Rialtas na hÉireann
Government of Ireland

Review of Air Quality-Related Citizen Science Projects

2025

Prepared by the Department of Climate, Energy and the Environment
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Table of Contents

Table of Contents 2
1. Introduction 4
1.1 Importance of Air Quality-Related Citizen Science Projects 4
1.2 Objectives of this Review Report 5
2. Approach to the Review of Air Quality-Related Citizen Science Projects 6
2.1 Project Definition 6
2.2 List of Projects to be Reviewed 6
2.3 Key Information Items Included in Project Summaries 8
2.4 Approach to gathering data for the project review summaries 9
3. Review of Citizen Science Projects in Ireland 9
3.1 Project Review Summaries 10
3.1.1 GLOBE Programme 10
3.1.2 Clean Air Together 13
3.1.3 Scoil-Aer: Citizen Science for Clean Air Routes to School 14
3.1.4 Campaign for Clean Air 15
3.1.5 I-CHANGE Dublin Living Lab 16
3.1.6 The Air We Share 17
3.2 Recent Citizen Science Projects that have Commenced in Ireland 18
3.3 Relevance of Data Quality in Citizen Science Projects 19
3.4 Key Strengths of Ireland's Citizen Science Projects 19
3.5 Key Gaps in Ireland's Citizen Science Projects 21
4. Opportunities for Citizen Science Projects 22
4.1 Overview 22
4.2 Opportunities for Improving Process 23
4.2.1 Opportunity 1: Open Project Resources 23

4.2.2 Opportunity 2: Whole Project Life Cycle Involvement of Citizen Scientists 24
4.2.3 Opportunity 3: Diversity of Engagement 26
4.3 Opportunities for Deepening Impact 28
4.3.1 Opportunity 4: Formal Impact Evaluations and Reporting 28
4.3.2 Opportunity 5: Data Sharing 30
4.3.3 Opportunity 6: Addressing Additional Emission Sources: 31
4.4 Opportunities for Increasing Efficiency 33
4.4.1 Opportunity 7: Funded Programmes for Citizen-led Actions 33
5. Conclusion and Recommendations 34

1. Introduction

1.1 Importance of Air Quality-Related Citizen Science Projects

Citizen science initiatives which focus on air quality can play a crucial role in raising public awareness, equipping communities with the knowledge and tools to advocate for stronger environmental policies and take proactive steps to protect public health. By involving nonprofessionals in the collection and analysis of air quality data, these projects can foster a deeper understanding of pollution sources, its health impacts, and potential solutions. They can also democratise scientific research, making it more inclusive and accessible. However, challenges such as inclusive participation, making data actionable, and the need for effective collaboration with policymakers must be addressed to maximise their impact. By overcoming these hurdles, air quality-related citizen science has the potential to drive meaningful change by engaging the public in evidence-based decision-making and environmental stewardship.

Air-quality related citizen science projects vary in form depending on their objectives. Engagement with local community members can foster environmental awareness through increased education and empower them to take action to improve local air quality. Often, this awareness is spread through a multiplier effect, beginning with young people in schools and expanding as they interact with other generations within the community. In parallel, data collection efforts, when yielding high quality data, can help identity pollution hotspots and trends. The findings from these efforts can in turn help influence local and national policies and initiatives concerning air quality.

To strengthen the design and implementation of effective citizen science projects across Ireland, a review of recent initiatives was conducted to identify opportunities for improvement. This review is a key communication action outlined in Ireland's Clean Air Strategy; aiming to assess current projects and determine future requirements and opportunities for citizen science in air quality monitoring. By drawing insights from both Irish and European projects, this review aims to ensure that future initiatives are well-designed, impactful, and capable of driving meaningful change.

1.2 Objectives of this Review Report

The objectives of this review report are to:

1. To provide a better understanding of the scope and impact of air quality-related citizen science projects that have taken place over the past five years.
2. To support the development, planning and positive impact of future citizen science projects in Ireland through practical recommendations based on identified areas for improvement.

2. Approach to the Review of Air Quality-Related Citizen Science Projects

This section presents the approach taken to review the air quality-related citizen science projects.

2.1 Project Definition

Citizen science projects are included in this report based on the following attributes:

- Project engages with issues of ambient air quality, or the quality of the air in outdoor environments.[1]
- Project actively involves members of the public in a scientific endeavour to generate new knowledge or understanding of air quality.
- These members of the public do not have a professional background in environmental science, or related, or are currently studying for a degree in this field.
- For the Ireland-based projects, the project has commenced prior to January 2025 and been active in the last 5 years (not necessarily completed).

Descriptions of various international citizen science projects are included in Section 4 Opportunities for Citizen Science Projects; however these are not part of the review and therefore do not fall under the same criteria for inclusion.

2.2 List of Projects to be Reviewed

The projects listed in Figure 1 are included in the review. This list has been compiled through desktop online searches for 'citizen science' projects in Ireland, the EU's citizen

[1] Pollutants that are in scope include particulate matter ($PM_{2.5}$ and PM_{10}), ozone (O_3), and nitrogen dioxide (NO_2).

science portal, Google Scholar for publications mentioning a project, and online web searches as well as engaging with the EPA.

