.

8.4 Observations from the case study assessments

Each of the case studies involved providing an outline of the project as well as a draft version of the tool a couple of days before a telephone interview. For the interview the respondents were asked to have data available about their projects. The interview lasted for 1-1½ hours with the first part describing the citizen science and then going through the tool in detail, discussing worksheet-by-worksheet each of the cells they might be expected to fill in. Their responses to the requirements of the tool were recorded. At the time of the call the worksheet for the high-level screening questions was not available and this was partially covered by the initial discussion instead.

Observations specific to the tool were as follows:

- Providing an estimate of the value of volunteer time was generally seen as very useful. As were the non-market benefits (well-being etc.) but additional information should be provided in order for these figures to be utilised correctly.
- In a number of cases there was no real baseline comparison. There may be some use in providing general costs of surveying to produce a hypothetical baseline.

-
- Projects are collaborative and therefore the tool was difficult to populate by a single person. Tool could be part of the project planning with input from multiple groups.
 - The multi-criteria section generally caused some confusion. This could be excluded from an initial version in order that the tool is used and not abandoned because of the ambiguity and difficulty conceptualising and responding to some of the issues here. The diversity of citizen science projects also makes this section difficult to provide a generalised tool.
 - The time period is beyond anything from the four case studies. A default setting might be up to 3 years with a longer period option available.

As well as the above feedback, a set of more general thoughts were expressed as to the nature of their citizen science work and how such a tool might interact with these projects:

- Umbrella groups such as the wildlife and rivers trusts are active over a longer period but create and manage a portfolio of projects that changes over time.
- The tool has potentially wider benefits in terms of planning citizen science activities across multiple partners as well as for use in bidding to funders.
- What seemed to have influenced some respondents thinking was the well-publicised success of bird monitoring schemes, with volunteers covering specific locations within a pre-determined time frame. Such a system may only be possible to construct over a period of time when the activity becomes something of a social norm with recognised groups and activities.
- Some questions depend upon the level of knowledge of the respondent as regards economic techniques that are available to estimate values for non-market impacts. Some were more aware of this than others and thus answered the question on whether benefits were qualitative differently.

9. Conclusions

9.1 Findings and observations

There is much information on best practice in citizen science, e.g. previous guides with a focus on environmental citizen science in the UK (Tweddle et al. 2012; Pocock et al. 2014). There are collections of resources to support the implementation of citizen science, notably the Federal Crowdsourcing and Citizen Science Toolkit in the USA (<https://crowdsourcing-toolkit.sites.usa.gov/>). While citizen science is already widely used by public bodies in the UK for environmental monitoring, there is clearly potential for it to be used more widely. Citizen science has benefits over traditional, professional monitoring but it also has risks and disadvantages (Pocock et al. 2014). It has the potential to be cheaper (and hence more cost-effective), but it still has costs and these costs can be substantial (e.g. supporting volunteers and running costs of recruitment and IT systems, data validation etc.). Citizen science also has the potential to provide benefits such as public engagement or wide-scale detection of rare events, which are more challenging through solely contracted environmental monitoring.

Our survey shows, for the first time, how well embedded citizen science is in the UK public sector and how it is used for environmental monitoring. Most people in our survey considered that their organisation's approach to evaluating citizen science is embryonic. This suggests that there is great potential for this to develop, and rigorous evaluation will lead to improved practice and justification for citizen science. Nevertheless, the survey found that citizen science is already well-used to monitor some environmental attributes, especially non-marine biodiversity, alien invasive species, weather and climate, and protected sites. For some of these, citizen science is already used in government headline indicators.

Staff and IT costs tended to be well-known, presumably because these can be so easily converted to a monetary value. Overall, this suggests that for many activities in many organisations, information could be gathered (either estimated, or already collated) to support the valuation of citizen science. It was striking that few respondents considered that perceived lack of interest from within the "citizen science community" was an important barrier to extending this approach. We suggest that this should be considered carefully. One of the risks of the development of citizen science is that the future success of citizen science (e.g. for monitoring new attributes) might be judged on its past successes. Although there may be initial interest by the public to undertake monitoring, it is vitally important to consider future recruitment and retention, especially where there is not a history of volunteer involvement.

This project aimed to assess the options for developing a framework that could be used to evaluate citizen science as a means for undertaking environmental monitoring. A review of the literature found that there are a number of approaches that could be used although some are better for particular circumstances and some have significant drawbacks. An evaluation of the approaches was undertaken and a short-list compiled. The approaches included: 'Return On Investment', 'Cost-Effectiveness Analysis', 'Cost-Benefit Analysis', and 'Multi-Criteria Analysis'.

Return on investment analysis is useful for simple comparisons of the financial costs associated with using citizen science, along with the value of the volunteer labour. However, this approach does not consider any of the wider benefits that can accrue to volunteers or wider society.

Cost-benefit analysis can include wider benefits. The main problem associated with using cost-benefit analysis is that it will favour options where benefits are able to be monetised. Where values have not been monetised they are effectively ignored. A further criticism of cost-benefit analysis is that it is often based on complex assumptions and hence likely to be inaccurate due to inherent uncertainties.

Cost-effectiveness analysis is used widely in the health sector to evaluate outcomes, and could be used to evaluate using citizen science against using staff or contractors. However, where varying outcomes across multiple factors exist (e.g. different quantities and qualities of skills benefits) then it cannot be used to rank options (i.e. further judgements/qualitative assessments will be required in order to determine the preferable option).

Multi-criteria analysis can be relatively easy to use, depending on the particular multi-criteria tool employed (DEFRA, 2003), and does not require specialist knowledge (e.g. economic skills to undertake a cost-benefit analysis). The choice of appropriate multi-criteria techniques? will require some expertise, but this can be acquired fairly easily. However, the final evaluation of a multi-criteria analysis output will rely on the exercise of some expert judgment. There do not currently appear to be any examples of MCA being used as a decision-making tool for evaluating use of volunteers.

Based on the evaluation of approaches it was found that there is not a single methodology that will allow UKEOF partners to undertake a simple and proportionate assessment of the viability of citizen monitoring; rather, a framework can be devised that utilises all four approaches. The theoretical framework was developed into a (MS Excel) spread-sheet tool. Following testing using a number of possible citizen science examples the tool was further refined. The tool requires entry of data on the costs and benefits, and information in relation to the Multi-Criteria Analysis. Whilst the tool can be used in its current form, further refinement would clearly be possible.

Below we make recommendations for the strategic development of citizen science, specifically applied to environmental monitoring by public bodies in the UK.

9.2 Knowledge gaps and recommendations

As part of this project some key knowledge gaps were identified. These related to the link between undertaking citizen science and the wider societal benefits that doing so many bring. This is both from the individual's perspective as well as at a community level. Whilst it is relatively straightforward to quantify the monetary value of time given by volunteers as a benefit to the organisations involved, but there are many other costs and benefits associated with citizen science that are harder to quantify in monetary terms.

Time given by volunteers can be valued in a number of different ways, as discussed in Section 5. However, the ways in which people volunteer vary in their level of formality, so an hour spent by a

volunteer may not always be of equivalent value to one spent by an employee, and outside of formal arrangements, hours spent on a voluntary basis by different individuals may yield different value (this is addressed in the tool by the relative effectiveness of the volunteer).

Citizen science can provide value to organisations above the level of specific activities, e.g. raising its profile. It would be valuable to value citizen science for the whole organisation as well as in respect to specific activities.

The citizen science evaluation tool produced by this project includes scope for assigning values to the benefits accrued by the volunteers themselves as well as the organisations for which they are volunteering. These are categorised as benefits to volunteers' health and well-being, and the value of education and skills benefits that the volunteer gains by undertaking citizen science.

