MANUAL FOR CITIZEN SCIENCE BIODIVERSITY MONITORING IN LEBANON

Prepared by Miriam Gately
For the Society for the Protection of Nature in Lebanon – SPNL
Under a project entitled: “BioConnect” and Funded by the European Union

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ABSTRACT

Engaging local communities and stakeholders in biodiversity conservation and environmental management is critical for protected areas. Lebanon's biodiversity is currently not being adequately monitored on a large scale, and Lebanese society in general is disconnected from biodiversity conservation. In order to ameliorate this, we made a manual to guide citizen science biodiversity monitoring projects in community based protected areas called Himas. The manual focuses on Himas in Lebanon, but the principles and processes can be widely applied. The manual is concerned with environmental and social outcomes and is guided by the idea of citizen science as democratic innovation in rural areas. This Manual outlining the use of formal citizen science for biodiversity monitoring is novel in Lebanon and the Middle East North Africa region. We hope that this manual will act as a starting point for similar projects in other countries as well as across Lebanon.

Key words: Biodiversity monitoring; citizen science; protected areas; Hima; democratic rural governance; Lebanon

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PREAMBLE

This manual is intended for scientists, environmental organizations, universities, practitioners, and researchers to be able to see and engage with in the work being done by the Society for the Protection of Nature Lebanon to create a culture of citizen science in Lebanon.

This manual outlines how to combine citizen science and biodiversity monitoring projects to create increased ecological and social benefits while strengthening Lebanon's biodiversity information. This way of conducting environmental management involves the community in all aspects from knowledge production to resultant landscape management practices.

Using citizen science methods supports research to investigate relevant and critical questions in Himas, community based protected areas that are deeply connected to community and rich in nature. Data collected through biodiversity monitoring in these protected areas is used to inform land use practices, and engaging local stakeholder communities in research, policy formation, and land management centering communities' needs and priorities.

Democratizing environmental governance and entwining environmental and socio-economic outcomes is critical to supporting rural Lebanese communities to flourish and act as stewards for Lebanon's precious biodiversity.

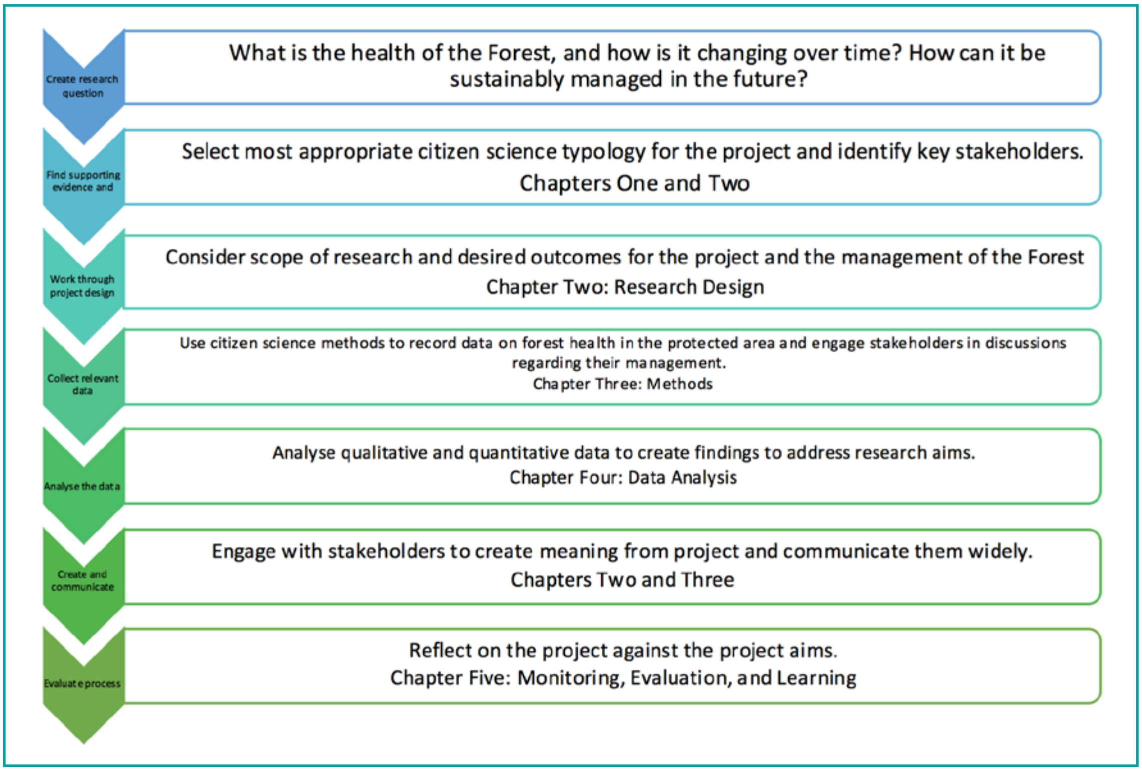
This manual is the first in Lebanon to cover multiple habitats and is leading in creating a citizen science culture in the Middle East North Africa region; Society for the Protection of Nature Lebanon welcomes engagement with it from all parts of society. There is much scope to iteratively improve the manual from stakeholder and practitioner experience and further research over the coming years.

HOW TO USE THIS MANUAL

The manual outlines how to create a citizen science biodiversity monitoring project in Lebanon. Created in the context of monitoring in Himas and protected areas, it can be applied to any ecological question or landscape that requires monitoring for biodiversity. The manual does not exhaustively outline methods for data collection but goes through each step of project design and implementation for citizen science biodiversity monitoring. Citizen science does not mean simply asking volunteers to undertake data collection: it is a way of thinking about knowledge creation and environmental management.

To provide a clear example of each step outlined in the manual, an example of a fictional citizen science project, monitoring Lebanese cedars (*Cedrus libani*) in North Forest, has been provided. This can be seen below in Figure 1, and in full in Appendix 1.

Figure 0 How to use this Manual, with an example of a fictional citizen science project to monitor a forest of Lebanese cedars (Cedrus libani).



GLOSSARY

Biodiversity
The variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems[1].

Citizen science
Volunteer collection of biodiversity and environmental information which contributes to expanding our knowledge of the natural environment, including biological monitoring and the collection or interpretation of environmental observations[2].

Citizen scientists
Lay people who choose to engage in scientific research, whether non-professional experts, stakeholders, or general members of the public.

Communities of place
People living in the area who have traditional and/or local knowledge which is based on a long-term association with the place. They often have their lives and livelihoods strongly linked to ecosystems and so are very invested in sustainable management of biodiversity. Their knowledge can be applied in environmental governance to better manage ecosystems and resources. Communities of place are not homogenous blocs of people but rather a theoretical grouping based on geographic proximity.

Democratic rural governance
A practice that deepens the role of citizen scientists in biodiversity monitoring and ecosystem management to foster legitimate democratic transitions for social and environmental outcomes in rural areas.

Ecological indicators
A component or assemblage of relevant environmental units, structures, or processes that can convey information about the system they are in.

Environmental management
A multi-disciplinary practice to guide a sustainable relationship between society and the natural world, including resource use, conservation, and ecosystem monitoring.

Habitats
The ecological space where a species is present, comprised of physical, abiotic, and resources and the relationships between them.

Hima
A traditional practice of community-based environmental management that balances production, conservation, and social use of the same landscape or area.

Homat Al Hima
An Arabic expression that is commonly used to acknowledge those who act as guardians and heroes of the Hima. These individuals and groups, known as Hima Guardians, are typically motivated, well-trained, and equipped young people from local communities of place. They lead activities that raise awareness of Himas, and the work being done in their communities to address environmental, economic, and social issues. They are also committed to ensuring the conservation of the site and its biodiversity, as well as the ecological and cultural services it provides. They are key stakeholders and practitioners of citizen scientists in Himas.

Horizontal engagement
A peer system where citizen scientists are co-producers of knowledge.

Local knowledge
The understanding, skills, philosophies, and resultant practices that are specific to a certain place and are held by the communities in that place.

Project
A planned collaborative exercise that uses a series of steps to achieve an aim.

Protected area
A defined geographical space that is recognized as such and managed through effective means to safeguard biodiversity, natural processes, and sustainable relationships between society and environment.

Qualitative methods
Practices to observe biological and social phenomena, and collect and analyze non-numerical data on them, using methodologies more open to subjectivity.

Quantitative methods
Practices to observe biological and social phenomena, and collect and analyze numerical data on them, using methodologies less open to subjectivity.

Stakeholders
People who can affect or are affected by environmental management decisions, such as people who live locally, farmers who use the land, and municipalities.

Vertical engagement
A peer system where citizen scientists are part of decision making.

1 Brazil 1992.
2 Tweddle et al. 2012.

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Herpetofauna Monitoring (Led by Dr. Riyad Sadek)

I. LITERATURE REVIEW

1.1 Citizen science

Citizen science is a very broad term that can encompass many approaches to doing science using volunteers for the collection, analysis, and application of environmental observations[3].

From crowd sourcing large datasets or the analysis of them, to working with a small group of volunteer experts, to engaging with local stakeholders, there are many ways for people to be meaningfully involved with environmental science[4].

When used well, citizen science is a democratic innovation that can increase the legitimacy of environmental monitoring and governance. Involving local communities in all stages addresses a deficit of democratic environmental governance in contexts where this is or could be an issue[5].

Citizen science is often applied as the public primarily being involved in data collection, but citizen scientists can also be involved in other stages, such as data processing; research design; communication of results; and policy formation[6]. Research indicates that involving the community every step of the way can foster better social and environmental outcomes[7].

There are many ways of engaging people in citizen science. For example, projects can:

- be open to everyone;
- use a group of trained volunteers who are often committed on a longer and more regular basis;
- involve communities of place specifically.

Why use citizen science?

There are many reasons why environmental projects may benefit from using citizen science. While citizen science may not be appropriate for all contexts, it can enrich projects and better environmental and social outcomes.

Conversely, centralized, and “expert”-led research, solutions, and policies may suffer from legitimacy issues[8]. By engaging local communities in environmental monitoring and governance, legitimacy can be gained, and more appropriate outcomes can be created and applied that really center social and ecological outcomes. In this way, citizen science can be horizontal, when the public engages with science to co-create knowledge, and/or vertical, when the public is engaged with and consulted on in terms of policy development and decision making[9].

For example, citizen science can be undertaken by community groups to heighten claims to protect the environment and to hold decision makers to account. The Victorian National Parks Association in Australia uses citizen science to monitor publicly owned National Parks across Victoria. They use their research to protect the environment by educating the public, filing court cases to protect nature, and holding governments and the private sector to account on conservation and biodiversity[10].

3 Pocock et al. 2018.
4 Tweddle et al. 2012.
5 Alarcon Ferrari et al. 2021.
6 Pocock et al. 2018.
7 Danielsen et al. 2017.
8 Alarcon Ferrari et al. 2021.
9 Alarcon Ferrari et al. 2021.
10 Ruchel 2020.

1.2 Biodiversity monitoring

Biodiversity is central to ecosystem health, and human peace and prosperity. Biodiversity should be conserved, managed sustainably, and shared equitably. Making and analyzing observations on the environment through ongoing monitoring is critical to supporting global biodiversity, as outlined under Article 7 of the Convention on Biological Diversity, which Lebanon is a party to.

Biodiversity is important at genetic, species, and ecosystem levels and monitoring can be carried out on all scales. This information can be coupled with information on system drivers to inform decision making. In this way, collecting a variety of information is critical for managing landscapes, resources, and processes in a way that supports biodiversity to flourish.

This manual focusses on biodiversity monitoring at the species and ecosystem level, as monitoring at the genetic level requires a deal of technical skills and equipment not wholly suited to be carried out by citizen scientists.

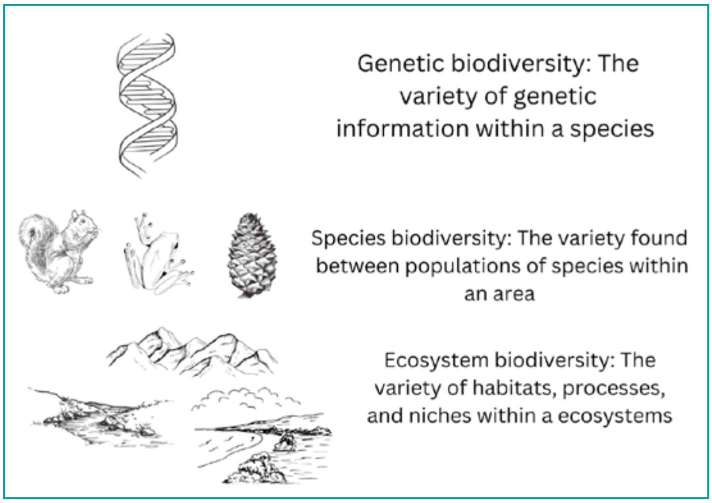


Figure 1.1 There are three levels of biodiversity that can be monitored. This manual focuses on species and ecosystem diversity.

Biodiversity monitoring can be applied in four main ways:

- assessing population health;
- assessing impact of environmental changes, including biotic and abiotic processes and factors, on biodiversity;
- evaluating the impact of management interventions and policy;
- assessing the relationship between society and environment.

Biodiversity monitoring can also be carried out at a number of socio-political scales. For example:

- at the international level to monitor global progress towards the UN's Sustainable Development Goals[11],
- at the national level to study the spread of an invasive species[12],
- at a hyper-local level to raise awareness about an ecosystem and create new support for more ecologically friendly management practices[13].

Using citizen science for biodiversity monitoring

Global environmental monitoring urgently needs to be upgraded in order to better care for the natural world. Meaningfully engaging the public with biodiversity monitoring at all levels leads to the best social and environmental outcomes. Some particular care must be applied to use citizen science to achieve this:

1. Projects must be feasible for citizen scientists to engage with; must fit with their motivations and interests; and must have outcomes that make their efforts worthwhile;

2. The science produced must be useful: of high enough quality to be used scientifically; and to provide a reliable database and information for decision making.

11 Alarcon Ferrari et al. 2021.
12 Goldstein et al. 2014.
13 Zacharias and Ressi 2018.

Citizen science can address legitimacy issues by providing an innovative path that democratizes environmental monitoring and socio-ecological governance, while developing the role of citizen science, both in data production and use.

Biodiversity monitoring using citizen science also contributes to Goals 13 to 17 of the United Nations' Sustainable Development Goals, which Lebanon is party to.

Table 1.1 Links between this manual for citizen science applications in Lebanon and the Goals of the United Nations' Sustainable Development Goals 13 to 17.

Goal	Example Target	Link to this manual
13 CLIMATE ACTION	**13.3** Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Through undertaking biodiversity monitoring and recommendation making, citizen scientists learn about the impacts of climate change on Lebanon's biodiversity, and possible mitigation and adaptation measures
14 LIFE BELOW WATER	**14.2** By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	Biodiversity monitoring in Lebanon's coastal ecosystems provides information for their sustainable management
15 LIFE ON LAND	**15.1** By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	Biodiversity monitoring in Lebanon's terrestrial ecosystems provides information for their sustainable management
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	**16.7** Ensure responsive, inclusive, participatory, and representative decision-making at all levels	Through vertically engaging with biodiversity conservation, citizen science creates responsive, inclusive, and participatory decision making in Lebanon's environmental management
17 PARTNERSHIPS FOR THE GOALS	**17.17** Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships	Using citizen science to monitor biodiversity invites all stakeholders in Lebanon to contribute their expertise, time, and effort to protecting Lebanon's spectacular socio-ecological environments

Challenges to citizen science

There can be challenges to undertaking citizen science projects, and it is not always appropriate for all research.

Forces that can impair the strength of citizen science include rejection of citizen science methods, aims, or outcomes by powerful actors and/or a lack of support from the wider public[14].