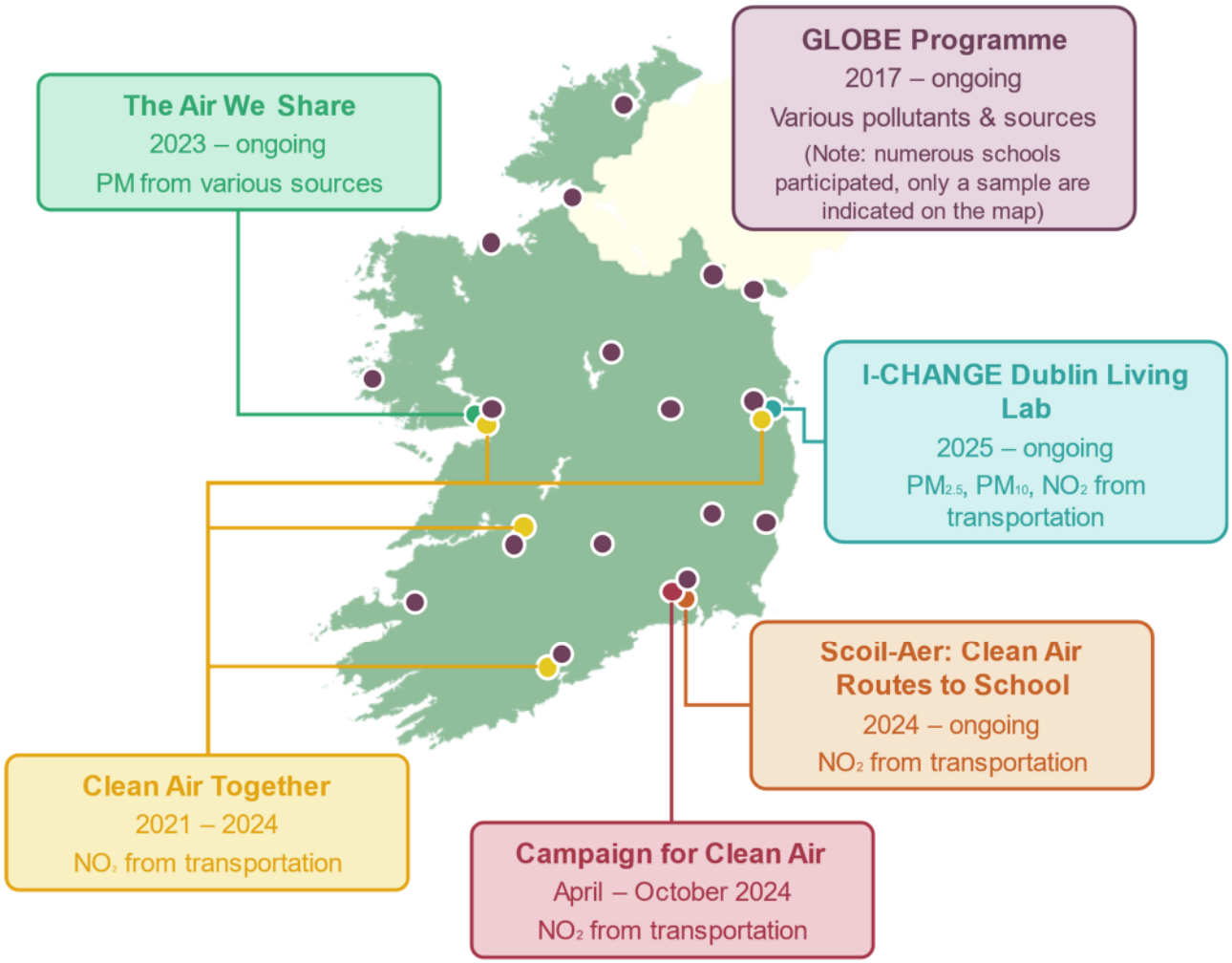

Figure 1. Irish Citizen Science Projects Included in the Review

2.3 Key Information Items Included in Project Summaries

Table 1 provides an overview of the key information fields, related to process, impact, and efficiency, reviewed for each citizen science project in Ireland in the previous five years. Process entails how a citizen science project is conducted, impact relates to the outcomes and influence of the project, and efficiency encompasses project costs and funding.

In reviewing process, key areas of interest included inclusive and diverse participant engagement, widespread knowledge engagement, and generating participant buy-in. In reviewing impact, areas of interest encompassed awareness and education, policy or citizen-led action, and behaviour change.

Table 1. Project Summary Fields and Descriptions

Category	Field Name	Description
Overview	**Organisation(s)**	List of organisations (public and private) that were involved in initiating and overseeing the project.
	Timeframe	Start and end year of the project.
	Objective	The specific goal or purpose of the project, such as monitoring air pollution, raising awareness, or informing policy.
Process	**Participants – type and number**	The different categories of groups and number of participants involved. Where exact number of participants is known, this information is provided. Otherwise, the next level of participant information is provided, i.e., number of schools involved.
	Type of citizen science	Projects can be organised into three general categories: • **Participatory citizen science**: involves using participants to collect data, but otherwise participants are not involved in developing the project or the methods • **Collaborative citizen science:** scientific researchers may design the project, but allow participants to help refine the project design. Participants will also analyse or disseminate information. • **Co-created citizen science:** participants are involved throughout the process from the design phase through to data analysis.
	Pollutant targeted	The primary ambient air pollutant being studied.
	Source targeted	The primary source emitting the air pollutant being studied.
	Technology used	Which monitor or technology was used, if any, to collect data.
	Description of implementation	A brief summary of how the project was implemented, including how the project was facilitated and how data was collected.

Impact	**Outputs**	The tangible products or data generated by the project, such as air quality measurements, maps, reports, or datasets.
	Outcomes	The broader impacts or effects of the project, including increased public awareness, policy changes, or improved air quality management.
	Outreach	The strategies and activities used to engage participants, raise awareness, and share project findings with the public and stakeholders.
Efficiency	**Funding Source**	The origin of financial support for the project.

2.4 Approach to gathering data for the project review summaries

To gather data on each of the projects, a combination of primary and secondary sources was used.

To gather primary data, a questionnaire was constructed, based on the key information components related to process, impact and efficiency, using open-ended surveys. This was disseminated amongst the project stakeholders for each of the included citizen science projects in Ireland. Responses were received in relation to the following projects: I-CHANGE Dublin Living Lab and Lichen_Art Citizen Science. Interviews were conducted with representatives from An Taisce and the EPA to gather information on the GLOBE Programme and Clean Air Together.

Secondary sources of information included publicly available project summaries, news articles, and research publications published online.

In some cases, information for all fields could not be gathered - where the information for a corresponding item was not publicly available, this item is absent from the individual project descriptions.

3. Review of Citizen Science Projects in Ireland

This section provides an overview of each project reviewed and concludes with a summary of the key strengths and gaps in Ireland's air quality-related citizen science projects.

3.1 Project Review Summaries

Citizen science projects in Ireland have made significant strides in various domains, particularly in environmental monitoring and community engagement. This section delves into the comprehensive review of these projects based on the information components presented in Section 2, focusing on their implementation process, the impact they have achieved, and their funding sources.

3.1.1 GLOBE Programme

Category	Field Name	Description
Overview	**Organisation(s)**	An Taisce; EPA
	Timeframe	2017 – ongoing
	Objective	The GLOBE Programme in Ireland aims to engage students in environmental science through citizen-science activities, fostering solutions-oriented thinking and sustainable actions to protect and improve local environments. As the emphasis is on learning about air quality, the programme is open to all schools, and they aim to have one school per county represented in the programme.
Process	**Participants – type and number**	Students - primary and secondary school
	Type of citizen science	Collaborative
	Pollutant targeted	NO_2
	Source targeted	Transportation
	Technology used	Diffusion tubes
	Description of implementation	The project relies on teachers to deliver the projects. Teachers receive all the materials (guidance, activity sheets, diffusion tubes, etc) from GLOBE. GLOBE will also provide webinars, some of which NASA scientists support.
Impact	**Outputs**	Students create science projects based on the monitor data and present at online webinars. In some years, GLOBE Ireland participants have collaborated with participants from other GLOBE projects in Europe which helps extend and deepen the students' engagement. Some schools designed Clean Air Action Plans off the back of the citizen science projects.

	Outcomes	GLOBE collaborates with Green Schools to deliver presentations building on the themes of air quality and motorised transportation to address anti-idling.
	Outreach	GLOBE has provided banners stating 'I am a clean air school' when the school has created a Clean Air Action Plan.
Efficiency	**Funding Source**	EPA

Additional GLOBE Programme Projects

The GLOBE programme entails various projects. Whilst the majority of projects are transportation-focussed, the programme is also trialling citizen science around solid fuel pollution. The programme has also experimented with various data collection methods including using lichens as a means to generate interest and engagement across a more diverse group of participants.

The **PM Pilot in Limerick** commenced in 2024, with the support of the EPA, with the aim to increase data literacy by teaching students how to interpret data by sharing the data with participants for analysis. For the GLOBE programme, the pilot is essential to test the efficiency of using relatively expensive air quality monitors as compared to the low cost sensors typically deployed in citizen science by evaluating whether people are engaging with the data collected and if schools can effectively work with the information. In three select schools already participating in the NO_2-based programme, GLOBE installed air quality monitors and weather stations. Multiple webinars/workshops were provided including on data literacy (led by GLOBE) and coding workshops and data analysis (facilitated by UCC) and air quality and health (led by the EPA). PM data was collected from monitors at three schools and processed by GLOBE. The project coordinators are currently reviewing the outcomes to determine if the key objective of improving data literacy among students was achieved.