Quantifying the value of these benefits is complex and at present there is no clear understanding of how these could best be valued in monetary terms. The financial benefit of gaining skills and knowledge could be quantified for an individual if there was a clear difference in the level of employment for which they were suited before and after they volunteered, depending on the exact nature of the activities they undertake and their level of prior expertise. For example, a volunteer undertaking only basic activities may have few opportunities to learn (UWE, 2013). There is also little understanding of how benefits vary over time, such as comparing the benefits of long-term, significant engagement, with short-term or casual involvement (Jones, Riddell and Morrow, 2013).

The effects on health and well-being are even more difficult to quantify, such as the benefit to individuals socially. Health benefits are likely to vary according to the type of volunteer activity undertaken. This may be supported by qualitative approach for summative evaluation.

Filling these knowledge gaps would improve understanding about the benefits of citizen science. Further recommendations are made below:

1. Best practice should be identified and shared. Learning from less successful activities should also be honestly and openly shared; not all investment in citizen science will lead to successful activities, but this investment is wasted if the lessons are not shared.
2. Legal responsibilities, such as ethics, data ownership and health and safety should be carefully considered, but these are rarely insurmountable.
3. Individual activities should be rigorously evaluated at key points in the life of the activity, so that activities can be improved, and best practice can be identified and shared (Tweddle et al. 2012). The balance of costs and benefits should be considered (e.g. using the operational tool developed for this project) both in the short term and the long term, as well as the fit-to-purpose of the data (including data quality and coverage). Evaluation should be planned in advance of the activity being developed.

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4. It is worth considering whether citizen science should be run by public sector organisations or should be contracted to other organisations (e.g. non-governmental organisations). Some NGOs will have more experience in engaging volunteers, and be able to adapt current IT systems. This may address the reputational risk to public bodies of monitoring being undertaken by volunteers.
 5. The survey showed that there is potential for citizen science to be further developed in public bodies in the UK. Therefore, a repeat of this survey in the future may help to determine whether organisations have advanced in their support for citizen science.
 6. It would be valuable to undertake a formal risk assessment for the development of citizen science, especially where it replaces current professional monitoring. Potential concerns are the lack of a guarantee of data collection (in terms of accuracy, coverage of sites and frequency of recording) and loss of institutional reputation. The risks of citizen science are less where it augments, or extends, current professional monitoring, rather than replacing it; but risks should still be considered.
 7. Overall, while organisations are able to evaluate the usefulness of the data and to monitor public engagement (e.g. website visits, participation in citizen science, and so on) the impact of this engagement is hard to evaluate, and should be a focus for further research. Better evaluation of the benefits of citizen science, specifically the outcomes of different types of volunteer activity in terms of health, well-being, skills and education impacts, is required.
 8. In order to make the monetary valuation of citizen science benefits more accurate a database of values could be created from existing research (though further primary valuation research would also be required in order to fill a number of gaps).
 9. Specific to the tool:
 - The tool should be piloted by some UKEOF members to further test the usefulness of the framework and help further refine the tool.
 - UKEOF could take responsibility for future development of the tool.
 - The tool could be made more interactive/automated so that it is easier to use.
 - An automated version of the sensitivity analysis could be developed, as it is likely that this may be ignored by users otherwise (depending on feedback from further trials).
 - How the Multi-Criteria Analysis option is presented should be considered further.
 - The tool should be made available to others outside of UKEOF as there is likely to be interest from a number of organisations, including internationally.

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Appendix A The operational tool

A1 Operational tool

The following outlines the pilot operational tool developed for this project, noting the functions under each worksheet. It should be noted that the tool is still in the development stage and could be further improved in terms of both the user interface as well as functionality.

A2 Screening

The high-level screening questions are used for assessing the feasibility of adopting citizen science.

GENERAL:

1. Is the activity initiated in collaboration with potential participants?
2. Have you piloted the methodology with your target audience? Have you evaluated the results of the pilot and concluded that citizen science is a suitable approach?
3. Have you referred to best practice guides and existing citizen science expertise?

REQUIREMENTS:

4. Have you defined your scientific aims? (e.g. a question to be addressed, or an environmental state to monitor)
5. Have you defined the number of records and coverage (over space and time) necessary for the activity to be successful?
6. Have you considered how you will assess the accuracy of the records?

ENGAGEMENT:

7. Have you defined a target audience (with the required skills) and considered their motivations for taking part?
8. Have you defined the message/s that will be communicated through the activity? Have you concluded that a citizen science approach is more suitable than a communication campaign?

RESOURCES:

9. Can you commit resources for the life of the activity?

10. Do you have resources to evaluate the project: the quality and amount of data and the participants' experience?

The tool requires answering all 10 screening questions (either Yes or No, using the drop-down list). Once it has been identified that citizen science is possible for use in the proposed environmental monitoring project then the viability can be assessed. The tool consists of a number of worksheets requiring inputs on the project being assessed.

A3 Set-up

In the set-up worksheet background information is entered on the citizen science project being evaluated, such as name, location, the alternative to using citizen science, and financial parameters. The tool then helps determine which evaluation approach may be suitable (based on the framework described above).

The two main calculation worksheets are the costs sheet and the benefits sheet.

A4 Costs

In the costs worksheet the user is required to enter information about the costs of using citizen science in the environmental monitoring project being assessed. These are as follows:

- Citizen science project planning: total staff costs related to the project (salary plus overheads etc.)
- Volunteering Coordinator: staff costs of time allocated to the specific citizen science project (salary plus overheads etc.)
- Volunteer administration and support: staff costs, as well as office expenses & travel to meetings for the project, plus cost of volunteer communications (e.g. newsletter) and social events
- Advertising and recruitment: cost of attending events, printing leaflets/posters etc., for recruitment purposes
- Induction and training: cost of room hire, materials, food & drink if provided, staff time (unless already included, above)/fees paid to external trainers
- Supplies and equipment: provided to volunteers, over and above that which staff/contractors would use
- Insurance: cost of the volunteer insurance policy or a percentage of the organisation's overall insurance policy to cover volunteers

-
- Volunteer clothing: protective clothing or uniforms, badges, etc. provided free to volunteers (in excess of that provided for staff or contractors)
 - Expenses: travel and out-of-pocket expenses that can be claimed by volunteers
 - IT systems for data collection / feedback of results: IT licensing or interface modification costs; App development (including upgrades)
 - Extra costs for special needs volunteers: for example the cost of support workers
 - Validation costs: additional staff costs for quality assurance checks / data verification

Where figures of staff salary costs are unavailable the tool offers the option of entering the number of Full-Time Equivalent staff instead, or use of a drop-down list of 'levels of costs' where these figures are not available. These values are linked to the default values worksheet (not only does the default values sheet contain data used for the calculations, but it also has some simple calculator tools to help the user generate some of these data), which should be updated for each organisation. If the citizen science activity takes place over more than one year then data for multiple years are required, with a separate column for each year. Some additional data are required in the costs worksheet if the Multi-Criteria Analysis evaluation approach is being used.

