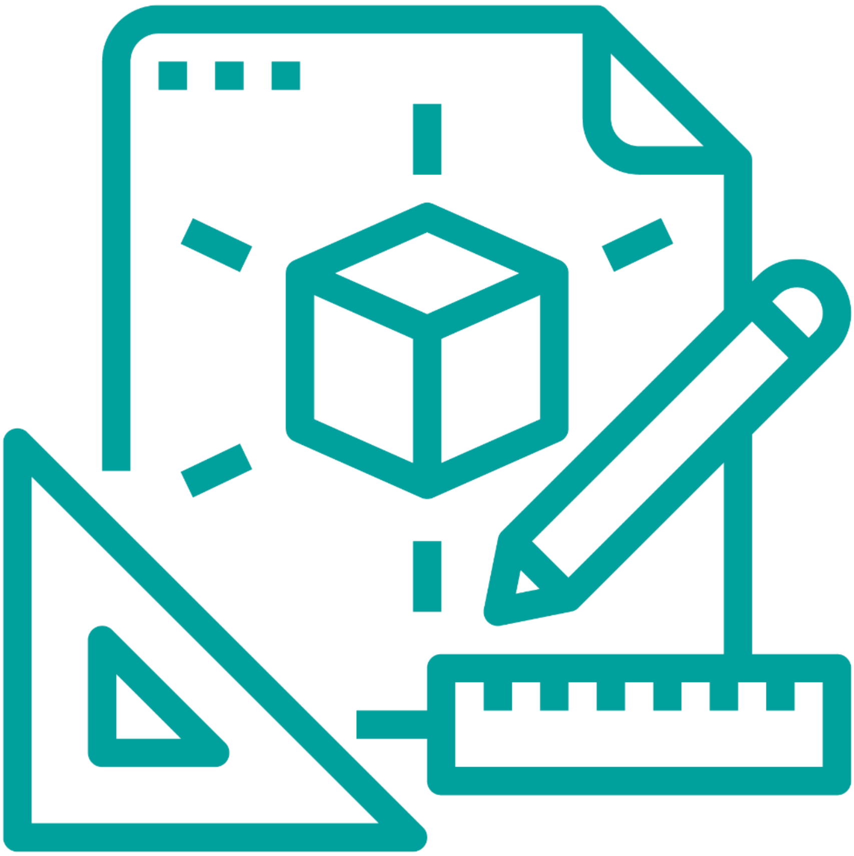
OPENAIR

Operational Network of Air quality Impact Resources

Best Practice Guide

BP212 | Develop

Citizen sensing



Introduction

Citizen sensing involves the use of smart sensing devices by members of the public to explore an issue of interest or concern to their community. It is a form of citizen science[1] where participants define an issue, design a sensing-based approach to studying it, deploy and manage a network of sensing devices, and collect data. Well-designed citizen sensing projects can be educational and empowering for communities, supporting increased understanding of the topic at hand, and more effective advocacy.

With the emergence of smart low-cost environmental sensing technologies, citizens have new tools at their disposal that have significantly expanded the range of accessible citizen sensing activities. Air quality monitoring has proven to be of particular interest to communities, because it impacts public health and well-being in important yet easy-to-understand ways. As a result, several notable citizen sensing projects using low-cost air quality sensing devices have emerged in recent years.

While citizen sensing is community-driven, local governments can adopt and support a similar approach as a core part of their own air quality monitoring activities. For example, a local government might support a citizen-led program by providing a space to build low-cost devices, sharing technical expertise, promoting skills development, or facilitating a process of participative discovery and change-making.

Citizen sensing data is often of high value, and can be used to support local government action on air quality. Citizen sensing projects can also support digital literacy and education outcomes, helping to build community trust in technology, data, and government-led action to improve local air quality.

Who is this resource for?

This chapter is designed to be a tool for local government staff responsible for the design and delivery of air quality monitoring projects, who may wish to adopt citizen sensing approaches as part of their activities. It is *not* intended to be a more general guide for use by community members. In addition to project staff, this resource may also be of interest to local government personnel in roles that support these kinds of projects, including senior management, and marketing and communications teams.

How to use this resource

This OPENAIR Best Practice Guide chapter provides guidance to local governments on citizen sensing as a productive approach to the collection of air quality data, and one that they can support in their own activities. It explores the value and benefits of citizen sensing, and provides a step-by-step guide to designing a citizen sensing project, collecting data, and using data to support action and impact. It also discusses the role played by local government in supporting community advocacy, and shares practical advice for sustaining community participation over the longer term.

[1] Citizen science refers to scientific research that is undertaken by the general public in collaboration with professional scientists (NSW Department of Planning and Environment, 2022).

This Best Practice Guide chapter is the **second** in a series of three OPENAIR resources that explore community engagement with air quality sensing. It is strongly recommended that you first read the OPENAIR Best Practice Guide chapter *Participative design practice* before engaging with this chapter, as it provides a foundation for best practice citizen sensing. The third resource in the series is the Best Practice Guide chapter *Engaging your community with air quality data*, which explores how to activate data within your community to support impact.

The value and benefits of citizen sensing

Citizen sensing can deliver significant value and benefits to participating citizens, the wider community, and local government.

- **Collaboration supports innovation and shared outcomes.** A citizen sensing approach encourages broad collaboration and knowledge sharing between community participants, city leaders, public servants, researchers, artists, and businesses, which in turn supports innovation and shared ownership of outcomes.
- **Digital literacy and participation support improved digital trust.** By learning about and working directly with sensing technologies, community members build ownership of (and trust in) the technology and the data it produces. This contributes to a broader sense of digital trust within the community, which is vital for local governments that are increasingly implementing data-driven solutions across all areas of their operations.
- **Environmental literacy builds a community mandate for government action.** Citizen sensing helps people to understand the environmental science behind air quality. This translates into deeper community support for local government action on air quality issues.
- **Diversity supports innovation.** Inclusion of people from diverse social, cultural, and economic backgrounds can lead to unique and innovative outcomes.
- **Education empowers communities.** Citizen sensing increases the public's knowledge and skills, empowering them and supporting improved equity, environmental justice, and a sense of shared civic responsibility.
- **Citizen science is a cost-effective and practical approach to data collection.** Citizen science has the particular advantage of supporting activities at scale, on relatively small budgets. A well-designed citizen sensing project might leverage the time, energy, and resources of a large and active community, achieving data collection in places that might be hard to access, and at a scale that might not be achievable by a small team of local government staff alone.
- **Citizen sensing data is often a trusted data source.** If the sensing devices used for citizen sensing are of appropriate quality, and the sensing methodology is well-managed to ensure trustworthy data is collected, then citizen sensing data may be used support local government action and advocacy on air quality. It can also supplement data from more centrally managed, higher-performance sensing devices, forming part of a hybrid monitoring system.

Before you begin: participative design as the foundation of citizen sensing

Community participants attend a participative design workshop focused on air quality citizen sensing at Fab Lab Barcelona in 2019. Image source: Creative Commons

Participative design describes an approach where community stakeholders are actively involved in the project design process, to ensure that any project outcomes directly meet the community's needs. Participative design is a critical foundation of citizen sensing projects that deliver real impact, because it cultivates shared ownership of a project within a community to build deep, long-lasting relationships that support sustained effort and collective action.

For more guidance on participative design and its links to citizen sensing, please refer to the OPENAIR Best Practice Guide chapter *Participative design practice*.

STEP 1: Establish your project

Project establishment (see Table 1) involves planning and gaining internal approval for your citizen sensing project, partnering with external organisations for co-delivery, and establishing a team and governance structure.

Approve and establish your project

Table 1. Steps and tasks involved in project establishment

Step	Tasks involved
Investigate community attitudes, behaviours, and motivations relating to your focus issue	Run a fact-finding community engagement exercise to establish an understanding of what community members care about, and their preferred modes of engagement, existing knowledge and skills, and ability to be involved.
Gain management approval	Gain approval for a participative approach to project design. Note that this may take longer, be more complex, and carry greater risk than more traditional project design/delivery approaches, but the benefits often outweigh these challenges. Confirm budget, scope, and time frame.
Establish partnerships	Establish strategic partnerships for project delivery (e.g. a technology delivery partner; a community engagement partner).
Establish a core team and governance structure	Establish a core project team with clearly defined roles and responsibilities, and establish a governance structure for your project. Commit formally to a participative design approach.