The **Lichen_ART Citizen Science Project** conducted in Dublin from 2021 to 2022 was an art-science collaboration, focusing on presenting lichens as bioindicators of air pollution from a different perspective. It involved over 300 school children, teachers and facilitators. The citizen science aspect of the project aimed at bringing awareness around air pollution through artistic expression, based on scientific discovery. Once the lichens were discovered, the students' role was to express that disco ery in a form of a poem. Diffusion tubes experiment data was shared with local authorities, TCD Estates and Facilities, TCD

geography student who looked at air quality studies, and Dublin County Council. Facilitators observed that awareness amongst the schoolchildren about lichens and their role as bioindicators was improved. An interdisciplinary approach to these projects by incorporating art was found to help increase literacy in air pollution amongst wider audience.

3.1.2 Clean Air Together

Category	Field Name	Description
Overview	**Organisation(s)**	EPA
	Timeframe	2021 – ongoing
	Objective	The objective is to engage citizens in measuring NO_2 pollution in their local areas to better understand and improve air quality.
Process	**Participants – type and number**	Over 1000 participants across Dublin, Cork, Galway, Limerick; anyone over 18 years old including residents, businesses and community groups (no specific demographic group targeted)
	Type of citizen science	Participatory
	Pollutant targeted	NO_2
	Source targeted	Transportation
	Technology used	Diffusion tubes
	Description of implementation	Each year a different city delivers the project in collaboration with the EPA. Residents, schools, businesses, and community groups across the participating city are invited to sign up through the project's website. Once enrolled, participants receive an NO_2 diffusion tube, a small device used to measure nitrogen dioxide levels, along with instructions for installation. They place the tube in a suitable outdoor location, where it remains for four weeks, absorbing NO_2 from the air. After the monitoring period, participants return the tubes for laboratory analysis, which determines the NO_2 concentration at each site.
Impact	**Outputs**	The data collected by citizens helps verify national air quality maps produced using models developed within the EPA's LIFE Emerald project. Participants receive a summary of their local air quality results, and the overall findings are made publicly available on the Clean Air Together website.
	Outcomes	The outcomes of Clean Air Together (CAT) across all four cities are to be assessed with the conclusion of the Limerick project. To understand the impact of CAT in Dublin, the Economic and Social Research Institute (ESRI) conducted an evaluation study.[2] The main objective was to assess the project's impact on participants' awareness, attitudes, and behaviours regarding air quality. ESRI researchers disseminated three surveys amongst the 1,000 study participants as well as a comparison group for baseline purposes. Subsequent data analysis yielded the following findings:

[2] Nolan, A., and Hoy, A. *Clean Air Together Dublin: Impact on Air Quality Awareness, Attitudes and Behaviour*. Economic and Social Research Institute, 2023. https://www.esri.ie/system/files/publications/SUSTAT120.pdf

		• **Participant Profile:** CAT participants were generally more concentrated in the middle age groups (35-64 years) and had higher educational qualifications compared to the general Dublin population aged 18+. • **Awareness and Attitudes:** CAT participants were more aware of NO_2 and other environmental risks than the general Dublin population. They were more likely to correctly identify the main source of NO_2 pollution. • **Changes Over Time:** Awareness of NO_2-related issues improved among selected participants over the course of the study. • **Behaviour:** There was limited evidence of significant changes in behaviour (e.g., transport mode choice) as a result of participation in CAT. Individual-level behaviour change needs to be accompanied by targeted public policies to achieve lower levels of air pollution. The study highlighted the need for greater diversity in participation in environmental citizen science projects. Practical actions such as alternative recruitment strategies and co-design of projects could help widen participation. Furthermore, to motivate individual behaviour change, enhanced information alone may not be enough; targeted public policies are essential.
	Outreach	Schools, businesses, and community groups are encouraged to take part, broadening the project's impact and fostering a sense of collective responsibility. Following analysis, participants receive personalised reports on their local NO_2 levels, and the overall findings are published online, making the data accessible to everyone.
Efficiency	**Funding Source**	EPA

3.1.3 Scoil-Aer: Citizen Science for Clean Air Routes to School

Category	Field Name	Description
Overview	**Organisation(s)**	Trilateral Research, Impetus
	Timeframe	2024 – 2025 (still ongoing)
	Objective	The main objective is to improve air quality, reduce exposure to pollution, and promote sustainable travel habits among students.
Process	**Participants – type and number**	Approximately 40 to 50 students
	Type of citizen science	Co-created
	Pollutant targeted	$PM_{2.5}$

	Source targeted	Transportation
	Technology used	PurpleAir sensors; STRIAD:AIR technology for modelling component
	Description of implementation	Students collaborated with researchers to design clean air walking, wheeling, and cycling routes around their schools. Students discussed their concerns and what is important for them in a walking route to help inform route design. Routes were then designed based on these discussions as well as modelled air quality of the streets. Students then went out to validate the routes using mobile air quality monitoring devices to measure pollution levels on streets. This data was then integrated into the maps and the results were shared with the participating students and wider school body.
Impact	**Outputs**	Collected data was analysed and combined with the contextual elements about pleasant and safe routes to school to help inform school walking routes.
	Outcomes	The project has not been completed and outcomes are still unknown.
	Outreach	Students will determine the best way to communicate the findings of the project. During Irish Science Week, they will present the maps and gather feedback and raise overall awareness of active travel as an air-friendly alternative to motorised transport.
Efficiency	**Funding Source**	Impetus, European Commission

3.1.4 Campaign for Clean Air

Category	Field Name	Description
Overview	**Organisation(s)**	Waterford City County Council Climate Action Team; Creative Ireland
	Timeframe	April – October 2024
	Objective	The project sought to explore air quality issues through the medium of art.
Process	**Participants – type and number**	Primary school students from two schools
	Type of citizen science	Participatory
	Pollutant targeted	$PM_{2.5}$
	Source targeted	Transportation
	Technology used	NA

	Description of implementation	The campaign also involved monitoring air quality outside the schools, which helped the students identify spikes in pollution levels during school drop-off and pick-up times.
Impact	**Outputs**	Data collected was analysed to predict future health impacts and the impact on the schools' efforts to reduce air pollution. Students also created banners with a local artist, which were displayed at their schools to communicate anti-idling messaging.
	Outcomes	The students took action by raising awareness about the harmful effects of idling car engines and encouraging parents to switch off their engines.
	Outreach	Students actively participated in the campaign by chanting slogans and holding posters to raise awareness. The campaign involved the local community, including parents and school staff, to address air pollution collectively.
Efficiency	**Funding Source**	Creative Ireland