A5 Benefits

The benefits worksheet is used to assess the different benefits from the use of citizen science. It requires the user to enter the volunteer data, which will be used to calculate the savings from using volunteers in the citizen science project instead of paid staff or contractors. This includes data on the hourly cost, total hours per week, number of weeks and number of volunteers for each role, as well as the work rate equivalent (to take account of the fact that volunteers' work output may be less than that of paid staff – or perhaps higher if less time is required to travel to monitoring locations). Additional columns are provided for entering data where a project runs for more than one year. Some benefit values for health/well-being and education/skills are included in the tool, based on default values. If using the Cost-Benefit Analysis approach then it is imperative firstly to update the benefit values in the default values worksheet based on data relevant to the circumstances. If using the Multi-Criteria Analysis approach then the user is required to enter the levels of benefit (using a drop-down menu choice) and the importance of the benefit to the organisation of a number of benefits (where these are relevant). These are listed under their headings as follows:

BENEFITS TO THE ORGANISATION:

1. Better data:
 - wider spatial coverage
 - longer temporal data sets
 - rapid response data
 - 'latent' detection of rare events
 - new data sets to improve policy-making

-
2. Awareness-raising of specific issue (and reporting of illegal activities)
 3. Meeting your organisation's mandate of engaging the public (where applicable)
 4. Improved staff morale in your organisation from volunteer involvement
 5. Increased support amongst the public for work of your organisation

BENEFITS TO THE VOLUNTEER:

7. Opportunity to socialize/connection with local community
8. Meaningful engagement with scientific research and increased education and skills (hence job opportunities/social mobility)
9. Health benefits (reason/motivation to be physically active)
10. Well-being benefits:
 - enjoyment of activity
 - feelings of doing something worthwhile
 - connection with nature

BENEFITS TO WIDER SOCIETY:

11. Increased general environmental awareness amongst population
12. Improved scientific knowledge in society (volunteers directly, as well as publication of findings in journals or the media)
13. Use of data to secure additional funding to do research by other organisations (developing the UK science base)
14. Community-building / social cohesion
15. Improved environment as a result of better knowledge to deliver desired outcomes

The level of benefit is used to create a score for each benefit. The benefit scale used is as follows:

High	10
Med-High	7.5
Medium	5.5
Med-Low	3.5
Low	1
None	0

The importance scale is used for weighting each benefit. There is also an additional question on the relative importance of the (combined) benefits identified above compared to the costs / savings from the use of citizen science.

The list is reasonably comprehensive and it could be time consuming to complete it. However, this is the nature of a Multi-Criteria Analysis and answers are only required for benefits that are expected to result from the citizen science activity.

A6 **Outputs**

The outputs summary worksheet contains all of the results for each evaluation approach (where completed), namely Return On Investment, Cost-Effectiveness Analysis, Cost-Benefit Analysis and Multi-Criteria Analysis. It should be noted that the Return On Investment analysis uses undiscounted values whilst the Cost-Effectiveness Analysis and Cost-Benefit Analysis uses discounted values (NPV function). This means that the total value of costs will be different between the discounted and undiscounted values.

The tool contains a note to the user to undertake sensitivity analysis once the initial calculation has been completed in order to determine the likely upper and lower bound case and to see which are the key variables that might influence the overall outcome. The same could be applied to the Multi-Criteria Analysis, where the user changes some of the estimated levels of the benefits.

A7 Screenshots

Introduction sheet:

Welcome to the citizen science evaluation tool (Beta version: 31st March 2016)

Introduction

This tool was developed as part of the UKEOF project: 'Citizen Science and Environmental Monitoring: Towards a Methodology for Evaluating Opportunities, Costs and Benefits' (2016)

The UKEOF Citizen Science Working Group has identified a need to better understand the potential for citizen scientists to become more involved in environmental monitoring programmes, and how to identify and calculate the costs and benefits of them doing so. A project team consisting of experts from WRc, CEH and fera were engaged to undertake an analysis of the current and potential use of citizen science in environmental monitoring, and to identify a method for assessing the feasibility and viability of using citizen science. The project was conducted over several months, between September 2015 and March 2016, and involved undertaking a survey of UKEOF members, conducting reviews of the literature, as well as developing an evaluation framework which was then realised in the form of an operational tool. Whilst there is much information on best practice in citizen science, there is no readily-available evaluation tool that meets UKEOF requirements. There are a number of approaches that could be used although some are better for particular circumstances and some have significant drawbacks. An evaluation of the approaches was undertaken and a short-list identified. The approaches included: 'Return On Investment', 'Cost-Effectiveness Analysis', 'Cost-Benefit Analysis', and 'Multi-Criteria Analysis'. Based on the evaluation of approaches it was found that there is not a single methodology that will allow UKEOF partners to undertake a simple and proportionate assessment of the viability of citizen monitoring; rather, a framework can be devised that utilises all four approaches. The theoretical framework was developed into a (spreadsheet) tool, which was tested with a number of scenarios. It was recommended that the tool should be piloted and further refined, but could be made available to others outside of UKEOF even at this stage as there is likely to be interest from a number of organisations, including internationally.

This tool is still under development, but you are welcome to use it. Feedback would be greatly received.

To use the tool please first open the Screening tab and answer all 10 questions, either Yes or No, using the drop-down list. Responses are provided to help guide your planning for CS.

In the Set-up tab please enter background information on the CS project/monitoring to be evaluated, including financial parameters. You can then determine which evaluation approach is most suitable.

In the Costs tab enter the required information about the costs of using CS. Also complete the MCA (Multi-Criteria Analysis information if you are using this evaluation approach).

In the Benefits tab enter the volunteer data. This is used to calculate the savings from using volunteers in the CS project/monitoring instead of paid staff or contractors to collect the data. If doing the MCA then please complete this section using the drop-down lists. For CBA (Cost-Benefit Analysis) update the benefit values in the Default values tab first.

The Outputs summary tab contains all of the results for each evaluation approach (where completed).

The Default values tab contains some data used for the calculations, and tools to help you generate some of this data. Where this data is used, it should be updated for your organisation.



Screening sheet:

(Beta version: 31st March 2016)

Screening questions*: please answer each question before continuing to the next

Feasibility of use of CS	Input Box (select from drop-down list)	Response
1 Is the project/monitoring initiated in collaboration with potential participants?		-
2 Have you piloted the methodology with your target audience? Have you evaluated the results of the pilot and concluded that citizen science is a suitable approach?		-
3 Have you referred to best practice guides and existing citizen science expertise?		-
REQUIREMENTS		
4 Have you defined your scientific aims? (e.g. a question to be addressed, or an environmental state to monitor)		-
5 Have you defined the number of records and coverage (over space and time) necessary for the activity to be successful?		-
6 Have you considered how you will assess the accuracy of the records?		-
ENGAGEMENT		
7 Have you defined a target audience (with the required skills) and considered their motivations for taking part?		-
8 Have you defined the message/s that will be communicated through the activity? Have you concluded that a citizen science approach is more suitable than a communication campaign?		-
RESOURCES		
9 Can you commit resources for the life of the activity?		-
10 Do you have resources to evaluate the project/monitoring: the quality and amount of data and the participant's experience?		-

Act upon 'Warning' responses before beginning your citizen science activity. It may be that citizen science is not appropriate. Now go on to the Set-up tab.

* These questions have been developed based upon expertise gained from Tweddle et al. (2012) & Pocock et al. (2014). Thanks to Helen Roy (Centre for Ecology & Hydrology) and Mary Gardiner (Ohio State University) for comments.