Develop a public program for citizen sensing

A successful citizen sensing project requires a well-designed public program that drives outreach and recruitment, and facilitates participative engagement and activities. The overall cost of developing and running a successful public program can exceed the cost of technology investment, often by a wide margin. Make sure to engage staff, partner organisations, or contractors to lead the program who have experience working in a deeply participative way with the wider community.

Design your citizen sensing program for long-term community self-sufficiency. This is best achieved by working with technologies and services that have negligible recurring costs (e.g. open source technologies), enabling community members to take full ownership of critical sensing infrastructure over the long term, once the official funded project period is over.

WAAG Futurelab is an independent, not-for-profit network of labs in the Netherlands. This image shows participants attending a workshop for the Hollandse luchten ('Dutch Skies') project, which was conducted in partnership with a local government. Civil society organisations like WAAG, with their technical knowledge and community networks, can be critical partners for local governments wanting to develop citizen sensing projects. Image source: Creative Commons

THE KEY FUNCTIONS OF A PUBLIC PROGRAM FOR CITIZEN SENSING

- Delivering public outreach, engagement, and recruitment
- Ensuring inclusion and accessibility
- Providing a space to meet, and organising regular events or gatherings
- Developing a well-structured process that maintains focus on impact creation, while also remaining responsive to the evolving ideas and vision of participants
- Facilitating the creation of a shared community vision for impact creation, which forms an essential common foundation for project activities
- Enabling citizens to take ownership of the project by identifying and supporting creative energy, ideas, and talent in the community, thus ensuring the project is steered by committed and enthusiastic community members
- Developing easy-to-use materials that guide and support participants through the citizen sensing process (e.g. technical and methodological how-to guides)
- Supporting the collection, storage, and interpretation of useable data that serves the community vision
- Supporting community-driven activities for impact that leverage new data to create change
- Providing a key point of contact for community members, project partners, and the media.

STEP 2: Identify a community vision

This step involves recruiting project participants and exploring their ideas for what a citizen sensing project might look like, and how it might be delivered, culminating in the creation of a shared community vision.

A. Recruit participants and build your community networks

Recruit participants

You can recruit community participants by connecting with community leaders (if identified), or by working with a community engagement partner to develop an appropriate and effective strategy. Tap into your organisation's existing community networks. Recruitment approaches may include:

- information evenings
- stalls at events or in public spaces
- social media campaigns
- creation of a project video or other multimedia engagement tools
- a public competition.

Conduct a 'commons mapping' exercise

'Commons mapping' is an approach to engaging with a new group of participants to discover and record the range of resources (e.g. technologies, meeting space, funds, time, or specific skills) that people are willing and able to contribute to a project. These contributions can then be aligned with the project vision, strategy, and planned activities, ensuring that the project plays to the strengths and interests of participants. Commons mapping supports inclusion and accessibility by welcoming diverse contributors. It also highlights gaps that may need to be filled (e.g. by bringing in additional collaborators).

The Commons Mapping tool (originally developed by the Knowles West Media Centre in Bristol, UK) has been widely used in citizen sensing projects across Europe. This tool can support the development of a citizen sensing project that is designed around the shared resources and capabilities of its participants, helping to ensure sustainable, long-term activity (UNaLAB, n.d.).

B. Create a shared community vision

Work with participants to create a shared community vision document (see Table 2) that provides a foundation for all future project activities. This document is a record of group consensus, and establishes shared ownership of an issue, as well as a strategic response to that issue. This helps to maintain sustained, long-term community support.

Table 2. The steps in the process of developing a community vision document

Step	Tasks involved
Define a specific air quality issue	It is important for the group to agree on a single, well-defined air quality issue as an anchor point for the project. Aim to identify a pollution source, a location, key stakeholders who are affected, and the negative impact(s) of concern.
Facilitate a group visioning exercise	Consider an ideal future where the air pollution issue is resolved. What does success look like? Consider the future experience of participants. What will they be able to do as a result of the vision being achieved?
Identify strategic project outcomes	Identify one or more project outcomes that can support the group vision. These must be the direct result of project activities. Each outcome should be SMART (specific, measurable, achievable, relevant, and time-bound).
Establish project scope	Consider the strengths and limitations of participant contributions (base this on the outputs of the commons mapping exercise). Consider budgetary, time-related, bureaucratic, legal, and policy constraints. Define the project scope. What is reasonably achievable, given all known capabilities and constraints?
Agree on data collection needs	Identify how data can support chosen outcomes, and agree on data requirements. Investigate the availability of existing data, and determine what new data needs to be collected. Stipulate what to measure, and where and when to measure it. Specify how this will be achieved within the project scope.
Agree on additional information needs	In addition to data collection using sensing devices, participants may need to gather information to support proposed project outcomes. This might come from internet searches, news articles, government reports, or academic literature. Participants may also need to engage more widely with the community, such as through surveys or interviews. Make a plan for collecting and interpreting this information, within the project scope.
Make a plan for data-driven action	Explore how data will be used, and by whom, to create impact. What specific activities can the group commit to, within the project scope?
Capture all the above in a single community vision document	The community vision document should include a 'data use action statement' (DUAS), which explains how new data will enable specific people to address a defined problem through specific activities, to produce measurable outcomes and impacts. Please refer to the OPENAIR supplementary resource *Identify template* for further guidance on creating a DUAS.

DEVELOP SHARED KNOWLEDGE AND SKILLS

Community participants learn how to build their own air quality sensing devices in the Hollandse luchten ('Dutch Skies') project. Image source: Creative Commons

Participants often need to learn new knowledge and skills to participate in a citizen sensing project. These can be shared by the organisations that are facilitating the project, for example through delivery of workshops and guidance resources. Alternatively, peer-to-peer learning can support the exchange of knowledge and skills between participants.

Knowledge and skill sharing should be a key part of the process for developing a shared community vision, but it should not end once the community vision document is created. Participants should continue to learn, and be actively supported to do so, throughout the entire lifetime of a citizen sensing project, helping to foster equity and empowerment.

There are four key types of shared knowledge in a citizen sensing project:

1. **Scientific knowledge**: air quality and environmental science
2. **Community knowledge**: health and social impacts of air quality
3. **Technological knowledge**: sensing technology, methodology, and data
4. **Impact design knowledge**: advocacy and change making, including participative design

As far as possible, knowledge and skill sharing should be enabled through doing, rather than telling. When people engage in practical self-discovery (with appropriate support), they are more likely to internalise and take ownership of new learning.

STEP 3: Develop a citizen sensing strategy

A community vision document articulates ‘why’, ‘what’, ‘where’, and ‘who for’, while a citizen sensing strategy covers ‘how’. This step involves selecting appropriate technology options, and the methodology for applying them.

A. Choose appropriate technology

Core technology components

Smart air quality sensing requires certain core technologies (see Figure 1). A citizen sensing project needs to ensure that all these technologies are available.

Data storage	This is where all the sensor data is stored, as well as the metadata (data *about* your devices and data). **Data storage** may be provided by sensing device manufacturers as part of their product and service offering. In some cases you may need to set up your own data storage service.
IoT platform	**IoT[2] platforms** are used to manage Internet of Things Devices such as low cost air quality sensing devices. They often will also provide data management, reporting and visualisation functionality..
Communications	Smart devices require **wireless communications** to send regular data updates. A variety of options is available: some require you to set up and manage them yourself (e.g. Wi-Fi, LoRaWAN); others may be managed by a device vendor (e.g. 4G).
Sensing devices	**Sensing devices** consist of sensors, a variety of electronic components, and a power supply, all contained within the device housing. A device should be capable of measuring one or more variables of interest, and transmitting data over a wireless communications network.