Citizen science can require a large input of time and effort, which must be managed realistically against the available resources and desired outcomes of the project. These can include inputs at every step from volunteer recruitment to data quality management[15].

1.3 Methods and methodologies of citizen science

There are different theories to structuring biodiversity monitoring undertaken with citizen science, but they all center some key methodologies and methods that are crucial to the success of a project.

Methods for citizen science monitoring projects broadly depend on project aims and available resources, while methodologies center relationships.

Research design will be more fully explored in Chapters Two and Three.

14 Gallo-Orsi and Werner 2016.
15 McDonough MacKenzie et al. 2017.
16 Meyburg and Angelov 2020.
17 Talhouk et al. 2018.
18 Talhouk et al. 2018; Martinoli et al. 2022.
19 Jawhary et al. 2016.

1.4 Citizen science for biodiversity monitoring in the Lebanese context

Lebanon is a small, mountainous country with five distinct geomorphic regions and a climate and ecology that is unique in the Eastern Mediterranean. It is also a major flyway for many bird species migrating between Europe and Africa and contains significant ecosystems including a number of Ramsar wetlands[16]. These features make it a biodiverse country with a high level of endemism[17].

Lebanon has been inhabited continuously for thousands of years by various peoples who have interacted with the natural world in many ways. The rich past includes ancient ways of farming, fishing, and pastoralism among other things like using the natural biodiversity of edible, medicinal, and economically valuable plants[18].

Himas are an example of this. “Hima” means “protected area” in Arabic, and Himas are managed by communities of place for multiple uses such as grazing, forestry, and non-timber forest products. Himas have been used for the sustainable management of natural resources for at least 1500 years in Lebanon and the Arabian Peninsula. There are 28 Himas in Lebanon, covering a variety of habitats and ecosystems, all managed alongside local communities[19].

Using citizen scientists to monitor biodiversity in Lebanon is a fitting and appropriate evolution and continuation of these traditions and creates opportunities for Lebanese people from all walks of life to practice their cultural heritage of careful and sustainable management of biodiversity.

Monitoring Lebanon’s biodiversity

A series of socio-economic events have led to social and institutional instability in Lebanon, and as such it has been identified as a country which critically needs intervention to protect its high and precious biodiversity[20]. This has led to a dearth of scientific research and institutions and knowledge base to carry out environmental governance underpinned by high quality data and knowledge.

High quality data is urgently needed in order to inform conservation and management actions to protect Lebanon's unique biodiversity.

Citizen science biodiversity monitoring in Lebanon

The difficult living circumstances much of Lebanon's population have experienced since 2019 coupled with an absence of environmental education in the country heightens the need for deep and fruitful collaboration with communities to create a culture of citizen science and a democratic environmental governance system.

Undertaking citizen science in this context can help create legitimate and democratic governance in rural areas where access to resources may exist in context with conflict and social unrest[21]. This positive social outcome is a priority in the Lebanese context and creates a positive feedback loop with greater environmental outcomes.

It is critical that the work that is being done includes local communities, not only to co-create knowledge and take advantage of existing knowledge, but to bring people into a culture of caring for biodiversity through identifying key stakeholders and working collaboratively and in a way that is rewarding and empowering[22].

Using participatory citizen science to monitor Lebanon's biodiversity also focuses on benefitting local communities in their roles as natural resource managers/users and environmental stewards[23].

For example, Lebanon's terraced agricultural landscapes are productive landscapes with high biodiversity. Farmers of these landscapes should be involved in biodiversity monitoring and management as key stakeholders: currently they are not adequately represented[24].

20 Talhouk et al. 2018.
21 Talhouk et al. 2018.
22 Karam et al. 2021; Alarcon Ferrari et al. 2021; Ebitu et al. 2021.
23 Danielsen et al. 2017; Pocock et al. 2018; Ebitu et al. 2021.
24 Nieto-Romero et al. 2014; Martinoli et al. 2022.

II. RESEARCH DESIGN

This chapter will outline how to design a citizen science project for biodiversity monitoring.

Using citizen scientists means in some ways “making a promise” to the public about the amount of involvement and decision-making power they can expect to have[25]. This is a central matter and should be taken seriously, especially in social contexts with low trust in institutions. Positive and generative experiences with high scientific and environmental outcomes that also meaningfully engage with and empower citizens are the best practices in this context.

Citizen science may be appropriate for some stages of a project but not others, and careful research design is needed to insert it in the most meaningful places[26].

Many citizen science projects only involve volunteers in the data collection phase, but projects may benefit from the inclusion of citizen science in other stages as well. Monitoring programs can have different levels of engagement to attract different types of citizen scientists. This makes both data sets and community engagement richer.

This chapter follows the steps outlined in Figure 2.1, which can be used to guide research design. Iterations of this process should be undertaken, with new learnings and reflections incorporated whenever possible. The details of the process will necessarily need to be adjusted to fit each particular question and context.

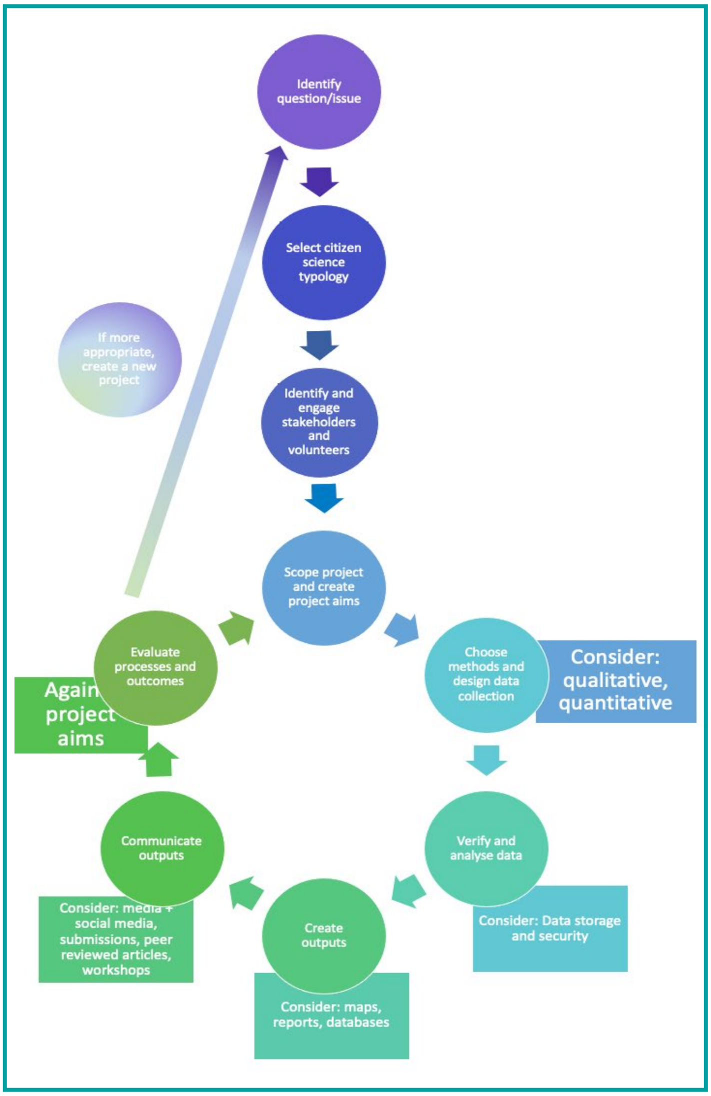


Figure 2.1 Outlining the guidelines to research design.

25 Eleta et al. 2019.
26 Tweddle et al. 2012.

2.1 Identify issues and objectives

The central issue frames biodiversity monitoring projects and informs monitoring objectives. This could be driven by a policy question or environmental needs, or by a community interest. Figure 2.2 shows the example of the village in North Forest, who have identified the ongoing health and management of a nearby forest as an issue. Monitoring objectives must be clear and meaningfully linked to recovery plans for relevant species and ecosystems and be able to be clearly translated into management outcomes.

See Table 2.1 for examples of issues being translated into measurable objectives and citizen science monitoring projects to assess them. Multiple objectives may exist in a single program[27].

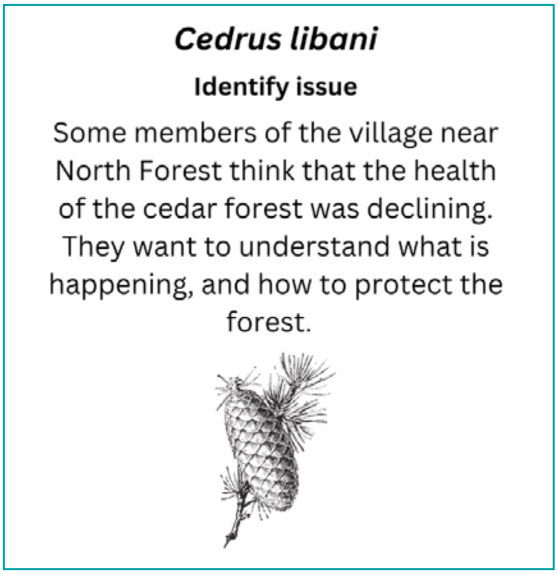


Figure 2.2 Members of a village near North Forest have identified the ongoing health and management of a nearby forest as an issue.

Table 2.1 Examples of some monitoring objectives that could be used to address identified issues. "Objective" after Lindemayer et al 2020.

Issue	Objective	Citizen science monitoring project
Assessing the health of a forest ecosystem against legislated commitments	Quantifying population or status trends using a range of indicators	Monitoring several indicator species over time to assess trends
A community is trying to improve the health of a local river by limiting run-off into it	Determining effectiveness of management interventions	Monitor crustaceans in the river over time as indicator species
There is a perceived lack of information and awareness on the impact of poaching on birds	Quantifying the magnitude of a threat	Using popular bird as a charismatic species for shaping a monitoring program around the impacts of poaching

The context for this manual is the issue of ongoing biodiversity monitoring in seven Himas, with the goals of building a relationship between environmental science and local communities and increasing democratic environmental governance. The project will create a database of Lebanon's biodiversity, which will inform management strategies and ultimately improve environmental and social outcomes across Lebanon.

2.2 Choose citizen science typologies

There are many citizen science typologies, with differences in how and when citizen scientists are involved in research. An appropriate typology may be clear at the commencement of a project, or it may become clear after considering some questions such as:

- How deeply engaged should citizen scientists be?
- In which stage/s of the process?
- What kind of engagement does the community want?
- What resources are available to support engagement?

Citizen scientists can be horizontally engaged as co-producers of knowledge, and vertically as actors in decision making[28]. Table 2.2 shows some typologies and their differing levels of horizontal and vertical engagement with citizen scientists. For example, the project partners monitoring North Forest decided to use participatory research as it allows for high levels of vertical and horizontal engagement (see Figure 2.3).

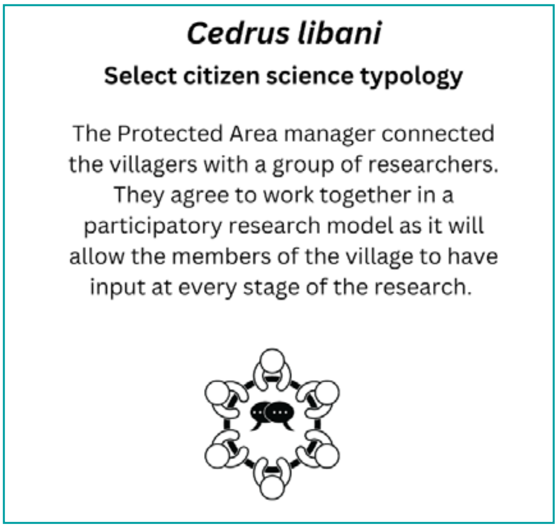


Figure 2.3 The project partners monitoring North Forest decide to use participatory research as it allows for high levels of vertical and horizontal engagement.

27 Lindenmayer et al. 2020.
28 Alarcon Ferrari et al. 2021.

Table 2.2 Amalgamated citizen science typologies showing increasing horizontal and vertical engagement. Each additional level of engagement of citizen scientists is assumed to include the roles of previous levels[29].

Citizen science typology	Role of professional researcher	Role of citizen scientist	Notes
Crowdsourcing; contributory projects; externally driven	Pose questions, design research, analyze and communicate results	Collect data, volunteer computing capacity, possibly some data analysis	No vertical engagement; lowest level of citizen scientist engagement
Distributed intelligence; collaborative monitoring; external analysis	Pose questions, design research, analyze and communicate results	Involved in more than one stage, which may include basic interpretation and/or management-oriented decision making	Some vertical engagement possible but not necessarily present; may require more training
Co-created projects; collaborative monitoring and analysis; participatory research	Facilitate research: guide problem definition and data collection, analyze results	Involved in all or most stages: participate in problem definition, collect data, higher level interpretation	Highest vertical and horizontal engagement: citizen scientists can suggest new research directions
Autonomous local monitoring; extreme citizen science	Advocate for scientific legitimacy of typology; provide guidance when requested	Design and carry out research: non-professional experts or scientists engaged in every aspect of research	Completely autonomous monitoring; experts may be invited to participate

These typologies must also be framed in how engagement should be carried out in terms of the social and governance aims of the project. In order to not merely monitor biophysical indicators, it is recommended that projects use both a participatory action research framework to horizontally engage citizen scientists as co-producers of knowledge and vertically in regard to decision making. Citizen science is then framed as a practice of transformative governance to foster public engagement and democratic transitions to drive social and environmental outcomes in rural areas[30].

29 Tweddle et al. 2012; Haklay 2013; Danielsen et al. 2017.
30 Alarcon Ferrari et al. 2021; Fischer et al. 2021.
31 Gallo-Orsi and Werner 2016.
32 Ebitu et al. 2021.

2.3 Identify key stakeholders

There may be a range of relevant stakeholders, from international to local levels, and each group may need to be engaged with differently throughout the project, including to different levels or at different stages[31]. Relevant stakeholders can include all those who have expertise; can provide capacity; are attached to the landscape, species, or issue; and will be affected by or benefiting from the monitoring activity. Scientists or NGOs extracting skills, capacity, or knowledge from stakeholders is a practice that does not build positive or lasting relationships[32].

Long term, consistent engagement with citizen science projects by volunteers is best supported by co-designing research with stakeholders so that they can see their efforts and knowledge being used and can shape and influence environmental governance.

Once key stakeholders have been identified and engaged with, those designing the research process should be open to reassessing the previous steps outlined in this Chapter, based on the wants, needs, and capacities of citizen scientists. This Chapter is merely a guide and should be iteratively adapted to suit each specific case.

Examples of citizen science stakeholder groups for biodiversity monitoring in Lebanon

There are some key stakeholder groups that can be engaged with in citizen science biodiversity monitoring. Recognizing expertise in non-professionals is a critical starting point to engaging with any group. The following is a list of them and recommendations for supporting their involvement.

Communities of place

They may have traditional and/or local knowledge which is based on a long-term association with the place. They often have their lives and livelihoods strongly linked to ecosystems and so are very invested in sustainable management of biodiversity. Their knowledge can be applied in environmental governance to better manage ecosystems and resources. Communities of place are not homogenous blocs of people but rather a theoretical grouping based on geographic proximity.

Birdwatchers

Bird watching is a popular hobby in Lebanon, a country with a unique and varied bird population including both resident and migratory birds. Bird watchers include hobbyists, non-professional experts, tourists, hunters, and scientists. Engaging with visiting bird watchers may have eco-tourism potential for Lebanon.

Divers, snorkelers, and free divers

These are popular hobbies in Lebanon, with thriving communities. Engaging with these groups will allow for monitoring in many marine areas. Those with different skill levels can be engaged differently, for example simple protocols with short pre-dive briefings in more popular dive spots, and longer more intensive trainings and engagement in less popular dive spots can recognize the skills of more proficient divers while keeping novices engaged in monitoring.