Set-up sheet:

(Beta version: 31st March 2016)

Please complete the information below:

Background information	Input Box	Notes
Citizen science project/monitoring name (optional - this is just for your reference)		Type text into box
Location of CS activity (optional - this is just for your reference)		Type text into box
CS project/monitoring type: why are you considering use of CS?		Select from drop-down list. If the citizen science activity will replace existing monitoring then you will need to collate data on the costs of this existing activity
Summarise alternative situation (In order to assess citizen science, it needs to be compared to an alternative, i.e. the existing or potential cost from not using citizen science)		Select from drop-down list
Summarise proposed CS option		Select from drop-down list. Ensure that the cost information used in this assessment reflects the option that you have selected here
The source of the CS project/monitoring funds		Select from drop-down list. If external funds are available for the citizen science activity then the costs of citizen science may not be relevant to a financial analysis from your organisation's perspective

Financial parameters	Input Box	Notes
Alternative option Present Value Cost for the element to be undertaken by use of CS (over entire period being considered)	£0	Enter cost: how much is the monitoring cost as undertaken by your organisation/contractors? (if not currently undertaken then please enter a value of 0). If taking place over multiple years (>1) then use the Present Value Cost tool in the Default values tab
Discount rate to apply in analysis	3.5%	Enter value. Note: a discount rate is the interest rate used in discounted cash flow analysis to determine the present value of future cash flows. A rate of 3.5% is set as default (check with
Period of analysis (number of years)	1	Enter value. Note: if more than 1 year then please fill in the yellow cells in the Costs and Benefits sheets (insert columns if more than 10 years are required)

Determining evaluation approach	Input box	Notes	Response
Do you simply want analysis of the direct costs and benefits to your organisation of using CS?		Select from drop-down list	If Yes, then use Return on Investment (RoI) analysis (this will give an indication of the financial savings compared with the costs of using CS)
Is the available evidence on the benefits of CS mainly qualitative (rather than quantitative or monetised)?		Select from drop-down list	If Yes, then use Multi-Criteria Analysis (MCA) (this takes account of difficult to value benefits) Note: MCA does NOT provide estimates of money costs or savings values and requires input of a large amount of information!
Do the important outcomes (benefits) of CS have a monetary value (either directly quantified, or estimated)?		Select from drop-down list	If Yes, then use Cost-Benefit Analysis (CBA) (this will indicate the net gain in monetary terms of using CS, but only include aspects that have monetary values assigned to them)
Do you want to compare monetised benefits with monetised costs (i.e. a net gain appraisal)?		Select from drop-down list	(If YES then the answer to the above question should also be YES. If not, then use Cost-Effectiveness Analysis)
<p>If an analysis option has not been identified from the above then Cost-Effectiveness Analysis (CEA) is the default option (it will compare the costs of using CS with the alternative)</p>			

Once the above is completed please move to the Costs tab

Costs sheet:

(Beta version: 31st March 2016)

Costs of use of citizen science for environmental monitoring

Please enter data (required for all analysis types; note for ROI analysis enter total amounts for CS project, NOT annual, in column D)

Note: once a direct value is entered the FTE calculation will not apply

-> Cost-Benefit & Cost-Effectiveness Analysis: if more than 1 year then enter different values of costs over time (excluding inflation):

Category of Expenditure*	Cost details - all expenditures are for the project (NOT per volunteer)	Annual Amount (£)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total Present Value	Assumptions used for this cost:
Project planning	Total staff costs related to planning the CS monitoring (salary plus overheads etc.) <i>Or enter number of Full-Time Equivalent staff if salary costs not known</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		Multiply salary by 1.13 to cover National Insurance Contributions and overheads
Volunteering Coordinator	Staff costs of time allocated to the specific citizen science project/monitoring (salary plus overheads etc.) <i>Or enter number of Full-Time Equivalent staff if salary costs not known</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		Multiply salary by 1.13 to cover National Insurance Contributions and overheads
Volunteer administration and support	Staff costs, as well as office expenses & travel to meetings for the project/monitoring, plus cost of volunteer communications (e.g. newsletter), social events <i>Or enter number of Full-Time Equivalent staff if salary costs not known</i> <i>Also estimate level of support costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		Multiply salary by 1.13 to cover National Insurance Contributions and overheads
Advertising and recruitment	Cost of attending events, printing leaflets/posters etc., for recruitment purposes <i>Or estimate level of advertising & recruitment costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Induction and training	Cost of room hire, materials, food & drink if provided, staff time (unless already included above)/fees paid to external trainers <i>Or estimate level of induction and training costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Supplies and equipment	Provided to volunteers, over and above that which staff/contractors would use <i>Or estimate level of supplies & equipment costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Insurance	Cost of the volunteer insurance policy or a percentage of the organisation's overall insurance policy to cover volunteers <i>Or estimate level of insurance costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Volunteer clothing	Protective clothing or uniforms, badges, etc provided free to volunteers (in excess of that provided for staff or contractors) <i>Or estimate level of uniform costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Expenses	Travel and subsistence expenses that can be claimed by volunteers <i>Or estimate level of volunteer expenses from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
IT systems for data collection / feedback of results	IT licensing or interface modification costs; App development (including upgrades) <i>Or estimate level of IT costs from drop-down list</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Extra costs for special needs volunteers	For example the cost of support workers <i>Or enter number of Full-Time Equivalent staff if salary costs not known</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Validation costs	Additional staff costs for quality assurance checks / data verification <i>Or enter number of Full-Time Equivalent staff if salary costs not known</i>	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00		
Total		£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	

Please enter responses below ONLY if undertaking MCA

Risks from using (or not using) CS for this activity (only require if undertaking a Multi-Criteria Analysis)

Organisation perspective:	Level of likelihood (select from drop-down list)	
What is the likelihood that there is a loss of staff expertise from use of CS?		Note: this is low if contractors are currently used
What is the likelihood that data collected by CS is poor?		Note: this is low if mitigation measures are planned to be put in place (e.g. training)
What is the likelihood that there is a loss of staff expertise from use of the alternative to CS?		Note: the alternative to citizen science is the existing situation or alternative monitoring option (i.e. use of organisation's staff or contractors)
What is the likelihood that data collected by the alternative to CS is poor?		
Level of impact (i.e. importance of issues) (select from drop-down list)		
Impact of loss of staff expertise (as relates to the particular skills involved in the monitoring)		
Impact of poor quality of data collected (i.e. the importance of this data)		

Once data entry is completed please move to the Benefits tab

* Some of these expenditure categories are based upon the work of Gaskin, K. (2011) VWR – The Volunteer Investment and Value Audit: A self-help guide. Second edition. Institute for Volunteering Research.

Outputs summary sheet:

(Beta version: 31st March 2016)

Results of analysis of use of citizen science for environmental monitoring

ROI	Investment in CS monitoring project	£	-	(Note: undiscounted value)
(Return on Investment)	Return (savings) from investment	£	-	(Note: undiscounted value)
	ROI ratio		#DIV/0!	(Note: undiscounted value)

Discount factor applied (for CEA and CBA)	3.50%	Present value (assumes all costs and benefits occur at year-end)
---	-------	--

CEA	Cost of use of CS for monitoring	£	-
(Cost-Effectiveness Analysis)	Cost of the monitoring using alternative	£	-

CBA	Costs of use of CS for monitoring	£	-
(Cost-Benefit Analysis)	Benefits from use of CS for monitoring	£	-
	Net total	£	-

Sensitivity analysis:
It is strongly recommended that you now vary the largest cost and benefit variables to their upper and lower likely levels. This helps your assessment to be more rigorous.

