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Wearables and droneS fOr CIty Socio-Environmental Observations and Behavioral ChangE

Guidelines on possible financing strategies for CS projects

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List of definitions & abbreviations

Abbreviation	Description
AI	Artificial Intelligence
BERT	Bidirectional Encoder Representations from Transformers
CNN	Convolutional Neural Network
CS	Citizens Science
DLT	Distributed Ledger Technology
GRU	Gated Recurrent Unit
LSTM	Long Short Term Memory
ML	Machine Learning
QB	Queen Bee
RNN	Recurrent Neural Network
RS	Recommendation System
WB	Worker Bees

Executive Summary

This deliverable presents the analysis of financing strategies for supporting SOCIO-BEE's mission to enhance air quality (AQ) monitoring and citizen engagement through citizen science (CS) campaigns. The report evaluates a range of public and private financing mechanisms, offering recommendations for securing sustainable funding while maximizing the project's social and environmental impact.

The document begins with a **theoretical review of existing financing frameworks**, exploring the air quality funding landscape and assessing various financial instruments. These include **Public-Private Partnerships (PPPs)**, **Social Impact Bonds (SIBs)**, **green bonds** and **crowdfunding platforms**. Each mechanism is analysed in terms of its potential to fund air quality initiatives, as well as its alignment with public interest goals. SOCIO-BEE's application of these financing strategies aims to bridge the funding gap by leveraging resources from both the public and private sectors.

A key component of the deliverable is the identification of **collaboration schemes with the public sector**, focusing on PPPs. Different PPP models, including **city-wide** and **school-centric initiatives**, are proposed as effective means to mobilize public and private resources for large-scale air quality monitoring campaigns. The deliverable highlights best practices and case studies from similar PPPs around Europe and beyond, offering insights into the optimal structuring of such partnerships.

The report also outlines various **private financing strategies** that SOCIO-BEE, and other citizen science project (independently whether they focus on air quality) can pursue. Instruments such as **social bonds** and **impact investment funds** are examined for their ability to support citizen science projects.

Performance parameters for measuring the success of financing strategies are detailed, including key performance indicators (KPIs) for assessing financial sustainability and metrics for evaluating the social and environmental impact of these strategies.

In terms of **guidelines for implementing financing strategies**, the document provides practical recommendations for project stakeholders on identifying funding sources, engaging stakeholders, and structuring financing arrangements to align with SOCIO-BEE's objectives. Lastly, the deliverable explores the **transferability** of SOCIO-BEE's financing strategies to other citizen science projects.

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1 Introduction

The SOCIO-BEE consortium endeavours to address a critical aspect of project sustainability: securing the necessary economic and financial support to ensure the continued operation and effectiveness of the SOCIO-BEE project. This task acknowledges that while the project's objectives are laudable, their realization relies heavily on robust financing mechanisms that can sustain the project's activities over the long term.

The purpose of the document is to identify and explore various solutions for financing the SOCIO-BEE project. This includes investigating potential public-private partnership (PPP) schemes, evaluating existing financing frameworks for innovative projects with public interest characteristics, and developing private financing strategies such as social bonds and green bonds. Additionally, the task aims to identify the services provided by SOCIO-BEE, define performance parameters for assessing financial sustainability, and ultimately develop guidelines for implementing financing strategies.

This deliverable serves as a guide to financing strategies for SOCIO-BEE and other CS projects. It synthesizes the findings and recommendations of Task 7.3, providing stakeholders with insights into securing the necessary funding to support the project's objectives effectively. The scope of D7.5 encompasses theoretical reviews of existing financing frameworks, analysis of collaboration schemes with the public sector, exploration of private financing instruments, identification of SOCIO-BEE services, definition of performance parameters, and development of guidelines for financing strategies.

2 Theoretical Review of Existing Financing Frameworks

This chapter provides an examination of **existing financing frameworks** applicable to innovative projects **with public interest characteristics**. Drawing on relevant literature and case studies, the chapter explores various models, methodologies, and best practices in project financing. Special attention is given to frameworks that **prioritize social and environmental impact**, aligning closely with the objectives of SOCIO-BEE. We analysed the strengths, weaknesses, opportunities, and threats of different financing approaches, this chapter aims to inform the development of tailored strategies for funding SOCIO-BEE and similar CS projects.

2.1 Overview of the Air Quality Funding Landscape

Established financial instruments, such as **guarantees and bonds**, constitute nearly **65% of the innovative financing market**; while new products dominate many conversations about innovative financing, most resources mobilized through innovative financing use existing products in new markets, or involve new investors[1]. Innovative financing has mobilized nearly $100 billion and grown by approximately 11% per year between 2001 and 2013[1]. Based on the 2011 report of the U.S. Environmental Protection Agency Office of Air and Radiation, **every $1 spent on air pollution control** yields an estimated **$30 in economic benefits**[2]. Today's clean technologies give countries the chance to achieve stable, sustainable development while reducing air pollution. Poor AQ hampers progress, reversing advancements. According to the OECD, if no action is taken, the number of **working days lost annually** due to outdoor air pollution could soar to **3.7 billion by 2060**, up from the current figure of around **1.2 billion**[8]. This highlights the urgency of addressing AQ to prevent further setbacks in development. The impacts of air pollution globally are summarized in Figure **1**[3].

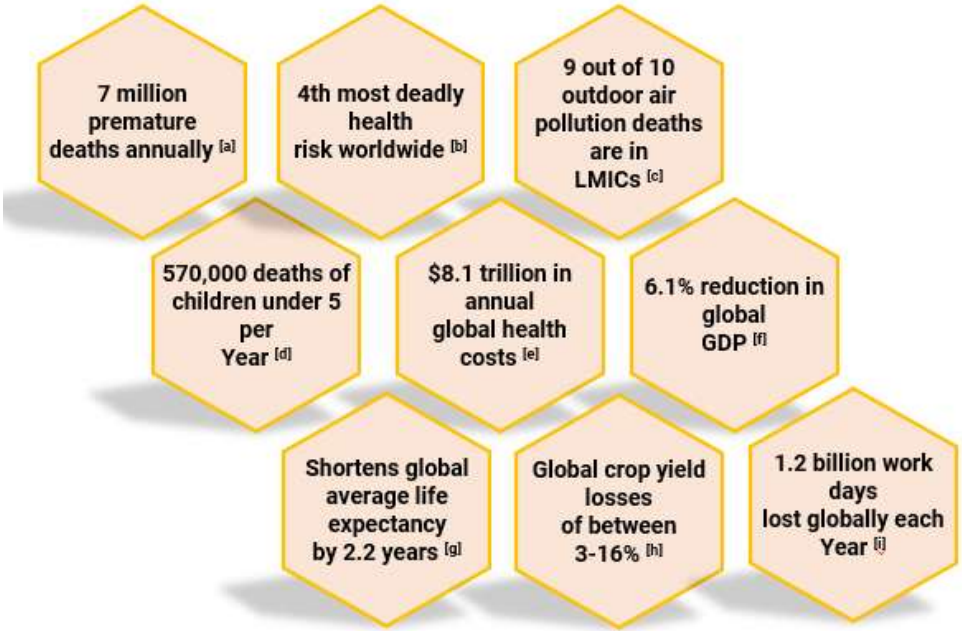

Figure 1: The adverse impacts of air pollution globally. [a] the combined effects of both outdoor and indoor air pollution, the annual deaths related to outdoor air pollution was at 2.6 million[4]. [b] Surpassed only by high blood pressure, tobacco use, and poor diet[5].[c] LMICs: Low- and Middle-Income Countries[6]. [d] Deaths from respiratory infections attributable to both outdoor air pollution and indoor air pollution. [e] Global health costs in 2019, of mortality and morbidity caused by exposure to PM2.5 air pollution. [f] Equivalent to $8.1 trillion in global health costs. [g] Global loss of average life expectancy from all air pollution. [h] Global crop losses specifically caused by ozone. [i] Which could reach 3.8 billion days by 2060. Employees breathing polluted air are much more likely to get sick and experience reduced cognitive performance[7].

Despite clear evidence of the severe harm caused by poor AQ, international development funders continue to neglect air pollution. AQ has long been sidelined in favour of other development areas, such as health and climate change, and receives inadequate funding, **only 1%** of all international development funding from 2018 to 2022[3, 8], which is not sufficiently focused on addressing the issue. In the period 2015-2021, **only $17.3 billion** was committed to projects tackling outdoor air pollution. Most of it was allocated to transport investments (46%) and multi-sector air pollution control programs (32%), while **minimal funding for monitoring and modelling (less than 1%)**[3].

To truly make a difference, AQ investment needs to be scaled up and integrated across development programs. Doing so will not only save lives but also foster sustainable economic growth and facilitate the crucial transition away from fossil fuels towards cleaner, less polluting energy sources. Investing in projects aimed at improving outdoor AQ holds significant potential for positively impacting human health, climate action, and economic growth globally. The lack of support stems from various challenges, including **funding constraints, barriers to policy implementation, and political complexities.** These obstacles are particularly pronounced **in low-income countries**, which also grapple with additional challenges such as debt distress, the aftermath of the Covid pandemic, climate change impacts, and disruptions in energy and food supplies due to geopolitical events like the conflict in Ukraine.

In analysing the financing of outdoor air quality initiatives, it is evident that the funding landscape is heavily dominated by loans. **Over 90% of outdoor AQ funding** is provided through **loans**, of which one-third are low-cost or concessional[3,8], making them particularly relevant for developing economies.

On the other hand, loans add financial burdens to recipient countries and limit their ability to fully benefit from this support[8]. **Grants**, which constitute **only 8%**[3,8] of the funding, play a crucial but limited role, particularly in facilitating concessional funding that supports sustainable economic transitions in poorer regions. This imbalance highlights the ongoing need for increased grant allocations in AQ projects, particularly in underserved regions. Furthermore, international development funders are not adequately directing their financial support to those who need it most. Donors should concentrate their AQ funding on populations and countries that are disproportionately impacted by air pollution, such as the elderly, pregnant women, children, and impoverished communities[8].