Figure 1. The four core technology components needed for a functioning sensing network

Open technology empowers communities

Open technology (see Table 3) is technology that can be openly used, accessed, and modified by anyone. It can be defined relative to proprietary technology, which is owned by an organisation or individual, with rules that restrict useability, access, and modification.

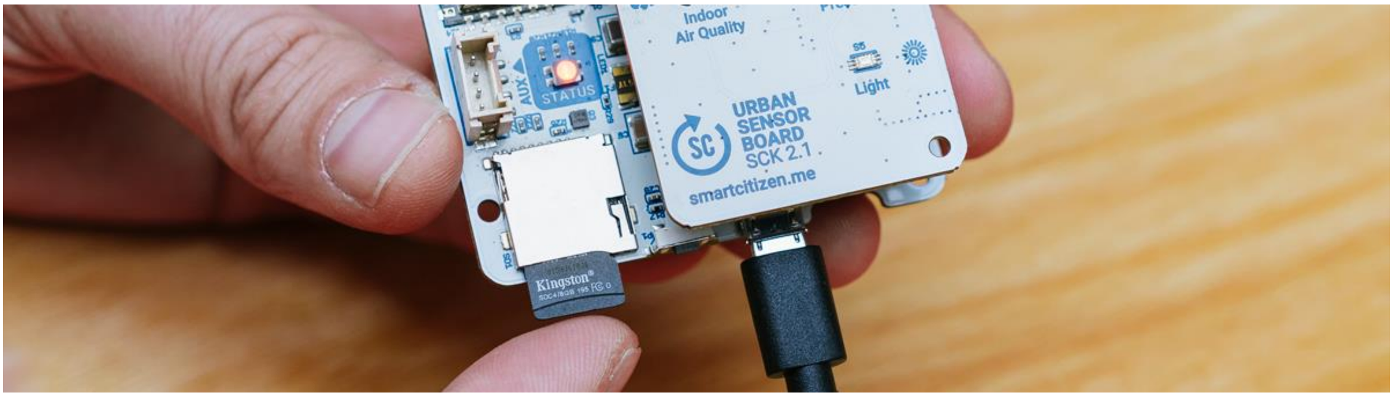
[2] The Internet of things (IoT) refers to the network of smart objects that collect and share data using sensors, software and connection to a network. Objects can include things like vehicles, personal devices and air quality sensors. (IBM, n.d.)

Table 3. The core principles of open technology

Principle	Description
Accessibility	Anyone can access and modify open technology, adapting it to meet a specific context. There is no direct cost associated with access and use of open technology.
Transparency	All aspects of how an open technology is designed and how it functions are visible, supporting a clear understanding of (and trust in) the data it produces.
Interoperability	Open technology is generally designed for maximum possible interoperability. This supports its integration with other technologies and systems, as part of a larger data ecosystem or 'open architecture'.
Open innovation	Open technology supports innovation because its inherent accessibility, transparency, and interoperability encourage iterative development by multiple stakeholders (often working in widespread collaboration).
Data ownership	A user of open technology owns all the data that it produces. This can be critical to community groups engaged with citizen sensing, particularly where data is used to drive advocacy.

Citizen sensing is best supported by open technology, particularly over the long term. Proprietary technologies can be easier to get started with, as the complexity and necessary skills for their delivery can be mostly outsourced to a contractor. However, once a project becomes more established, proprietary technology will often fail to work in a community's favour. This is due to recurring licence costs, and an inability to engage with (and adapt) the design to meet community needs.

For further guidance on the topic of open technology, please refer to the OPENAIR Best Practice Guide chapter *Sensing device procurement*.



An open-source sensor board. Image source: Creative Commons

DIY vs out-of-the-box devices

DIY ("do it yourself") devices can be assembled, programmed, and configured by the user. Some DIY devices come as pre-packaged kits, with all parts and instructions included. Others exist as a set of instructions that indicate commonly available components (which must be individually sourced by the user). In either case, DIY devices are almost always examples of open technology.

Out-of-the-box devices are complete, fully assembled sensing devices that work straight out of the box (with varying onboarding and configuration requirements). Most commercial products fall into this category. They can be either open or proprietary technologies.

Table 4 provides an overview of the relative pros and cons of both options. Table 5 presents guiding questions to consider when determining which approach is right for your project.

Table 4. The relative pros and cons of DIY and out-of-the-box devices

	Pros	Cons
DIY devices	• Flexible technology that can be modified to meet the needs of a community and a project. • No recurring fees. • Engages community participants in the development of digital literacy and STEM skills. This improves community understanding of (and trust in) digital technology and data, supporting broader benefits for local government/community relations.	• Assembly requires access to a facility with tools/equipment, which can be a barrier to use of DIY devices. • Requires a relatively high amount of in-house technical expertise (and/or a project partner with these skills). • May require the establishment of a stand-alone data platform and storage solutions (adding additional complexity). • Requires a notable commitment of time and funds for an appropriate and well-designed public delivery program.
Out-of-the-box devices	• Quick and easy to set up. Usually will include a complete package of platform and data storage. • Accessible if you lack in-house technical expertise and need a 'plug-and-play' option.	• May lack flexibility in the design, constraining project options. • Less engaging for the community. Provides fewer opportunities to explore STEM skills. • Generally more costly than DIY options, particularly if they come as part of a managed service. Recurring fees are common. • More likely to be proprietary technology, which may present transparency, interoperability, and data ownership challenges.

Table 5. Considerations in deciding if a DIY approach is right for your project

Consideration	Situations where a DIY approach is appropriate
Do you have the facilities?	Facilities require the space and tools for safely running hands-on workshops involving microelectronics. You will likely need to use soldering irons, and have a well-ventilated space with large benchtops and multiple power points. Fab Labs and Makerspaces are ideal facilities for this type of activity.
Do you have the expertise?	You will need to have at least one person available to run community sessions where devices are assembled and programmed. This person must have adequate knowledge of the technology, as well as skills as a communicator and group facilitator. Additional expertise is required for overall technical design, and system establishment and operation of the complete sensing network, including all integrated components (devices, communications, platforms, and data storage).
Do you have the time and funding?	DIY devices can take longer to set up than out-of-the-box options, particularly when you are delivering them via an in-depth community program. Be aware that a successful DIY sensing project requires more than just the technology. It also requires high-quality support materials, and a sustained, well-executed program of engagement. This kind of program can require significant additional funding in order for it to succeed.

FIT-FOR-PURPOSE TECHNOLOGY TO SUPPORT CITIZEN SENSING

Smart low-cost sensing devices (and associated platforms and services) vary considerably in their accessibility, functionality, and the quality of the data they produce. It is important that the technology chosen for a project is ‘fit-for-purpose’. In the context of citizen sensing, a fit-for-purpose approach requires that a chosen technology is accessible to all participants, and that it collects, interprets, manages, stores, visualises, and shares data in ways that meet community needs and serve the community vision.

In some cases, a hands-on, open-source, DIY sensing solution may be the most appropriate choice for your project. In other cases, a pre-packaged, out-of-the-box solution with strong vendor support services may be the better option. A well-defined community vision document provides the foundation for making an informed choice.

Pre-packaged DIY device kits for citizen sensing

Some DIY air quality sensing devices are available to be purchased as pre-packaged kits, occupying a convenient middle ground that takes the hard work out of DIY sensing.

The Smart Citizen Kit developed by Fab Lab Barcelona. Image source: Creative Commons

The Lake Mac DIY air quality sensing device

Lake Macquarie City Council (in NSW) has developed a DIY air quality sensing device through their Fab Lab. The portable, battery-powered device transmits data over a community LoRaWAN wireless communications network (The Things Network). Using a range of low-cost sensors inside the device housing, it can measure temperature, air pressure, humidity, and gases, and can easily be deployed in a wide variety of locations. The kit can be purchased as a package via Core Electronics, who co-developed the device in partnership with the Council (Lake Mac Libraries, n.d.).