MCA						
General criteria	Specific item	Weighting	Values for CS	Values for alternative	Results for CS	Results for alternative
Monetised costs	Financial savings from use of CS	0	#DIV/0!	0	#DIV/0!	0
Monetised benefits	Financial savings from use of alternative	0	0	#DIV/0!	0	#DIV/0!
Non monetised costs	Impact on staff skills	0	0	0	0	0
Non monetised costs	Loss of quality of data	0	0	0	0	0
Non monetised benefits: organisation	Better data: wider spatial coverage	0	0	0	0	0
Non monetised benefits: organisation	Better data: longer temporal data sets	0	0	0	0	0
Non monetised benefits: organisation	Better data: rapid response	0	0	0	0	0
Non monetised benefits: organisation	Better data: latent detection of rare events	0	0	0	0	0
Non monetised benefits: organisation	Better data: new data sets to improve policy-making	0	0	0	0	0
Non monetised benefits: organisation	Awareness-raising of specific issue	0	0	0	0	0
Non monetised benefits: organisation	Meeting mandate of engaging the public	0	0	0	0	0
Non monetised benefits: organisation	Improved staff morale	0	0	0	0	0
Non monetised benefits: organisation	Increased support amongst the public for work	0	0	0	0	0
Non monetised benefits: volunteer	Opportunity to socialize/connection with local community	0	0	0	0	0
Non monetised benefits: volunteer	Engagement with scientific research / increased skills	0	0	0	0	0
Non monetised benefits: volunteer	Health benefits	0	0	0	0	0
Non monetised benefits: volunteer	Enjoyment of activity	0	0	0	0	0
Non monetised benefits: volunteer	Feelings of doing something worthwhile	0	0	0	0	0
Non monetised benefits: volunteer	Connection with nature	0	0	0	0	0
Non monetised benefits: society	Increased awareness amongst population	0	0	0	0	0
Non monetised benefits: society	Improved scientific knowledge in society	0	0	0	0	0
Non monetised benefits: society	Use of data to secure additional funding	0	0	0	0	0
Non monetised benefits: society	Community-building / social cohesion	0	0	0	0	0
Non monetised benefits: society	Improved environment as a result of better knowledge	0	0	0	0	0
Total score					#DIV/0! <small>(citizen science)</small>	#DIV/0! <small>(alternative)</small>

Default values sheet:

(Beta version: 31st March 2016)

Default values *Note: please calibrate for your organisation*

		Value in a year
Citizen science project planning	Staff costs per annum	£30,000
Volunteering Coordinator	Staff costs per annum	£25,000
Volunteer administration and support	Staff costs per annum	£20,000

Note: should include overhead costs

Note: should include overhead costs

Note: should include overhead costs

		High	Medium	Low
Volunteer administration and support	Office expenses & travel to meetings for the project, plus cost of volunteer communications (e.g. newsletter), social events	£1,000	£500	£100
Advertising and recruitment	Cost of attending events, printing leaflets/posters etc., for recruitment purposes	£1,000	£500	£100
Induction and training	Cost of room hire, materials, food & drink if provided, staff time (unless already included, above)/fees paid to external	£1,000	£500	£100
Supplies and equipment	Provided to volunteers, over and above that which staff/contractors would use	£1,000	£500	£100
Insurance	Cost of the volunteer insurance policy or a percentage of the organisation's overall insurance policy to cover volunteers.	£1,000	£500	£100
Volunteer clothing	Protective clothing or uniform, badges, etc provided free to volunteers (in excess of that provided for staff or contractors)	£1,000	£500	£100
Expenses	Travel and subsistence expenses that can be claimed by volunteers	£1,000	£500	£100
IT systems for data collection / feedback of results	IT licensing or interface modification costs; App development (inc. upgrades)	£1,000	£500	£100

Extra costs for special needs volunteers	Support worker costs per annum (including any overheads)	£25,000
Validation costs	Staff costs for quality assurance checks / data verification per annum	£20,000

Value of health & well-being benefits that accrue to the volunteer	£6,000.00	<i>Note: should be relevant to the particular CS activity</i>
Value of education and skills benefits that accrue to the volunteer	£1,533.00	<i>Note: should be relevant to the particular CS activity</i>

You can use this calculator to help estimate the High, Medium and Low costs:

Cost per volunteer	Number of volunteers in project	Total cost	High	Medium	Low
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
£0	0	£0	£0	£0	£0
Enter the multiplication percentage to be applied:			2	1	0.5

Alternative option: Present Value Cost tool	Year	1	2	3	4	5	6	7	8	9	10	Present value:
Note that these are the costs of the alternative that are relevant to the activity being considered	Cost	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0.00

Appendix B Initially proposed case studies

Proposal 1: Early detection of an expanding invasive species: The oak processionary moth has caterpillars which feed on oak trees and have urticating hairs which pose a human health risk. It has been spreading from initial points of introduction in London. It is important to monitor its presence in order to identify new outbreaks and its continued spread and based on this to take action through the Defra-funded OPM Control Programme (OPMCP). One efficient ways of undertaking this monitoring is via pheromone traps placed high in oak trees. Over the winter 2015/16 many hundreds of these pheromone traps are being deployed across Greater London, Surrey and Berkshire – all deployed by contractors funded through the OPMCP. Andrew Hoppit (Forestry Commission) manages the OPMCP and so is responsible for budgetary decisions. He has agreed to work with us on developing this case study so that we can ensure that the costings are realistic and to evaluate the potential for citizen science to contribute to monitoring the oak processionary moth.

Proposal 2: Non-Native Species Initiative: The GB Non-Native Species Secretariat (NNSS) work with a number of Local Action Groups that have been set up by local organisations and volunteers to lead work on invasive species in their areas. A key feature of LAGs is their ability to mobilise volunteers and ‘citizen scientists’ to identify problems locally and contribute to the co-ordination of local action. Some of these have been operating for many years with some forming in the 1980’s. A case study in this area would focus on one of the longer running LAGs and use historic data to show the value already accrued from its operation. A secondary aim of this case study relates to the potential use of the tool to make the case for funding. To date the LAGs have received some amount of Defra and other public funding but given budget pressures they are increasingly having to seek alternatives and make the case for funding. Initial discussions with the NNSS also suggested an interest is using the tool to engage with their volunteers to illustrate the value of the work undertaken.

Proposal 3: Earth Observation Data Integration Pilot: A recent Defra ITT (*22713 Earth Observation Data Integration Pilot – Developing community and crowd sources validation of Living Maps*) seeks to build volunteer support to validate Living Maps, based on Earth observation and other data. The CS element is to validate detailed habitat maps and other Earth observation products. This potential case study is interesting but more risky as it has yet to be let. We would seek to work with the selected consultants to apply the tool.

Proposal 4: Fresh water quality monitoring – analysis of chemical parameters: In general, chemical data are collected through routine visits to sites at which measurements are made, or samples taken for analysis at a laboratory. This is sometimes criticised because an isolated event will escape detection. There are some sites where the risks are unusual or the water especially sensitive. A related issue is that samples are usually taken in office hours and that one or two aspects of water quality may show strong and regular fluctuations within a 24-hour period (they may also show poorer quality outside office hours). Special additional monitoring that can further inform of the ecological status of rivers could be undertaken by volunteers using hand-held monitoring devices (such as a Dissolved Oxygen Meter), avoiding the need for collection of samples that then need to be sent to the laboratory for analysis (though the devices would need regular calibration in order to meet quality control standards).

Such use of volunteer monitoring may be able to either supplement or replace the existing monitoring activity.

Proposal 5: Monitoring of designated sites – species surveillance: Monitoring the condition of nature conservation features of special interest on designated sites includes habitats (e.g. woodland), species populations (e.g. butterflies) or geological formations (e.g. fossil bed). The purpose of which is to determine the condition of the designated natural feature within a site and establish whether it will be maintained under the current management regime. These are usually monitored on a rolling programme following guidance produced by JNCC. Monitoring work is currently carried out by agency staff and by specialist contractors. However, it may be possible to increase the frequency of monitoring at sites for some specific features of interest, e.g. species population counts, where such species are easily identifiable by volunteers. This may even be able to replace the standard infrequent monitoring of these particular features carried out by staff/contractors as part of the monitoring programme.