3.1.5 I-CHANGE Dublin Living Lab

Category	Field Name	Description
Overview	**Organisation(s)**	University College Dublin (UCD)
	Timeframe	2022 – 2025 (still ongoing)
	Objective	The project is part of a wider initiative taking place across Europe and Africa that aims to establish citizen science initiatives and show that behavioural change on the part of single citizens can have an impact on the environment. This project, or living lab, seeks to reduce traffic and air pollution at school gates by changing citizens' behaviours.
Process	**Participants – type and number**	Students across 20 schools
	Type of citizen science	Participatory
	Pollutant targeted	$PM_{2.5}$, PM_{10}, NO_X
	Source targeted	Transportation
	Technology used	Low-cost sensors
	Description of implementation	UCD provided automatic traffic counters and air quality monitors to measure the number of cars, bikes, and pedestrians, as well as particulate matter in the air. UCD developed activities to promote walking and cycling to school, aiming to reduce the number of cars outside school gates, and school children acted as ambassadors for change. Data from the traffic counters and air quality monitors

		was used to demonstrate the impact of these activities on air quality and active travel uptake.
Impact	**Outputs**	The collected data on traffic patterns and air quality will be made publicly available to demonstrate the effectiveness of these activities.
	Outcomes	This initiative aims to show that changing citizens' behaviours can lead to significant environmental benefits, such as reduced traffic congestion, improved air quality, and enhanced road safety.
	Outreach	Schoolchildren act as ambassadors of change, promoting sustainable, eco-friendly behaviours within their communities.
Efficiency	**Funding Source**	European Union's Horizon 2020

3.1.6 The Air We Share

Category	Field Name	Description
Overview	**Organisation(s)**	Galway City Council (lead); University of Galway; Galway Arts Centre; Westside Resource Centre; Galway Culture Company
	Timeframe	December 2023 - July 2025
	Objective	The project aims to foster a deeper understanding of air pollution, its impacts, and potential solutions, empowering citizens to take meaningful action on climate change through a combination of citizen science, artistic interventions, and community engagement.
Process	**Participants – type and number**	Local citizen community groups in Westside, students in local schools
	Type of citizen science	Participatory
	Pollutant targeted	$PM_{2.5}$, PM_{10}
	Source targeted	Fossil and solid fuels burning
	Technology used	PurpleAir sensors
	Description of implementation	The project involves installing eight air sensors throughout Westside (decarbonisation zone) to measure particulate matter, and sharing this data with artists who are tasked with engaging citizens from the local community in workshops to co-create art pieces illustrating the findings and make 'the invisible visible'. The project also hosted a 'build your own sensor' workshop with students from the local community to equip young peoplewith the knowledge, methods, and data needed to bring about change.

Impact	**Outputs**	Data from the eight air quality sensors measured the concentration of PM in the air. Artists will work with communities to find ways to communicate air quality, making the invisible visible.
	Outcomes	By closely engaging with various groups within the localcommunity, this project aims to build an understanding of climate issues and empower people to take action. This project worked closely alongside the Net Zero Cities Project, a European-wide carbon emissions reduction programme, to inform the development of Galway City Council climate policies.
	Outreach	Key outreach initiatives include the Artist-in-Residence Programme whereby three artists were recently selected for nine-month residencies to create sensory visual representations of air quality data. These artists will work with the community to explore the connections between air quality, climate, and health. Examples of the art projects that will be created and presented in July 2025 include: creating "data sculptures" from air quality data and envisaging Galway in 2054, creating a speculative future scenario and collective textile artwork to reimagine air as a shared resource.
Efficiency	**Funding Source**	Creative Climate Action fund - funded by the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media in collaboration with the Department of the Environment, Climate and Communications

3.2 Recent Citizen Science Projects that have Commenced in Ireland

While it falls outside the scope of the main review, it is worth noting the recent commencement of an air quality-related citizen science project in Ireland (since January 2025). The UCC Green Campus & Cork Smart Gateway Smart Bike Project commenced February 2025 and aims to measure air quality around the university. Students and staff have attached SODAQ air sensors to their bicycles to collect air quality during their cycle journeys to and from the Cork campus. This project is similar to the Snifferbike project from 2018 in Utrecht, the Netherlands, whereby cyclists used SODAQ sensors to collect data about air quality along cycle routes. In that case, the sensor data fed into an open data portal the pu lic could iew and was also shared with the country's national institute for public health and environment to get calibrated to official, static measuring station readings.

3.3 Relevance of Data Quality in Citizen Science Projects

Most of the citizen science projects in Ireland had the aim of raising knowledge and awareness of air pollution to demonstrate how behaviours impact air quality. As the objective of the data collection was to demonstrate how an intervention or behaviour change improves or worsens local air quality, numerical accuracy was less important than the relative accuracy of the data. That is, knowing whether a behaviour change, intervention, or different environmental conditions, leads to an improvement or decline in air quality was the main objective.

In other cases, the numerical data gathered in the projects was more important as the outputs of the projects, the air quality concentrations, helped identify hotspots to inform policy decisions. This type of project, of which Clean Air Together is an example, required greater accuracy and reliability of data to help inform decisions in policy than those projects where indirect outcomes of engagement and raising awareness were more important.

3.4 Key Strengths of Ireland's Citizen Science Projects

Based on the review of various citizen science projects in Ireland, several key strengths emerged that contributed to their success and impact. Strengths included the ability of the projects to engage diverse communities, tackling transport-related air pollution, embedding objectives of data literacy, and actively involving participants in outreach activities to drive change.

Disseminating results via creative expression and the arts:

One notable strength was the integration of creative expression and the arts, which made these projects, such as the Air We Share and the Lichen ART project under the GLOBE programme, more inclusive to individuals who may not have a strong background in science. By incorporating artistic elements such as visual storytelling, music, or community-based exhibitions, these initiatives were able to engage a broader audience and foster greater public participation. The significant interest among artists in Ireland to be involved in projects like the Air We Share indicates further potential to leverage this strength in the Irish context and engage a wider population.

Diversity in approach to transport emissions:

Another significant strength was the diverse range of projects and approaches taken to address motorised transport emissions. Given the growing concerns over air pollution and its health impacts, citizen science projects focusing on vehicle emissions help raise awareness and provide valuable local data that can inform policy decisions and mitigation strategies. Projects in Ireland tackled the issue of transport emissions from various angles including the issue of idling outside of schools (Campaign for Clean Air and I-CHANGE Dublin Living Lab) and co-designing routes to school to support active travel and reduce exposure for students (Scoil-Aer). These projects empowered communities to take an active role in monitoring air quality and advocating for cleaner transportation options.

Data literacy:

While citizen science projects are commonly used to improve awareness of air pollution, one challenge in particular that the Ireland-based projects honed in on is data literacy—specifically, the ability of participants to read, interpret, and effectively use the data they collect. Programmes like GLOBE recognised this challenge and have been working to improve data literacy through educational resources and training sessions. By equipping participants with the skills to analyse data accurately, these projects could enhance the reliability of citizen-generated information and empower individuals to make data-driven contributions to environmental discussions.

Active use of data to drive change:

Additionally, by encouraging participants to actively use collected and analysed data to drive change, the projects helped better empower participants with a deeper awareness of their agency in bringing about change. When participants see that their efforts lead to tangible policy changes, through collaboration with local governments, or community improvements, they feel a stronger sense of purpose and accomplishment. Outreach initiatives not only amplify the impact of the data collected but also helped participants build confidence in their ability to effect change. By translating scientific findings into actionable community interventions, such encouraging the reduction of idling near schools, in the case of the Campaign for Clean Air, or influencing local transportation policies, participants became active contributors to environmental improvement rather than passive observers. Furthermore, engaging students in public forums like Irish Science Week, as Scoil-Aer plans to do, provided them with valuable communication experience, allowing them to articulate their findings to a wider audience. This exposure reinforced the importance of citizen science

and can inspire others to take part in similar initiatives, creating a ripple effect that extends beyond the immediate project.