Farmers

A critical group in Lebanon, those who own, work, or live on farms have daily interactions with nature, and their decisions can play a central role in securing Lebanon's biodiversity. Research must be relevant to the farmer's needs, and they should be treated as co-researchers in research design, interpretation, communication, and presentation of policy proposals where possible. Farming communities can also play a central role in improving sustainable rural governance. As their livelihoods are directly impacted by environmental policy, farmers should be engaged vertically (decision making in research and resulting policies and management) as well as horizontally (carrying out research).

Hikers and guides

Hiking is a popular pastime in Lebanon, with many guides leading hikes through a variety of ecosystems. These guides may have broad ecological knowledge relevant to monitoring efforts that could be captured through qualitative methods, while hikers can be invited to collect randomly sampled data on their hikes. Engaging with these groups has high potential to raise awareness and support for biodiversity monitoring and conservation in Lebanon.

Hunters

Responsible hunters have knowledge on the movements and habits of many species in Lebanon and are a critical ally in the fight against poaching. They can be readily engaged in field work, and in reporting on the health of populations that they are interested in and knowledgeable about.

Municipalities

Municipalities have an essential role to play in managing and protecting Lebanon's environment. They act as an important authority for managing Protected Areas, including Himas. Municipalities have the potential to lead on biodiversity conservation activities: they can organize community-based initiatives and partnerships to manage and protect local ecosystems; foster a sense of community ownership and stewardship of the environment; and facilitate public participation in decision-making processes related to environmental and conservation issues.

Pastoralists

Lebanese pastoralists may have specific environmental knowledge. They can be engaged on matters around plants and animals changing across the seasons, both to monitor biodiversity and keep their local ecological knowledge alive. As their livelihoods are directly impacted by environmental policy, pastoralists should be engaged vertically (decision making in research and resulting policies and management) as well as horizontally (carrying out research). See Figure 2.4 as an example of this.

Protected area managers

Protected areas form a critical part of the biodiversity conservation network. Lands that are protected for environmental reasons form patches where plants and animals can create healthy ecosystems. Managers of these areas may want to undertake their own citizen science projects or be a partner in other projects that are relevant to them. They will often have useful knowledge and insights about local biodiversity, as well as physical access to the land.

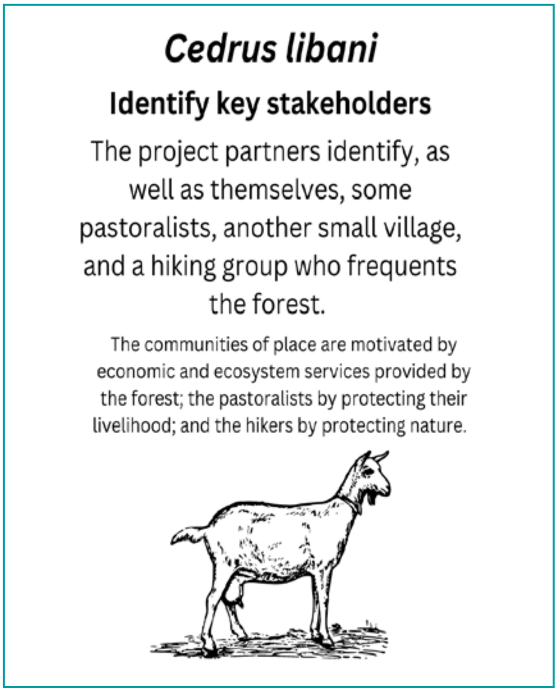


Figure 2.4 Key stakeholders identified are protected area managers, communities of place, hikers, and pastoralists. Each group has different main motivations.

Photographers

Smartphones with high quality cameras are ubiquitous, leading to a huge volume of photographs being created every day. Some people also practice photography as a hobby or profession. Images of Lebanese birds, wildlife, plants, and landscapes can provide data on biodiversity in the country. These can be taken specifically for citizen science, or just opportunistically taken and uploaded to databases.

Women

Women are often underrepresented in environmental decision making, and in all levels of government. Their knowledge, concerns, and goals must be respected and considered in all efforts to improve sustainability. Empowering women to take part in citizen science is a critical aspect of improving rural democratic governance and improving biodiversity outcomes.

Young people

Young people are integral to the future of biodiversity. From school children to older teenagers, they all deserve to grow up with knowledge about the biodiversity and ecosystems of Lebanon. Engaging with them meaningfully is critical to the success and sustainability of environmental management.

The general public

Engaging with non-specific groups is also critical to the success of citizen science projects. General engagement can raise awareness, create a dialogue about the importance of biodiversity, and increase society's scientific literacy. Predictable sampling in permanent plots is a critical method of biodiversity monitoring, and volunteers from the general public can be trained to carry out these set tasks. "Friends Of" groups can support this: encouraging people to adopt a space to care for. Creating "Friends Of" groups can connect people to nature, increase rural democratic governance, increase natural literacy, and create a network of skilled citizen scientists who can carry out monitoring and other tasks.

Journeys

Once citizen scientists have been recruited to participate in biodiversity monitoring, they need pathways to take so that their efforts lead to something meaningful. This will depend somewhat on the typology of a project, but some things to further consider are:

- Can citizen scientists see clear positive outcomes from their efforts?
- What skills, training, or knowledge do citizen scientists get from being involved?
- Are their efforts recognized and celebrated?
- Are there opportunities for long-term and skilled volunteers to take on extra responsibilities?
- Are their initial motivations for joining a project being addressed?

Motivations

It is important to have some understanding of the motivations that drive people to become citizen scientists and get involved with biodiversity monitoring projects. Different groups of stakeholders will have different, but potentially overlapping, motivations and project design must be cognizant of this.

Hikers may want to become involved to learn more about the biodiversity of an area they are walking through, divers may want to help conserve marine ecosystems, and farmers may want to increase on farm biodiversity in order to create a more resilient and profitable farm.

The personal interest and motivations of citizen scientists in the project is a crucial factor for them continuing with the project through challenging times, so motivations need to be taken seriously[33].

Overcoming barriers

Every citizen science project may at some point experience barriers or setbacks. When designing research projects, it is imperative to consider what may go wrong, and how to address this and move forward. Experiencing challenges in the life cycle of a project is not a negative thing to be feared, but rather a situation that can be managed through careful consideration, and the goodwill and trust built between citizen scientists, professional researchers, and stakeholders.

33 Fischer et al. 2021.

2.4 Create targets/ project aims

Citizen science projects often have three aims: social engagement in science and environmental issues; creating robust and useful scientific data; and informing strong plans for the sustainable management of environments. It is challenging but rewarding to balance these targets. Figure 2.5 shows an example of creating a project with multiple aims.

Questions to consider when scoping a project include:

- What a successful project will look like in terms of:
  - Scientific outcomes,
  - Social outcomes,
  - Policy outcomes and changes to management?
- What data is needed to address the three types of outcomes?
- How will outcomes be measured?
- What is the capacity of researchers, citizen scientists, and other stakeholders?
- What is the scope of a project? For example:
  - How long can it run for?
  - What is the study area size? (One valley? One field? The range of one species?)
  - How many target species can the project cover?
- What funding is available and how long can it last?
- How to keep citizen scientists engaged, and guide them on meaningful journeys?

34 Gallo-Orsi and Werner 2016.

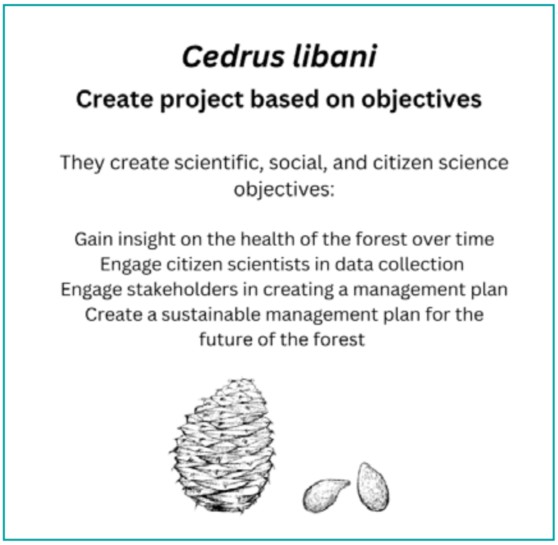


Figure 2.5 The multiple aims of the North Forest monitoring project cover social, scientific, and environmental questions.

What to record

Projects should focus on the level or levels of biodiversity that most serve the projects' aims and should also monitor threats to biodiversity at relevant scales to inform robust environmental management.

Indicators can be monitored to create an overall snapshot of an ecosystem[34]. Indicators that are intuitive and/or have emotional value will be easier and more rewarding for citizen scientists to engage with. When selecting indicators, consider:

- Sustainability of monitoring this indicator: what are the inputs needed to collect high quality and meaningful data?
- Information availability: is there historical data to act as a baseline, or some other pre-existing knowledge or framework to guide this?

As well as collecting data on biodiversity directly or through indicators, citizen scientists can also monitor relevant threats to biodiversity. Threat monitoring can be incorporated into worksheets and other monitoring projects or be done specifically. It is important for creating robust biodiversity management schemes that there is sufficient and up to date data on the threats to biodiversity. These can operate at a number of spatial and temporal scales and monitoring for them will need to be carried out accordingly.

For example, monitoring the loss of tree cover in a municipality over ten years or the amount of hard rubbish being dumped near a stream over a year will inform conservation efforts. Threats to biodiversity are complex and dynamic, so careful and ongoing monitoring of threats is critical to managing these and their impacts proactively.

Carefully selecting a small number of indicators that are sufficient to generate necessary data and do not overly burden a project is pivotal. Projects often must be balanced between the need to monitor to test ecological hypotheses and the need to respond to policy and/or management requirements. For example, a project on the species richness of water birds may only have funding for three years, or citizen scientists may not be motivated by birds but by monitoring the health of their river ecosystem as a whole instead.

How to record

Robust citizen science projects also require consideration not just for what to record, but how to engage the public in the recording. This should be guided by the aims of the project, resource constraints, data that needs to be produced, and the needs and interests of relevant stakeholders.

Things to consider include:

- Using qualitative methods,
- Using quantitative methods,
- Whether to monitor directly or indirectly,
- Whether to use structured or unstructured methods.

Engaging with stakeholders at every step - research design, data collection, data analysis, policy creation and communication - is central to this process.

Research design will also have to consider when to record. A project focused on wildflowers would best take place in spring and summer so that they are in bloom, while a project on birds may need to coincide with migration. Citizen scientists who work during the week may only be able to undertake field work on the weekends or on holidays and may be easily put off by bad weather.

Where to record

There are two main types of places that citizen science biodiversity monitoring can take place:

- Public land, such as cities, parks, reserves, beaches, roads, mountains, rivers; and
- Private land, such farms, gardens, estates, vineyards, and private parks.

Different types of places will have different access requirements and may lend themselves differently to different kinds of data collection.

For example, projects on public land may be more appropriate for involving more people on projects like recording sightings of a charismatic species; while those on private land may require a deeper relationship with those stakeholders and can be more easily monitored with methods like fixed plots or transect lines.

2.5 Select methods of data collection

Methods need to be simple, standardized, and create scientifically meaningful output so that citizen scientists can truly contribute to biodiversity monitoring. Methods must create data that is useful for addressing project aims and can create more understanding of and appreciation for biodiversity.

Selecting methods will be more fully discussed in Chapter Three, using examples and case studies.

2.6 Analyze data

Data analysis in citizen science can take many forms and will be informed by a project's ecological and social aims, as well as what outputs are required. The level of involvement of volunteers can vary in this stage of the project and while it is best practice for stakeholders to be as engaged as possible throughout the whole research process, this stage may require more specialist skills and training.

The collection, storage, and analysis of data will be further discussed in Chapter Four.

2.7 Create outputs

Outputs created from biodiversity monitoring projects must address the scientific, policy, and social aims of the overall project while increasing the democratic governance potential of biodiversity and the natural world. See Figure 2.6 for examples of ways that outputs can create and communicate multiple aims.

If citizen scientists feel that all their efforts amounted to nothing, or to something significantly different from what they initially had in mind, the project, as well as the organization/people carrying it out, may lose legitimacy. Issues of legitimacy are important to get right in contexts like Lebanon where there may be distrust of institutions and processes generally.

When creating outputs, it is important to celebrate all "wins" from the project, even small ones. Recognizing and celebrating success is crucial to maintain interest and engagement from citizen scientists.

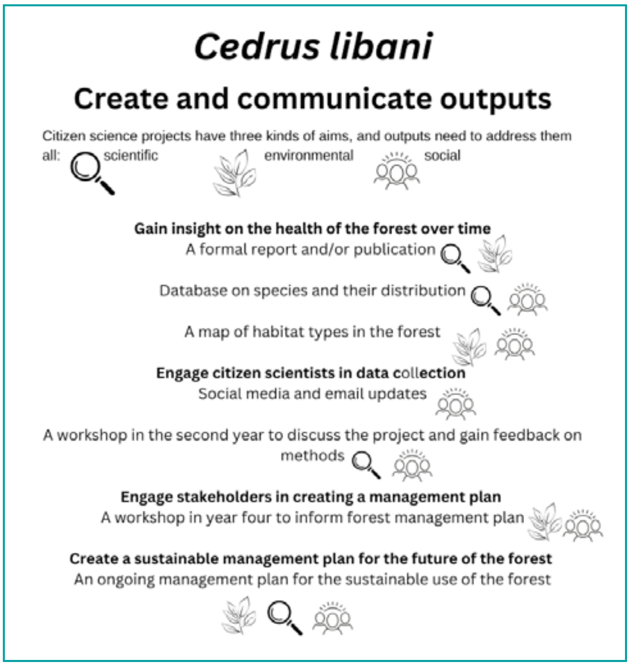


Figure 2.6 The North Forest monitoring project had four main aims. Outputs were created and communicated in several different ways during and after the project to engage with different groups while addressing each aim.

2.8 Communicate outputs

Once the outputs have been made, they must be communicated. This process will be informed by the project aims: Who needs to know about this work? Who will be affected by the findings or recommendations? Have all of the relevant stakeholders been contacted? Allowing some spontaneity and creativity in this process as well as reaching out to groups who may not seem obvious and may lead to exciting and unexpected outcomes. See Figure 2.6 for examples of communication activities that can be directed towards different stakeholders.

Some examples of ways to communicate a project:

- Peer reviewed articles may meet a project's scientific aims,
- Presenting the project at conferences will create

opportunities for input from new sources;

- Town halls can invite communities of place into the conversation,
- Workshops for stakeholders can pass on new skills and knowledge, as well as direct future projects,
- Traditional and social media will inform the general public and invite them to become citizen scientists,
- Policy submissions will engage directly with policy makers about how to manage and conserve biodiversity,
- Talks to students at all levels will educate young people and may lead to research interest from universities and older high school students,
- Public lectures can create awareness and understanding in the general public while increasing perceived legitimacy,
- Websites can tell people from anywhere in the world about the project and invite more participation.

2.9 Evaluate the research project

Biodiversity monitoring projects should themselves be monitored! Monitoring a project's performance at all stages of the life cycle; evaluating different aspects in line with project aims and stakeholder expectations; and learning from the results of this is a critical process to constantly improve citizen science.

Monitoring, evaluation, and learning will be discussed in Chapter Five.

2.10 Identify the next steps

Biodiversity monitoring is an iterative, and citizen scientists will gain more from staying involved from one project to the next. The end of project evaluation will help to inform whether to start again at the stage of identifying questions and issues, or to go back to re-scoping project aims.

This may be dependent on factors such as data needed, availability of funding, citizen scientist capacity, and season. See for example Figure 2.7. Project leaders should remain open and willing to change their plans in line with social and environmental needs.

Figure 2.7 After considering many factors, the project partners decided to continue with ongoing citizen science monitoring of North Forest, continuing both horizontal and vertical engagement.