Multilateral development finance institutions (DFIs) contribute significantly to outdoor AQ financing, **accounting for 51% of the total funding**. Bilateral DFIs and national governments also play notable roles, contributing 37% and 7%, respectively. The geographical distribution of these funds is highly concentrated, with 86% directed toward five Asian countries: China, the Philippines, Bangladesh, and others[3]. Meanwhile, Latin America, the Caribbean, and Africa face significant funding shortages, despite enduring high levels of pollution.

At the city level, **68% of the funding is directed toward specific projects in cities** such as Beijing, Dhaka, and Ulaanbaatar, which face some of the world's worst air pollution[3]. However, major funding gaps persist in other highly polluted cities worldwide, emphasizing the need for more investments in urban AQ projects. The overall conclusion is that outdoor AQ funding remains insufficient and unevenly distributed across regions and cities. More targeted and expansive initiatives are required to achieve safe AQ levels and address the growing environmental and health challenges caused by air pollution globally.

2.2 Financial instruments

This section reviews the financial instruments available for AQ funding, including:

- Grants, debt, equity
- Secondary capital market instruments
- Results-based financing
- Structured finance mechanisms
- Risk mitigation tools.

When effectively combined with supportive policies, regulations, and incentives, these instruments can enhance AQ improvements while creating business opportunities for the private sector. Traditional instruments like **grants and debt** are commonly used by **international funders** but could be better targeted to attract private investment. More complex tools, such as **secondary capital market instruments** and **structured finance mechanisms**, have the potential to mobilize significant additional capital but are **not yet widely applied** in less developed markets or for dedicated AQ projects.

Grants, debt, and equity are common financial instruments used to fund AQ projects, especially in developing countries with less advanced capital markets. Grants are essential in the early stages of project development, supporting activities like research, technology testing, and market building. For instance, the EU's Horizon 2020 program funded innovative air pollution reduction technologies, such as Green City Solutions' biotech dust filters[9] (€1.2 million[3]) and Insplorion's[10] pollutant sensors (€50,000[3]).

Blended finance, which combines concessional (lower-cost) and private capital, is another key tool for reducing investment risks in high-risk markets and sectors. This structure encourages private investors by providing **a financial safety net**, such as absorbing project losses. Development funders are already using blended finance but could increase their efforts to mobilize more private funding.

Traditional Project-Level Financial Instruments (Grants, Debt, Equity)

Figure 2: SWOT analysis on traditional project-level financial instruments (grants, debt, equity)

Debt financing through on-lending structures is also significant, where development funders provide funds to **local financial institutions** rather than directly to projects. These institutions then lend to AQ projects at more favourable terms, with technical support to build internal capacity. This financing approach could be more directly tied to achieving AQ goals.

Secondary capital market instruments, such as green bonds, sukuks[11], social bonds, sustainability bonds, and sovereign bonds, are debt instruments traded in secondary markets. These instruments provide **access to large pools of capital**, including institutional investors seeking stable, long-term returns. By the end of 2022, the green bond market reached $2.2 trillion, while social and sustainability bonds each surpassed $650 billion[3].

These instruments can pool various projects, offering larger investments and reducing risk for investors. Bonds can also be issued by local governments in local currencies, reducing currency risk. AQ projects, which offer environmental and social benefits, can be funded through green, social, and sustainability bonds. Although many bonds indirectly support AQ improvements (e.g., clean energy and urban transport projects), AQ objectives could be more explicitly integrated into new bond programs.

Dedicated AQ bonds are emerging, such as the **Breath Better Bond Initiative[12]** proposed by the International Finance Corporation (IFC)[13] and the Asian Development Bank's (ADB)[14] conceptualization of Clean Air Bonds in China[15]. Additionally, **sovereign bonds** have been used to finance public transport projects that contribute to better AQ, like Thailand's 2020 bond issuance for the Bangkok MRT[16].

However, governments in developing countries could more explicitly link sovereign bonds to AQ objectives.

Secondary Capital Market Instruments (Green Bonds, Social Bonds)

Figure 3: SWOT analysis on secondary capital market instruments (green bonds, social bonds).

Results-based finance (RBF) instruments, such as carbon finance, environmental impact bonds, and sustainability-linked bonds (SLBs), make funding contingent on achieving specific environmental or sustainability outcomes, like reductions in air pollutants ($PM_{2.5}$, PM_{10}) or greenhouse gas emissions. RBF incentivizes measurable improvements in AQ by linking financing terms to verified performance outcomes. For example, results-based lending has been used by the ADB to reduce air pollution in China's Beijing-Tianjin-Hebei region[17] ($300 million[3]), achieving significant reductions in CO_2, SO_2, $PM_{2.5}$, and NO_x. Similarly, the World Bank used a $500 million program to reduce emissions in the Jing-Jin-Ji region[18].

Carbon finance allows project operators **to monetize carbon emissions avoided**, helping secure funding for climate projects that also improve AQ. **SLBs**, on the other hand, **tie borrowing costs to the achievement of sustainability targets**, rewarding companies with lower interest rates if goals are met. They can also **penalize issuers** for failing to meet AQ targets, encouraging sustainable practices. Environmental impact bonds further incentivize AQ improvements by paying investors only when measurable environmental outcomes are achieved.

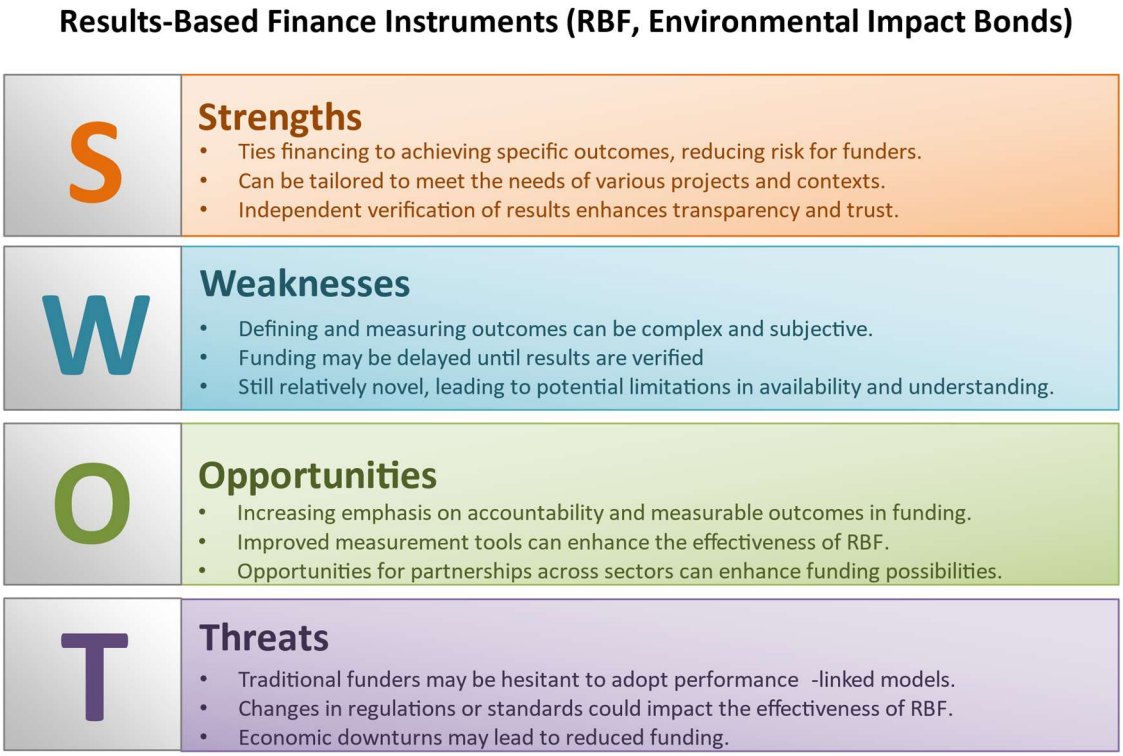

Figure 4: SWOT analysis on results-based finance instruments (RBF, Environmental Impact Bonds).

Structured finance mechanisms like aggregation and securitization enhance investment size and reduce administrative complexities, facilitating long-term capital mobilization. **Aggregation** involves bundling small-scale projects with similar contracts to create larger, diversified investments. Standardized contracts, such as power purchase agreements, simplify due diligence and minimize the need for specialized legal expertise. **Securitization** further divides these bundled projects into various financial tranches, each with distinct risk-return profiles, making them more appealing to different investors and lowering overall capital costs. Green securitization targets low-carbon projects, potentially financing AQ initiatives, but market demand may be limited without clear revenue models or public sector funding. The **UNDP's Climate Aggregation Platform**[19] exemplifies how financial aggregation can scale up funding for low-carbon projects in developing nations, although it does not specifically emphasize air pollution reduction.

Pooled procurement allows organizations to combine resources and negotiate better terms with suppliers, making purchases more affordable and reducing risks associated with financing. This approach is particularly beneficial for public goods like air quality. For instance, the **EU's Joint Procurement Agreement**[20] facilitates collective purchasing for healthcare systems, which proved vital during the COVID-19 pandemic. A similar model could be implemented for procuring AQ monitoring equipment, enabling institutions to access advanced technologies efficiently and cost-effectively.