3.5 Key Gaps in Ireland's Citizen Science Projects

Based on the analysis of air quality-related citizen science projects in Ireland, several gaps have been revealed. These gaps highlight areas for further improvement to enhance delivery and outcomes of citizen science projects in Ireland. Table 2 outlines the gaps observed across the projects reviewed, and their related consequences, though it should be noted that not all projects in Ireland have these gaps.

Table 2. Overview of Gaps and Consequences Observed Across Ireland's Citizen Science Projects

	Gap	Consequence	
1	**Open Project Resources:** Lack of general, publicly available documentation of the resources designed for and used in the project.	Incomplete or non-existent online access to the project resources makes it difficult for others to borrow from a project's approach for future projects, particularly where the project objectives mirror each other and efforts are duplicated.	Process
2	**Whole Project Lifecycle Involvement of Citizen Scientists:** Citizen science projects in Ireland tend to involve participants in the monitoring of air pollution as opposed to the stages post and prior to this - design and data analysis.	Limited involvement across all stages of a project, can reduce sense of ownership and thus motivation. This lack of involvement can impact project outcomes and broader awareness-building objectives. Additionally, it can limit innovation during the design phase, reduce the relevance of the project outcomes for improving the public's awareness and understanding of their role in improving air quality, and hinder the learning opportunities that could be gained from data analysis, such as improving data literacy.	
3	**Diversity of Engagement:** Air quality-related citizen science projects in Ireland are predominantly focussed on urban centres, with a lack of projects addressing air quality across rural regions and inclusive of low-income groups.	Projects with a limited reach and exclusive to certain participant groups lead to limited data collection, making it challenging to effectively address air pollution in underrepresented areas. A lack of air quality projects in rural regions can negatively impact project outcomes and awareness-building efforts due to insufficient data collection across a diverse cohort. Furthermore, the absence of participants from diverse regions and socioeconomic groups can hinder overall awareness-building initiatives.	

4	**Formal Impact Evaluation:** Lack of formal evaluation studies or reporting on the findings of Irish citizen science projects on air quality.	A lack of formal avenues and reporting tools for assessing the impact of air quality-related citizen science projects hinders the ability to effectively compare project outcomes. This limitation also prevents new projects from building on the results of previous initiatives and restricts the dissemination of learning to a broader audience.	Impact
5	**Data Sharing:** Data collected is not shared beyond the individual project.	Where data is not made visible or accessible beyond the immediate project, the data's usefulness and lifespan becomes limited to the project timeline itself and cannot be used for other purposes beyond the project.	
6	**Additional Emission Sources:** Citizen science projects in Ireland predominantly focussed on transport-related pollutants, with relatively few initiatives addressing the prevalent issue of solid fuel burning.	Citizen science projects are valuable ways of improving public awareness of and responsibility for air pollution issues. The limited scope of projects to a single emission source fails to fully maximise the potential of these projects engaging the public to respond to other sources of emissions.	
7	**Funded Programmes for Citizen-led Actions:** Whilst funding is available for data collection, the availability of support for the implementation of citizen-led actions/ solutions for improved air quality is limited.	A lack of programmes providing support (including funding) for air quality-related citizen-led actions, including for actions which build on citizen science project results, limits citizens' ability to enact real change. This reduces motivation among participants and thus the subsequent impact potential of data gathered.	Efficiency

4. Opportunities for Citizen Science Projects

4.1 Overview

Each of the gaps identified in the review of the Ireland-based projects presents an opportunity to strengthen citizen science projects in Ireland by improving process, deepening impact, and increasing efficiency.

This section delves into these opportunities for process, impact, and efficiency, drawing on examples from across Europe to illustrate best practice. For each opportunity, specific benefits are noted for Ireland's air quality and citizen science facilitators, in terms of deepening the success of the projects, that might be expected as a result of pursuing this opportunity.

Table 3 provides an overview of the high-level primary and secondary benefits of addressing each of the gaps observed as a result of the review of Ireland's air quality-related citizen science projects. Addressing each of these gaps can be an opportunity to derive benefits for future projects. It should be noted that in some cases these secondary benefits may only be

realised by subsequent projects – for example the sharing of materials may not benefit the project sharing these materials but would benefit other projects.

Table 3. Matrix of gaps and associated benefits of implementation across process, impact and efficiency

Gaps as Opportunities	Process			Impact			Efficiency
	Inclusive and Diverse Engagement	Widespread Knowledge Dissemination	Generating Participant Buy-in	Awareness and Education	Policy or Citizen-led Action	Behaviour Change	Cost Efficiency
Open Project Resources		●		○	○	○	○
Whole Project Lifecycle Involvement of Citizen Scientists	●		●	○	○	○	○
Diversity of Engagement	●	●		○			○
Formal Impact Evaluation		○	○	○	●		
Data Sharing		○	○	○	●		○
Additional Emissions Sources	○		○	●	●	●	
Funded Programmes for Citizen-led Actions				○	○	○	●

●	Primary Benefit of Implementation
○	Secondary Benefit of Implementation

4.2 Opportunities for Improving Process

Improving process ensures higher-quality data, greater participant engagement, and more reliable outcomes that can influence decision-making. Key opportunities for improving process include:

- *Opportunity 1:* Open Project Resources
- *Opportunity 2:* Whole Project Life Cycle Involvement of Citizen Scientists
- *Opportunity 3:* Diversity of Engagement

4.2.1 Opportunity 1: Open Project Resources

Open access to resources on previous and current citizen science projects supports the success of future projects across all stages, particularly where access to these resources is paired with any lessons learned. By publishing resources online, similar to how the GLOBE Programme in Ireland has been doing over the years, these resources can efficiently be used to help jumpstart further projects, thereby helping make better use of the initial funding

provided to design these resources and extend the reach of impact. Additionally, by looking at past initiatives, project facilitators can identify effective methodologies, avoid common pitfalls, and refine their approaches to data collection, participant engagement, and analysis.

Collating citizen science projects and their respective documentation in one platform can help act as a centralised resource for all stakeholders. The EU hosts the *eu-citizen.science* platform to act as a central hub for pointing to projects across Europe while also offering resources, trainings and tools to support participants and project organisers and facilitators in the citizen science community. Some EU countries have also set up their own dedicated central platforms including Austria, Germany, and Belgium. These country-level pages tend to provide tailored information for their local contexts. For example, the German platform, *mit:forschen! Gemeinsam Wissen schaffen*, presents information on over 300 projects from various disciplines and provides guidelines to support projects in encouraging participation, sound research, tips for working with schools, and legal guidance amongst other resources.

BENEFITS
For Ireland's Air Quality: Promoting the availability of publicly accessible information on citizen science projects can help improve the replicability of projects in other contexts, thereby increasing awareness of air pollution and impact on public health. **For Citizen Science Facilitators:** Greater information and knowledge sharing of resources can help encourage collaboration and innovation. Increasing the visibility of existing projects enhances learning, reduces the potential for redundant efforts and promotes education and awareness.

4.2.2 Opportunity 2: Whole Project Life Cycle Involvement of Citizen Scientists

Co-created citizen science projects encompass the full involvement of citizen scientists in the conduct and governance of the projects. This approach promotes meaningful interactions between citizens and researchers, allowing them to work together to gather data to support meaningful impact.