The Smart Citizen Kit

The Smart Citizen Kit was developed by Fab Lab Barcelona, and is available to purchase worldwide. The compact, battery-powered devices can measure a variety of air quality parameters, and also communicate via LoRaWAN (over The Things Network). Devices connect to a single, shared global platform, and display live data openly by default.

Sensor.Community Sensor Kit #1

Sensor.Community began in Stuttgart (Germany), and has grown into a global open data network with nearly 13,000 active sensing devices in 79 countries, operating out of 58 community labs and Makerspaces (Sensor.Community, n.d.). At the core of the community is the Sensor Kit #1, which measures temperature, humidity, and particulate matter. There are detailed online instructions for how to source and assemble parts, and program the device. The device can also be purchased as a pre-flashed kit that is quick and easy to assemble and activate.

Communications technology for citizen sensing

Various communications technologies are currently available for use by smart sensing projects. Some of these technologies will be better suited to citizen sensing projects than others (see Table 6 for guidance on what to consider when making your choice).

Table 6. Assessing the suitability of different communications technologies for use in citizen sensing

	Considerations
Wi-Fi	• High power demand means that mains power is required. This is a barrier for DIY devices, as it requires a licensed electrician to do the assembly. • Can be simple and accessible, given that many people run Wi-Fi in their own homes. However, it is prone to being turned off (e.g. when people go on holiday), creating a higher risk of data gaps. • May exclude lower socio-economic groups who do not have home Wi-Fi. There may also be ethical issues related to a local government project relying on the paid Wi-Fi connections of local residents. • Wi-Fi range can be poor. For example, it would work well for sensing devices on apartment balconies, but may be inappropriate if devices need to be placed further from residences.
LoRaWAN	• Low power demand supports battery-powered DIY devices. • Open versions (e.g. via The Things Network) can be managed directly by participants, with no service fees. • Local governments can invest in open LoRaWAN to support community access. This reduces reliance on individuals, and resolves equity concerns associated with Wi-Fi. • LoRaWAN coverage can be patchy because the signal is easily blocked by hills, buildings, and trees, preventing some participants from connecting to a device at home.
Sigfox	• Sigfox operates with low power demand, and may be managed centrally by a local government. It experiences the same signal coverage issues as LoRaWAN. • It is a solely proprietary service, with recurring, per-device service fees. This tends to be a barrier to its use in community contexts.
NBIoT	• Low power demand supports battery-powered DIY devices. • A per-device service fee is a barrier to community use. • Lack of direct operational access for community users. • Set-up and onboarding can be complex, requiring a SIM card to be registered with a telecommunications provider.
4G/LTE	• High power demand requires solar or mains power, and precludes the choice of battery-powered devices. This tends to be a barrier to community use. • Considerations are otherwise the same as for NBIoT.

B. Develop an appropriate sensing methodology

A sensing methodology refers to the way that sensing technologies are configured and deployed to collect data that supports the needs of a project. This methodology can be outlined in a formal technical document, or exist as a series of less formal working documents and notes.

Key questions to guide the choice of a sensing methodology

Project needs are articulated in the community vision document. Project participants should now co-design a sensing methodology that is guided by these needs.

The following questions should be addressed as part of this process:

- How should devices be configured and calibrated to ensure appropriate data quality?
- Where exactly will you deploy devices?
- What will you mount devices on?
- Who will be responsible for installing and maintaining devices?
- What sort of technical support will be required once the device network is operational?
- How can participants access data, and how widely will data be shared?
- What data interpretation and visualisation will be required to support the desired data insights?

COMMUNITY-LEVEL INDICATORS (CLIs)

Community-level indicators are measurements collected by community participants, to complement data from sensing devices. CLIs are chosen by participants, and should support the project's shared community vision and sensing methodology.

CLIs can be diverse, and may include:

- photographs of a location (taken regularly at set times each day)
- personal journals that explore things like daily activities, physical comfort, and feelings of health and well-being
- manual counts (e.g. of traffic or pedestrians).

CLIs can prove invaluable for interpreting sensor data, helping to connect that data to the real-life, lived experience of participants. These kinds of indicators can also double as measures to track impact, and can help to iteratively improve the sensing strategy over time. CLIs are thus a unique opportunity associated with citizen sensing.

A step-by-step guide to developing CLIs via a community workshop can be found in the Making Sense Toolkit (pages 56-61).

Planning the deployment of citizen sensing devices

Please refer to the OPENAIR Best Practice Guide chapters *Sensing device deployment planning: high-level design* and *Sensing device deployment planning: detailed design* for in-depth guidance on device deployment planning.

However, there are a few additional considerations specifically related to the deployment of citizen sensing devices:

Deployment of devices on private residential property

- Government staff may be restricted from physically entering residential properties. A workaround is the creation of high-quality guidance materials, combined with strong technical support.
- There may be liability concerns for local government if participants are injured during installation activities (e.g. falling off a ladder), requiring legal waivers to be drawn up and signed.
- In some cases, the simplest approach is to hand over ownership of the device to the participant.

Deployment of devices via school programs

- School programs are a common and effective approach to citizen sensing, providing a framework for scaling sensing device deployment across wide areas (e.g. a large school or education district).
- A lack of technical knowledge and confidence among teaching staff can be a major barrier to participation. A ‘train-the-trainer’ model may be needed (at additional time and cost).
- Responsibility and liability relating to device deployment can be handed over to schools, so long as clear guidelines are provided.

A sensing device being installed as part of the Lake Macquarie Adopt-a-Sensor initiative, Charlestown, NSW. Image source: Lake Macquarie City Council

Standardising the deployment approach

The deployment context of a sensing device has a significant impact on the data it collects. Citizen scientists may deploy their sensing devices in a wide variety of contexts, resulting in variable data outputs. To ensure that data from multiple devices can be usefully compared, it is necessary to standardise the deployment approach as much as possible.

Different projects will have different contextual requirements. These standardisation tips are thus suggested as indicative rather than definitive, but could still be usefully incorporated into deployment guidance materials for citizens:

- **Define clear parameters for mounting infrastructure** (e.g. avoid walls in full sun; favour narrow poles with good air circulation around them)
- **Standardise height off the ground** (e.g. devices should all be deployed at a height between 2-3 metres above the ground)
- **Stipulate a minimum distance from a building** (e.g. 2 metres)
- **Avoid positioning devices immediately above rooftops** (due to localised heat and wind effects).

You will also need to formalise a project **data schema**, which should include a set of **deployment metadata** that participants can easily collect and report. For more information on how to do this, please refer to the OPENAIR Best Practice Guide chapter *Data labelling for smart air quality monitoring*.

The SCK 2.1 outdoor particulate monitoring device (developed for the Smart Citizen program) deployed on a street pole. Image source: Creative Commons

CASE STUDY: DIY air quality sensing at the Knowle West Media Centre (Bristol, UK)

A 'ladybird' sensor designed and manufactured by community partipants. Image source: Knowle West Media Centre

The Knowle West Media Centre (KWMC) is a not-for-profit community centre in Bristol's Knowle West neighbourhood, with a strong history of leading dynamic participative community projects. Between 2017 and 2019, KWMC ran a project[3] to explore local air quality concerns with cyclists, schoolchildren and their parents, taxi drivers, and social housing tenants.

A series of artist-led workshops supported citizens to develop DIY devices using the KWMC digital manufacturing space (called The Factory). The final design was a portable device shaped like a ladybird, which could be attached to bicycles, bags, and car windscreens to gather Nitrogen dioxide (NO_2) [4] data on the move. Participants also collected data using community level indicators about weather, traffic, and how they were feeling in personal journals.

Following a period of data collection, a series of 'making sense of your data' workshops were held, where participants came up with creative ways of telling their data stories. Data was shared via an open platform, and data visualisations and insights were printed onto postcards that were distributed around the city. The hyperlocal air quality information gathered by citizens helped them to make informed choices about their travel behaviour, and to better understand air pollution in order to champion change on a wider scale.