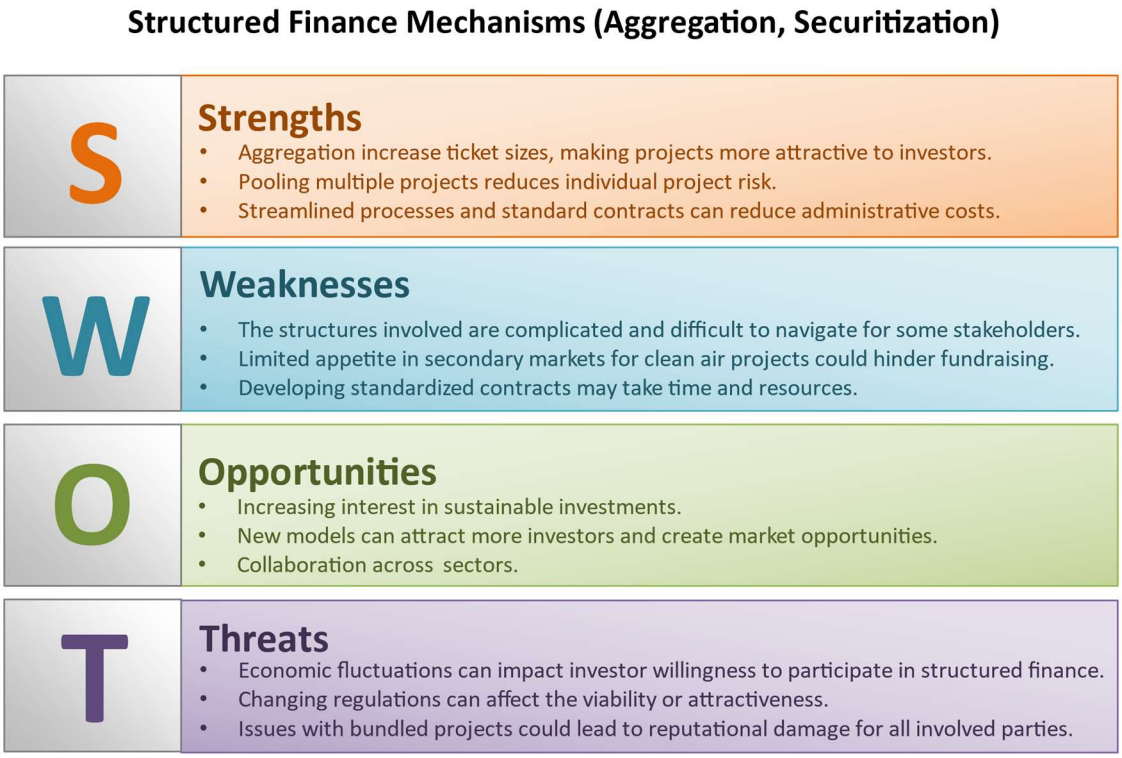

Figure 5: SWOT analysis on structured finance mechanisms (aggregation, securitization).

Risk mitigation, or credit enhancement instruments, encompass various tools like currency hedging instruments, guarantees, and insurance products designed to reduce specific risks and enhance project return profiles. These instruments are particularly vital for mobilizing private capital in developing countries, where investors often perceive higher risks, including for AQ projects.

Currency hedging tools, such as currency forwards, futures, swaps, and options, manage exchange rate risks for lenders, thereby minimizing market risks linked to currency mismatches. This capability enables borrowers in developing and emerging markets to access long-term financing in local currencies rather than hard currencies like EUR or USD. An example is the **Currency Exchange Fund (TCX)**[21], established in 2007 to provide currency hedging instruments for over 100 currencies across most developing nations. In 2021, TCX de-risked $1.4 billion in new development finance investments[22].

Guarantees introduce a third party into a legal agreement, adding a layer of protection for the beneficiary. They help overcome political, credit, and counterparty risks by enhancing the creditworthiness of otherwise risky investments while also lowering capital costs.

Insurance products can cover various risks, including losses from political unrest (political risk insurance) or property damage (property insurance). These guarantees and insurance products have been extensively used in AQ projects by development finance institutions, including the **Multilateral Investment Guarantee Agency (MIGA)**[23] and the **Islamic Corporation for the Insurance of Investment and Export Credit (ICIEC)**[24]. For instance, in 2022, MIGA approved a €17 million political risk insurance for the **Zrenjanin Wastewater Treatment Plant** in Serbia, and in 2023, it approved €20.8 million for a **Bus Rapid Transit (BRT)** project in Dakar[3], aimed at reducing air pollution.

In 2022, ICIEC launched its **Green Sukuk Insurance Policy**, providing coverage to Sukuk issuers in developing countries to enhance their credit ratings and attract private investment. A notable case

involved a seven-year breach of contract and political risk insurance granted to **Alcazar Energy** for its $68 million investment in the **200 MW Benban Solar Complex** in Aswan, Egypt[25].
At the end of 2022, a new €6.1 billion **guarantee program** was approved under the **European Fund for Sustainable Development Plus (EFSD+)**[26], which, although not explicitly focused on air pollution, supports several initiatives in Sub-Saharan Africa, Latin America, and Asia Pacific that offer air quality co-benefits, such as urban mobility and energy-efficient buildings.

Risk Mitigation Instruments (Currency Hedging, Guarantees, Insurance)

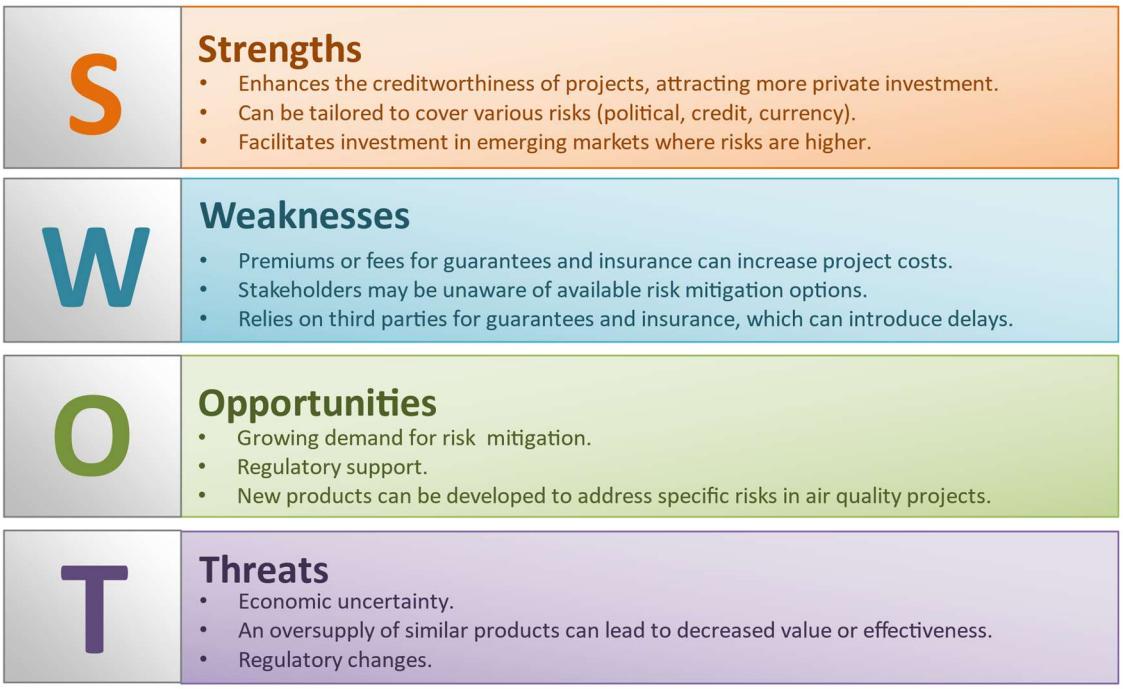

Figure 6: SWOT analysis on risk mitigation instruments (currency hedging, guarantees, insurance).

2.3 Analysis of Financing Mechanisms

In this chapter, we explore various financing mechanisms suitable for innovative projects like SOCIO-BEE. Given the project's objectives of enhancing AQ monitoring and promoting citizen engagement, it is essential to analyse a range of financial tools that can support its goals sustainably. We will examine traditional instruments alongside emerging options, such as PPPs, **social impact bonds, green bonds, and crowdfunding platforms**, assessing their feasibility, scalability, risk profile, and potential for generating sustainable funding streams.

2.3.1 Grant Funding

Grant funding involves financial support provided by governments, foundations, or organizations to fund projects that meet specific criteria or objectives. Grants are typically non-repayable and are aimed at fostering innovation, research, and community development.

Feasibility and scalability:

- **Feasibility:** Many EU programs, such as Horizon Europe and LIFE, specifically allocate funds for projects that contribute to environmental sustainability and CS. For instance, the Horizon 2020 program has funded various AQ monitoring projects, enabling municipalities to implement innovative technologies without incurring debt.

- **Scalability:** Successful grant-funded initiatives can often be expanded by applying for additional funding in subsequent funding cycles. Projects funded by grants, like the Citizen Science in Europe initiative[27], have demonstrated the potential for scalability across different regions, fostering collaboration among stakeholders.

Risk profile: The primary risks associated with grant funding include the competitiveness of the funding process, the need to comply with strict reporting and accountability measures, and the potential for funding to be discontinued after the initial grant period. Projects that rely heavily on grants may face sustainability challenges if they do not develop alternative funding streams.

Examples:

1. **Horizon 2020[28]:** This EU program has provided significant funding for various environmental and CS projects, emphasizing innovative solutions to climate-related challenges.
2. **LIFE Programme[29]:** The EU's financial instrument for the environment has supported numerous projects aimed at improving AQ and promoting sustainability.
3. **National Institutes of Health (NIH)[30]:** In the U.S., NIH grants have funded CS initiatives that collect health-related data, illustrating the potential for public health and environmental intersections.
4. **The Environmental Protection Agency (EPA)[31]:** Provides grant funding for community-based projects aimed at improving AQ and public health outcomes.
5. **Local government grants:** Many municipalities offer their grant programs for community engagement projects related to environmental monitoring, such as the Community Environmental Fund (CEF)[32] in the UK.

2.3.2 Public-Private Partnerships (PPPs)

PPPs involve collaboration between government entities and private sector organizations to finance, develop, and manage projects that serve the public good. In the context of SOCIO-BEE, PPPs can facilitate the deployment of AQ monitoring technologies and community engagement initiatives.