While co-creation principles promote a decentralised approach that can lead to uncertainties due to the lack of predetermined data collection and analysis plans, it can better foster grassroots innovation and open up possibilities for co-creating solutions that are responsive

to local community interests.[3] Co-creation promotes the creation of an inclusive environment that ensures representation from all sections of society, irrespective of social status, gender, religious beliefs, literacy level, or age. This approach helps in addressing environmental justice and ensures that the benefits of citizen science are accessible to all sections of society.

By including citizens in the early problem identification phase of the project, the project can be designed to yield data insights that citizens more proactively engage with. This can inspire increased collective action amongst participants, positively influencing changes in their own behaviours to mitigate air pollution as well as prompting them to advocate for policy changes. For example, for the *xAire Project* in Barcelona, parents and children monitored air pollution around schools, proving that pollution levels were dangerously high. This led to new traffic restrictions near schools and the introduction of "superblocks" (lowtraffic zones).[4]

European CitieS-Health project

Country: The Netherlands

Organisations: Local universities, national and local public health institutes, and research organisations

Summary:[5]

The project aimed to investigate the association between short-term changes in outdoor woodsmoke exposure and respiratory health in adults. The study was conducted between February and May 2021 and involved adults from four Dutch towns.

Participating citizens were identified and contacted through stakeholder meetings, online calls for research questions, physical and virtual meetings, and flyers distributed in various neighbourhoods. The list of citizens grew throughout the project through word-of-mouth advertisement by involved parties. Citizens played a significant role in formulating the research question, designing the study, recruiting participants, and interpreting the findings. They helped ensure that the research question was socially relevant and that the design elements met the needs of the involved citizens.

Participants recorded their symptoms and medication use daily and conducted morning and evening spirometry measurements. Woodsmoke exposure was characterised by

[3] Mahajan, S. et al. (2022). Translating citizen-generated air quality data into evidence for shaping policy. *Humanities and Social Sciences Communications 9*(122). https://doi.org/10.1057/s41599-02201135-2

[4] Perello, J. et al. (2021). Large-scale citizen science provides high-resolution nitrogen dioxide values and health impact while enhancing community knowledge and collective action. *Science of the Total Environment 789*: 147750. https://doi.org/10.1016/j.scitotenv.2021.147750

[5] Froeling, F. et al. (2024). A co-created citizen science project on the short term effects of outdoor residential woodsmoke on the respiratory health of adults in the Netherlands. *Environ Health 23*(90) (2024). https://doi.org/10.1186/s12940-024-01124-9

measuring levoglucosan, a specific marker for woodsmoke, along with other pollutants like black/brown carbon and fine/ultrafine particulate matter at central monitoring sites.

The study highlighted that woodsmoke exposure is not just an individual problem but a community-wide issue that needs to be addressed.

BENEFITS

For Ireland's Air Quality:

Involving citizens at every stage of a project, from design to data analysis, can foster a stronger sense of ownership among participants. This enhanced engagement can improve project outcomes by increasing the quality and quantity of data collected and ensuring more efficient use of resources.

For Citizen Science Facilitators:

Co-creation empowers communities by involving them in scientific research and decision-making. Additionally, it promotes data literacy and encourages pro-environmental behaviours, leading to more sustainable practices and a stronger sense of community.

4.2.3 Opportunity 3: Diversity of Engagement

Air pollution is not an issue that belongs to only one group of citizens to address, but rather is a challenge that requires collective efforts across a diverse population. Citizen science projects have the ability to spark awareness of and responsibility for combatting air pollution which makes them a powerful means of engaging citizens. Reaching a diverse range of citizen scientists is key, particularly outside of the cities where air pollution may not be perceived as a pressing concern and amongst low-income groups who may be excluded from participation y nature of the project's design To this end projects in Ireland ha e taken innovative approaches to reaching widespread audiences through creative mediums including art, song, and poetry, to make citizen science projects more inclusive and appealing to people and projects such as the Air We Share have demonstrated that there is scope to broaden this approach given significant interest amongst Artists in Ireland

However, there is benefit in further extending the reach of projects to engage vulnerable population groups such as the elderly, economically disadvantaged groups in areas disproportionately affected by air pollution, as well as extending beyond urban areas to incorporate rural participants. By doing so, the scope of air quality-related citizen science, as well as the impact of these projects in Ireland overall, can continue to expand as further

barriers and methods for engagement are taken into consideration. Barriers to participation for these groups needs to e considered and could include the rele ance of a project's scope for these participants (e.g., focus on congestion vs idling outside of schools), and financial barriers to participation (e.g., access to a home computer to analyse data).

COMPAIR – Community Observation Measurement & Participation in AIR Science

Country: Greece, Germany, Belgium, and Bulgaria

Organisations: Numerous international organisations, local universities, local administrations, and public bodies, with the initiative led by Digitaal Vlaanderen

Summary:[6]

The project aimed to empower citizens across Europe to actively participate in monitoring and improving air quality. By engaging the public in citizen science experiments, COMPAIR seeks to address gaps in official air quality data, thereby facilitating more effective social actions and influencing urban policy to foster healthier and greener cities.

The project focussed on engaging diverse communities, particularly those from lower socioeconomic backgrounds and regions with less established citizen science cultures, such as Eastern and Southern Europe. This inclusive approach ensured a comprehensive understanding of air quality issues across different urban settings.

To include communities who tend to be the most adversely affected by air pollution, COMPAIR aimed to engage people typically underrepresented in citizen science – young people, the elderly and minority groups. For example, in Sofia, Bulgaria air pollution tends to be exacerbated in economically deprived neighbourhoods with vulnerable groups where solid fuels are used for home heating. To overcome the hurdles of engaging with hard-to-reach population groups, COMPAIR partnered with local Roma minority organisations to recruit citizen scientists from the Roma community and provide them with an opportunity to better learn about the harmful effects of air pollution and measures they could take to mitigate this problem and protect public health. In Athens, where the elderly were identified as a particularly vulnerable group, engagement was facilitated via recreational centres for senior citizens.

[6] Kogut, P., Raes, L. and McAleer, S. (2023). Improving Urban Air Quality and Climate-resilience in Cities with Inclusive, Policy-relevant Citizen Science. *Climate Resilient Society.* Retrieved from: https://ercim-news.ercim.eu/en135/special/improving-urban-air-quality-and-climate-resilience-in-cities-with-inclusive-policy-relevant-citizen-science

BENEFITS
For Ireland's Air Quality: Promoting the delivery of air-quality related projects across currently underrepresented regions and groups would support greater awareness building among the wider population through more diverse participation. It would also ensure that data collected is representative of all geographical areas and socio-economic groups, providing more comprehensive insights for policy decisions. **For Citizen Science Facilitators:** Fostering greater participation and interest in air quality across the entire population enabling more comprehensive data collection and heightened public awareness of air quality issues.