Appendix C Case study (final selection) interviews

The case studies are outlined below and they follow the discussion in the interviews. The opening section describes the rationale for the work to get a sense of how the CS project interacts with the aims and objectives of the organisation that the interviewer represents. Then short bullets are provided about each of the tabs in the draft tool.

C1 Case study 1: Oak Processionary Moth outbreak management – monitoring spread

Respondent: Andrew Hoppit (OPM Project Manager) – coordinating FC work to control the spread of Oak Processionary Moth in London³.

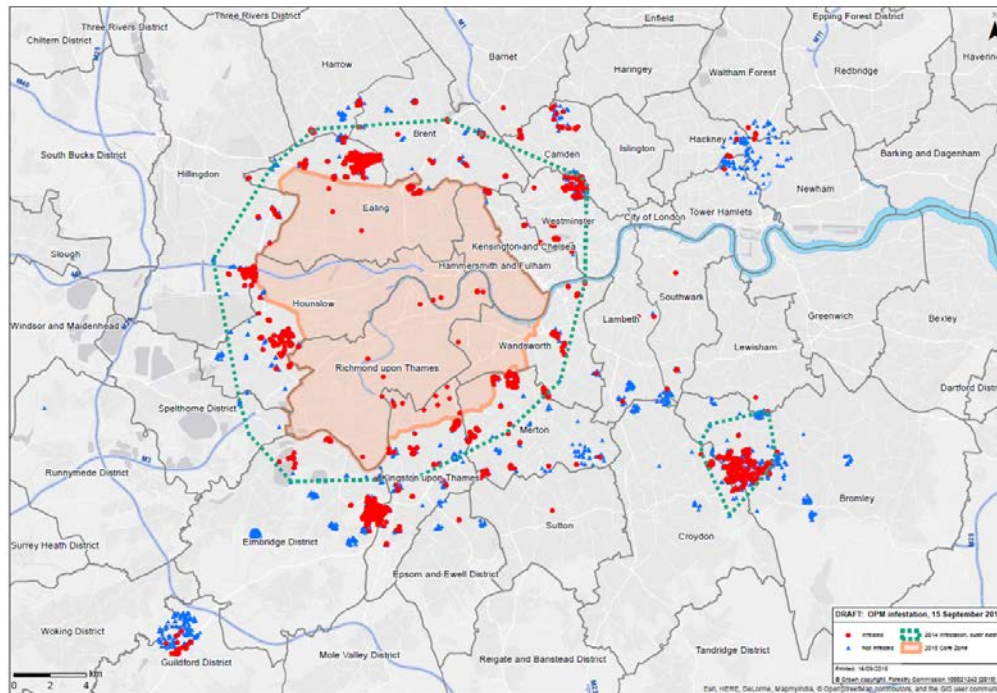
As part of his role in co-ordinating the Forestry Commission work in the attempt to control OPM in London, Andrew had enquired about utilising Observatree volunteers (<http://www.observatree.org.uk/about/volunteers/>) as part of the programme. The initial idea was for the volunteers to provide a systematic monitoring of specific locations, namely to survey every oak tree within a 250m radius around locations where OPM have been caught in pheromone traps. Difficulties materialised quite quickly with the realisation that the requirement was not necessarily well suited to what a volunteer might do. Not least this related to location of the volunteer as compared to the OPM.

Subsequent thought about the problem at hand focussed upon the difference between surveillance, where a coarser grain set of information is acceptable (i.e. general tree health and not OPM specific), as compared to detection which might require more intense activity and training/management. Thus, Andrew suggested that there was a need to go through the “logic chain” of requirements i.e. still at the design stage for the CS project. For OPM this means actually knowing where the oak trees are given that there is less than 100% knowledge for this basic requirement. This is likely true of many tree species in urban environments given the range of current and future threats. Mapping the location of tree species in an urban setting is a non-trivial exercise as illustrated by the recent effort to map trees in London ([http://www.forestry.gov.uk/pdf/2890-Forest_Report_Pages.pdf/\\$FILE/2890-Forest_Report_Pages.pdf](http://www.forestry.gov.uk/pdf/2890-Forest_Report_Pages.pdf/$FILE/2890-Forest_Report_Pages.pdf)) which involved around 120 volunteers, in which volunteers surveyed 476 of the total 724 plots.

Figure 8 below shows the level of OPM infestation known toward the end of 2015 which illustrates the scale and “terrain” within which a citizen science approach would be conducted.

³ See <http://www.forestry.gov.uk/oakprocessionarymoth> for a description of the pest and current control activity

Figure 8 OPM Infestation Map - September 2015



Observations on the tool:

- Set up tab:
 - Background – some confusion as to who to put down as funders. He is paid by FC, funding for the OPM control comes from Defra, and Observatree volunteers funded by Heritage Lottery – who funded the creation of the volunteers but not their specific use in OPM control.
 - Financial parameters – baseline costs related to cost of the OPM programme part of which could be utilised in a CS project. Would need to know the cost equivalent of using volunteers which would be contractors. Respondent not interested in choice of discount rate. Time period could be variable with potential for a one year extension.
 - Determining evaluation approach – a number of the questions could be interpreted differently by respondents with different backgrounds.
- Costs tab:
 - Category of expenditure – would be useful to add notes against each cost category. Query that some costs are per person and some are totals.
 - Other risks – need to clarify some of the questions but also different perspectives dependent on current or prospective project.

- Benefits tab:
 - Value of savings – relatively straightforward.
 - Other benefits (health/education for CBA) – these are interesting but of less use for a project like this.
 - Other benefits (for MCA) – some poor wording in the “organisation” set of questions.

Figure 9 Screenshot of Tool (costs sheet) for OPM case study

	C	D	E	F	G
2				-> Cost-Benefit & Cost-Effectiveness Analysis	
3	Cost details	Annual Amount (£)	Year 1	Year 2	Year 3
4	Staff costs related to the project (salary plus overheads etc)	Glyn Jones: Guess - 15-20 days per year	£3,390.00	£0.00	£0.00
5	Or enter number of Full-Time Equivalent staff if salary costs not known				
6	Staff costs of time allocated to the specific citizen science project (salary plus overheads etc)		£14,125.00	£0.00	£0.00
7	Or enter number of Full-Time Equivalent staff if salary costs not known				
8	Staff costs, as well as office expenses & travel to meetings for the project, plus cost of volunteer communications (e.g. newsletter) and social events	Glyn Jones: Expecting to be the Observatree person		£0.00	£0.00
9	Or enter number of Full-Time Equivalent staff if salary costs not known				
10	also estimate level of support costs from drop-down list	Glyn Jones: does nothing!			
11	Cost of attending events, printing leaflets/posters etc., for recruitment purposes	Glyn Jones: typo		£0.00	£0.00
12	or estimate level of advertising & recruitment costs from drop-down list				
13	Cost of room hire, materials, food & drink if provided, staff time (unless already included, above)/fees paid to external trainers	Medium	£500.00	£0.00	£0.00
14	or estimate level of induction and training costs from drop-down list				
15	Provided to volunteers, over and above that which staff/contractors would use	Glyn Jones: Put all fixed costs per volunteer in a single category	£100.00	£0.00	£0.00
16	or estimate level of supplies & equipment costs from drop-down list				
17	Cost of the volunteer insurance policy or a percentage of the organisation's overall insurance policy to cover volunteers.	Low	£100.00	£0.00	£0.00
18	or estimate level of insurance costs from drop-down list				
19	Protective clothing or uniform, badges, etc provided free to volunteers (in excess of that provided for staff or contractors)	£100.00			£0.00
20	or estimate level of uniform costs from drop-down list				
21	Travel and out-of-pocket expenses that can be claimed by	Glyn Jones: OPM - Southampton Uni paid £70k pa. Think could be 5% = above current range available	£0.00		£0.00
22	or estimate level of volunteer expenses from drop-down list				
23	IT licensing or interface modification costs; App development (inc. upgrades)	Medium	£3,500.00	£0.00	£0.00
24	or estimate level of IT costs from drop-down list				
25	For example the cost of a support worker	Glyn Jones: hadn't considered for this project	£0.00		£0.00
26	Or enter number of Full-Time Equivalent staff if salary costs not known				

The comments on the tool on the costs sheet Figure 9 illustrates that the discussion varied from typos, individual cell function, and the degree to which the cost detail had been considered, if at all.