Through several pilot programs, KWMC engaged over 1,000 people with the process of 'citizen sensing'. The work was deeply inclusive and participative at all stages, and was developed around topics and concerns that the community identified (rather than having topics imposed on them by organisers). Participants came up with the approach, and the role of KWMC was simply to facilitate the process. This meant that the community developed ownership of the data and the insights that it supported (The Bristol Approach, n.d.-a).

[3] They worked in partnership with the City of Bristol, the EU-funded REPLICATE project, and the University of West England.
[4] Nitrogen dioxide is a potentially harmful gas that is produced by industrial processes and vehicles amongst other sources. (Brender, 2020)

ENGAGE WITH AND SUPPORT YOUR LOCAL MAKER COMMUNITY

An open-source air quality station designed and manufactured by Fab Lab Barcelona.
Image source: Creative Commons

Maker communities are grassroots networks of technology enthusiasts, often organised around centralised facilities (such as Fab Labs or makerspaces). They have a strong focus on open-source technology, and can develop innovative DIY solutions to community challenges. Local governments can actively support maker communities (and the facilities they need) as one way of delivering high-quality, citizen-led sensing projects. In some cases, local governments directly manage Fab Labs, and run programs that build and sustain maker communities (e.g. Lake Macquarie Fab Lab in NSW).

There are many benefits to this approach, which may include:

- reducing project costs by making use of existing facilities and tools
- tapping into a wealth of technical knowledge and skills already existent within the community
- engaging and leveraging the influence of existing community leaders (e.g. as the basis for creating community champions or data stewards[5])
- keeping the project accessible and inclusive
- helping with recruitment, as many active members of the maker community are likely to become project participants (and may help to promote the project to others)
- supporting local innovation and a grassroots knowledge economy
- creating a foundation for digital literacy and upskilling, which can support improved digital trust within the community, as well as training pathways for staff
- ensuring the long-term sustainability of a citizen sensing initiative (the activity can be embedded into a maker community, and 'handed over').

[5] See the OPENAIR Best Practice Guide chapter *Engaging your community with air quality data* for further information about community champions or data stewards.

STEP 4: Implement and operate a citizen sensing network

This step covers calibration of sensing devices, the creation of a citizen sensing guide, how to capture device deployment metadata, and how to support participants with troubleshooting and system operations.

Calibrate citizen sensing devices

DIY air quality sensing devices created at Fab Lab Barcelona, co-located with a regulatory air quality monitoring station. Image source: Creative Commons

The OPENAIR supplementary resource *A framework for categorising air quality sensing devices* identifies four tiers of data use cases[6].

DIY devices and citizen sensing activities that focus mostly on education and community engagement relate to Tier 1 data use cases (which do not require devices to be calibrated against regulatory air quality monitoring stations). They might explore trends and basic site comparisons (e.g. which location has cleaner air), with a relatively high tolerance for lower data quality.

However, citizen sensing *can* support Tier 2 data use cases (which relate to the identification of air pollution hotspots) *if* sensing devices can be calibrated to confirm suitable data quality. To achieve this, devices must be co-located with a regulatory air quality monitoring station, in order to calibrate them prior to deployment. This approach was successfully demonstrated by Fab Lab Barcelona and WAAG Society's Mobility Urban Values (MUV) project in 2016 (*see related image on page 17 of this chapter*).

A more detailed guide to calibration and co-location of smart low-cost sensing devices can be found in the OPENAIR Best Practice Guide chapter *Sensing device calibration*.

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[6] The four tiers of data use cases are used to categorise how different uses of air quality monitoring are associated with different levels of data quality, cost, complexity and sensing device functionality..

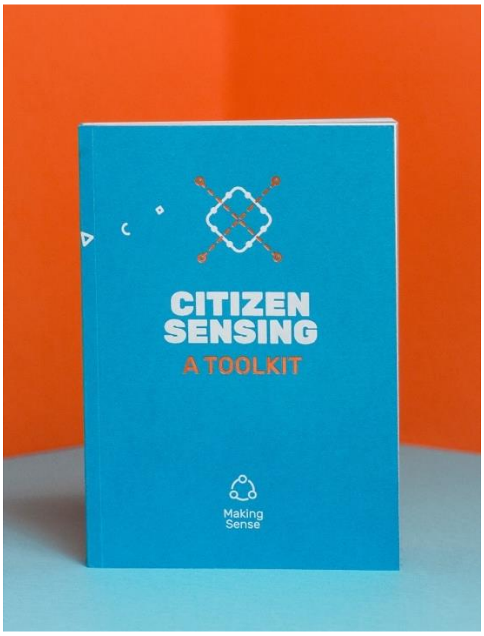
To arrange a co-location, contact the responsible government agency for your region. In NSW, this is the Department of Planning and Environment. If you lack access to a regulatory station, bench testing your devices against a higher-performance reference monitor can be an acceptable stand-in (in some cases).

Create a citizen sensing guide

A citizen sensing guide is an easy-to-follow, practical articulation of your sensing strategy. It should be accessible to all participants. Many of the more technical concepts may be new to participants, and it is recommended that one (or more) upskilling sessions are delivered to develop community knowledge and understanding.

A citizen sensing guide should include:

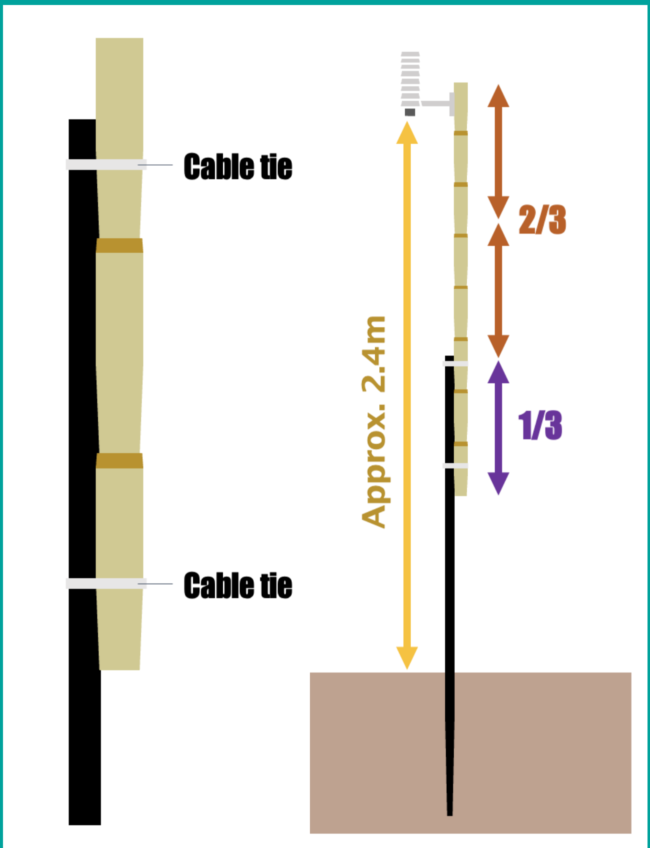
- the environmental parameters being measured
- details that describe what the data should look like (e.g. units of measurement; reporting interval[7]; data accuracy[8]; range[9])
- where, when, and for how long sensing activities will occur
- details of the sensing device(s) being used, and associated technologies (e.g. communications; platforms)
- details of how the sensing device is to be configured and calibrated
- guidelines for choosing a specific sensing device deployment location (including selection of appropriate mounting infrastructure; height; orientation; access and safety considerations)
- step-by-step instructions for activation and installation of a sensing device
- basic troubleshooting guidelines
- operation and maintenance guidelines
- data access and management instructions.



Citizen Sensing: A Toolkit *(produced by Making Sense) contains further information on creating a citizen sensing guide. Image source: Creative Commons*

[7] Reporting interval refers to the frequency of measurements (e.g. one per hour).
[8] Data accuracy is a metric expressed as ±X, where X = a bias of units either side of an 'accurate' value.
[9] Range is defined by upper and lower units of measurement. It describes a range of values for a variable that can be measured (e.g. -10 to 100°C).