Feasibility and scalability:

- **Feasibility:** PPPs can leverage private investment, reducing the financial burden on public entities. They often result in more efficient project delivery due to the expertise and innovation that private firms bring.
- **Scalability:** Successful PPPs can be replicated in different municipalities, allowing SOCIO-BEE to expand its impact across various cities. For example, the **Breath London[33]** project, which utilized a PPP model, expanded AQ monitoring across London through collaboration between the mayor's office, universities, and private firms.

Risk profile: While PPPs can mitigate some risks through shared responsibility, they also carry challenges, such as potential misalignment of public and private interests and the complexities involved in contract management.

Four types of PPP models have been identified[34]:

1. **Institutional PPPs:** In this model, an entire institution operates within a PPP framework, delivering various services such as research, analysis, development of best practices, and security audits. These partnerships are often linked to critical infrastructure protection, as mandated by legal acts (e.g., emergency management). Cooperation typically occurs through working groups and rapid-response teams, with a primary focus on safeguarding critical infrastructure from cyber threats.
2. **Goal-Oriented PPPs:** These partnerships aim to cultivate a cybersecurity culture within member states. A platform or council is established to facilitate knowledge exchange between the public and private sectors, with members working together toward a specific objective or theme.
3. **Service Outsourcing PPPs:** Initiatives formed by government and private sector collaboration; these partnerships focus on enhancing cybersecurity awareness among stakeholders. They serve as third-party entities, providing services that meet industry needs and supporting government policymaking, such as implementing the NIS directive and developing national cybersecurity strategies.
4. **Hybrid PPPs:** This type encompasses Computer Security Incident Response Teams (CSIRTs) operating within a PPP framework. Governments may delegate CSIRT services to experienced entities with a proven track record in cybersecurity, thus benefiting public administration or the nation as a whole.

2.3.3 Social Impact Bonds (SIBs)

SIBs are a relatively new financial instrument where private investors fund social programs upfront and are repaid by the government only if the projects achieve predefined outcomes[35].

Feasibility and scalability

- **Feasibility:** SIBs are appealing for projects like SOCIO-BEE because they attract private capital for social and environmental objectives without upfront costs to the public sector. For instance, the **Rough Sleepers Social Impact Bond**[36] in the UK funded services aimed at reducing homelessness.
- **Scalability:** If successful, SIBs can be scaled to other regions or issues, fostering a broader approach to community engagement and environmental monitoring.

Risk profile: The main risks associated with SIBs include the complexity of measuring outcomes and potential challenges in achieving the agreed-upon metrics.

2.3.4 Green Bonds

Green bonds are fixed-income financial instruments designed specifically to support projects that have positive environmental impacts. They have gained popularity in financing initiatives that aim to combat climate change, such as renewable energy and sustainable infrastructure.

Feasibility and scalability

- **Feasibility:** Green bonds can attract institutional investors looking to meet sustainability goals, making them suitable for financing SOCIO-BEE's AQ monitoring initiatives. The **World Bank**[37] has issued green bonds for projects in developing countries, providing examples of how this mechanism can be utilized effectively.
- **Scalability:** As the demand for sustainable investments grows, green bonds can provide a scalable financing mechanism for expanding SOCIO-BEE's initiatives to new cities.

Risk profile: The primary risks involve the need for stringent criteria to ensure funds are used for genuine environmental benefits and the potential for greenwashing, where projects may falsely claim sustainability.

2.3.5 Crowdfunding Platforms

Crowdfunding involves raising small amounts of money from many people, typically via online platforms. This mechanism can be particularly effective for engaging communities in CS projects[38].

Feasibility and scalability

- **Feasibility:** Platforms like **Kickstarter**[39] and **Indiegogo**[40] have successfully funded various projects, demonstrating the feasibility of crowdfunding for community-driven initiatives. The **Civic Crowdfunding** model allows local governments to directly engage with citizens and fund projects that matter to them. Crowdfunding can be particularly effective for CS initiatives as it not only raises funds but also builds community engagement and awareness.
- **Scalability:** Crowdfunding can easily scale as SOCIO-BEE expands, allowing each new city or community to run tailored campaigns. The **#WeLoveParks**[41] campaign in the UK raised funds for local park improvements through community contributions, highlighting a successful crowdfunding model.

Risk profile: Risks include dependency on public interest and engagement, as well as the possibility of not reaching funding goals. Additionally, the success of crowdfunding campaigns can be unpredictable.

Examples:

- Successful campaigns in the environmental space, such as the "Air Quality Egg[42]," which raised funds to develop low-cost air quality sensors, demonstrated the viability of this approach.

2.3.6 Venture philanthropy

Venture philanthropy combines philanthropic donations with a focus on social return on investment (SROI). This funding mechanism supports social enterprises and innovative projects by providing not just capital but also expertise and mentorship.

Feasibility and scalability: Organizations like The Global Fund for Community Foundations[43] provide funding that can help scale projects like SOCIO-BEE by emphasizing impact measurement alongside financial returns.

Examples: The Skoll Foundation[44] has funded social enterprises that focus on environmental sustainability, making them a potential partner for initiatives aimed at improving AQ through community engagement.

2.3.7 Innovative Financing Mechanisms

Innovative financing refers to new approaches that leverage private and public capital to fund social projects. This category can include mechanisms like results-based financing or blended finance.

Feasibility and scalability: These approaches often involve partnerships between governments, philanthropic organizations, and private investors, making them suitable for large-scale initiatives. The Innovative Financing for Development program[45] by the World Bank is one such example.

Examples: The Global Financing Facility[46] uses innovative financing to improve health outcomes in developing countries, which can be adapted for environmental health initiatives like SOCIO-BEE.

2.3.8 Corporate sponsorship and partnerships

Corporations often engage in sponsorships or partnerships as part of their CSR initiatives. These partnerships can provide funding, resources, and expertise.

Feasibility and scalability: Collaborations with companies that have a vested interest in environmental sustainability can help leverage additional resources for CS projects. Companies like Unilever[47] and Nestlé[48] have engaged in projects focused on sustainability[49,50], making them potential sponsors for SOCIO-BEE.

Examples: The Coca-Cola Foundation[51] has funded projects aimed at improving urban sustainability, highlighting opportunities for corporate partnerships.

The financing landscape for innovative projects like SOCIO-BEE is rich with opportunities across various mechanisms. Each method presents unique advantages and challenges that can be strategically leveraged to support the project's objectives. By considering a diversified funding approach that includes PPPs, SIBs, green bonds, and crowdfunding, SOCIO-BEE can create a sustainable funding model that fosters community engagement and drives positive environmental outcomes.

2.4 Review of Public Interest Characteristics in Financing Models

This chapter explores how public interest characteristics can be integrated into financing strategies for initiatives like SOCIO-BEE. By examining various financing models, including PPPs, social impact bonds, green bonds, and grants, we can assess their alignment with societal needs and environmental goals. Understanding these relationships will enable stakeholders to identify synergies and trade-offs that may arise when prioritizing public interest in financing decisions.

2.4.1 Defining public interest characteristics

Public interest characteristics refer to the elements that **prioritize the well-being of society and the environment** in financing mechanisms. These characteristics include **accessibility, social equity, sustainability, transparency, and accountability**. Incorporating public interest into financing models ensures that projects not only achieve financial viability but also contribute positively to societal and environmental outcomes.

2.4.2 Financing models and their public interest alignment

Public-Private Partnerships (PPPs)

Public-Private Partnerships are collaborative agreements between government entities and private sector organizations aimed at delivering public services or infrastructure projects. In the context of SOCIO-BEE, PPPs can leverage private sector efficiency while ensuring that public goals, such as improving AQ and fostering citizen engagement, are met. Successful PPPs often include measures for community involvement and public accountability[52].

Example: The *Clean Air Initiative* in São Paulo, Brazil, is a PPP that has successfully reduced air pollution through collaborative efforts between the government and private stakeholders, demonstrating the potential for aligning public interests with private incentives.

Social Impact Bonds (SIBs)

Social Impact Bonds are a financing mechanism where private investors fund social services and are repaid by the government only if specific outcomes are achieved. This model can be particularly effective for initiatives like SOCIO-BEE, which seek to enhance public health and environmental sustainability. By linking funding to measurable social outcomes, SIBs ensure that investments align with public interests and deliver real benefits to communities.

Example: The *Peterborough Social Impact Bond* in the UK was one of the first SIBs aimed at reducing reoffending rates, showcasing how financial returns can be directly linked to social outcomes.

Green Bonds

Green Bonds are fixed-income financial instruments designed specifically to support climate-related or environmental projects. By financing projects that contribute to sustainability, such as those focusing on AQ improvement, green bonds align closely with public interest characteristics. They provide a transparent and accountable mechanism for attracting private capital to environmental initiatives while ensuring that the funds are used effectively for the public good.

Example: The *World Bank Green Bond* program has financed numerous projects worldwide that aim to address climate change, thereby demonstrating the effectiveness of this model in supporting public interests.

Grants

Grants are non-repayable funds provided by governments, foundations, or organizations to support specific projects that align with public interest objectives. They play a critical role in funding innovative initiatives that may not yet demonstrate financial viability. Grants can foster innovation in citizen science projects like SOCIO-BEE by providing essential funding for research, development, and implementation.

Example: The *Horizon Europe program* offers grants for projects focused on environmental sustainability and citizen engagement, facilitating the development of initiatives that serve the public interest across Europe.

Synergies and Trade-offs

By understanding the public interest characteristics inherent in various financing models, stakeholders can identify synergies that enhance the effectiveness of funding strategies for SOCIO-BEE. For instance, combining PPPs with grant funding can create a robust financing framework that balances

private efficiency with public accountability. However, trade-offs may arise; for example, prioritizing short-term financial returns may conflict with long-term public interest goals, necessitating careful consideration in financing decisions.

Incorporating public interest characteristics into financing models is essential for ensuring that initiatives like SOCIO-BEE achieve not only financial sustainability but also positive social and environmental impacts. By leveraging a combination of financing mechanisms, stakeholders can create a more resilient funding strategy that aligns with broader societal goals. Understanding the complexities and interdependencies of these models will empower stakeholders to make informed choices that maximize the potential benefits of their projects while maintaining accountability and transparency.