Figure 10 Screenshot of Tool (Benefits sheet) from OPM case study

										J	K	L	M	N	O	P	Q	R	S		
22	Total										£5,203	£5,203	£0	£0	£0	£0	£0	£0	£0	£0	
23																					
24	Other benefits from use/non-use of CS (only required if undertaking Multi-Criteria Analysis)										benefit delivered from CS	benefit delivered from	to organisation								
25											Select from drop-down list	Select from drop-down list	Select from drop-down list								
26	Organisation:																				
27	1. Better data:																				
28	wider spatial coverage													Not considered							
29	longer temporal data sets													Not consider Difficult to answer if being run by government							
30	rapid response data													Need for a standing army							
31	"latent" detection of rare events													Not considering where the edge of the invasion is - go to place where think is present							
32	new data sets to improve policy													Helping inform ongoing datasets							
33	2. Awareness-raising of specific CS										Legal activities	Medium-High	Medium	High							
34	3. Meeting agency mandate of env										Not applicable			Don't have a mandate							
35	4. Possible improved agency staff													Don't understand question?							
36	5. Increased support amongst the public for work of agencies													Difficult wording - need to change wording - benefits to work of your organisation							
37	Volunteers:																				
38	7. Opportunity to socialise/connect													If volunteer - it's why they volunteer							
39	8. Meaningful engagement with CS																				
40	9. Health benefits (season/motivation to be physically active)																				
41	10. Well-being benefits:																				
42	enjoyment of activity																				
43	feelings of doing something worthwhile																				
44	connection with nature																				
45	Wider society:																				
46	11. Increased general environment										population										
47	12. Improved scientific knowledge										teach, as well as publication of findings in journals or the media										
48	13. Use of data to secure additional funding to do research by other organisations (developing the UK science base)																				
49	14. Community-building / social cohesion																				
50	15. Improved environment as a result of better knowledge to deliver desired outcomes																				
51																					
52	What is the relative importance of the benefits identified above compared to the monitoring costs										Med-Low	Please use drop down. Only possible answer?????									

Figure 10 shows the response to the MCA questions and illustrates the difficulties experienced by the respondent.

C2 Case study 2: Lowland heathland species surveillance – pilot study

Respondent: Dr David Roy, Head of the Biological Records Centre, CEH

This case study is based upon work undertaken by CEH for Natural England (Roy et al., 2014). The aim was to explore the feasibility of establishing and operating a national species surveillance network for lowland heathlands across England that could co-ordinate and support recording activity. A co-ordinator was available to support volunteers with gaining access permission to allocated survey sites and to provide general support on survey methods. At regular intervals (approximately every 3 weeks) the volunteers who signed up to take part were emailed to see how they were getting on and if they needed any help. The main requirement for support was based around assigning squares and gaining access permission to carry out surveys from the site managers.

Figure 11 below shows the number of volunteers (column 2) and the proportion that actually undertook some survey work. Subsequent columns show the area covered by the volunteers compared to the target. The pattern is one of relatively low levels of realisation of outputs even after training.

Figure 11 Number of volunteers trained/ participated and km² squares allocated and actually surveyed

Region	Number of people involved	Participants	Number of squares allocated	Number of squares surveyed
Dorset	23	11 (48%)	36	15 (42%)
Staffordshire	14	3 (21%)	13	3 (27%)
Thames Basin	6	2 (33%)	4	1 (25%)
Other	4	2 (25%)	2	2 (100%)
Total	47	18 (38%)	55	21 (38%)

Conclusions suggested that the tasks set for volunteers were initially too complex and that adjustments to the survey method were required. The survey sheets for the pilot and the survey of volunteers don't appear to a record much detail that would allow provide much information for the tool developed in this project.

Observations on the tool:

- Set up tab:
 - Background – No real baseline for this project but could be costed as a survey by contractors
 - Financial parameters – see above
 - Determining evaluation approach – this case study was a pilot study and not really focussed upon what activity would be replaced. Liked the idea of including culture and health benefits. The respondent was unclear about some of the questions – this may have been because it was a scientist responding and not someone more fully versed in citizen science
- Costs tab:
 - Category of expenditure – some confusion over per person or total values required
 - Other risks – need for “not applicable” as well as “none” since different from that.
- Benefits tab:
 - Value of savings – relatively easy and useful
 - Other benefits (health/education for CBA) – no comment provided

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- Other benefits (for MCA) – Important to have “not applicable” as an option and some difficulty with wording of the questions. The benefits to the volunteer would seem to be a given.

C3 Case Study 3: River Obstacles – smartphone app

Respondent: Jim Gregory, Senior Technical Specialist, National Fisheries Services, Environment Agency

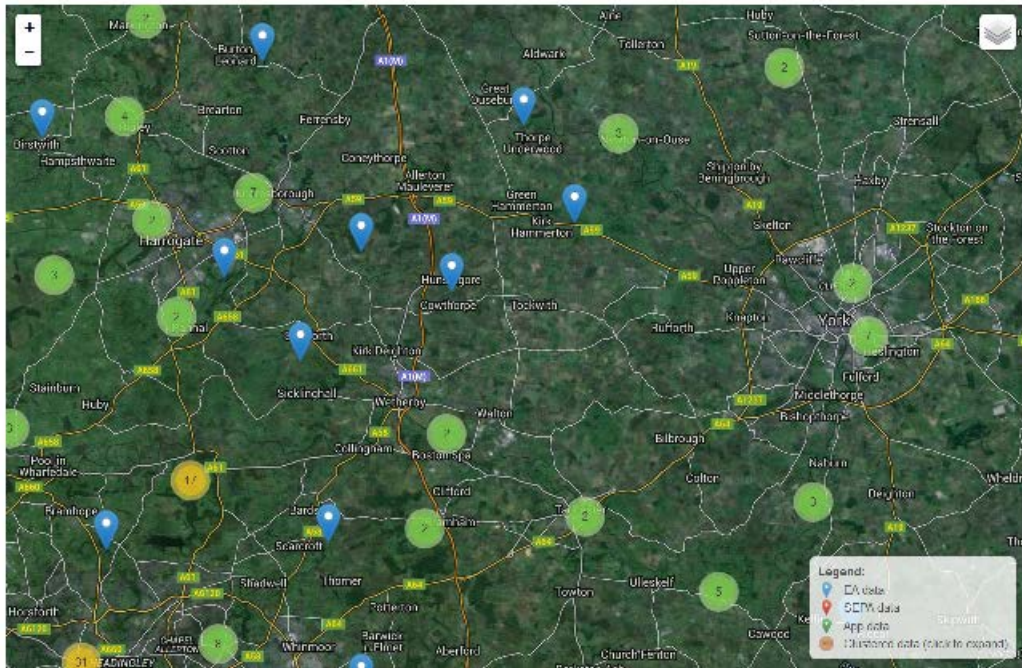
The River Obstacles project is a joint endeavour by the Scottish Environment Protection Agency (SEPA), the Rivers and Fisheries Trust for Scotland (RAFTS), the Environment Agency (EA) and the Nature Locator team. Its main aim is to provide a free to use mobile app (for iPhone and Android devices), a website and data repository that enables the collection and use of important information on the location and type of man-made and natural obstacles in rivers across the UK. The funders had somewhat different objectives (See <http://www.river-obstacles.org.uk/home>). The information received from the app will be used by public bodies, groups of river users, local authorities and private companies to identify redundant man made obstacles that can be removed from rivers, and prioritise improvements to other obstacles that will yield the biggest environmental improvements. Information on natural obstacles will also be used to determine the natural limits to movement for different species of fish.