CASE STUDY: Adopt-a-Sensor initiative, Lake Macquarie, NSW



A diagram from the Adopt-a-Sensor Sensing Guide, illustrating sensing device installation. Image source: UTS

A preschool educator from Lake Macquarie Preschool, Mt Hutton, NSW, holds a temperature and humidity sensing device. Source: Lake Macquarie City Council

The Adopt-a-Sensor initiative was delivered by Lake Macquarie City Council and the University of Technology Sydney (UTS) in 2019. A total of 26 smart low-cost urban heat and air quality sensing devices were distributed among local residents, community groups, sports facilities, and schools. These devices formed part of a larger network of more than 80 smart low-cost sensing devices that were deployed by Council at the time.

The initiative demonstrated how a local government can work directly with community partners to deploy sensing devices on private land, in areas where there would otherwise be no viable deployment options on public land. It also demonstrated how a local government can start to position itself as a data steward and facilitator of IoT in the community, rather than remaining the sole owner and manager of equipment and data (UTS-ISF, n.d.).

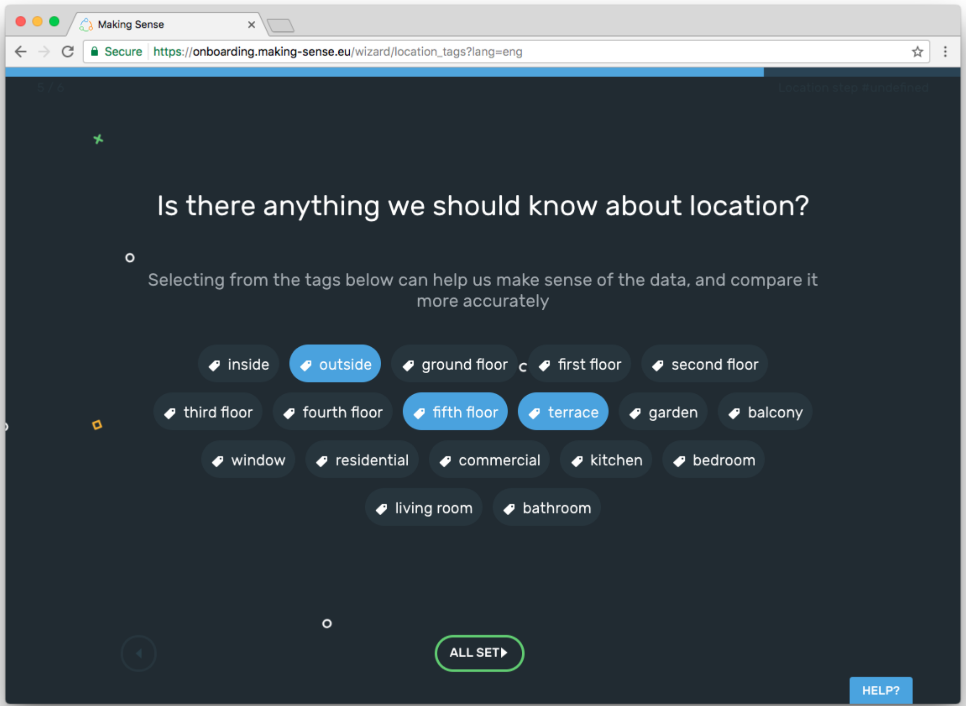
Capture deployment metadata

Deployment metadata records the contextual information about a device deployment. It is vital for managing devices, and interpreting sensor data.

Deployment metadata typically includes:

- device make and model
- device ID
- device owner and contact details
- date and time of deployment
- longitude and latitude
- deployment address
- site owner and access details
- micro-siting details (e.g. height; orientation; mounting infrastructure).

To ensure that metadata is collected in a reliable and standardised way, you can create an easy-to-use form to be completed by participants. The advantage of an online form is that it automates the data entry process by helping to ensure that all fields get completed, validating field entries, and automatically producing a collated spreadsheet of all participant entries. Online forms can be accessed and completed on smartphones or tablets, making them a practical and accessible option for community participants.



The Making Sense project developed an interactive online form for capturing device deployment metadata. This screenshot shows one of a series of questions posed to participants. Image source: Creative Commons

Support citizens with troubleshooting and system operations

A community participant carries out maintenance on a Smart Citizen air quality sensing device in Barcelona, Spain. Image source: Creative Commons

Even the best-designed sensing projects will experience technical difficulties. For an in-depth discussion of these difficulties and how to address them, please refer to the OPENAIR Best Practice Guide chapter *Sensing device troubleshooting: common problems and how to fix them*.

Participants in citizen sensing projects are highly likely to encounter troubleshooting challenges. To ensure that participants remain confident and enthusiastic about being involved, it is important to support them when these challenges arise. One way a local government can do this is by creating a dedicated technical support role, at least during the early establishment phase of the sensing network.

Furthermore, any sensing device network will have various system operations tasks that require active management to ensure that data collection continues reliably.

While a troubleshooting support and system operations role may be covered by project staff, there could also be an opportunity to reduce the pressure on the core team by leveraging community expertise. A commons mapping exercise (*see Step 1 in this chapter*) may identify community members with the necessary skills and willingness to help.

Local government support for community advocacy

A best practice citizen sensing project should be designed around a community vision and agenda. This often relates to a specific local concern or issue. Action on that issue, from a community perspective, tends to take the form of advocacy and campaigning that is supported by new sensor data (and combined with the deepening knowledge and empowerment of participants that results from active engagement).

The local government role in citizen sensing is to actively support community members throughout this process: from initial strategy and design, through data collection activities, and onwards into impact creation. Local government support for impact creation therefore equates to support for community advocacy.

Community protest against WestConnex road and tunnel-building projects in Sydney, NSW. Community members deployed a network of Sensor.Community DIY sensing devices to generate data in support of their advocacy efforts. Image source: No Westconnex: Public Transport

Be aware of the political implications of a citizen sensing project

Community advocacy tends to involve a call for change that can relate directly to government activities (e.g. planning and infrastructure), or to third-party activities that can be regulated or controlled by government policy, law, or enforcement. Assuming the target of community advocacy is not the local government itself[10], the focus may be on state or federal government, or a variety of public or private sector organisations.

Direct support for community advocacy by a local government is therefore likely to position it in conflict with one or more of these stakeholders. This may have significant political implications for the local government. These implications need to be considered and discussed with senior management, as a prerequisite for executive buy-in and support for the project.

Put simply, it is a bad idea for a local government to support citizen sensing related to a politically sensitive issue, only to get cold feet once the data arrives and advocacy begins. To do this erodes community trust, and undoes most of the benefits of the program. A better approach is to ensure that there is a commitment at the highest levels to taking an official stand on a given issue, and maintaining that position in solidarity with the community.

It is not always possible for a local government to know – at the outset of a project – precisely where community focus will settle, leaving possible political implications and risk undefined. This risk can be mitigated by undertaking a significant fact-finding engagement exercise prior to initiating or supporting a particular project. The engagement should seek to understand existing community concerns relating to a specific local air quality issue, in order to grasp how a related citizen sensing project might unfold.

Practical approaches to supporting community advocacy

If a local government chooses to support community advocacy on local air quality or urban heat issues, there are several practical actions that can be taken:

- **Issue a statement on the focus issue**, supporting the community voice. This might explicitly name the target of community advocacy efforts, or might be more general (and less direct).
- **Use existing communications channels** to actively promote the efforts and agenda of your community. Include storytelling about citizen sensing activities, and platforming of citizen voices.
- **Update policy/strategy** to reflect a position that aligns with community interests (e.g. an amendment to the Development Control Plan; or explicit mention of air quality in your organisation’s climate change and resilience strategy).
- **Provide a small amount of sustained direct support** to a community group beyond an initial citizen sensing project period (*see the ‘sustaining community participation’ section below*).

[10] It certainly can be, though it is reasonable to assume that a local government would not be actively supporting a campaign against its own activities.