III. METHODS

Method selection should be guided by the research question or issue at hand, and the data needed to address it. This is the same as any other biodiversity monitoring project. However, using these methods for citizen science generally requires different considerations and may need to be carried out with a different approach.

This chapter discusses key quantitative and qualitative methods for citizen science biodiversity monitoring and outlines some examples of their use.

This manual is focused on broad scale monitoring to assess biodiversity in protected areas, with a focus on Himas, and changes to this over time. Mixed qualitative and quantitative methods are recommended as they allow the collection of different data from various sources. Table 3.1 outlines the methods that this chapter discusses.

Table 3.1 This chapter has six key subsections that outline relevant monitoring methods.

Quantitative methods 3.1		
Method		**Section**
Habitat monitoring	Using indicators to monitor broad trends within protected areas	3.1.1
Species or taxa	Monitoring a species or taxa specifically, recording them or indicators of their presence directly	3.1.2
Broad scale monitoring	Opportunistic biodiversity monitoring	3.1.3
Qualitative methods 3.2		
Methods		**Section**
Discussions	Speaking with stakeholders and citizen scientists to gain insight and knowledge	3.2.1
Participatory research	Stakeholders and citizen scientists as participants in research	3.2.2
Threats monitoring 3.3		
Threats monitoring	Monitoring the impacts threatening processes have on biodiversity	3.3

Data on species number, species composition, vegetation assemblages and other such indicators are collected through quantitative methods, both systematically and opportunistically.

Qualitative methods are particularly good at drawing out stakeholder needs/goals/interests/ capacities so should be done iteratively and in ways that can inform quantitative methods. Knowledge, changes over time, insights and emergent information may be gained this way too. This values traditional and local knowledge; increases research legitimacy; and democratizes socio-ecological governance.

Both horizontal and vertical engagement are important - where appropriate, have citizen scientists' input on what methods are used when and why. Wherever possible, robust pilot studies should be carried out.

Centre stakeholder relationships

The core attribute of citizen science is the ongoing and collaborative relationships built between individuals, communities, and bodies undertaking scientific research. Identifying and working collaboratively with stakeholders is central to the success of any citizen science project.

Having genuine and positive relationships with stakeholders is critical to the successful monitoring of biodiversity and for legitimacy in the eyes of local communities. It is also required for knowledge sharing and co-creation between parties[35].

Method selection

In any citizen science project, there are many different types of data that can be recorded: species presence; population data; ecosystem data; traditional and local knowledge; and records such as photographs and maps. Deciding what, how, and where to record will depend on the projects' aims, stakeholder needs and interests, and available resources.

35 Danielsen et al. 2017; Alarcon Ferrari et al. 2021.

When deciding on methods consider the following as a starting point:

- The types of data needed to address the aims;
- Ways to make it as simple as possible for citizen scientists to be engaged while still generating scientifically meaning data set;
- The minimum amount of data needed;
- The maximum amount of data needed, and ways to decide this;
- The fact that the data will be analyzed;
- The capacity for data analysis.

Questions around capacity, technological demands, required time, and potential hazards should be kept in mind when assessing a method's appropriateness. That is, research needs are not the only consideration when selecting methods. For example:

- The capacity of researchers and volunteers;
- The experience the team has in training and supporting volunteers;
- The presence, targets, and period of funding,
- Time needed to find and train volunteers, run fieldwork, with seasonal considerations, and adjusting to the timing of what is being measured;
- The infrastructure or technology needed, if it already exists, and if it is reliable;
- Who will train volunteers, to what end, how trained are they already, what do they want from the experience;
- Which stakeholder groups are being engaged and which ones are not, how to decide this;
- Consideration of social issues like what is or is not allowed to be discussed, what may make people distrust the process or researchers;
- Physical safety in the field including personal protective equipment, first aid training, weather considerations, physical and mental preparedness;
- Free, prior, and informed consent obtained from volunteers where necessary; and
- Researchers and volunteers have some level of agreement regarding knowledge co creation versus knowledge extraction.

It is critical to collect metadata whenever data is being recorded. This includes date, weather, altitude, location, time of day, aspect, and temperature, researcher identity, as well as longitude and latitude if possible. There are many mobile phone applications that can provide some of this data, or geo locators can be used. Metadata also needs to be standardized.

A reliable way to do this is through the use of data sheets. For example, a simplified way to record weather conditions is by providing all possible answers using pictographs, as shown in Figure 3.1.

Figure 3.1 Make all data as easy to collect and interpret as possible, including meta data. Using weather pictographs is an example of this.

If the data being collected is qualitative consider who was or was not there, how long did a conversation go for, where data was collected (for example in someone's house, in the field, or in a community space), how the research was advertised, if anyone left before the event finished, how was it recorded, and so on.

3.1 Quantitative methods

Quantitative methods are the most easily recognizable and understandable methods of biodiversity monitoring. Citizen scientists will often be excited to get out into nature and interact meaningfully with plants and animals, so they can be very rewarding to undertake.

Quantitative biodiversity monitoring can be carried out at many scales and have various focuses, for example, by monitoring a whole site (a forest), monitoring a whole habitat (a representative sample of the pine-oak forests), or a species or taxa (monitoring butterflies). These can interact in different ways: monitoring butterflies in pine-oak forests; monitoring quality of habitat for butterflies in one site; monitoring a specific forest to check the presence of a specific butterfly, and so on.
These physical scales also interact with temporal ones: monitoring may take place over a season; over some years; during migration of a certain bird; or only at night.

Finally, robust biodiversity monitoring should also engage with the threats to biodiversity. Are the butterflies in the forest threatened? If so, by what? What policies or management practices need to change to protect them? This information is not central to many biodiversity monitoring projects but should be considered as critical context.

Integrated monitoring of sites forms the goal of biodiversity monitoring in protected areas, and projects should work iteratively towards it. Each Hima may have a number of habitats in it, supporting a range of species, and these should be monitored through specific monitoring projects, with methods and data that are comparable across sites.

There are many possible methods to use, and it is outside the scope of this manual to create a comprehensive list. Instead, this Chapter outlines examples of common methods and how they can be applied in a citizen science context as a way of creating a guideline for designing biodiversity monitoring projects in Lebanon. This section will be iteratively updated in later editions of this manual to reflect suggested changes from both theorists and practitioners.

3.1.1 Habitat monitoring

Habitats with sufficient baseline data can be monitored using indicators. In cases where baseline data is missing or incomplete, theoretical data based on a robust review of relevant grey and peer-reviewed literature can complement this approach if utilized with care.

Methods used and data created should be comparable across and within sites so the broad trends can be identified across sites and regions. This builds robust data sets to inform grounded management.

This approach is helpful when a habitat is still broadly intact in terms of functionality and structure. Projects with aims of understanding the current state of the habitat, designing restoration and rehabilitation interventions, and monitoring the outcomes of these interventions will benefit from the use of habitat indicators. Some examples of these are outlined below.

This first example outlines the mapping of habitat quality through an indicator species, taken from Hill et al. (2005)[36], following the steps below:

1. Use total counts of individual plants to:

a. Monitor the presence or abundance of indicator or rare floral species chosen to represent the habitat quality of a vegetation community,

b. Track the spread of invasive floral species by creating detailed and precise data on their spread.

Create a map of the area with small grid lines that are marked alphabetically on one axis and numerically on the other, to give each gird a unique coordinate,

2. Search carefully along the grid lines and mark the location of any of the target plant species, as well as any notes on their condition or other relevant information.

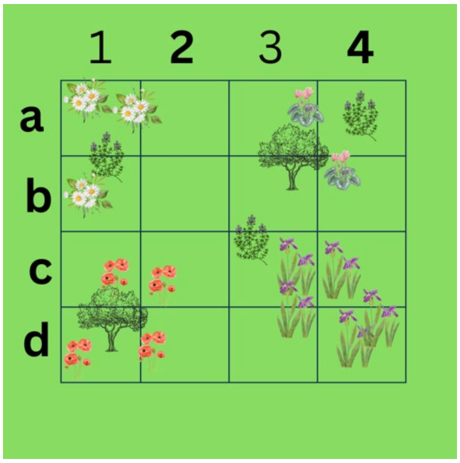


Figure 3.2 Gridlines representing the map of the studied area with species allowing habitat quality assessment, inspired by Hill et al. (2005).

This type of method is characterized by the following qualities:

- Creates a precise and accurate map of the habitat area,
- Time and labor intensive; not suitable for large or complex sites,
- Can be easy for citizen scientists to learn to identify a small number of species.

The second example, from Tasser et al (2019), illustrates the assessment of farmland biodiversity using two parallel methods which were then compared statistically to evaluate the choices of user-friendly indicators.[37]

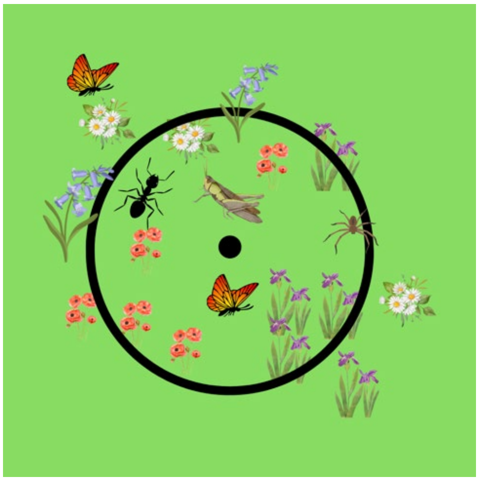


Figure 3.3 Representation of the farm patch with indicators acting as proxies to biodiversity assessment, inspired by Tasser et al (2019).

Random patches were selected on farms and experts evaluated indicators which were technical and commonly used in scientific biodiversity assessment:

- Heterogeneity of landscapes/structuring degree (using orthophotos and mapping),
- Shannon diversity index of patches (using phytosociological surveys).

36 Hill et al. 2005.
37 Tasser et al. 2019.

On the same day, farmers accompanied experts on their patches, and they were assigned more feasible and cost-effective indicators:

- **Flower color:** this indicator acted as a proxy to plant species richness where farmers only had to count the number of flowers for each different color,
- **Butterfly abundance:** butterflies act as good indicators of landscape health, and their numbers were measured by farmers provided with visual lists beforehand.

When the results from the two sets of indicators were statistically compared, it was shown that the farmer-assigned set of indicators is sensitive enough to be more commonly used in biodiversity assessment.

Habitat types in Lebanon

Six broad habitat types have been identified across Lebanon. They are not the only habitat types in Lebanon, but the consideration of others is outside the scope of the current edition of this manual. The location of the six habitat types is indicated in Figure 3.4, and some of their general characteristics are outlined in Table 3.2.

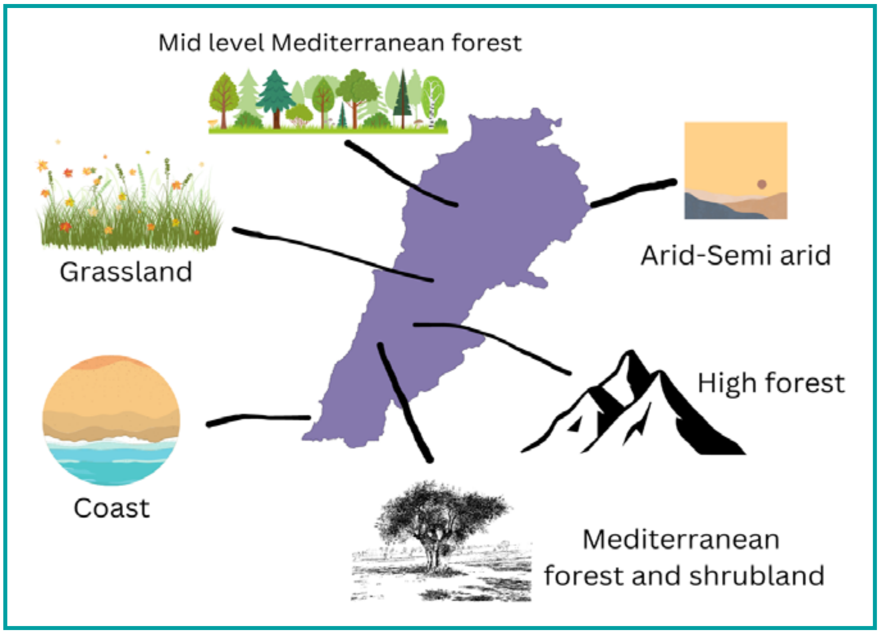


Figure 3.4 Map of Lebanon showing where the six habitats may occur in a plan view.

Table 3.2 Six broad habitat types across Lebanon and some of their general characteristics.

Habitat type	Vegetation type	Some key species	Land use	Main threats to biodiversity
Coast	Coastal forests, dune systems, rock platforms, beaches, sea cliffs, heath. Olive, lentisks, late narcissus, common myrtle	Mediterranean monk seal (*Monachus monachus*), rock samphire (*Crithmum maritimum*)	Dominated by human made land cover. Highly developed, haphazard, and unmitigated urban sprawl: farms, towns, cities, villages, and Lebanon's international airport	Habitat loss and fragmentation, overfishing and other exploitation of natural resources, pollution, climate change, invasive species
Mediterranean forest and shrubland, <500	**Limestone:** Carb-Lentisk Scrub, Pine woodlands, Evergreen oak woodlands, Mixed oak-pine woodlands Marl and marly limestone: Pine Forest, Mixed conifer forest, Cypress Forest **Sandstone:** Pine forests	Lebanon viper (*Montivipera bornmuelleri*), Palestinian oak (*Quercus coccifera*)	Heavily modified. Highly developed, haphazard, and unmitigated urban sprawl, agriculture, houses, roads, towns, villages.	Habitat loss and fragmentation, exploitation of natural resources, pollution, forest fires.
Mid-level Mediterranean forest, 1 000 - 1 500m	**Limestone:** Evergreen oak forests, Mixed oak and juniper forests, Deciduous oak forests, Hop hornbeam mixed forests **Sandstone:** Stone pine forests, Deciduous oak forests	Persian squirrel (*Sciurus anomalus*), Sofar iris *(Iris sofarana)*	Houses, towns, grazing, resource use including quarries and timber harvesting, agriculture.	Habitat loss and fragmentation, exploitation of natural resources, forest fires.
High forest, >1 600m	Mixed conifer, Mixed conifer/oak forests, Oak forests, Juniper woodlands	Greater spotted eagle (*Aquila clanga*), Lebanese cedar (*Cedrus libani*)	Protected areas, snowfields, transhumance, recreation, some small villages.	Habitat loss and fragmentation, climate change.
Grasslands	Sumac, Lebanon shrubby sage,	Hyrax (*Procavia capensis*), Greek tortoise (*Testudo graeca terrestris*), white-bellied hedgehog *(Erinaceus concolor)*	Heavily modified for agriculture. Also includes towns, villages, industry.	Habitat loss and fragmentation, exploitation of natural resources, forest fires, development, desertification.
Arid to semi-arid	White wormwood, Lowne's tulip, Lebanon savory, Pinard's sage, Palestinian sage, fragrant lavender cotton	Caracal (*Caracal caracal*), field almond *(Prunus agrestis)*	Pastoralism	Desertification, habitat loss and fragmentation, exploitation of natural resources

These habitat types are a necessary simplification of those found in the literature. For example, Talhouk et al. (2018) who give several bio-climactic zones and forest/vegetation types in Lebanon and Khoury et al. (2021) identify five geo-morphological zones.[38] They are amended for the purposes of this manual following the SPNL Special Issue.[39]

Some Lebanese habitats are heavily modified for example, olive groves; crop lands; and coastal areas. Monitoring of these land use types will require biodiversity and ecosystem health goals to be made for these landscapes in their specific social contexts as they may interact strongly with urban and peri-urban areas. The following can be used as guidelines in these situations.

Appendix 2 contains an example of a data collection sheet for monitoring a forested habitat.