4.3 Opportunities for Deepening Impact

Deepening impact maximises the real-world effects of citizen science by driving policy changes, fostering community action, and creating lasting environmental or social improvements. Key opportunities for deepening impact include:

- *Opportunity 4:* Formal Impact Evaluations and Reporting
- *Opportunity 5:* Data Sharing
- *Opportunity 6:* Addressing Additional Emissions Sources

4.3.1 Opportunity 4: Formal Impact Evaluations and Reporting

Running a comprehensive impact evaluation for a citizen science project is valuable because it helps measure the project's effectiveness and value, understand its broader influence, and inform future improvements for subsequent projects. To strengthen the quality of the findings, introducing an impact evaluation early on in the project is necessary as evaluation methodologies typically require pre and post studies to measure change. The evaluation can employ both quantitative methods, such as surveys, as well as qualitative approaches, including focus groups, to evaluate outcomes based on clear objectives set at the outset of the project.

The benefits of conducting an impact evaluation are substantial. It provides evidence of success and areas for improvement, helping to justify funding and resources. It enhances the credibility of citizen science by assessing data reliability, making it more valuable for professional research and institutional collaborations. Furthermore, understanding what drives participation and retention allows for more effective engagement strategies.

Evaluations also show how citizen science data can inform policy decisions, encouraging its use in environmental and public health regulations. Where multiple implementations of a project are planned impact e aluations can help iterate on the project's initial implementation to help better shape the success of following iterations of the project. For example, surveys to gauge participation of Clean Air Together in Dublin, Cork, and Galway found that, though the projects attracted numerous participants, the socio-economic demographic diversity of these participants was low. Subsequently, to increase participation diversity in Limerick, concerted efforts were made with the support of local authorities to engage hard-to-reach groups.

CAPTOR - Collective Awareness Platform for Tropospheric Ozone Pollution

Country: Austria, Italy, Spain

Organisations: Numerous local universities, research organisations, technological centres, and environmental organisations including: Ecologistas en accion, Legambiente, Global 2000

Summary:[7]

The multi-year project deployed 46 low-cost sensors in homes and public spaces to measure ozone levels and aimed to influence individual learning, behavioural change, and civic activism, as well as regional and political change. Citizen scientists in three countries were provided monitors to place at their homes and in community spaces to collect data during the summer across several years.

To measure and evaluate the project's success against expected impact, the project team drafted a socio-ecological impact assessment strategy to collect evidence around impact, success factors and barriers encountered in the project's citizen science approach. To assess impact, the project used guided interviews and pre-/post-questionnaires. Insights from 53 interviews showed that participants gained knowledge, promoted awareness in their networks, and, in some cases, engaged in political activism. As the project spanned multiple years, the longer-term nature of the project lent well to measuring the effects of the project overtime, however the evaluation was still limited in terms of measuring long-term effects beyond the project's timeframe. Furthermore, while interviews allow for deeper, richer insights and might be more appropriate where a small group of citizen scientists is concerned, they can be a resource intensive method for measuring impact amongst a larger group as compared to survey questionnaire.

[7] Schaefer, T., Kieslinger, B., Brandt, M., and van den Bogaert, V. (2021). Evaluation in Citizen Science: The Art of Tracing a Moving Target. In: Vohland, K., et al. *The Science of Citizen Science*. Springer, Cham. https://doi.org/10.1007/978-3-030-58278-4_25

BENEFITS

For Ireland's Air Quality:

Establishing formal avenues and reporting tools for assessing the impact of air quality citizen science projects would support a growing evidence base that can be drawn on when conceptualising future projects to maximise impact and help inform resource allocation.

For Citizen Science Facilitators:

Conducting impact evaluations provides insights into the effectiveness of the methods used to implement the project, helping improve project design and participant engagement. It also strengthens their credibility and can attract funding or partnerships for future initiatives.

4.3.2 Opportunity 5: Data Sharing

Data transparency and openness are essential for air quality citizen science projects because they foster trust and credibility among participants and the broader community. When data is openly shared, it allows individuals to verify the results, enhancing the project's reliability. Additionally, open data promotes collaboration between various stakeholders, including scientists, policymakers, and the public, leading to more comprehensive and effective solutions to air quality issues.

Where data is openly provided the source of the data, i.e. the technology used to collect the data, and measures taken to ensure proper implementation of the technology, needs to be cited as this gives insight into how robust and accurate the data is. While scientific led projects, like Clean Air Together, tend to provide this information and make data open and accessible, projects with an awareness focus tend to not publish captured data or the metadata required to be able to use the data for anything more than information to guide the awareness campaign.

xAire

Country: Spain

Organisations: OpenSystems of the University of Barcelona, the Barcelona Institute for Global Health (ISGlobal), and promoted by La Caixa Foundation and the 4Sfera company

Summary:[8]

The primary objective of the xAire project was to obtain high-resolution NO_2 levels across Barcelona, particularly around 18 primary schools, to provide valuable insights into air quality differences at a granular level.

The project involved a broad partnership with 1,650 citizens, including children, families, and teachers from the participating schools. The collected data included NO_2 levels from 725 locations, categorised into outdoor urban traffic, outdoor urban background, playgrounds, and inside school buildings.

The high-resolution data provided by the project was valuable for environmental scientists and urban planners, allowing them to contribute health impact assessments for diseases associated with low air quality.

The data was shared with all participating schools through an interactive online map, which included explicit information on whether each location exceeded the NO_2 level established by the EU Directive and WHO reference level.

BENEFITS

For Ireland's Air Quality:

Sharing collected data from projects, particularly where a large quantity of monitors was used that generate good quality data, can allow for broader analysis, enabling researchers, policymakers, and other stakeholders to validate findings, identify trends, and make data-driven decisions.

For Citizen Science Facilitators:

Data sharing can help ensure that the efforts of citizen scientists are acknowledged, which in turn can lend to enhanced motivation and engagement during the project's implementation and generate enthusiasm for increased participation in future projects.

4.3.3 Opportunity 6: Addressing Additional Emission Sources:

Citizen science projects should be targeted towards sectoral emissions that citizens can readily act on to improve through their own behaviours. These should be coupled with activities to engage citizens in the interpretation of the data and translation of the findings into actions by taking a co-created approach to the project. While there are many successful

[8] Perello, J. et al. (2021). Data set from large-scale citizen science provides high-resolution nitrogen dioxide values for enhancing community knowledge and collective action to related health issues. *Data in Brief* 37: 107269. https://doi.org/10.1016/j.dib.2021.107269

examples of transportation-oriented air quality-related citizen science projects, there is room for exploring other sources of pollution.

Solid fuel burning, such as from wood for home heating, is one of the leading causes of $PM_{2.5}$ emissions according to Ireland's Clean Air Strategy and is a key area citizens can actively engage in to help reduce emissions in the residential sector, in particular. However, running projects targeting solid fuel burning can be a challenge due to various factors, such as the seasonal nature that makes it difficult to capture consistent data and the more expensive sensors required to measure the type of pollutants emitted.

Slow the Smoke

Country: United Kingdom

Organisations: Bristol City Council; University of the West of England; Knowle West Media Centre

Summary:

The *Slow the Smoke* project in Bristol exemplifies an approach whereby, though the number of sensors employed was limited as compared to monitors used in transportation-focussed projects, the data results were disseminated to include a diversity of citizens in a way that magnified the impact of the project. This project was one of the first to use citizen science to influence behaviour related to domestic air emissions from wood burning.

The project targeted a ward in Bristol that had a higher level of solid fuel burning than average. Ten citizen scientists living in the ward were provided with initial training in using the sensors via a workshop in July 2022. The participants used SDS011 sensors to capture data.