Sustaining community participation

Sustaining community participation throughout a project

Citizen sensing projects can occur over several years. Keeping community participants actively engaged, energised, and enthusiastically contributing throughout that time can sometimes be a challenge. Sustained community participation relies upon four key elements: **issue; ownership; agency; and impact** (see Figure 2).

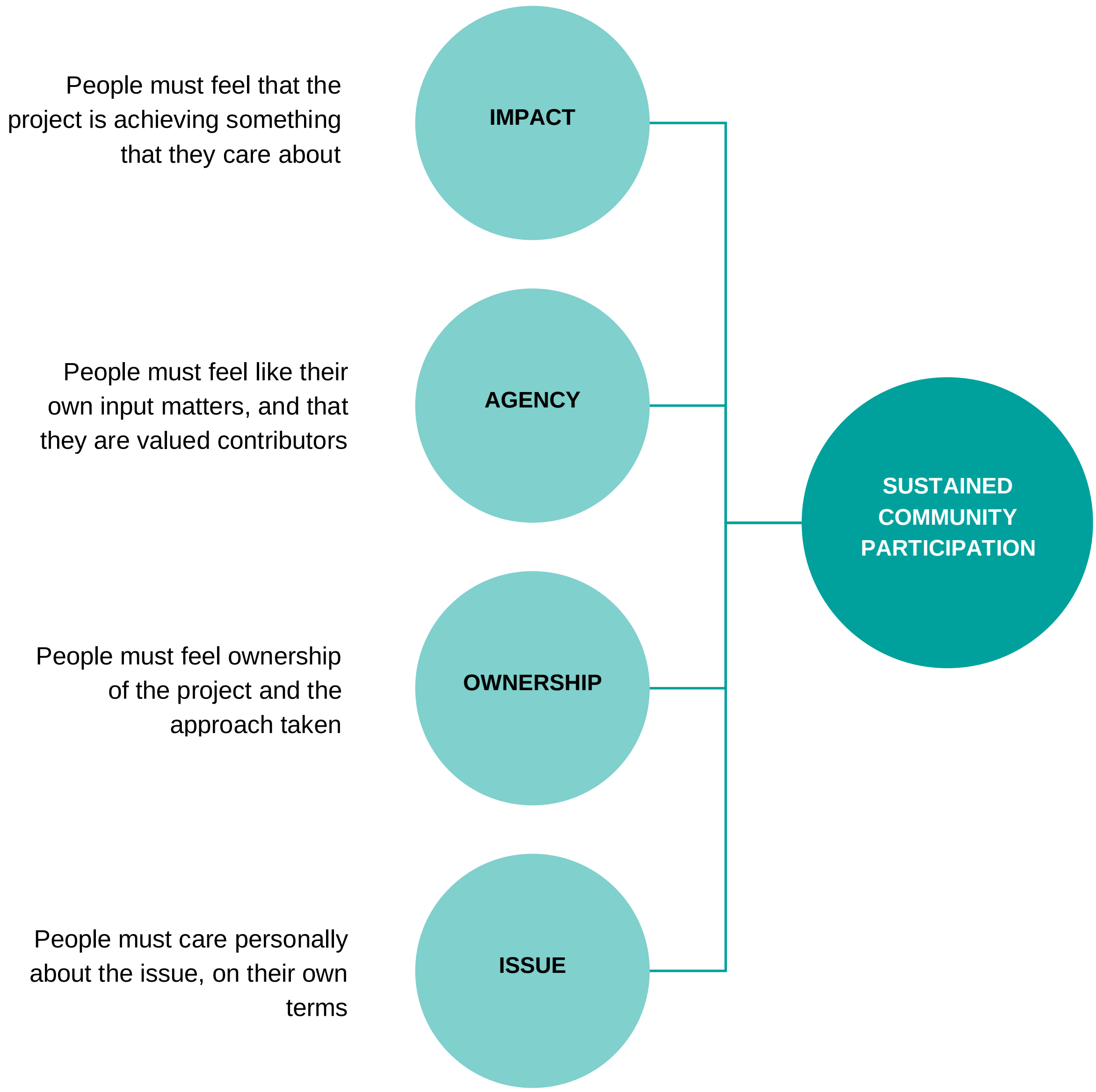


Figure 2. The four key elements of sustained community participation

Strategies for ensuring sustained community participation

- **Invest in strong participative design.** Spend a significant amount of time at the beginning of a project on participative design. This is the key to ensuring that the project is addressing an issue that a majority of people really care about. Do not rush this process.
- **Hold face-to-face events.** Bring people together with regular face-to-face events and gatherings. This builds relationships and personal connections, which form the foundation of strong group identity and shared commitment to a cause.
- **Ensure expert facilitation.** Pay attention to the way that workshops and group discussions are facilitated, to ensure that everyone present is equally heard and represented, actively making space for quieter voices. It can be helpful to engage an experienced community facilitator as a core delivery partner. By doing this, you maximise the buy-in and commitment from all participants, which is critical to sustaining projects over the longer term.
- **Develop knowledge and skills.** Ensure that participants have ample opportunity to learn the knowledge and skills associated with the project, boosting their confidence and sense of ownership of the approach.
- **Celebrate milestones.** Set milestones throughout the project, and celebrate them with participants. This maintains a sense of progress and shared achievement.
- **Keep all participants informed about impact.** As the project progresses, ensure that everyone involved understands how data is being used to support the shared community vision. This is particularly important in a commons mapping approach to project design, which identifies diverse roles for different participants, based on their skills and interests. Many participants may not see the full project picture from the perspective of their own personal contribution, so it helps if the facilitating organisation keeps everyone updated.
- **Actively promote the hard work of participants.** Develop a communications plan for the project, and assign appropriate resources. Focus on actively promoting the hard work of participants to a wider audience. This positive attention affirms the time and effort that people contribute, and helps to ensure that it is sustained.
- **Recognise leaders.** Recognise and celebrate community champions – those participants who go above and beyond as leaders and role models.
- **Keep an interactive online presence.** Maintain an online presence for the project to keep the wider community informed about the latest project activities and news. This might include a website, blog, or social media. Ideally, aim to use interactive platforms and forums that create spaces for participants to lead these efforts themselves.

Supporting sustained longer-term citizen sensing activities

It can take a long time to achieve significant impact on a local air quality or urban heat issue. Funding and supporting a citizen sensing project to explore a particular issue can be an effective strategy for local government, yet such efforts are likely to be only the start of a much longer journey of change making and impact creation. How can that full journey be supported, beyond an initial project period?

Strategies for sustaining community participation throughout a project (such as those listed in the previous section) can provide an essential foundation for longer-term citizen sensing activities. They help to establish an engaged, empowered, and upskilled group of participants by the end of a project.

But what happens next? The challenge is to design a project in such a way that it has the potential to become self-sustaining within the community, with minimal ongoing support from local government.

The following strategies can help to achieve this:

- **Use open technology.** Choose open-source DIY sensing devices and open-access platforms and services during a citizen sensing project, to support sustained, longer-term use. This ensures that community members can understand, access, fix, and modify all aspects of the technology they rely upon, without needing costly vendor support services. Open-source technologies have global communities of users, and there tends to be a wealth of support in online forums.
- **Keep the IoT platform simple and low-cost.** Commercial IoT platforms come with all sorts of advanced functionality, as well as large recurring service fees. When grant funding is available, it may be tempting to choose such an option, but when the funding dries up, service fees cannot be sustained. An alternative approach is to choose from one of several low-cost or free platforms that provide simpler but still very effective device hosting and IoT data services (e.g. Grafana, ThingSpeak, Datacake, Power BI). By choosing these options, you may be sacrificing advanced functionality, but you are helping to ensure that the platform can be maintained over the long term, on a shoestring budget. Total platform fees amounting to a couple of hundred dollars a year can reasonably be covered as an ongoing commitment to community sensing by local government.
- **Ensure ongoing access to community making and meeting spaces**. Ensure that the citizen sensing community has ongoing access to a space for meeting and making. There are two ways this can be done with little or no additional cost to local government:
    - A local government can establish its own Fab Lab/makerspace. A citizen sensing program can become one of many initiatives that use (and justify the existence of) that space. An example of this is the Lake Mac Fab Lab (in Swansea, NSW).
    - A local government can cultivate a partnership with another local organisation that has space and its own funding streams. An example is the Knowle West Media Centre, an independent charity in Bristol (UK) that has a makerspace, and runs citizen sensing programs in partnership with the City of Bristol (The Bristol Approach, n.d.-b).
- **Support community advocacy over the longer term**. This support can be relatively passive, so long as there is no apparent conflict between community and local government positioning. The key is to maintain an ongoing presence as an ally.