2.5 Overview of Funding Examples for Air Quality and Citizen Science Projects

Exploring the funding landscape, we identified existing examples of funding and amounts of funding at European, regional, and local levels. This included also PPPs in AQ and CS, projects financed by private financing instruments (Social Bonds, Green Bonds) as well as other types of innovative mechanisms. This exploration of existing initiatives makes our financing analysis more tangible, by giving us insights into funding amounts, project types, and the specific focus areas of similar projects.

Summary of Potential Funding Sources for SOCIO-BEE

Funding Level	Source
EU	Horizon Europe, LIFE, EIC, ERDF
Regional	INTERREG, S3
Local	Local Gov Grants, PPPs
Private	Foundations, Crowdfunding

The funding examples at **EU**, **regional**, and **local levels** for projects related to CS, environmental monitoring, and AQ initiatives, including the total amounts funded are summarized in tables Table 1 to Table 6.

Table 1: European-level funding examples - Horizon Europe.

Horizon Europe (or Horizon 2020 before 2021)				
Project	**Focus areas**	**Status**	**Total Budget[53]**	**EU contribution[53]**
CARES – City Air Remote Emission Sensing[54]	• AQ monitoring • Remote sensing • Transportation and air pollution • AQ sensors and data	Closed	€ 3.44 million	€ 3.32 million
GroundTruth 2.0[55]	• Citizen science • Citizen observatories • Explicit and implicit-sensed citizen data • Flora and fauna • Water availability and quality • Mobile apps and social media analytics	Closed	€ 5.75 million	€ 4.97 million
iSCAPE - Improving the Smart Control of	• AQ and carbon emissions control • Climate change adaptation • Smart cities	Closed	€ 5.85 million	€ 5.85 million

Air Pollution in Europe[56,57]	• Passive air pollution remediation • Behavioural change • Sustainable urban development			
D-NOSES - Distributed Network for Odour Sensing, Empowerment and Sustainability [58]	• Citizen science • Citizen observatories • Odour pollution • Regulation and policy	Closed	€ 3.15 million	€ 3.15 million
WeCount - Citizens Observing UrbaN Transport[59]	• Citizen science • Transportation and mobility • Citizen-driven data collection • Policy influence • Cost-effective traffic monitoring • Social and policy tools	Closed	€ 1.95 million	€ 1.95 million

Table 2: European-level funding examples - LIFE Programme.

LIFE Programme				
Project	**Focus areas**	**Status**	**Total Budget[60]**	**EU contribution[60]**
RESPIRA - Reduction of exposure of cyclists to urban pollutants[61]	• AQ monitoring • Urban development • Risk assessment and monitoring • Environmental impact of transport • Human exposure to pollutants	Closed	€ 2.24 million	€ 1.12 million
AIRUSE - Testing and Development of air quality mitigation measures in southern Europe[62]	• AQ monitoring • Pollutants reduction • Urban traffic pollution • Biomass burning • Industrial emissions • Collaboration and policy impact	Closed	€ 2.35 million	€ 1.13 million
ASTI - Implementation of a forecasting system for urban heat Island effect for the development of urban adaptation strategies[63]	• AQ modelling and forecast • Public health (Heat health warning systems) • Climate change adaptation • Urban heat island effect • Decision making support • Support for climate change policies	Closed	€ 1.25 million	€ 0.73 million
GySTRA - Global system for sustainable traffic emissions management [64]	• AQ monitoring and management • Traffic and emissions monitoring • Remote-sensing • Public awareness • Collaboration and policy impact	Closed	€ 1.53 million	€ 0.79 million
HungAIRy - Improving air quality at eight Hungarian regions through the implementation of air quality plan measures[65]	• AQ monitoring and management • Capacity building and support for decision-makers • Public awareness campaigns • Automated AQ monitoring stations	Ongoing	€ 15.96 million	€ 9.58 million

SK AQ Improvement - Enhancing the implementation of Air Quality Management Plans in Slovakia by strengthening capacities and competencies of regional and local authorities and promoting air quality measures [66]	• AQ monitoring and management • Public awareness and education • Capacity building and support for decision-makers • Energy efficiency • Transport system improvements	Ongoing	€ 15 million	€ 9 million
RICH WATERS - Integrated approach to mobilise resources for resilient ecosystems and rich waters in the North Baltic Sea River Basin[67]	• Water quality monitoring and management • Citizen engagement • River basin management • Eutrophication control • Capacity building and knowledge sharing	Ongoing	€ 23.74 million	€ 9.73 million

Another example of EU level grant is Barcelona's city council has received an ERDF grant, through the Urban Innovative Actions programme (4 million Euro) to improve the climatic comfort of 10 schools and transform them into climatic refuges[78].

Table 3: European-level funding examples - European Innovation Council.

European Innovation Council (EIC) Accelerator		
Start-up	**Focus areas**	**Funding**
Skytree (2022)[68]	Clean-tech and modular CO_2 capture solutions.	€ 2.5 million[69]
LIXEA (formerly Chrysalix Technologies)[70]	Circular bioeconomy processes	€ 2 million[71]
Agrosustain[72]	Organic coatings and biological fungicides for fruits, vegetables and flowers.	€ 2.4 million[73]

Table 4: Regional-Level funding examples - INTERREG Programme.

INTERREG Programmes			
Project	**Focus areas**	**Status**	**Total Funding**
CitiCap - Citizen's cap-and-trade co-created[74]	• Promotion of sustainable urban mobility • Personal carbon trade • Behavioural change • Smart mobility solutions	Closed	€ 3.79 million[75] ERDF
PURE (INTERREG North Sea) [76]	• Public participation • Water and natural resources management • Regional planning	Closed	**Total budget:** €11.4 million **EU funding (amount):** € 5.7 million[76]

Local level grants usually cover from 50% to 70% of the funding for smaller scale implementations. For example, in Greece the Green Fund of the ministry of environment and energy offers grant opportunities up to €50,000 per project, for innovative actions with citizens[77].

Table 5: Local Government sustainability grants.

Initiative	Description	Amount allocated
Barcelona's Air Quality Plan[78]	• Local government funding for citizen science air quality projects	€ 3.37 million[78]
London Air Quality Initiative[79]	• London City Council providing grants for local AQ monitoring projects.	€ 2.2 million[80]

To get a more detailed picture we explored the local grants from the UK's Air Quality Grant[81], those grants were awarded in 2022 and are summarized in Table 6.

Table 6: Local grants from UK's Air quality Grant.

Local authority	Project	Amount[79]
Blaby District Council	Purchase of particulate matter monitors and development of a public facing app supported by communication and engagement activities for most vulnerable. Recruitment of an AQ Officer.	€ 185,286
Bradford Metropolitan District Council	Purchase of particulate matter monitors and development of the existing public facing website for information on particulate matter relating to domestic combustion and Non-Road Mobile Machinery. Supported by communication and engagement activities for vulnerable groups.	€ 302,715
Brighton and Hove City Council	Sensors upgrade to monitor particulate matter; supported by community engagement with a focus in schools.	€ 450,000
Canterbury City Council	Purchase of sensors to publicise real time data on particulate matter and NO2 on existing website - supported by an education and communication campaign.	€ 154,899
Cheshire East Borough Council	Communication campaign to raise awareness in Cheshire East on the health impacts around idling and domestic burning to encourage behavioural change.	€ 65,226
Doncaster Council	Schools' street closure, and communication and engagement project to raise awareness of transport emissions to change attitudes and influence behaviour and encourage mode shift from car to active travel.	€ 124,224
Dorset Council	Additional monitoring and public awareness campaign to improve knowledge of particulate matter.	€ 63,711
Essex County Council	Schools' education and awareness theatre production and AQ monitoring in schools. Plus, updates to existing local AQ website.	€ 333,839
Hammersmith and Fulham Council	Monitoring, engagement, and awareness raising in schools.	€ 173,901

Hertfordshire County Council	AQ data collection for particulate matter and NO_2 communications campaign to raise community awareness.	€ 157,669
London Borough of Camden	Large communication campaign across 13 London Boroughs on particulate matter and domestic burning.	€ 358,338
London Borough of Ealing	Air Quality Educational resource supported by live data.	€ 283,687
London Borough of Hackney	Creation and promotion of local web site to improve knowledge and encourage behaviour change in vulnerable groups.	€ 374,726
Southampton City Council	Clean Air schools' engagement and behaviour change programme.	€ 418,698
London Borough of Southwark	Air quality mapping tool to gather data and share info via air TEXT, schools messaging and hospital outpatient clinics (In partnership with London Borough of Lambeth).	€ 736,983
Tonbridge and Malling Borough Council	Air Quality monitoring and anti-idling campaign with schools	€ 43,793
Transport for Greater Manchester	Particulate matter monitoring and communication campaign to improve community knowledge and influence behaviour.	€ 685,569
Uttlesford District Council	Particulate matter awareness and behaviour change. Clean air pilot scheme through try before you buy e-bikes, e-cargo bikes and e-vehicle car club, and a traffic management scheme.	€ 617,685
West Northamptonshire Council	Data gathering on congested routes and public information campaign.	€ 177,135
Wokingham Borough Council	Information and behaviour changes campaign to promote active travel in favour of cars and school buses	€ 221,310
Total amount of local funds for similar AQ and CS projects of different scales		**€ 5.92 million**

3 Collaboration Schemes with the Public Sector

This chapter explores different ways in which SOCIO-BEE can collaborate with public sector entities, with a focus on maximizing synergies for the project's long-term sustainability. Public sector collaboration can take many forms, from informal partnerships to more structured arrangements like PPPs. These collaborations can provide SOCIO-BEE with access to critical resources such as funding, technical expertise, policy support, and broader public engagement, while also ensuring that the project's outcomes align with government priorities in areas like air quality monitoring, citizen science, and environmental sustainability

3.1 Exploration of Public-Private Partnership (PPP) Schemes

PPPs offer a valuable framework for SOCIO-BEE to collaborate with government entities while engaging private sector capabilities and resources. PPPs enable the sharing of risks, responsibilities, and rewards between public and private partners, creating a conducive environment for large-scale projects like SOCIO-BEE to flourish. This chapter delves into the mechanics of different PPP schemes, examining their potential for SOCIO-BEE.