3.1.2 Species or taxa

This is useful when researchers have a particular species to monitor, or are working in very modified landscapes, or if the research uses particular species or taxa as an indicator. These methods generally but not exclusively use structured monitoring. These methods can be very exciting for citizen scientists to be involved in as they are hands on and often offer the chance to spot birds and wildlife in nature. If a charismatic species is the focus of the research or the poster species of it the public may more readily engage with it.

Direct methods

Data is collected directly through sightings of groups or individuals of fauna, recording present vegetation, camera traps, and taking photographs. This data can give a variety of information suited to many different purposes. Some examples are outlined below.

- **Total counts:** every individual in a group is counted. This method can be inaccurate in the short term and needs to be very carefully standardized and statistically analyzed. This is a practical method for estimating the population of migratory birds either wintering/summering at a site or transitioning through on their migration. Large groups of citizen scientists are needed to participate in synchronous counts at key sites for seeing migration and observe the target species/groups of species.
- **Spotlighting:** this method is useful for taking observations of nocturnal species and can give estimates of population. Walks are carried out through the habitat along transects at night with a high-powered torch and point counts at predetermined intervals are done. Animals can be identified by eyeshine, coat/feather pattern, or other dominant features. Surveys should be taken on clear nights at times of night and year when the target species are likely to be active. Species observed this way can include owls, frogs, and badgers. Citizen scientists love spotlighting as it can be very exciting and a new way of seeing nature. When designing these surveys for citizen scientists, additional consideration must be taken for the safety aspect of undertaking research at night.

Calls

Recording the calls of a target species/taxa can give data on presence/absence, as well as estimates on population density. After adequate training, citizen scientists should be able to accurately carry out these methods relatively independently.

- Bird calls can be observed to give presence/absence and habitat association when recorded with some habitat data. This can be done by carrying out a point count for a set time across the area of study. Point counts are good for dense vegetation and steep terrain. Citizen scientists would need training in recognizing relevant calls, and having sound files of them on their phones when they carry out the research can help with this. When collecting data differentiation must be done between the birds/species that were seen and heard, versus those who were only heard or only seen.
- **Howls:** howls are long range communication between carnivores and can be recorded. Giannatos et al (2005) set out to assess the population status of golden jackals in Greece, where this mammal is

38 Talhouk et al. 2018; Khoury et al. 2021.
39 Anon 2021.

the rarest canid species. Recordings of the howls of a group of jackals were repeatedly broadcast at selected sites during the night with groups of listeners noting down the direction and number of individuals responsible for a response, if any at all. If a response was quick, visual observations were carried out with binoculars at, at least, a 250-meter distance from any approaching animal.

Presence

Indicators that an animal or bird has been in an area can give a variety of information, such as population density, species presence, and clues to behavior. Some examples of these are outlined below.

- **Feeding sites:** some animals leave noticeable traces when they feed. Examples in Lebanon include the digging sites of wild boar (*Sus scrofa libycus* and *Sus scrofa scrofa*) and the gnawed pinecones that squirrels (*Sciurus anomalus*) drop. The presence and distribution of these species can be indicated by these markers by searching systemically within quadrats or along transects. Some animals may leave similar presence sites, for example herbivores who may strip bark from trees in winter, so their presence may need to be amalgamated.
- **Droppings:** many mammals can be identified from their droppings, though some species within a taxon have very similar droppings that may require expert identification. Droppings of carnivores should not be disturbed as they are placed in specific locations by the animals to mark territory or otherwise communicate. This technique is then best used to create presence/absence or distribution mapping for carnivores. Herbivores do not do this and leave many more droppings, so their population size and habitat preferences can also be ascertained using this method. Droppings can be sampled along transects or in plots, and undertaking this work across seasons can indicate seasonal habitat preference of herbivores.
- **Shells, skin:** Insects, reptiles, and mollusks leave traces of themselves when they shed their skin, their old exoskeleton, or die leaving behind their shells. These elements can be seen as an indication that those taxa have been present in the area. These markers can be very hard to date and accurately identify so should be used as general indicators only. They can be exciting too for citizen scientists to find and can be very educational on the life cycles of some species.

Trapping

In general, trapping wildlife should only be done when necessary, and by experts. Being trapped and handled is stressful for wild animals and handling them can be dangerous. The most appropriate trapping methods for citizen science is of insects; more than that is beyond the scope of this manual. There are a number of methods for trapping insects; the most commonly used method is the pitfall trap. This is an easy and safe method of trapping ground dwelling insects which citizen scientists can easily replicate without guidance.

The following three steps are a brief description of the insect pitfall trapping method:

1. Find a container with steep sides and drill holes into the bottom for drainage.
2. Set the container into the ground so that the rim of it is flush with the surface.
3. Place the traps either along a transect or in specific microhabitats and check them periodically.

Insects mostly die by this method, something that should be explained to citizen scientists as an absolute necessity rather than a common practice in biodiversity monitoring. Pitfall trapping is mainly used to indicate population size.

3.1.3 Unstructured broad scale monitoring

Unstructured monitoring is monitoring that can take place at any time by anyone who wants to be involved. This kind of data collection is the most common in citizen science and is often what people think of when they think of citizen science. Unstructured monitoring is usually used when a project requires a large amount of easy to collect data.

Table 3.3 Examples of citizen science biodiversity monitoring projects that have used unstructured methods of data collection.

Method	Data captured	Resources needed	Citizen science groups	Citation
Invite people to upload their photos of snakes that they have taken in the study areas	Photographs of snakes	Somewhere for the photos to be uploaded to; someone to go through them and add relevant data to a database/map	Anyone	Durso et al 2021
A platform for divers and snorkelers to upload geotagged photos of species and assemblages	Species' presence, including exotic species	Somewhere for the photos to be uploaded to; someone to go through them and add relevant data to a database/map	Divers, snorkelers	Azzuro *et al.*, 2013
Asking people to get in contact if they see a grey squirrel	Species, date, location of sighting, habitat type, condition (i.e., dead, or alive)	Public awareness campaign, infrastructure to take sightings and record them	General public, in particular those who go into forests	Goldstein et al 2014

Unstructured, or lightly structured, monitoring can be easy to participate in as it generally does not require training, a large time commitment, or travelling anywhere and so can easily be integrated into everyday life. Researchers simply create a project, invite people to participate, then collect the data as it comes in. This can create issues of data quality that must be considered carefully when designing a project.[40]

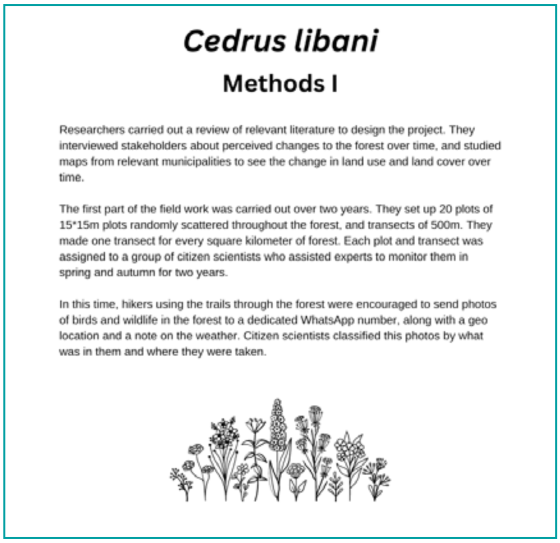


Figure 3.5 Both direct species quantification methods, along transects assigned to given groups, and broad scale unstructured monitoring, with hikers sending their pictures, were used to monitor Cedrus libani.

3.2 Qualitative methods

Qualitative methods are sometimes neglected in biodiversity monitoring as they may be seen as a secondary and less reliable source of information. However, engaging deeply with citizen scientists and inviting the public into the conceptualization and management of biodiversity is a critical concern for the long-term sustainability and success of biodiversity conservation.

Qualitative methods can give information, insights, and direction that researchers perhaps would not otherwise realize were needed. This allows better monitoring of the state of ecosystems, landscapes, and target species, giving a more holistic view of the health of biodiversity and its relationship

40 Kamp et al. 2016.

to society. Participants with local knowledge or specific knowledge sources like family histories and photo libraries can help to provide baseline and historical data to frame and guide research in socio-ecological landscapes.

3.2.1 Discussion-based qualitative methods

Having an iterative research design with multiple opportunities for stakeholders to provide input creates avenues to assess the project, both in approach and outcomes. Critically, it also creates opportunities for citizen scientists to ask questions of researchers, creating a dialogue.

Cedrus libani

Methods II

At the end of the second year they used the preliminary data to start creating a new management plan for the forest.

To help with this, they held some workshops so people could be part of creating the new plan. They carried out a one day workshop with other stakeholders such as women, communities of place, and people who work in eco-tourism around North Forest. They made sure that the workshop included coffee and cake breaks to make it as comfortable and social as possible.

The citizen scientists also researched national and international priorities for biodiversity conservation and management that would be relevant to North Forest.

Figure 3.6 In addition to quantitative methods, discussions and participatory research were implemented as part of the second phase of the Cedrus libani project.

When qualitative methods are used well it can increase trust in science generally and the organization carrying out the research specifically, as well as any policy and management outcomes of the research. Throughout this process stakeholders can see that they have been heard, and that what they have said has been translated into outcomes.

The careful application of qualitative methods in biodiversity monitoring and conservation is a practice of democratic rural governance; a conceptual lens for theorizing citizen science as an innovative way to enhance legitimacy of both process and outcome.[41] This is critical to creating the genuine and generative relationships between actors necessary for a respectful and sustained culture of collective action for the environment.

Some examples of discussion-based qualitative data methods and their possible use can be seen in Table 3.4. When using these methods, be clear whether the citizen scientists are the ones being engaged with, or are the ones carrying out the research, or if a mix of both would be best.

41 Alarcon Ferrari et al. 2021.
42 Karam et al. 2021.
43 Yacoub 2018.
44 Giannatos et al. 2005.
45 Bradley 2011.

Table 3.4 Examples of qualitative methods and when to use them.

Method	Use in biodiversity monitoring	Citizen science groups	Where to use
Workshops	Participants share and create knowledge, give feedback on the project, create submissions, and represent their citizen science groups. Workshops can be resource intensive to carry out and are best used when engaging citizen scientists vertically.	Stakeholders who hold relevant biodiversity knowledge or unique/specific knowledge, such as pastoralists, women, and communities of place.	When in depth knowledge/agreement about an issue needs to be shared/created. Most suitable to issues affecting groups. For example, Karam et al (2021) used group discussions to understand how a new biosphere reserve was impacting communities in Lebanon.[42] Workshops can also be used to direct a project's focus by engaging early with citizen scientists. See Appendix 3 for an example of this.
Interviews - structured, semi-structured, and unstructured	Participants share knowledge, give feedback on the project, and represent themselves. Group interviews can be used to get an overall understanding of that group's views or experience, whereas in individual interviews people may be more willing to give sensitive information. Can be used to engage people both vertically and horizontally. Creates opportunities for creating dialogue between researchers and participants.	Stakeholders who hold relevant biodiversity knowledge or unique/specific knowledge, such as pastoralists, women, and communities of place.	Interviews are a powerful tool when researchers are aiming to find out personal insights, knowledge, skills, and so on from informants. How these are undertaken (e.g., in the field, over tea, recorded or not) will depend greatly on context. For example, Yacoub (2018) interviewed Bedouin and non-Bedouin individuals on the changing wild plant use of Bedouin pastoralists using both closed and open-ended questions. Due to the Bedouins' dislike of recordings, Yacoub did not record the interviews or take any notes during them.[43]
Questionnaires	Can collect a large amount of information quickly and easily. Little to no opportunity for creating dialogue between researchers and participants.	These can be targeted, for example to any protected area managers working on a site, or general, for example to any farmer who wants to participate.	Questionnaires can be used to direct further research, inform possible presence areas, and can create understanding of people's opinions/views on biodiversity. For example, Giannatos et al (2005) sent questionnaires to forestry workers, hunters, and environmental activists on the possible presence of golden jackals (*Canis aureus*) to direct their fieldwork.[44]
Walking on the land	Biodiversity monitoring can be done through walking through the project sites with citizen scientists who hold specialized knowledge about them. This traditional/local ecological knowledge can give information about species' habitat preference, habitat quality, land and resource use, and any changes perceived over time.	People who hold knowledge about a place, such as pastoralists, long-time locals of an area, farmers, and bird watchers.	Walking through the landscape can generate knowledge, insights, and relationships that may be novel and beyond what a project knew it was looking for. In this way, it can be very valuable at the start of a project to direct research. Bradley (2011) used this method in a farming landscape in Australia and argue that it is a rich way to engage with socio-ecological landscapes.[45]

3.2.2 Participatory research

People, both as unique individuals and as integral parts of communities, are at the heart of participatory monitoring. It is possible for an assigned group of experts to decide on the type of data to be gathered, how to arrange it, and how it will be utilized in the end, or for the citizen scientists and stakeholders to decide these things collectively through deliberation.

A project shouldn't be harshly judged based on the level of participatory research as full power given to citizen scientists is not always the goal. It is probably most advantageous to strive to advance to the highest level that is appropriate for the particular project, in terms of engagement and involvement of stakeholders[46].

The amount of citizen science participation is not the only indicator of the success of a project. Goal fulfillment should also be considered like biodiversity conservation, spread of knowledge and education, number of actions taken, and so on.

3.2.3 FPIC

When engaging with citizen scientists as stakeholders with the goal of extracting or co-creating knowledge free, prior, and informed consent (FPIC) is critical.

- **Free:** Citizen scientists willingly give their knowledge and insight as participants. They are not coerced, manipulated, or otherwise pressured into engaging with a project.
- **Prior:** Stakeholders give their consent to be involved in a project before it starts and where appropriate are given some opportunity to engage with the creation of the project. In some cases, the desirability of some stakeholders' participation will only become apparent later in the project. It is important to receive their consent to provide qualitative data as soon as possible.
- **Informed:** Participants know what qualitative data is being collected, how it is being stored and analyzed, what it is being used for, and what they stand to gain from being involved in a project.

> *I give my free, prior, and informed consent to take part in this research.*
> *Free: I have not been coerced, intimidated, or manipulated into becoming involved.*
> *Prior: I have given this consent at the start of my engagement with the project.*
> *Informed: I understand the goals and aims of this research project, and how I will be involved in it. I understand how my contributions will be used, and how my contributions will be acknowledged. I understand the possible benefits and risks of being involved, and how these might be shared.*
> *Consent: I have agreed to be part of this project. I can withdraw this agreement at any time, for any reason.*

Figure 3.7 An example of text that a participating citizen science could agree to.

Gaining FPIC from citizen scientists, either verbally or in writing, is advised in situations where the project will collect and use their knowledge, or data about them. For example:

- If engaging with children or young people, their parents will be reassured to know that they can freely stop participating in the research at any time.
- Farmers may be more willing to give their knowledge about biodiversity in their area if they have understood that they are consenting for it to be used for a specific purpose, and not to judge their farming practices.
- People may be more likely to give over sensitive information or opinions on the management of biodiversity if they know that their interview will be stored and analyzed anonymously.

3.3 Threats monitoring

Examining threats is a consequential step of ecosystem monitoring. Knowing what is happening to whom, to which compartment of the environment, where and when offers a structured procedure which can help make decisions about risks produced by particular activities.

There are four steps in the process of threats monitoring:
1. Evaluating the potential outcomes following exposure at a specific level (hazard identification/characterization),
2. Evaluating the exposure (probability that a hazard will occur),
3. Describing the risk by combining the hazard and exposure, and
4. Evaluating uncertainties.