Additional resources

Making Sense* | *Citizen Sensing: A Toolkit

The Making Sense Toolkit profiles nine citizen sensing campaigns in the Netherlands, Kosovo, and Spain. It uses these real-world examples to guide others through the complete process of designing and delivering a successful citizen sensing project. This resource is highly useful to anyone thinking of running their own citizen sensing project.

iSCAPE* | *iSCAPE Citizen Science Guide: An actionable guide for Living Labs

A detailed and practical guide to citizen sensing and air quality, geared towards use by local governments. The guide features a series of workshop templates.

Tracking California* | *Guidebook for Developing a Community Air Monitoring Network

This guidebook provides extensive, in-depth guidance on implementing a particulate matter community air monitoring network, drawing on the approach and knowledge generated by the Imperial County Community Air Monitoring Project in California.

The Australian Citizen Science Association

ACSA is member-based incorporated association that seeks to advance citizen science through the sharing of knowledge, collaboration, capacity building and advocacy.

Fab Foundation website

The Fab Foundation is a not-for-profit organisation that exists to facilitate and support the growth of the international Fab Lab network. Their website contains extensive information about Fab Labs and the maker movement.

The Smart Citizen Flickr account

Smart Citizen is based out of Fab Lab Barcelona, and is one of the best-established citizen sensing initiatives in the world. The Smart Citizen Flickr account is a useful and inspiring visual diary, featuring hundreds of clearly captioned images from a diverse range of community projects.

Mahajan, S. et al.* (2022) | *Translating citizen-generated air quality data into evidence for shaping policy

This article (published in a respected international journal) provides a global review of how air quality data from citizen sensing is being used to support public policy, as well as an exploration of barriers and challenges to this practice. The authors conclude that participative design and the use of simple, accessible, open technologies are likely the keys to impact creation.

Associated OPENAIR resources

Identifying a community vision

The following OPENAIR resources can support the creation of a community vision document.

Air quality as a local issue

This Best Practice Guide chapter provides a detailed introduction to air quality as a local issue. It explores sources and types of air pollution, impacts of air pollution, and why local action is needed.

The Impact Planning Cycle overview

This Best Practice Guide chapter introduces the OPENAIR Impact Planning Cycle, a planning tool that can help to maximise the impact of a project, and address the needs of an organisation and community.

Identify template

This supplementary resource supports creation of a business plan and 'data use action statement' as strategic foundations for a smart low-cost sensing project. A community vision document can be thought of as a citizen sensing version of a business plan.

Participative design practice

This Best Practice Guide chapter provides guidance for inclusion of participative design approaches in a smart air quality monitoring project. The chapter explores the benefits of participative design for local government in this context, practical approaches to implementation, and common challenges that arise.

Developing a citizen sensing strategy

A citizen sensing strategy aligns with a more general approach to smart low-cost sensing. For more detailed guidance, please refer to the following OPENAIR resources.

Sensing device procurement

This Best Practice Guide chapter provides guidance on the selection and procurement of smart low-cost air quality sensing devices that are appropriate for the needs of a project and organisation.

Data communications procurement

This Best Practice Guide chapter explores the various communications technologies that can support smart low-cost air quality sensing, and provides advice on selecting appropriate technologies.

Sensing device calibration

This Best Practice Guide chapter provides guidance on the calibration of smart low-cost air quality sensing devices.

Sensing device deployment planning: high-level design

This Best Practice Guide chapter explores the high-level design of a smart air quality monitoring network. It provides general guidance for selecting where to deploy devices, what to mount them on, how to mount them, and how to support their operation.

Sensing device deployment planning: detailed design

This Best Practice Guide chapter explores the detailed design of a smart air quality monitoring network. It builds upon high-level design activities, and provides guidance for planning and documenting the details of specific device deployments.

Air quality sensing device activation and deployment

This Best Practice Guide chapter provides guidance for activating and deploying smart low-cost air quality sensing devices.

Sensing device troubleshooting: common problems and how to fix them

This Best Practice Guide chapter introduces a framework of common problems that can arise with smart low-cost air quality sensors and the provision of useful data. It includes some practical information to help diagnose issues, fix them, and mitigate against reoccurrence.

Supporting community impact

Once data has been collected, it can be used to help drive community impact. The following OPENAIR resources provide guidance on how to achieve this.

Data interpretation: overview

This Best Practice Guide chapter explores how raw sensor data can be interpreted to support insights and drive impact. It defines a series of data interpretation steps: correction and harmonisation; quality control; and analysis. The platforms and services chosen to support a citizen sensing project must include data interpretation functionality that enables the planned use of data by the community.

Data labelling for smart air quality monitoring

This Best Practice Guide chapter explores how data can be labelled to ensure that it is useable. This is critical for effective data sharing, and activation of data by community.

Sharing air quality data

This Best Practice Guide chapter explores the technical and governance considerations of data sharing, and provides a practical how-to guide.

Engaging your community with air quality data

This Best Practice Guide chapter continues the focus on community participation, exploring examples of engagement activities and participative approaches to the management and sharing of data (such as data stewards, data commons, and civic data trusts).

Activities for impact

This Best Practice Guide chapter explores an extensive range of activities that can create positive impact by leveraging the value of new data. Many of these activities align well with community sensing.

References

Brender, J. D. (2020). Human Health Effects of Exposure to Nitrate, Nitrite, and Nitrogen Dioxide. In M. A. Sutton, K. E. Mason, A. Bleeker, W. K. Hicks, C. Masso, N. Raghuram, S. Reis, & M. Bekunda (Eds.), *Just Enough Nitrogen: Perspectives on how to get there for regions with too much and too little nitrogen* (pp. 283-294). Springer International Publishing. https://doi.org/10.1007/978-3-030-58065-0_18

IBM. (n.d.). *What is internet of things?* https://www.ibm.com/topics/internet-of-things

Lake Mac Libraries. (n.d.). *Fab Lab*. https://library.lakemac.com.au/Explore/Fab-Lab

NSW Department of Planning and Environment. (2022). *What is citizen science?* https://www.environment.nsw.gov.au/research-and-publications/your-research/citizen-science/about-citizen-science

Sensor.Community. (n.d.). *Home*. https://sensor.community/en/

The Bristol Approach. (n.d.-a). *Air Quality*. https://www.bristolapproach.org/projects/air-quality/

The Bristol Approach. (n.d.-b). *Home*. https://www.bristolapproach.org/#:~:text=The%20Bristol%20Approach%20is%20a,design%20solutions%20for%20everyday%20issues.&text=It%20was%20developed%20by%20Knowle,Change%2C%20and%20Bristol%20City%20Council.

UNaLAB. (n.d.). *Commons Mapping*. https://unalab.enoll.org/commons-mapping/

UTS-ISF. (n.d.). *Technology for Urban Liveability Program (TULIP)*. https://www.uts.edu.au/isf/explore-research/projects/technology-urban-liveability-program-tulip#:~:text=The%20Adopt%2Da%2DSensor%20program,deployed%20them%20on%20their%20properties.

Further information

For more information about this project, please contact:

Peter Runcie

Project Lead, NSW Smart Sensing Network (NSSN)
Email: peter@natirar.com.au

This Best Practice Guide chapter is part of a suite of resources designed to support local government action on air quality through the use of smart low-cost sensing technologies. It is the first Australian project of its kind. Visit www.openair.org.au for more information.

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