SEPA were starting from scratch to find where obstacles were located and to target the general public to use the app. The EA have already mapped 90% of such obstacles in England and Wales and are working with the Rivers Trusts to provide consistent information overtime and fill gaps in the dataset in order to prioritise work to remove obstructions to maintain natural flows and fish movements. SEPA provided the majority of development funding (c£15,000) and EA running costs are around £1,000 per year (ensuring app is available for users).

Historic survey/monitoring work had been undertaken by EA staff using OS Master Map combined with some river walks. The Rivers Trusts (there are over 40 in England and Wales) were providing on-going information but the flow from this source was not consistent as data was collected in an ad hoc way and not in forms that allowed easy collation and comparison. The app standardises data collection that significantly increases the options for collation and comparison across space and over time. Information will be placed on a website that provides a tool for visualising the range of river obstacles recorded by agency staff and via citizen science, and information about them (Figure 12).

Figure 12 Mapped river obstacles around York

Obstacle map



Observations on the tool (responses reflect the Environment Agency view – becomes more complex if viewing from more than one funder/user):

- Set up tab:
 - Background – comparatively straightforward but the drop down list misses some of the interesting context.
 - Financial parameters – baseline costs not part of EA consideration since much of their survey work had been historic (sunk cost). Discount rate not useful – should be a default value with an option to change for users with sufficient expertise. Time frame – difficult to put a number of years in but expected/wanted to be more than one.
 - Determining evaluation approach – some of the questions were difficult to understand and therefore need clarification/simplifying
- Costs tab:
 - Category of expenditure – useful breakdown of the different categories. Illustrated that costs of development mostly borne by others and volunteer costs by the Rivers Trusts. Where costs may occur (validation) yet to see volume and quality that will be returned but haven't estimated how much this might be
 - Other risks – difficult to understand the second two risk questions

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- Benefits tab:
 - Value of savings – all this data is held at the Rivers Trusts level i.e. to use this tool for the wider use of the app requires input/information from multiple organisations
 - Other benefits (health/education for CBA) – requires information from Rivers Trusts
 - Other benefits (for MCA) – some of the benefits accrue to the EA (wider spatial data set) but others to the Rivers Trusts. Benefits to wider society are all secondary to primary aims but unlikely to say that these don't exist – potential to “game” this section to “sell” the approach. Difficult to provide evidence of outcomes

C4 Case study 4: Non-native species Initiative

Respondent: Mike-Sutton Croft (Non-native Species Specialist, Animal and Plant Health Agency).

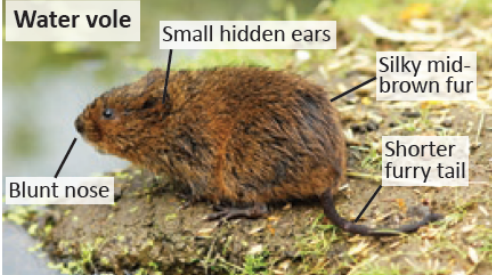
Mike's role includes co-ordinating the Invasive Non-Native Species Local Action Groups and he has worked prior to this as a local co-ordinator for the well-established Norfolk initiative (see <http://www.norfolkbiodiversity.org/nonnativespecies/> for more details). It was in this latter role that the tool was considered and three particular survey type projects. Each of these involved monitoring for non-native species but also included protected native species. They were in partnership with different organisations such as wildlife trusts or the Broads Authority. A key principle to the activities undertaken was to link existing data and fill spatial gaps to produce a more coherent and meaningful dataset. The three surveys considered here looked at ponds, gardens and river courses to identify specific invasives and some natives.

Local Action Groups (LAGs) are local organisations who undertake practical actions to eradicate, control or monitor invasive non-native species of plants and animals. They generally operate within short-term funding cycles that significantly constrain their effectiveness in terms of monitoring and eradicating bio-security hazards. The geographical organisation of current groups is generally around river catchments and volunteers have the potential to make significant contributions but require the support and coordination of LAG project officers to be effective. Improved access to and ability to submit up-to-date monitoring information records could improve the effectiveness and coordination of LAG actions for control and eradication of new non-native species.

Figure 13 Part of the wildlife ID kit for Norfolk volunteers

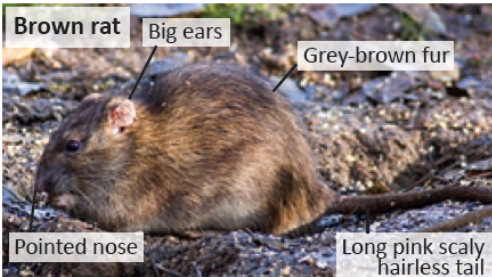
Key ID Features
 Water voles are rat-sized with a distinctive blunt nose, dark chestnut-brown/black fur, short rounded ears and hair covered tail. As water voles are elusive their presence is best identified through field signs, their footprints, however, are very similar to that of brown rats.

Water vole




Water voles can be confused with brown rats which are often found near water

Brown rat




Field signs: Characteristic tracks are left in mud flats close to the water.



Forefoot: four toes in a distinctive star shape

Hind foot: five toes. First and fifth are at right angles to the central toes



Water vole

Brown rat

Water voles often leave droppings in the same place, creating a latrine.

Observations on the tool (response restricted to the three Norfolk surveys):

- Set up tab:
 - Background – for the LAG these questions highlighted some issues around defining a baseline. For the type of projects undertaken the LAG looks at the regional context and tries to link and fill in gaps
 - Financial parameters – with no clear baseline this becomes difficult. Work is seen as additive. The timeline is also somewhat indeterminate with funding available for a fixed period but the data collection likely to last beyond this
 - Determining evaluation approach – struggles with the meaning of some of the questions as well as thinking about what the benefits actually were (they can be quantitative and qualitative) and who they accrue to. What is an outcome

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- Costs tab:
 - Category of expenditure – there are a number of categories that had not entered their thinking and this was seen as a useful way to consider a wider set of eventualities for bidding and reporting. Currently has 10 years that could be included – too many?
 - Other risks – some of the questions are not clear
 - Benefits tab:
 - Value of savings – valuing the input of volunteers seen as potentially very useful
 - Other benefits (health/education for CBA) – again, seen as potentially very useful
 - Other benefits (for MCA) – given the number of partners in the projects there was some difficulty in terms of response. Different partners could respond in different ways

The respondent wants to use the tool in the coming months. The Yorkshire Local Action Group, in conjunction with the Yorkshire Wildlife Trust, has developed a web portal that is mapping positive and negative findings of particular species. They have expressed an interest in using the tool to better prepare and cost an EU funding bid in September 2016. In particular the list of possible costs was useful as it covered many areas previously not considered. In addition, the ability to put values to the benefits (including those associated with well-being etc.) was considered to be of use for the bid. The Fera end of the project team will maintain contact to see how the tool is incorporate and provide advice after this project is completed.