Threat monitoring approaches determine the levels of harm to organisms, populations and, ultimately, species exposed to certain threats, as well as their ecological functioning and therefore the structure of the community[47].
For example, Mitri et al (2019) examined, in three administrative districts in the Qaraoun catchment in Lebanon, multiple indicators which served as proxies to land degradation and loss of ecosystem services. This threat monitoring approach was a valuable tool to effectively prioritize and implement sustainable land management practices on degraded lands in the decision-making process.[48]

The main threats to biodiversity in Lebanon are[49]:
- Habitat loss and fragmentation,
- Hunting and overfishing,
- Unsustainable tree cutting and harvesting of medicinal plants,
- Uncontrolled grazing,
- Pollution,
- Non-native invasive species,
- Replacement of local animals and plants by new introduced varieties for agricultural use,
- Climate change,
- Inadequate and insufficient data.

46 Haklay et al. 2018.
47 Fossi et al. 2018.
48 Mitri et al. 2019.
49 Khoury et al. 2016.

IV. ANALYSIS OF DATA

Data analysis in citizen science can take many forms and will be informed by a project's ecological and social aims, as well as what outputs are required.

In any citizen science project, three key things must be considered:

1. Whether the data is structured or unstructured;
2. What the data can show, for example species abundance, richness, behavior, population density or population size - these are all different questions that require different analysis; and
3. What baseline or idea the data is being analyzed against.

The level of involvement of volunteers can vary in this stage of the project and while it is best practice for citizen scientists to be as engaged as possible throughout the whole research process, this stage may require more specialist skills and training.

For example, in a project with the aim of identifying species occurrence, sightings can be used as waypoints to make maps, and include information such as density of sightings. These maps can then be used to communicate and manage the species' presence, a task which may require knowledge of specialist programs or theories.

4.1 Collection and storage of data

Responsibility for data collection and storage needs to be clearly outlined from the beginning of the project.

Collection

Modes of data collection will largely depend on the types of data the project's chosen methods generate. For example, a project based on opportunistic photographs of birds will have different collection modes to one built around discussions about alpine plants had with pastoralists.

Some things to consider include:

- Have the data entry methods been tested?
- Will the data come in on a rolling basis or in lots, and can the collection method cope with this?
- Will the data be collected all at once? For example, in a workshop
- Will there be iterations of data collection, including collecting different kinds of data at different stages in a project?

Storage

Best practice data storage is long term, secure, and searchable. Data needs to be stored in a consistent way and safely backed up; considerations on who needs to access the data and how will help inform storage processes.

Raw quantitative data should be kept so others can use it. It should be cleaned and organized, to create two versions: raw and clean. The clean one can be used for analysis and distributed where appropriate.

The storage methods for qualitative data should be agreed upon ahead of time and outlined in free, prior, and informed consent forms signed by participants. These forms must be kept, along with records of all questionnaires, workshops, and so on. These should be kept in two versions: raw and clean. For example, the original audio recording of an interview and a clean transcription.

4.2 Validating data

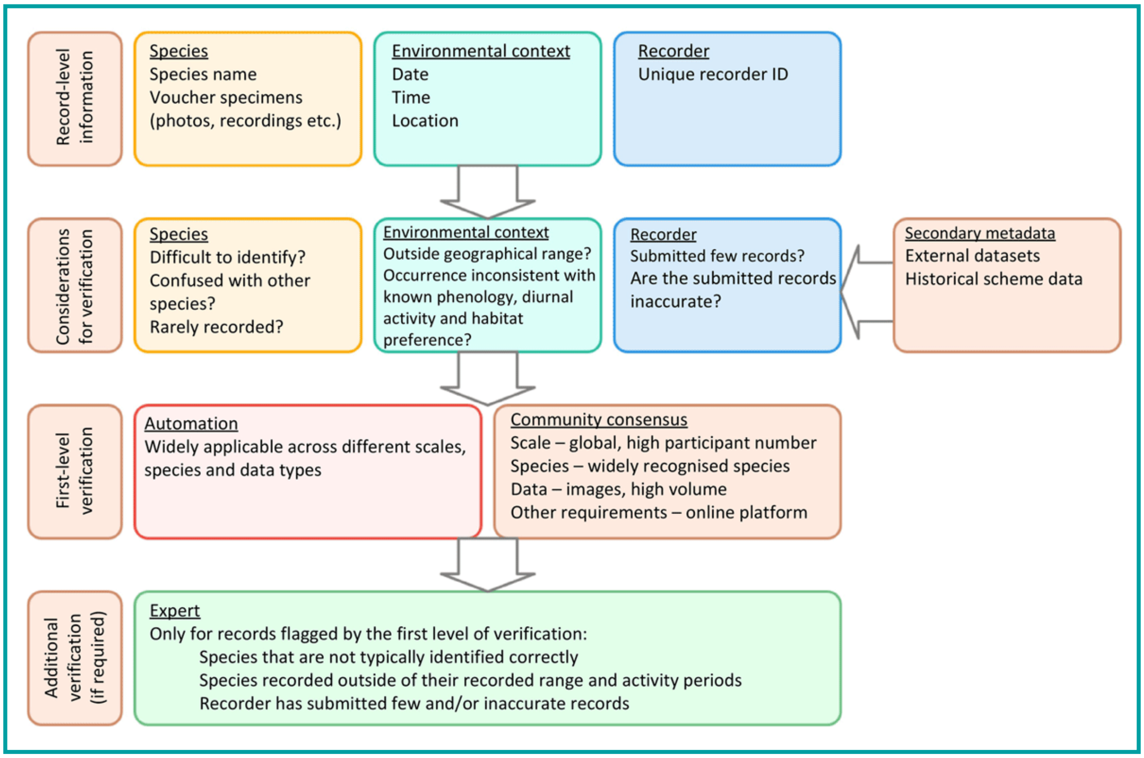
Having transparent and robust systems of data collection, storage, validation, and analysis will give your project more credibility and increase the scientific utility of your work.

Failing to do this could lead to negative outcomes if the data is used in management decisions, could damage an organization or group's reputation, and can lead to citizen scientists feeling like their time and efforts were wasted. This is particularly true if stakeholders' livelihoods are impacted, for example fishers or pastoralists.

For example, Kamp et al. (2016) found that, in unstructured citizen science data of birds in Denmark, some common species had stable populations, or were growing.[50] However, higher quality structured citizen science data showed that many of these species were declining.

Ongoing data validation also supports projects to collect the right amount of data to address project goals: too little will not adequately address project aims while too much creates unnecessary work. Figure 4.1 lays out how a data validation system can be incorporated into overall research design.

Figure 4.1 Scheme showing how validation can be structured, what and when to consider.[51]



4.3 Quantitative data analysis

The best analysis to carry out will depend on project aims and the data that has been collected. There are many ways to analyze quantitative data, from simple tests to tailor-made methods, and various ways of analyzing quantitative data through non-statistical means. For example:

- Simple statistical tests,
- Technical analysis.
- Compare data to base or ideal,
- Maps with data points.

When analysis is carried out, whether at the end of a project or on an ongoing basis as data comes in, will depend on factors like capacity, data type, and collection methods.

While designing data analysis, consider which of three main groups - or a mix - can carry it out:

- Researchers who are leading the project;
- Citizen scientists;
- External professionals.

This should be decided as early as possible as this part of the project may need more specialized skills or training.

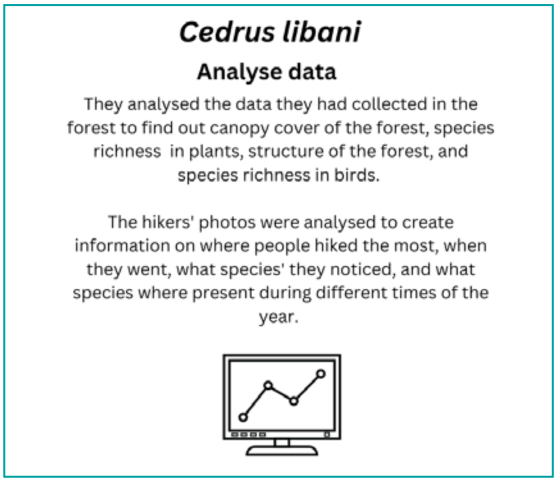


Figure 4.2 Example of data analysis in the Cedrus libani project.

4.4 Qualitative data analysis

Analyzing qualitative data needs to be approached with the understanding that there will not necessarily be objective standards or metrics to seek. Interviewing stakeholders about biodiversity on their farms and getting school students to give their feedback on their experiences carrying out biodiversity monitoring is valuable insight and connection to citizen scientists. When engaging with people and communities, the depth and strength of the relationship and the trust between parties is often more important than creating large amounts of data from many participants.

Analyzing what people are saying and how they want to be understood is a delicate process and can be enriched by being carried out iteratively. For example, sending early qualitative results back to citizen scientists allows them to add missing information, draw new conclusions, or correct any miscommunications.

Analyzing data can take many forms and will depend on the type of data generated. For example:

- Making notes of feedback and grouping them by theme, place, stakeholder group;
- Coding and emergent coding of interviews;
- Explore changing perceptions over time and across stakeholder groups;
- Reflections from scientists and citizen scientists in field diaries;
- Plot on a map the reported occurrence of a species.

50 Kamp et al. 2016.
51 Baker et al. 2021.

4.5 Ownership and access of data

Who owns and can access data created in citizen science biodiversity monitoring projects is an important consideration. It can largely depend on the citizen science typology that was chosen at the start of the project, and if there are any data clauses from funding bodies or related organizations like universities. Likewise, the free, informed, and prior consent agreements stakeholders signed can outline their access to the data they created or helped create, such as transcripts of group discussions or data on birds on their farm that they helped collect.

These issues should be clearly agreed upon before a project commences.

4.6 Common issues

All projects will suffer setbacks and issues at some stage and being aware of these from the start will allow mitigating steps to be built into research design. Some common issues with data analysis in citizen science projects include:

- Data analysis is hard, and specific skills are often needed to undertake data management and analysis;
- Sometimes data collected by citizen scientists may not be of a high quality and may need rigorous cleaning and validation to be useable;
- Disagreements about how to store, manage, analyze and interpret data may arise during the project;
- There may not be the infrastructure and culture to store data safely, securely, and consistently.

Bird Monitoring - Chady Saad

V. MONITORING, EVALUATION, AND LEARNING

Biodiversity monitoring projects should themselves be monitored!

Monitoring a project's performance at all stages of the life cycle, evaluating different aspects in line with project aims and stakeholder expectations, and learning from the results of this is a critical process to constantly improve citizen science.

It can be tempting to skip this step with the view that it creates unnecessary work, but it is important to make sure the project is scientifically and environmentally useful. Critically, working with citizen scientists and stakeholders aims to build trust, increase scientific literacy, foster connectedness to the environment, and build support for biodiversity conservation. To make projects as successful as possible, monitoring, evaluation, and learning (MEAL) in citizen science projects is an important tool for achieving social, scientific, and environmental outcomes.[52]

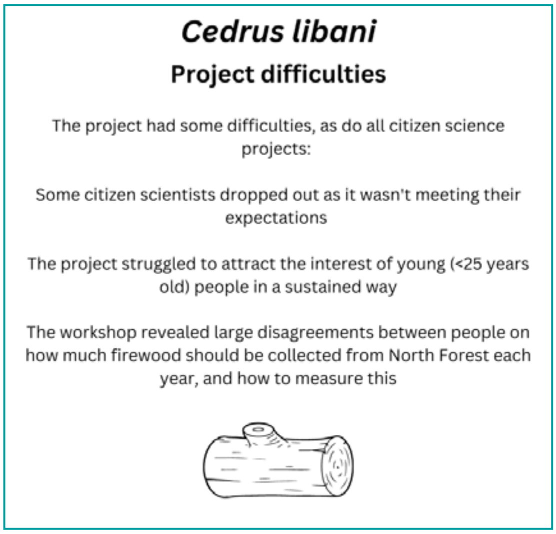


Figure 5.1 The Cedrus libani project had its struggles, and it was important to monitor the factors decreasing engagement and quality of results.

5.1 How to approach monitoring, evaluation, and learning

A four-stage approach applied throughout the whole project can integrate MEAL easily, lowering the burden on project leads if left until the end. Figure 5.2 outlines this approach and outlines how to consider both the process and results of the project.

52 Davis et al. 2022.

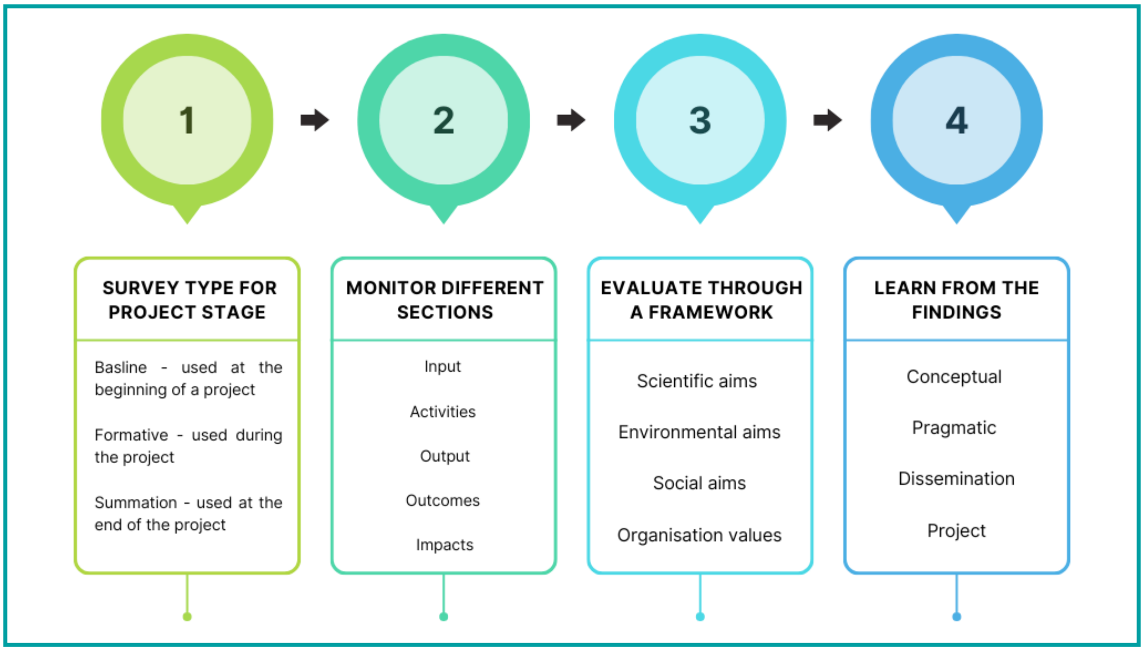


Figure 5.2 A four-stage approach to monitoring, evaluation, and learning can make it easier to approach conceptually. Each stage can be adapted to project needs.

Survey type for project stage

There are different types of surveys to undertake depending on the project stage that is being evaluated.

- **Baseline:** before the start of the project. This sets a base from which to measure change.
- **Formative:** this is done iteratively throughout the project and informs changes that will improve a project's effectiveness. It is process-based, identifies strengths and weaknesses, improves process while project in progress, gives ongoing quality assurance in continuous feedback loops.
- **Summative:** this can occur at the end of a project or during a long pause (for example, over winter). It is outcome-based and assesses the overall project against initial project aims. It assesses impacts and benefits and can be used for showing impact to external stakeholders.

Monitoring different sections of the project

The "logic" model of evaluation is widely used to assess the success of a project and can be applied here. This model is an indication as not every section will be relevant to each survey type, so it should be adapted to suit project needs.

- **Input:** resources available for projects and activities,
- **Activities:** actions planned and implemented to achieve desired outputs,
- **Outputs:** products or services resulting from activities,
- **Outcomes:** effects of outputs on target group,
- **Impact:** long-term changes on a societal or policy level.