Data collected by citizen scientists using low-cost air quality sensors was processed through automated ingestion and processing systems. The processed data was then shared with participants and the public via user-friendly data products, such as interactive dashboards and visualisations. Data was further communicated and made accessible to the public through various innovative platforms including a showcase exhibition presenting data narratives interpreted by the community, sonic artwork transforming the data into sound, and Minecraft workshops. Through the Minecraft workshops, young participants used the game to design solutions to address air pollution. By embedding maps of local areas within the game, they explored better approaches to transport, home heating, and urban design.

BENEFITS
For Ireland's Air Quality: By targeting a wider range of emission sources, new projects can enhance societal understanding of all environmental impacts, engage citizens in a fuller understanding of contributors to air pollution, and promote broader environmental action in air quality improvement priority areas. **For Citizen Science Facilitators:** Expanding the scope of emission sources targeted through citizen science can help attract participation from different groups and regions who may find certain sources more personally relevant.

4.4 Opportunities for Increasing Efficiency

Increasing efficiency allows for a more impactful allocation of resources and more scalable projects that can engage larger audiences. A key opportunity for increasing efficiency includes:

4.4.1 Opportunity 7: Funded Programmes for Citizen-led Actions

Translating findings into citizen-led action can help magnify the impact of the citizen science project. This can be supported through dedicated funding – either for projects whose primary objective is to drive citizen-led action, or by supporting the development of programmes in collaboration with government participants, to enable citizen scientists to leverage funding or support through local government channels.

Compared to the lengthy timelines related to implementing national policy-driven actions, empowering citizens to take direct action can significantly enhance the efficiency of addressing societal issues. The benefits of citizen science to society are twofold; increasing participation in citizen science projects can lead, in itself, to positive societal outcomes such as data literacy improvements and increased awareness of environmental issues amongst the general public. [9] In addition to the positive societal outcomes associated with involvement in citizen science projects, findings can also motivate impactful change-oriented action with further positive implications for society.

[9] Haklay, M.., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., Vohland, K. (2021). What Is Citizen Science? The Challenges of Definition. In: Vohland, K., *et al.* The Science of Citizen Science. Springer, Cham. https://doi.org/10.1007/978-3-030-58278-4_2

Funding for citizen-led action is common in other categories of citizen science in Ireland. For instance, the Local Authority Waters Programme encourages local communities and groups in Ireland to apply for financial assistance to support projects and initiatives aimed at enhancing local water bodies, water quality, and biodiversity.

CleanAir@School [10]

Country: Scotland, UK

Organisations: Scottish Environmental Protection Agency; European Environment Agency

Summary: The EEA supported 10 EPAs across Europe in carrying out measurement campaigns at schools across the participating countries. This initiative aimed to promote behavioural change related to mobility around schools by engaging students, their parents, and teachers. A dual approach was taken in some schools whereby students both monitored air quality and also took part in a competition for the best banner on air quality.

As part of this initiative, Scotland has specifically partnered with local authorities and environment officers, to deliver on the ground impacts. As a result of this partnership, and based on the results of citizen science projects carried out, the city council responsible for operating buses was encouraged to explore alternative options, such as promoting walking, scooting, and cycling. Additionally, one participating school successfully closed a street to vehicles during school hours.

BENEFITS

For DECC: Enhancing access to funding and support through programmes for citizen-led actions related to air quality projects, particularly at the Local Authority level, would significantly improve the efficiency of delivering outcomes. Given the knowledge citizen scientists gain through project participation, they can offer relevant and innovative actions that directly address the project's findings. Additionally, the quality of data collected may be improved as participants are motivated by the potential to create real change.

For Citizen Science Facilitators: The potential to create real change at local level can enhance motivation of participants and willingness to participate, ultimately leading to improvements in the quality and quantity of data collected as well as heightened awareness of air quality issues.

5. Conclusion and Recommendations

Over the past five years, several citizen science projects focussed on air quality have been conducted across Ireland. These projects have primarily targeted transport emissions albeit through varied approaches. Recently, efforts have been made to expand the scope to include emissions from sources like solid fuel burning. Irish projects place a strong emphasis

[10] CleanAir@School – Citizen science on air quality

on using creative expression and the arts to foster participation and engagement in air quality-related citizen science.

The review of Irish projects highlighted a number key strengths in an Irish context, but it also revealed several areas for improvement in approaches to raise the profile, including scale and impact, of air quality-related citizen science in Ireland. These include areas such as increasing the availability of publicly accessible project resources and sharing resulting data, involving citizen scientists at all stages of the projects, conducting formal impact evaluations, and establishing channels for action based on project results.

Based on the opportunities identified across process, impact and efficiency, key recommendations are outlined for realising the benefits in Ireland through future citizen science projects. Not all recommendations are relevant for each individual project but should be considered as opportunities for strengthening the overall portfolio of citizen science projects in Ireland.

	Opportunities	Recommendations	
1	 Open Project Resources	**For Policy Makers:** Creation and funding of a central database/repository of projects with the option for expressions of interest from citizens. **For Citizen Science Facilitators:** Ensuring that project information such as objectives, participant involvement, outcomes and financing are available to the public. Where possible, project collateral e.g. information and worksheets provided to participants should be made available.	Process
2	 Whole Project Lifecycle Involvement of Citizen Scientists	**For Policy Makers:** Supporting and promoting co-created citizen science projects whereby citizens are involved at all stages of the project including project design. **For Citizen Science Facilitators:** Incorporating citizens at the design stage to define key research questions and co-create solutions that have significant societal impact and ensure that citizens continue to be involved throughout project stages.	
3	 Diversity of Engagement	**For Policy Makers:** Allocation of funding for citizen science projects which specifically target greater representation from underrepresented groups. **For Citizen Science Facilitators:** Before launching engagement activities, projects can conduct desk research and fieldwork to understand the social realities of affected communities. Subsequent stakeholder mapping helped tailor engagement strategies to different community needs.	

4	Formal Impact Evaluations	**For Policy Makers:** Creation of a standardised impact assessment methodology for funded projects (that can also be replicated by non-funded projects). **For Citizen Science Facilitators:** Ensure that KPIs are monitored throughout all project stages and that the data is accessible for future integration into a standardised impact assessment methodology.	Impact
5	Data Sharing	**For Policy Makers:** To facilitate the sharing of data and accessibility of that data, a single web-based platform can integrate the data generated by various projects. **For Citizen Science Facilitators:** Data, together with meta-data such as on the technology used, implementation of the technology and guidance provided to citizen scientists to use the technology, should be anonymised and shared by default.	
6	Addressing Additional Emissions Sources	**For Policy Makers:** Establishing a funding initiative for citizen science projects which target sources of air pollution other than transport emissions. **For Citizen Science Facilitators:** Exploring avenues to adapt the processes and methodologies and leverage networks established as a result of projects focussed on transport emissions to effectively address other types of emissions, such as those from solid fuel burning.	
7	Funded Programmes for Citizen-led Actions	**For Policy Makers:** Establishing funding for projects whose primary objective is to drive citizen-led action and supporting local government to create programmes which provide support and or funding for local communities and in particular citizen scientists to deliver direct action based on citizen science project outcomes. **For Citizen Science Facilitators:** Ensuring that participants have access to all the data and resources that they need to take action and implement changes at the local level.	Efficiency