Concession agreements: Under concession agreements, a public authority grants the private sector the right to finance, develop, and manage infrastructure or services. In SOCIO-BEE's context, this could

involve private companies financing AQ monitoring infrastructure in exchange for rights to manage and collect data or derive commercial benefits from the technology deployed. Concession models are particularly effective when there is a clear need for infrastructure development, which aligns with SOCIO-BEE's objective of expanding the capacity for AQ monitoring in cities.

Joint Ventures: Joint ventures between public bodies (like local governments) and private companies could provide SOCIO-BEE with a robust collaboration framework, where both partners share ownership and governance of air quality projects. SOCIO-BEE, as a CS initiative, could benefit from this scheme by sharing project risks with the private sector while leveraging public sector networks and regulatory support. An example of a successful joint venture is the UK's Joint Air Quality Unit (JAQU)[82], where multiple stakeholders collaborate on a coordinated response to AQ issues.

Revenue-Sharing agreements: Revenue-sharing agreements can be established where both public and private partners share the income generated from air quality data services or environmental technologies. SOCIO-BEE could leverage this model to generate revenue from proprietary AQ data or CS services, reinvesting profits into further development.

Key success factors for PPP implementation[83,84]:

- **Clear legal frameworks:** A robust regulatory environment is essential to define the roles and responsibilities of public and private partners.
- **Risk allocation:** Risk-sharing mechanisms should be in place, ensuring that public and private partners are protected from uncertainties such as technological failures or funding shortfalls.
- **Public interest alignment:** Ensuring that the private partner's profit motives are aligned with public interest goals (like improving AQ or enhancing citizen engagement) is crucial to the success of PPPs in SOCIO-BEE.

Best Practices[85]:

- **Transparency and accountability:** All agreements between partners should be transparent, with clearly defined performance metrics and reporting systems.
- **Public participation:** As a citizen-driven project, SOCIO-BEE should ensure that the citizen science aspect of its initiative remains central, even within a PPP framework.
- **Long-term sustainability:** Structuring PPPs with long-term sustainability goals will ensure that projects remain financially viable after public or private funding streams end.

Case studies such as the Clean Air Zones in the UK and the Air Quality Monitoring Network in Beijing demonstrate how effective PPPs can contribute to public health objectives and urban sustainability efforts.

3.2 Examples of Public-Private Partnerships and Financing Mechanisms

PPP	Scheme	Partners	Description	Funding
Breathe London Network (UK) [33]	Data-sharing, formalized public-private partnership for air monitoring.	Greater London Authority (public), Environmental Defense Fund (NGO), Google (private), Local Boroughs.	Combines mobile and static sensors to monitor air pollution across London, providing real-time data for policy use.	£750,000, additional in-kind support from Google.

CityTree Initiative (Germany)[86]	Infrastructure-based environmental monitoring.	Green City Solutions (private), City of Berlin (public), local councils.	Installs moss-covered "CityTrees" that absorb air pollutants in urban areas, integrating private innovation with public city management.	€1.5 million from Berlin's environmental fund, private sector contributions.
London Ultra Low Emission Zone (ULEZ) (UK)[87, 88]	Public-private emissions control and monitoring collaboration.	Transport for London (public), private sector tech firms.	Monitors and enforces vehicle emissions standards in London using advanced data and enforcement technologies.	Approx. £200 million from public sector congestion charges, private sector tech investments.
Curieuzeneuzen (Belgium)[89]	Citizen science project within a public-private framework.	University of Antwerp (public), Flemish Environment Agency, private sector sponsors.	Citizens measure nitrogen dioxide levels, with data used in both research and policy-making.	€1.5 million from Flemish government, €500,000 from private tech sponsors.
Clean Air Partnership (Canada)[90]	Formalized collaboration for urban AQ improvement.	City of Toronto (public), private firms, NGOs.	Aims to reduce urban air pollution through policy, monitoring, and real-time sensor deployment.	$2 million CAD from local government, $800,000 from corporate partners.
AIRLAB (France)[91]	Innovation-focused PPP for AQ technologies.	Airparif (public), City of Paris, private tech companies.	Offers an experimental platform for new air quality monitoring technologies, helping to refine policy and public health strategies.	€3 million from the Paris City Council, €1 million from private tech firms.
Helsinki Smart City (Finland)[92]	Formal public-private partnership in smart city technologies.	Helsinki City Council (public), private tech firms.	Uses urban sensors to track air pollution, integrating data into transport and urban planning systems.	€20 million from city budget, €10 million from private tech investors.
Sweden's Vision Zero (Sweden)[93]	Environmental and transport-focused PPP.	Swedish Transport Administration (public), Volvo (private), tech companies.	Aims for zero emissions and traffic-related deaths, incorporating air quality monitoring into urban mobility systems.	€1 billion over five years from public and private investments.

These examples illustrate that successful public sector collaborations hinge on mutual benefit, transparency, and clear alignment of objectives. Whether through formal PPP structures or informal

collaborations, SOCIO-BEE can leverage public resources, technical expertise, and public policy influence to expand its reach and impact. Crucially, ensuring that these partnerships prioritize citizen engagement and public interest will ensure SOCIO-BEE maintains its core values while benefiting from broader collaboration.

4 Private Financing Strategies

This section explores the range of private financing strategies available to ensure SOCIO-BEE's sustainability and potential for growth. Leveraging private financing can provide SOCIO-BEE with the capital needed to scale operations, develop technology, and enhance citizen engagement. By tapping into financial instruments such as social bonds, green bonds, impact investment funds, and crowdfunding platforms, SOCIO-BEE can diversify its funding sources and reduce reliance on traditional public grants.

4.1 Overview of Private Financing Instruments (e.g., Social Bonds, Green Bonds)

Private financing instruments such as social bonds, green bonds, impact investment funds, and crowdfunding have become increasingly important for funding social and environmental projects. These instruments offer unique advantages by attracting private capital that aligns with broader social and environmental goals. For SOCIO-BEE, these instruments could provide the necessary resources for scaling citizen science initiatives and air quality monitoring efforts across various regions.

Social bonds are debt instruments designed to raise capital for projects that generate positive social outcomes, such as improving healthcare, education, or community development. Issuers, typically governments or corporations, raise funds through these bonds with the commitment that the proceeds will go toward initiatives with measurable social impact. In recent years, social bonds have gained popularity, with major issuances in Europe and beyond, aimed at financing projects aligned with the SDGs.

- **Market trends**: Social bond issuance globally exceeded $200 billion in 2023[94], with significant participation from European markets. These bonds are particularly relevant to projects that address social equity and public health, making them a viable option for SOCIO-BEE, which focuses on improving AQ and engaging communities.
- **Applicability to SOCIO-BEE**: Given SOCIO-BEE's goal of enhancing public health through AQ monitoring and CS, social bonds present a compelling funding option. Capital raised through social bonds could be directed toward technology deployment, public engagement efforts, and education programs, all of which align with the social impact themes typically associated with these bonds.

Green bonds are similar to social bonds but are explicitly aimed at financing environmental projects. They are designed to raise funds for initiatives that promote sustainability, such as renewable energy, clean transportation, and pollution reduction. Issuers of green bonds are required to adhere to guidelines, ensuring that the proceeds are allocated to projects with tangible environmental benefits.

- **Market trends**: The global green bond market has expanded rapidly, with cumulative issuances surpassing $1.6 trillion by 2023[94]. The European Union remains a leader in the green bond market, launching its NextGenerationEU Green Bond program[95] to fund sustainable recovery efforts.
- **Applicability to SOCIO-BEE**: For SOCIO-BEE, green bonds could be a suitable option for funding AQ monitoring technology and infrastructure that directly contributes to environmental improvement. Green bonds could also support the development of low-emission zones in cities

or the installation of pollution control measures. Given SOCIO-BEE's environmental focus, these bonds align well with the initiative's goals.

Impact investment funds aim to generate measurable social or environmental impact alongside a financial return. These funds pool capital from investors who seek not only profits but also positive change, making them particularly relevant for initiatives like SOCIO-BEE. Impact investors typically look for projects with clear, evidence-based outcomes, such as improved air quality or enhanced public health, which can be quantified and reported.

- **Market trends**: The impact investing market was valued at $1.16 trillion in 2022[96], with a significant portion of investments targeting sectors like clean energy, sustainable agriculture, and health.
- **Applicability to SOCIO-BEE**: Impact investment funds are well-suited to SOCIO-BEE's mission of promoting CS and environmental health. By demonstrating tangible results, such as improved AQ and increased community engagement, SOCIO-BEE could attract capital from impact investors who are aligned with these goals.

Crowdfunding is a decentralized form of raising capital, often relying on small contributions from many people. Platforms like Kickstarter or GoFundMe have been widely used to fund both commercial ventures and community-based projects. In the context of SOCIO-BEE, crowdfunding could be an effective way to engage the public in its mission, allowing individuals to contribute directly to the initiative.

- **Market trends**: Crowdfunding has become an increasingly popular way to fund environmental and social projects, particularly those that rely on grassroots support. In 2020, the global crowdfunding market was valued at over $15 billion[97] and is projected to grow further in the coming years.
- **Applicability to SOCIO-BEE**: Crowdfunding could serve as a supplemental financing strategy for SOCIO-BEE, especially for specific community-driven projects like the deployment of AQ sensors or public education campaigns. It also offers the added benefit of strengthening public engagement by allowing citizens to take a financial stake in the project.