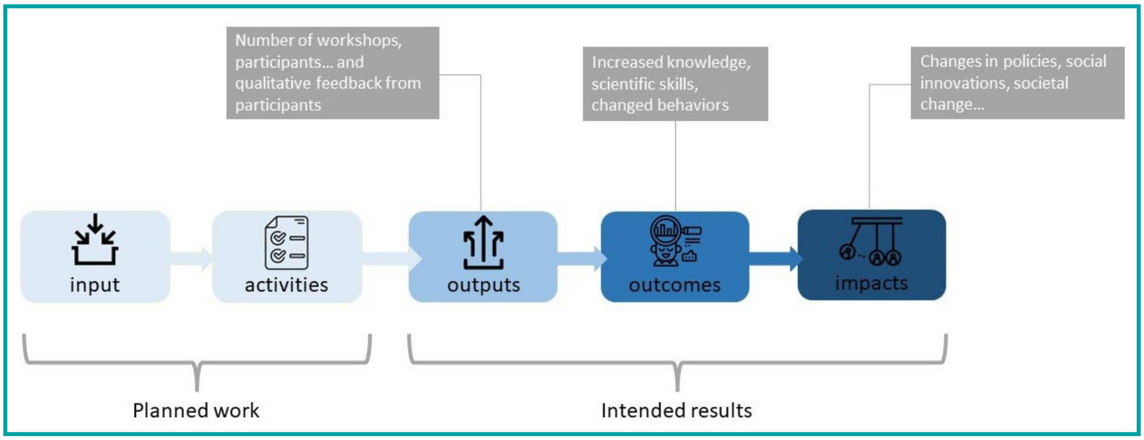


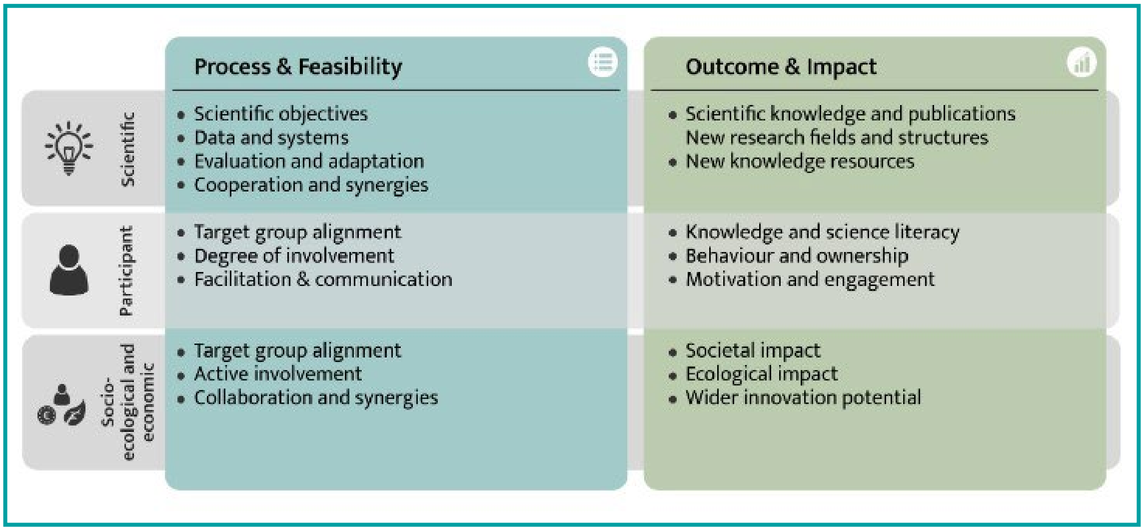
Figure 5.3 Different sections of the project that can be monitored to gain an understanding of the success of both project process and project results.

Difficulties of causal attributions may arise in linking certain changes directly and inclusively to the project. However, evaluation remains essential as it is important that alongside the scientific quality of data, projects are delivering quality social outcomes.

Evaluate through a framework

Citizen science projects have social, environmental, and scientific aims. These aims must all be monitored in order to assess the project's overall success.

Figure 5.4 Citizen science project evaluation framework.



This framework can be tailored and contextualized based on the spatial, temporal, and socio-economic demands of the project. Different criteria may receive different weightings depending on project goals and priorities.[53]

The next section will briefly outline frameworks for evaluating these three aims, as well as how to consider any relevant organizational values.

Scientific aims

The scientific outcomes of citizen science projects must be able to comprehensively address the research questions in question.

Kamp et al (2016) found that unstructured citizen science data collected on bird species in Denmark over 28 years were found to show steady or increasing populations of some species, while in fact they were declining.

The lack of precision in this method when aggregated across time shows the importance of ongoing evaluation of projects' scientific processes and outcomes.

It also shows the need to evaluate them in context of other research to gain insight on how the project relates to relevant literature.

Figure 5.5 Careful and thorough monitoring of scientific outcomes is critical to robust citizen science.

These outcomes should not only address project aims through clear and robust science, but also be able to contribute to global knowledge pools. Collaboration with citizens can also lead to the development of new scientific methods, the identification of new leading questions for further research, or the establishment of new collaborations amongst actors. All these aspects can be considered when evaluating the outcomes for individual scientists and their institutions.

Science communication is often an aim of citizen science projects, and scientists can benefit from knowledge increases related to

- engaging the public in research;
- communicating research process and results to citizens; and
- jointly analyzing scientific findings.

There are several ways to increase the quality of scientific output of citizen science projects, and for ongoing project evaluation to make sure that this is the case.[54] The framework for this should be agreed upon at the start of the project.

Environmental aims

Monitoring projects for biodiversity conservation should create helpful data and insights for the sustainable management of the environment.

The environmental aims of citizen science projects may be anything from creating a new forest management policy to gathering information on one particular species of butterflies, but they should all in some way contribute to biodiversity conservation.

Social aims

Robust evaluation considers the wider social, economic, and political context in which projects are embedded.

These levels are difficult to evaluate due to their size and complexity, and the longer time scales in which they may operate. Evaluation should at least consider these wider issues which are especially relevant for citizen science projects that are initiated by local communities, originating outside of academia or other more formal settings. The question of how a project interacts with principles of democratic rural governance is an example of a guiding framework in this context.

Citizen science is a way for the public to become more informed about and connected with the environment and to understand threatening processes and how to address them. Being involved in biodiversity monitoring projects will equip citizen scientists with the skills and understanding to help with this work:[55]

- Knowledge of the subject under investigation. For example, in a project related to climate change, participants can gain new knowledge on the origins of climate change, its consequences, and how to fight against it.
- Scientific inquiry skills and knowledge on the research process: participants can for instance learn how to set up a scientific inquiry process, how to collect data, guarantee the data quality, share scientific results.

Assessing the relationship between biodiversity conservation and individual/communities is a critical factor in sustainable outcomes for conservation.

The Jabal Moussa Biosphere in Lebanon was found to have been set up with very little consultation of stakeholders, creating ill feelings towards it in local communities. Pastoralists and others have been disallowed from using key parts of the area, and communities say it has impeded local economic growth.

A citizen science approach to biodiversity conservation should see citizen scientists as not just data collectors, but as valuable informants on how to best undertake conservation through vertical integration.

Evaluating a project's social impact is a key part of this.

Figure 5.6 Karam et al (2021) found that Lebanon's Jabal Moussa Biosphere Reserve has created some issues for local communities. Citizen science can be used as a rich and powerful tool to create more socially sustainable conservation outcomes.

In addition to knowledge gains, project evaluation can consider more transformative effects of learning:

- changing attitudes towards themes relevant to the project, such as conservation,
- active promotion of these in one's social network,
- changing behaviors in line with these changing attitudes.

Critically, involvement in a citizen science project should increase self-efficacy perceptions, indicating that a person thinks they are capable of actively contributing to science or protecting the environment.

Individuals' learning and behavior change can cascade and affect whole communities and regions, as individual citizens might diffuse their knowledge, and drive civic action and policy formation.

Organizational values

If the project is being led by an organization, or if one of the main project partners is one, it could be helpful to consider whether those values are being acted out in the project. For example, an organization leading a project may be committed to gender mainstreaming and institutional transparency. Asking whether and how these things have been built into the project may prove insightful.

53 Kieslinger et al. 2017.
54 Freitag et al. 2016.
55 Phillips et al. 2018.

5.2 Evaluation application typology

The insights gained through project evaluation can be used in a number of ways. Four typologies of use are:[56]

- Conceptual use,
- Pragmatic/instrumental use,
- Dissemination/symbolic use,
- Project use.

These typologies contribute differently to research, and all can be applied in a citizen science project as shown below.

Table 5.1 Typologies of evaluation for citizen science projects.[57]

Use typology	Definition	*Cedarus libani* example
Conceptual use	Indirect use of systematically generated knowledge that opens up new ways of thinking and understanding, or that generates new attitudes or changes existing ones	Citizen scientists gain more understanding of the complexity of the forest ecosystem and threats facing it
Pragmatic/instrumental	Direct use of systematically generated knowledge (for example, evaluations) to act or make decisions	Local municipalities work to create a tree planting program after evaluation shows lack of natural recruitment
Dissemination/symbolic	Use of evaluations to support an already preconceived position in order to legitimize, justify or convince others of their position	An environmental NGO uses the results of the project to show the need for greater protection for forests and their species in Lebanon
Project	Use that occurs due to the process and not due to the results of an evaluation	A project leader develops new skills in working with citizen scientists through the project

5.3 Tools and methods for project evaluation

The tools and methods used for evaluation in citizen science follow standard social science practice, ranging from questionnaires, interviews, focus groups, participant observations, and documented self-reflections from the involved scientists and volunteers.[58] These range from structured or semi-structured sets of questions to very open and exploratory formats.

Narratives and other forms of storytelling can also be used in evaluation. For example, combining narrative interviews with instruments like photo essays, research diaries, and storyboards reveals the context-based, tacit, and intangible factors involved in personal outcomes.[59]

5.4 Main challenges

Evaluation, monitoring, and learning is a critical part of citizen science and should be made an ongoing priority in any project. It can be faced with several issues, and researchers should be aware of these when designing evaluation processes.

- **timing and budgeting:** projects often do not plan enough time and resources for evaluation; projects should not underestimate the resources needed,
- **choosing appropriate tools for data collection and analysis:** there are many ways of collecting and analyzing data and often a mix of qualitative and quantitative data is a good choice to understand the breadth and depth of citizen science activities,
- **showing impact, especially social impact, during limited project periods:** effects often show up only later, sometimes after the projects have already finished,
- **engaging all relevant stakeholders in the process:** some stakeholders may be easy to forget (or ignore) as they might be difficult to engage or, they may not be in favor of a certain intervention. Successful project implementation and an effective evaluation process necessitate considering different stakeholder views. Creating ownership across the stakeholders may also be a challenge but may be rewarding later in the process.

56 Davis et al. 2022.
57 Bundi and Pattyn 2022; Davis et al. 2022.
58 Peter et al. 2021.
59 Constant and Roberts 2017.

VI. CONCLUSIONS

To better protect the environment, there is an urgent need to strengthen global environmental monitoring. To this end, it is essential to collect a diverse set of information so that the management of land, resources and processes can be made in order to promote biodiversity. The best social and environmental outcomes result from meaningfully including the public in biodiversity monitoring at all levels as problems with legitimacy can arise in centralized, expert-led research.

By offering a novel route that democratizes environmental monitoring and socio-ecological governance and expands the role of citizen scientists in data creation and usage, citizen science can address these legitimacy challenges.

In the Lebanese context, the citizen science approach of biodiversity monitoring is an especially pertinent approach as it respects and continues people's traditions of upholding and protecting their heritage through sustainable practices agreed upon thanks to data collected and shared by the people themselves.

The first steps of a successful citizen science project for biodiversity monitoring are to define the three following steppingstones:

1. The main issues and objectives: what are the ongoing biodiversity issues that the project aims to alleviate with its outcomes?

2. The degree to which citizen scientists are involved in the decision-making process: what is the best balance between participation of citizens and input of professional researchers and technicians?

3. The key stakeholders of the project: who are the groups able to provide the best information for the success of the project, and who are the citizens most affected by any biodiversity conservation decisions and legislation resulting from this?

The data for biodiversity monitoring is then collected depending on the chosen methods and collectors (quantitative data, qualitative data, threat monitoring), stored and analyzed appropriately to create outputs and bring about impacts.
Evaluation followed by adaptation is a very important step of citizen science-led projects. This evaluation does not only consider outputs like research papers, created maps or legislation for example, but it also considers the societal impacts of the work. Increased knowledge, curiosity, and desire for further participation in citizen scientists are very important throughout and at the end of a project.

This manual will be very useful for the management of Himas in Lebanon, as they are by design community-based protected areas. It will hopefully pave the path for the creation of additional Hima sites and potentially other protected and natural areas, and the implementation of more in-depth participation of stakeholders in decision-making.

This manual is infinitely flexible and will only become more pertinent as it changes in time to be increasingly on par with stakeholder needs and desires for biodiversity monitoring and conservation.

VII. FURTHER READING

SPNL Special Issue. (2021). Society for the Protection of Nature Lebanon.
This report describes the evolution of the Hima in modern times in Lebanon. It is a great starting point for understanding the different ecosystems in Lebanon, and the relationships between nature and society.

Jawhary, D., Khaddage, V., & Rady, Z. (2016). *Homat Al Hima Guideline Manual* [Guideline Manual]. Society for the Protection of Nature Lebanon.
This report outlines how citizen science is already being practised in Lebanon through the engagement of young people in the management of Himas.

Tweddle, J. C., Robinson, L., Pocock, M., & Roy, H. (2012). *Guide to citizen science: Developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK*.
This report is a wonderful introduction to citizen science and how to use it in a general context.

Khoury, R., Atiyah, P., Nader, M., Alhaj, D., & Ismail, D. (2021). *Mainstreaming biodiversity conservation in Lebanon*. Amman, Jordan IUCN ROWA, and Beirut, Lebanon Lebanese Ministry of the Environment.
This report is focused on marine and coastal environments and outlines many key concepts for biodiversity monitoring in the Lebanese context.

Citizen Science: Theory and Practice. (n.d.). Retrieved April 23, 2023, from http://theoryandpractice.citizenscience-association.org/
This website is an invaluable resource for anyone wishing to learn more about citizen science. It describes itself thus: *Citizen Science: Theory and Practice is an open-access, peer-reviewed journal published by Ubiquity Press on behalf of the Citizen Science Association. The journal focuses on advancing the global field of citizen science by providing a venue for citizen science researchers and practitioners to share best practices in conceiving, developing, implementing, evaluating, and sustaining projects that facilitate public participation in scientific endeavors in any discipline.*

Hill, D., Fasham, M., Tucker, G., Shewry, M., & Shaw, P. (Eds.). (2005). *Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring*. Cambridge University Press.
This book exhaustively outlines field methods for biodiversity monitoring. It is simple, comprehensive, and invaluable.

VIII. REFERENCES

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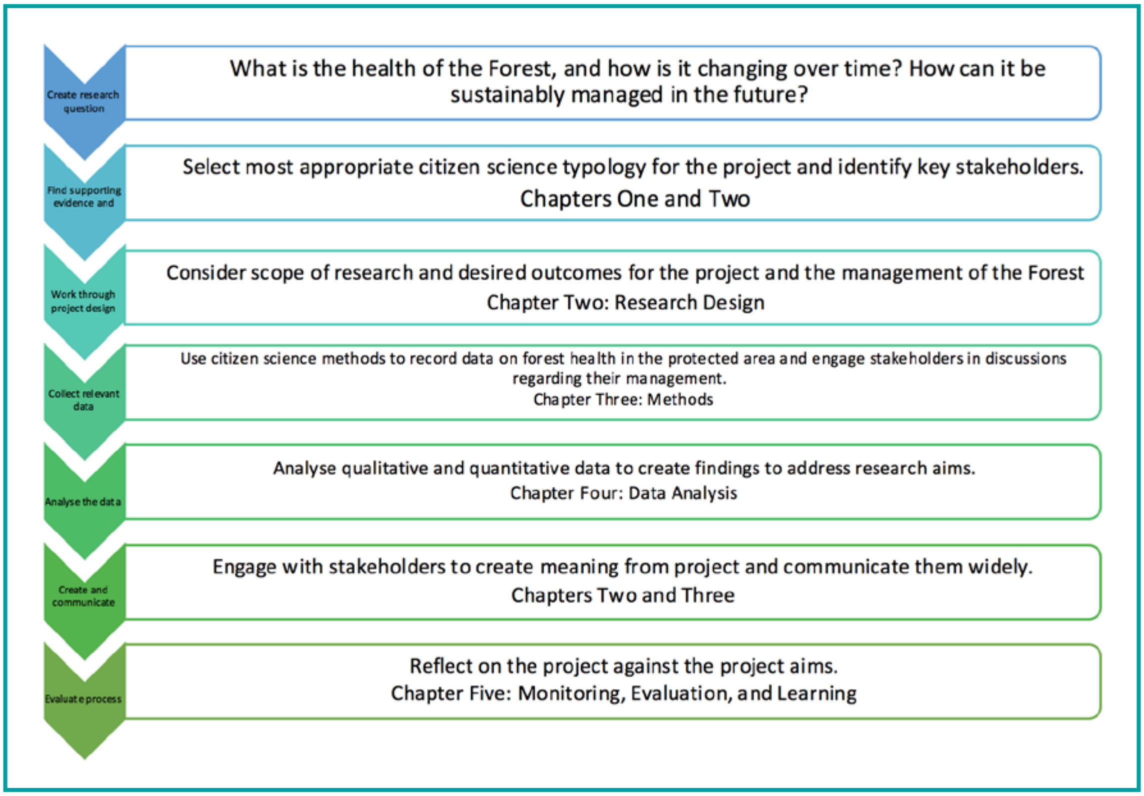
IX. APPENDICES

Appendix 1: Example of a citizen science biodiversity monitoring project

To provide a clear example of each step outlined in the Manual, an example of a fictional citizen science project, monitoring Lebanese cedars (*Cedrus libani*) in North Forest, has been provided.



Create research question	***Cedrus libani*** **Identify issue** Some members of the village near North Forest think that the health of the cedar forest was declining. They want to understand what is happening, and how to protect the forest. 
Select citizen science typology	***Cedrus libani*** **Select citizen science typology** The Protected Area manager connected the villagers with a group of researchers. They agree to work together in a participatory research model as it will allow the members of the village to have input at every stage of the research. 
Identify key stakeholders and place research in context	***Cedrus libani*** **Identify key stakeholders** The project partners identify, as well as themselves, some pastoralists, another small village, and a hiking group who frequents the forest. The communities of place are motivated by economic and ecosystem services provided by the forest; the pastoralists by protecting their livelihood; and the hikers by protecting nature. 
Consider scope and desired outcomes; work through project design	***Cedrus libani*** **Create project based on objectives** They create scientific, social, and citizen science objectives: Gain insight on the health of the forest over time Engage citizen scientists in data collection Engage stakeholders in creating a management plan Create a sustainable management plan for the future of the forest 
Use citizen science methods to collect relevant data	***Cedrus libani*** **Methods I** Researchers carried out a review of relevant literature to design the project. They interviewed stakeholders about perceived changes to the forest over time, and studied maps from relevant municipalities to see the change in land use and land cover over time. The first part of the field work was carried out over two years. They set up 20 plots of 15*15m plots randomly scattered throughout the forest, and transects of 500m. They made one transect for every square kilometer of forest. Each plot and transect was assigned to a group of citizen scientists who assisted experts to monitor them in spring and autumn for two years. In this time, hikers using the trails through the forest were encouraged to send photos of birds and wildlife in the forest to a dedicated WhatsApp number, along with a geo location and a note on the weather. Citizen scientists classified this photos by what was in them and where they were taken. 

	Cedrus libani **Methods II** At the end of the second year they used the preliminary data to start creating a new management plan for the forest. To help with this, they held some workshops so people could be part of creating the new plan. They carried out a one day workshop with other stakeholders such as women, communities of place, and people who work in eco-tourism around North Forest. They made sure that the workshop included coffee and cake breaks to make it as comfortable and social as possible. The citizen scientists also researched national and international priorities for biodiversity conservation and management that would be relevant to North Forest. 
Analyse qualitative and quantitative data to create findings to address research aims	***Cedrus libani*** **Analyse data** They analysed the data they had collected in the forest to find out canopy cover of the forest, species richness in plants, structure of the forest, and species richness in birds. The hikers' photos were analysed to create information on where people hiked the most, when they went, what species' they noticed, and what species where present during different times of the year. 
Engage with stakeholders to create meaning from project and communicate them widely	***Cedrus libani*** **Create and communicate outputs** Citizen science projects have three kinds of aims, and outputs need to address them all: scientific environmental social **Gain insight on the health of the forest over time** A formal report and/or publication Database on species and their distribution A map of habitat types in the forest **Engage citizen scientists in data collection** Social media and email updates A workshop in the second year to discuss the project and gain feedback on methods **Engage stakeholders in creating a management plan** A workshop in year four to inform forest management plan **Create a sustainable management plan for the future of the forest** An ongoing management plan for the sustainable use of the forest
Reflect on the project against the project aims	***Cedrus libani*** **Project difficulties** The project had some difficulties, as do all citizen science projects: Some citizen scientists dropped out as it wasn't meeting their expectations The project struggled to attract the interest of young (<25 years old) people in a sustained way The workshop revealed large disagreements between people on how much firewood should be collected from North Forest each year, and how to measure this  ***Cedrus libani*** **Next steps** The project partners considered the social, environmental, and scientific needs of the project as well as the capacity to do more research. They decide to carry out a smaller ongoing monitoring program in the forest. They also decided to evaluate the management plan for the forest every two years through a workshop.

Appendix 2: Example of data collection sheets in Hima Ras el Maten

Bird Surveys

General Information

Date		Weather conditions	*...rainy, windy, sunny, cloudy*
Name		Temperature	
Time started		Wind speed	
Time finished		Site and point name	

Priority Bird List

Species	Number	Comment
Barn swallow		
Black-winged stilt		
Chukar partridge		
Common cormorant		
Common crane		
Common kingfisher		
Common sandpiper		
Common swift		
Eastern imperial eagle		
Egyptian vulture		
Eurasian stone curlew		
Eurasian wryneck		
European bee-eater		
European goldfinch		
Greater spotted eagle		
Green sandpiper		
Hooded crow		
House sparrow		
Little egret		
Palestine sunbird		
Purple heron		
Rock dove		
Rock sparrow		
Ruff		
Somber tit		
Syrian serin		
Syrian woodpecker		

Turtle dove		
White stork		
White wagtail		

Other Birds List

Species	Number	Comment

Other Fauna List

Species	Number	Comment

Bird Diversity Questionnaire for Hunters

General Information

Name		Weather conditions	*rainy, windy, sunny, cloudy...*
Date		Site name	
Time		Point name	

Contents of Bags

Note down the number of each of the following bird species that you have caught today:

Bag of water birds

- [ ] Mallard
- [ ] Teal
- [ ] Garganey

Other birds

- [ ] Quail
- [ ] Eurasian Woodcock
- [ ] Calandra Lark
- [ ] Fieldfare
- [ ] Chaffinch

Bag of pigeons

- [ ] Rock Dove
- [ ] Woodpigeon

Bag of thrushes

- [ ] Mistle Thrush
- [ ] Song Thrush

Other Bird Species

Did you see and/or any other bird species that you recognize? [ ] No [ ] Yes

If you answered Yes, please fill out the following:

Species	Number	Comment

Flora Surveys

General Information

Date		Weather conditions	*...rainy, windy, sunny, cloudy*
Name		Temperature	
Time started		Wind speed	
Time finished		Humidity	
Site and point name		Signs of hunting	*yes/no*
Quadrant name		Signs of quarrying	*yes/no*

Canopy Characteristics

Canopy cover	
# trees <5m	
# trees 5-10m	
# trees 10-20m	
# trees 20-30m	
# trees >30m	

Canopy scope	
Canopy Openness	*% of sky covered by trees when looking up*
Tree species	
Dominant species	

Fire Risk Factors

Distance to roads	
Distance to urban settlements	
Distance to agricultural land	

% of moss, lichens, ferns	
% of dead woody material	
Moisture of forest litter	*wet/moist/dry*

Grazing Pressure

Accessibility	*yes/no*
Livestock dung piles	*yes/no*

% of vegetation ground cover	
% of weed species	

Herbivore and Human Disturbance

Impact	Tree species/mammal species/comment/observation
Bark stripping and stem breakage	*disturbance + tree species + number of affected trees*
Ground disturbance	*note down tracks, scrapes, depressions in mud or water...*
Herbivore signs	*note down wool, hair, fecal pellets, eaten cones...*

Diseases and Parasites

Disease/Parasite	Plant species	Plant part	Number of affected individuals

Priority Flora Species List

Species	Number	Comment
Abies cilicica		
Anemone coronaria phoenicea		
Arbutus andrachne		
Arum hygrophilum		
Cedrus libani		
Convolvulus arvenis		
Cousinia libanotica		
Crithmum maritimum		
Crocus graveolens		
Cyclamen persicum		
Daucus carota maximus		
Ficus carica		
Fraxinus angustifolia syriaca		
Iris sofarana		
Micromeria libanotica		
Olea europaea (silvestris)		
Orchis romana libanotica		
Origanum ehrenbergii		
Origanum syriacum		
Otanthus maritimus		
Pinus halepensis		
Prunus agrestis		
Quercus calliprinos		
Quercus infectoria		
Ranunculus schweinfurthii		
Rhus coriaria		
Romulea bulbocodium		
Romulea nivalis		
Silene makmeliana		
Stachys ehrenbergii		
Veronica syriaca		

Other Species List

Species	Number	Comment

Land Productivity Questionnaire for Pastoralists

Name		Date	
Site and Point name		Time	

Where would you say the most productive land in Ras el Maten is, and why?

Where would you say the least productive land in Ras el Maten is, and why?

What is the average size of your cattle herd?

What animals constitute your cattle herd?

What is the product generated by your herd?

- [ ] Meat
- [ ] Milk
- [ ] Animal skin
- [ ] Wool

What is your grazing system?

☐ Continuous grazing *(no or infrequent pauses from grazing)*

☐ Rotational grazing *(rotations of cattle organized around plant growth)*

☐ Cell grazing *(rotation of cattle inside paddocks)*

Do you combine your pastoral activities with agriculture? ☐ No ☐ Yes

Do you supplement your income from pastoralism with any other job? ☐ No ☐ Yes

If you answered Yes on the last question, feel free to elaborate:

____

____

Which priority species have you been observing this season?

Species	Number	Comment

Land Productivity Questionnaire for Farmers

Name		Date	
Site name		Time	

What is your approximation of the area (in square meters) of the following land categories on your farm?

Total farm area	
Productive land	
Non-productive land	
Hedges	
Grasslands	
Woodlands	
Water courses	

What are the crops produced on your farm?

Crop	**Area covered (m^2)**

Do you use fertilizers? ☐ No ☐ Yes

If you answered Yes, what type of fertilizer do you use?

____

____

Do you use pesticides? ☐ No ☐ Yes

Do you use any alternative methods to control pests and plant diseases? ☐ No ☐ Yes

If you answered Yes, what methods do you use?

____

____

Do you use herbicides?	☐	No	☐	Yes
Do you use any additional practices to manage weeds?	☐	No	☐	Yes

If you answered Yes, what practices do you use?

____

____

Do you practice crop rotation?	☐	No	☐	Yes
Does your farm have any livestock?	☐	No	☐	Yes
Do you use antibiotics for livestock disease management?	☐	No	☐	Yes

What livestock do you have on your farm?

Animal	Number

Which priority species have you been observing this season?

Species	Number	Comment

Riverine Ecosystem Assessments

General Information

Name		Weather conditions	*rainy, windy, sunny, cloudy...*
Date		Site name	
Time		Point name	

Riverine Ecosystems

Water turbidity	*to 5 1*
Presence of fish	*yes/no*
Presence of rubbish	*yes/no*

water flow test

Distance travelled	
Duration of travel	
River width	

Type of rubbish found

☐	Dead animals
☐	Plastic
☐	Metal
☐	Other

Appendix 3:
Example of a workshop to gain citizen science feedback on project design

Workshop with farmers
Stakeholders: Farmers
Desired outcomes:

1. Relationship building
2. Engage citizen scientists with nature and concept of citizen science.
3. Assessing what knowledge already exists.
4. Assessing people's openness/willingness to get involved.
5. Assessing community capacity - includes gaining information on where gaps are that we can fill in terms of capacity.
6. Getting information on what species are present and estimate densities.
7. Get information on species including migration patterns etc.

Structure:

Activity	Purpose	Desired outcomes	Resources needed
Introduce the outline of the day, and what we want to achieve	Let farmers know the aims of the workshop and the project; be open and honest	1	A slideshow, handouts

Introduce citizen science and biodiversity monitoring in the context of how it can help farmers	Let farmers know the aims of the workshop and the project; be open and honest. Stress the importance of biodiversity monitoring	1, 2, 4, 5	A slideshow
Ask citizen scientists where if they have seen target species, and if so when and where; estimate population	Open up conversation, get a general overview of the area	1, 2, 3, 6, 7	Photos of species, area map, markers for drawing on maps
Ask them to reflect on key species - what is the relationship with them, how are they utilized	Create an understanding of the relationship between farmers and nature in the area	1, 2, 3, 6, 7	Note taking materials
Confirm the information and draw out key findings	Make sure information is being understood accurately; acknowledge their contributions	2, 6, 7	Note taking materials
Break for tea and coffee	Re-energize, break it up	1	Tea, coffee, biscuits
Given what they have said, re-state the aims of the project: monitoring for biodiversity to create better outcomes; have local people engaged with protected areas in a way that helps in the management of them. Could be useful to have an example here of where this sort of project has worked before	Re-center on the aims of the project and CS generally. Present involvement in the project as CS as something that will be rewarding both for them as farmers and locals	1, 2, 4, 5	None needed
Visioning exercise: ask citizen scientists what they want to see for their farms, the biodiversity in their areas, and their communities. What they like, what they don't like, what they want to see. Link their responses back to projects aims.	Encourage people to make links between social and environmental health by linking their goals and needs to the project aims.	1, 4, 5	Note taking materials
Methods: Discuss the proposed methods for the project and for feedback	Create buy-in from farmers by engaging them in project design; create more robust methods.	4, 5	Outline of methods, writing materials
Data analysis and communication: Talk about how the data will be used and what it will create in terms of ongoing biodiversity management	Create buy-in from farmers by engaging them in project design	1, 2	Outline of data analysis methods, writing materials
Reflection: strengths, weakness, and the way forward	Invite farmers to give feedback both on the project proposal and the workshop itself. This creates a conversation about the project and makes farmers active contributors to it	1, 2	Slideshow, note taking materials

Appendix 4: Free, prior, and informed consent template

The following text can be used to make sure that people have given their free, prior, and informed consent to having their knowledge, data, stories, and so on used for a monitoring project. It can be a verbal or written agreement.

> *"I give my free, prior, and informed consent to take part in this research.*
> *Free: I have not been coerced, intimidated, or manipulated into becoming involved.*
> *Prior: I have given this consent at the start of my engagement with the project.*
> *Informed: I understand the goals and aims of this research project, and how I will be involved in it. I understand how my contributions will be used, and how my contributions will be acknowledged. I understand the possible benefits and risks of being involved, and how these might be shared.*
> *Consent: I have agreed to be part of this project. I can withdraw this agreement at any time, for any reason."*


Plants monitoring - Husein Zorkot

Mammal Monitoring - Dr. Mounir Abi Said

Credits

Content by | Miriam Gately, Elie El-Haddad, and Yara AlChammas

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Printing | ...

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