4.2 Application of private financing strategies to SOCIO-BEE

The application of private financing strategies to SOCIO-BEE's context requires careful consideration of the initiative's objectives, scale, and stakeholder needs. By leveraging private financing instruments, SOCIO-BEE can tap into diverse funding sources that align with both its social and environmental missions.

- **Feasibility**: Social and green bonds are particularly feasible for SOCIO-BEE, as the initiative aligns with the criteria for both instruments: enhancing public health through better AQ and promoting sustainability. The issuance of such bonds could be facilitated through partnerships with municipalities or environmental agencies, which can serve as bond issuers.

- **Risks**: The main risks associated with private financing instruments include market volatility and the potential for limited investor interest. In the case of crowdfunding, there is also the risk of not reaching the desired funding target. Furthermore, private investors often expect clear financial returns, which could challenge SOCIO-BEE's ability to balance profit with social impact.

Benefits:

- **Diversification of funding**: Private financing strategies offer SOCIO-BEE the ability to diversify its funding streams, reducing reliance on grants or public funding. This not only enhances the initiative's financial resilience but also allows it to scale its operations more rapidly.

- **Strengthened community engagement**: Crowdfunding and impact investment funds can enhance community involvement by allowing the public to contribute financially to SOCIO-BEE's mission. This engagement strengthens the project's legitimacy and public support.

Strategic application:

SOCIO-BEE can integrate private financing strategies by developing targeted initiatives that appeal to specific investors or funding mechanisms. For example:

- **Green bonds**: Could fund large-scale deployment AQ monitoring sensors, while simultaneously supporting local environmental goals.
- **Social bonds**: Could finance public health campaigns or educational programs aimed at raising awareness about AQ and pollution control.
- **Impact investment funds**: Could back technological innovations within SOCIO-BEE, such as the development of advanced AQ monitoring use cases (like combined sensor drone systems, or sensors on buses and public buildings).

5 Identification of services provided by SOCIO-BEE

This section examines the range of services offered by SOCIO-BEE to its stakeholders and participants. It evaluates SOCIO-BEE's value proposition, including its unique features, benefits, and potential impact on stakeholders.

5.1 Analysis of SOCIO-BEE's value proposition

SOCIO-BEE positions itself as a complementary AQ monitoring solution that fosters community participation and empowers citizens through engaging and playful interactions. More detailed information on the project's value proposition may be found in D8.5. SOCIO-BEE's core objectives include:

- **Community participation**: SOCIO-BEE emphasizes the importance of active citizen engagement by assigning distinct roles to participants, thereby encouraging ownership and involvement in AQ monitoring efforts.
- **Co-creation of campaigns**: By involving stakeholders in the co-creation and management of AQ campaigns, SOCIO-BEE ensures that initiatives are grounded in local needs and realities.
- **Real-time data analytics**: The provision of real-time data analytics equips stakeholders with timely information, enhancing their ability to make informed decisions regarding AQ and environmental strategies.
- **Citizen engagement enablers**: SOCIO-BEE acts as an enabler for citizen participation and data contribution, facilitating a collaborative environment for data collection and analysis.

- **Policy insights**: The initiative provides insights for policy formulation and environmental strategies aimed at mitigating pollution, thereby influencing broader community health outcomes.
- **Open-access resources**: By promoting open-access resources, SOCIO-BEE encourages widespread utilization of data and findings, making it accessible to a larger audience.
- **Customized consulting services**: SOCIO-BEE may offer tailored consulting services to municipalities, aiding them in initiating and maintaining SOCIO-BEE for AQ improvement.

5.2 Identification of services offered to stakeholders and participants

SOCIO-BEE provides a diverse portfolio of services categorized by their nature, scope, and intended beneficiaries:

Monitoring solutions: Air quality sensor monitoring systems that work alongside existing infrastructure to enhance data collection efforts.

Community engagement programs: Initiatives (campaigns) designed to foster citizen participation, including educational workshops, awareness campaigns, and interactive platforms for data sharing.

Campaign co-creation: Opportunities for stakeholders to collaboratively design and manage AQ campaigns, ensuring they are tailored to specific community needs.

Data analytics and reporting: Provision of real-time analytics and comprehensive reports that help stakeholders make data-driven decisions for improving air quality.

Consulting services: Customized consulting for municipalities to support the implementation of SOCIO-BEE for local AQ management efforts.

Access to open resources: A repository of open-access materials, including research findings, tools, and guides that promote broader community involvement in AQ issues.

5.3 PPPs and SOCIO-BEE: Collaborative models for AQ initiatives

This chapter presents an in-depth exploration of potential PPP schemes tailored for SOCIO-BEE, focusing on leveraging collaborations to enhance AQ monitoring and citizen engagement initiatives. In an era where urban air pollution poses significant health risks and environmental challenges, innovative financing and partnership models become crucial for effective intervention. We designed 5 main archetypes of PPPs that SOCIO-BEE may implement in the future.

1. **City-Wide PPP:** A collaboration between SOCIO-BEE, government agencies, and corporations to fund large-scale AQ monitoring and citizen engagement initiatives.
2. **School-Centric PPP:** This initiative is designed to engage students, educators, and the broader community in active participation and awareness of air quality issues, leveraging the educational environment to foster informed future citizens.
3. **Community Centre PPP:** Collaboration with local community centres and nonprofits to deploy AQ monitoring equipment and educational resources tailored for community engagement.
4. **Corporate Sponsorship PPP:** Partnering with corporations in sectors such as transportation, energy, and manufacturing to sponsor air quality monitoring projects, while enhancing their CSR profiles.
5. **University Research PPP:** Collaborating with universities to conduct research on air quality and citizen science, enhancing the academic study of air pollution while benefiting local communities.

The main aspects of those PPP archetypes are summarized in Table 7. **Disclaimer: The costs reported in Table 7 are estimations based on the market conditions at the time of authoring this deliverable. The SOCIO-BEE consortium retains the right to negotiate prices and recalculate the estimated costs based on any market updates and the personnel-hour rate.**

Table 7: Main aspects of SOCIO-BEE's PPP archetypes.

Scheme	Target clients	Total cost	Contributions	Features
City-Wide	Municipalities, Corporations, Local Governments	[redacted]	• Municipality covers 40% • Private corporation (e.g., transport, energy sector) covers 40% • SOCIO-BEE covers 20% through grants or operational investments	• Full deployment of SOCIO-BEE platform across the city • Integration with existing municipal systems for environmental data monitoring • Co-creation and citizen engagement tools and support for public campaigns • Tailored analytics and environmental impact reports for all partners. • Deployment of 400 sensor devices
School-Centric	School networks, teachers, and students	[redacted]	• Municipality covers 30% • Private sector (local businesses or national companies) covers 50% • SOCIO-BEE covers 20% through grants or operational investments	• Deployment of SOCIO-BEE sensors and tools in 5-10 schools • Educational programs for students and teachers • Co-branded campaigns between the municipality, private partner, and SOCIO-BEE.
Community Centre Partnership Program	Community Centres, Local Nonprofits	[redacted]	• Community centre covers 20% • Local nonprofits or businesses cover 40% • SOCIO-BEE covers 40% through grants or operational investments	• Workshops and seminars on AQ awareness • Development of local campaigns to promote clean air initiatives and citizen science participation • Deployment of 60 sensor devices
Corporate Sponsorship Initiative	Corporations in Pollution-Heavy Industries	[redacted] (for multiple corporate sponsorships)	• Corporations cover 70% • Municipalities or local governments cover 20% • SOCIO-BEE covers 10% through grants or operational investments	• Deployment of air quality monitoring sensors in industrial areas (at least 300, the total number is negotiable depending on needs) • Co-branded reports on environmental impact for corporate sponsors • Engagement programs involving employees in

				local monitoring and community education
University Research Partnership	Academic Institutions	[redacted]	• Universities cover 50% through research funds • Local governments cover 30% • SOCIO-BEE covers 20% through grants or operational investments	• Joint research projects that analyse AQ data collected by SOCIO-BEE • Deployment of at least 100 sensors (negotiable depending on needs) • Development of internship programs for students to participate in monitoring efforts • Public seminars showcasing research findings and community engagement strategies

6 Performance parameters identification

This section focuses on identifying key performance parameters to assess the financial sustainability and impact of SOCIO-BEE's financing strategies. It provides stakeholders with a framework for measuring the effectiveness, efficiency, and outcomes of different financing models, enabling informed decision-making and continuous improvement.

6.1 Key Performance Indicators (KPIs) for assessing financial sustainability

To evaluate SOCIO-BEE's financial sustainability over time, a set of KPIs is established. These KPIs will serve as specific metrics related to various aspects of financial performance, providing stakeholders with a comprehensive tool for monitoring and managing resources effectively. The proposed KPIs include:

Revenue generation:

- **Total revenue**: Measures overall income from various sources, including grants, partnerships, and private financing.
- **Revenue growth rate**: Tracks the percentage increase in revenue year-over-year to assess financial growth trends.

Cost efficiency:

- **Cost per project**: Evaluates the average expenditure for each project undertaken by SOCIO-BEE, helping to identify areas for cost reduction.
- **Operational efficiency ratio**: Compares total operational costs to total revenue, aiming for a lower ratio to indicate greater efficiency.

Resource allocation:

- **Percentage of budget allocated to program services**: Measures the portion of the budget dedicated to direct service delivery versus administrative expenses, ensuring funds are utilized effectively.
- **Funding diversity index**: Assesses the variety of funding sources (e.g., grants, donations, private investments), with a higher index indicating reduced financial risk through diversification.

Long-term viability:

- **Net assets ratio**: Compares total assets to total liabilities, indicating financial stability and the capacity to sustain operations.
- **Liquidity ratio**: Measures the organization's ability to meet short-term obligations, ensuring sufficient cash flow for ongoing activities.

These KPIs will provide stakeholders with actionable insights into any project's financial health, enabling proactive management and strategic planning to enhance long-term sustainability.

6.2 Metrics for Evaluating the Impact of Financing Strategies

In addition to financial sustainability, it is crucial to assess the impact of SOCIO-BEE's financing strategies on project outcomes, stakeholder engagement, and community empowerment. The following metrics will be utilized to measure both qualitative and quantitative indicators:

Project outcomes:

- **Impact assessment score**: A composite score evaluating the effectiveness of projects in achieving intended environmental and social outcomes, based on pre-defined criteria.
- **Reduction in air pollution levels**: Quantifies changes in AQ metrics (e.g., $PM_{2.5}$, NO_2 levels) attributable to the project's initiatives.

Stakeholder engagement:

- **Participant satisfaction rate**: Measures the percentage of stakeholders who report satisfaction with their engagement and participation in the project's activities.
- **Engagement growth rate**: Tracks the increase in active participants over time, reflecting the success of outreach and engagement efforts.

Community empowerment:

- **Community knowledge improvement index**: Assesses changes in community awareness and understanding of AQ issues before and after participation in SOCIO-BEE initiatives.
- **Policy influence score**: It evaluates the extent to which SOCIO-BEE's findings and campaigns have influenced local environmental policies or regulations.

Social, environmental, and economic benefits:

- **Cost-Benefit ratio**: Compares the economic benefits generated (e.g., healthcare cost savings from improved air quality) against the costs incurred to implement financing strategies.
- **Return on Investment (ROI)**: Measures the financial return relative to the investments made in projects, providing a clear indication of the economic impact of the project's initiatives.

7 Guidelines for Financing Strategies

This section presents guidelines and recommendations for implementing financing models within the SOCIO-BEE framework. It distils insights from Task 7.3's research and analysis into actionable guidance for project stakeholders, providing practical advice on designing, implementing, and managing financing strategies to support SOCIO-BEE's mission and objectives.

7.1 Recommendations for Implementing Financing Models

To effectively implement financing models, stakeholders should consider the following recommendations:

Conduct a thorough needs assessment:

- Begin by identifying the specific financial needs and objectives of your project. This includes assessing project costs, required resources, and potential funding gaps.
- Engage stakeholders in the assessment process to ensure that all perspectives and needs are considered.

Diversify funding sources:

- Explore multiple funding avenues, including private investments, public grants, corporate sponsorships, and crowdfunding. Diversification reduces reliance on a single source and enhances financial stability.
- Establish partnerships with various organisations, including NGOs, government agencies, and private companies, to tap into different funding streams.

Leverage Public-Private Partnerships (PPPs):

- Utilise PPPs to enhance resource availability and expertise. Collaborate with public sector agencies to co-create projects that align with both public interests and your project's objectives.
- Develop clear frameworks and agreements that define roles, responsibilities, and funding contributions from each partner.

Create a transparent funding model:

- Implement a transparent financial management system that allows for the tracking of funds, expenditures, and outcomes to build trust among stakeholders and funders.
- Regularly report on financial performance and project impact to demonstrate accountability and secure ongoing support.

Engage the community:

- Foster community involvement through awareness campaigns and participatory activities. Engaging citizens can lead to grassroots funding and enhance project visibility.
- Encourage citizen participation in fundraising initiatives, which can amplify outreach and attract additional support.

Monitor and evaluate financial performance:

- Establish a set of KPIs to monitor financial sustainability and impact. This enables ongoing assessment and adjustment of financing strategies as needed.
- Regularly evaluate the effectiveness of different financing models and be willing to pivot based on data-driven insights.

7.2 Best Practices and Lessons Learned from Task 7.3

Through Task 7.3's research and analysis, several best practices and lessons learned have emerged that can inform the implementation of financing strategies for SOCIO-BEE, as well as other similar projects:

Collaboration is key:

- Successful financing strategies often stem from strong partnerships among stakeholders. Collaborative efforts increase resource sharing, knowledge exchange, and funding opportunities.
- Engage early with potential partners to build relationships and align goals.

Tailor financing solutions to context:

- Different financing models may be more effective depending on the local context, including socio-economic conditions and regulatory environments. Tailoring strategies ensure greater relevance and impact.
- Conduct localised research to understand community needs and preferences before finalising funding approaches.

Emphasise impact and accountability:

- Funders are increasingly focused on measurable outcomes and social impact. Articulating a clear value proposition and demonstrating accountability through regular reporting can enhance funding success.
- Use qualitative and quantitative metrics to convey the impact of your initiatives effectively.

Innovate funding approaches:

- Explore innovative financing mechanisms such as social bonds, green bonds, and impact investing, which align financial returns with social and environmental benefits.
- Stay updated on emerging trends in sustainable finance to identify new opportunities for funding.

Address challenges proactively:

- Identify potential challenges early in the financing process, such as regulatory hurdles or stakeholder resistance. Developing strategies to address these challenges can mitigate risks and enhance the likelihood of success.
- Foster open communication and engagement with all stakeholders to pre-emptively resolve conflicts and build consensus.

Iterate and adapt:

- Financing strategies should not be static; instead, they must evolve based on lessons learned, stakeholder feedback, and changing conditions. Emphasise a culture of continuous improvement and adaptability.
- Regularly revisit and refine financing models to ensure they remain aligned with SOCIO-BEE's goals and the broader context in which it operates.

8 Transferability to other citizen science projects

This section explores the transferability of SOCIO-BEE's financing strategies to other CS projects and initiatives. It identifies considerations for adapting SOCIO-BEE's financing guidelines to different contexts, including project scale, geographic location, and stakeholder preferences. Furthermore, it discusses potential applications of SOCIO-BEE's financing models in diverse settings.

8.1 Considerations for adapting financing strategies to different contexts

When considering the transferability of SOCIO-BEE's financing strategies to other CS projects, several contextual factors must be considered:

Regulatory environments:

- Different regions have varying laws and regulations that govern funding and resource allocation for CS projects. Understanding local legal frameworks is crucial for designing financing strategies that comply with regulations and leverage available public resources.
- Engage with legal experts or local authorities to navigate regulatory requirements and ensure the financing model is sustainable and compliant.

Cultural norms and values:

- Cultural attitudes towards CS, environmental issues, and public engagement can significantly influence project design and funding approaches. Tailoring communication and outreach strategies to align with local cultural values can enhance community buy-in and participation.
- Consider conducting focus groups or surveys to gather insights on local perspectives and preferences, ensuring that financing strategies resonate with community values.

Resource availability:

- The availability of financial, human, and technological resources can vary widely across regions. Projects in resource-rich environments may have access to diverse funding sources, while those in underserved areas may face constraints.
- Assess the local resource landscape and identify potential collaborators, including NGOs, local businesses, and academic institutions, to pool resources and share expertise.

Project scale and scope:

- The size and complexity of CS initiatives can impact the suitability of specific financing strategies. Larger projects may require more sophisticated funding arrangements, while smaller initiatives might benefit from simplified models.
- Evaluate the project's objectives, target audience, and anticipated outcomes to determine the most appropriate financing structures, ensuring they are scalable and adaptable.

Stakeholder preferences:

- Engaging stakeholders, including community members, local organisations, and funding bodies, in the financing strategy development process can ensure that their needs and preferences are considered. This collaborative approach fosters a sense of ownership and accountability.
- Utilise participatory approaches to gather input and feedback from stakeholders, enabling them to shape financing strategies that reflect their interests and priorities.

8.2 Potential Applications of SOCIO-BEE's Financing Guidelines

SOCIO-BEE's financing guidelines have the potential to inform and inspire various CS initiatives, social enterprises, and community-driven projects:

Citizen Science Initiatives:

- Other CS projects can adopt SOCIO-BEE's financing models, leveraging similar strategies for community engagement and resource mobilisation. For instance, using social bonds or impact investing can attract funding while demonstrating social and environmental outcomes.
- By adapting these financing strategies to their unique contexts, CS initiatives can enhance their sustainability and expand their reach, ultimately increasing their impact.

Social enterprises:

- Social enterprises focused on environmental sustainability and community well-being can benefit from SOCIO-BEE's financing approaches. These models can help align business goals with social objectives, enabling enterprises to secure funding while creating positive community impact.
- Integrating CS elements into social enterprise operations can enhance engagement and transparency, fostering trust and collaboration among stakeholders.

Community-Driven projects:

- Community organisations and grassroots initiatives can utilise SOCIO-BEE's guidelines to structure their financing strategies effectively. By incorporating local knowledge and addressing community needs, these projects can mobilise resources and support from within the community.
- Sharing best practices and lessons learned from SOCIO-BEE can empower community leaders to implement innovative financing solutions, driving social and environmental change at the local level.

Collaboration across sectors:

- SOCIO-BEE's experiences can encourage collaboration among diverse stakeholders (including public agencies, private sector actors, and civil society organisations) to develop holistic financing strategies that address complex societal challenges.
- SOCIO-BEE can facilitate knowledge exchange and resource sharing, ultimately fostering a collaborative ecosystem for CS and social innovation.

9 Conclusions

SOCIO-BEE has identified a framework for advancing AQ monitoring and citizen engagement through various financing strategies and partnership models. Key findings from this deliverable highlight the importance of PPPs, private financing instruments, and collaboration with public sector entities in achieving sustainable impact.

The exploration of different financing mechanisms, including grants, social bonds, and green bonds, underscores the diverse opportunities available for funding AQ initiatives. The analysis reveals that while there is a significant demand for resources to address AQ issues, existing funding remains highly concentrated, particularly in certain geographic areas. Effective strategies for SOCIO-BEE involve:

Leveraging PPPs:

- Engaging municipalities and private sector partners in city-wide and school-centric PPP models to fund comprehensive air quality monitoring solutions.

Exploring private financing options:

- Utilizing instruments such as social bonds and crowdfunding platforms to attract private investments for CS projects.

Creating a strong value proposition:

- Offering tailored services and educational programs that enhance community participation, thus increasing the initiative's attractiveness to potential funders and partners.

Monitoring performance:

- Establishing KPIs and impact metrics to track the effectiveness of financing strategies, thereby ensuring accountability and demonstrating outcomes to stakeholders.

Thank you for reading!

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