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Habitable Air HLPF Policy Brief: Enhancing Community-Level Air Quality Monitoring

UNIVERSITY OF BERGEN

HABITABLE AIR

Executive Summary **This policy brief advocates further integration of accurate and durable low-cost air quality sensors in community-level monitoring to address environmental and climate justice and public health issues. These low-cost air quality sensors should interface and supplement with regulatory monitoring but not replace it. It highlights the need for updated regulatory frameworks within and across nation states in light of new technologies and scientific knowledge, and stronger community involvement to ensure equitable and effective air quality management.**

Recommendations

1. **Policy Updates:**
   - Incorporate Low-Cost Sensors: Revise regulatory frameworks to include data from approved low-cost sensors in air quality assessments and decision-making.
   - Localised Standards: Develop air quality standards at the neighbourhood level, ensuring vulnerable communities receive adequate protection.
2. **Community Training and Resources:**
   - Capacity Building: Provide training on the effective use of air quality monitoring technologies.
   - Data Literacy: Educate communities on interpreting air quality data to advocate for policy changes.
3. **Data Privacy and Protection:**
   - Anonymised Data Collection: Ensure community monitoring data is anonymised to protect privacy.
   - Transparent Data Sharing: Establish clear protocols for data sharing among communities, researchers, and regulators to build trust and collaboration.
4. **Standardisation and Certification:** Develop standardised procedures for low-cost sensor data to enhance credibility. Ensure residents can report somatic responses, such as seeing, smelling, or feeling pollution, through accessible resources like hotlines or maps, and treat these reports as valid scientific and legal evidence.
5. **Support for Large-Scale Monitoring:** Invest in the widespread, highly localised deployment of low-cost sensors to create a robust network for reliable regulatory data.

Background

Air pollution poses a significant and persistent threat to public health, economic productivity, and environmental quality. Disparities in exposure to air pollutants exacerbate existing social inequities, making this a critical issue for contemporary local, cross-regional and cross-border governance, which in turn all have national implications (Bullard 1993). While existing regulatory frameworks have progressed, they often fail to address highly localised pollution and pollution hotspots and protect vulnerable communities.

Recent advancements in low-cost air quality sensor technologies offer unprecedented opportunities for granular monitoring and community-level datWa generation. Our research project, 'Habitable Air: Urban Inequality in the Time of Climate Change,' conducted an air monitoring pilot study in Germany, South Africa, and the USA. Preliminary findings were presented at the UN High-Level Political Forum on Sustainable Development (HLPF) in July 2024. The project hosted an official side event titled 'Measuring and Monitoring Community-Level Emissions: Scalable Qualitative Solutions toward SDGs #1 and #13,' featuring panellists from government, academia, community leaders, and technology innovators. A closed-door policy discussion followed, leading to the development of this policy brief.

Policy Context and Case Studies

United States: The Clean Air Act is insufficient to address neighbourhood-level pollution, for example, in so-called "fenceline communities" in Louisiana. Residents living near industrial plants experience higher rates of respiratory illnesses and cancers, often referred to as "Cancer Alley"

(Landrigan et al. 2018). Despite de jure legal protections, these communities continue to suffer from air pollution due to regulatory gaps. In Louisiana, low-cost sensors have provided publicly available and accessible data to ordinary citizens in real-time in contrast to the emissions reports from petrochemical plants. Community-driven monitoring has brought attention to the discrepancies between industry-reported data, government data, and localised community-level air quality. There is a demand among citizens in that region for increased regulatory scrutiny and enforcement actions. This policy brief supports past efforts by the federal government to expand funding for accurate and reliable community-based air monitoring but also reasserts the importance of energy transition and the need to shore up legal protections as well as to expand and refine air monitoring.

South Africa: Industrial emissions significantly impact neighbouring communities, leading to high rates of respiratory diseases (Frazenburg, Sepadi, and Chitakira 2025). The lack of robust regulatory frameworks and inadequate enforcement of existing legislation exacerbates these issues, making it difficult for these communities to advocate for their right to clean air. The South African Constitution enshrines the "right to a clean environment" (Section 24), which is an important protection. However, the practical application of this right is still being tested in the courts. Historical pollution, often driven by the mining, energy, and shipping industries, has caused long-term health impacts on local communities. Despite significant environmental degradation and plans to decarbonise, regulatory action has been slow. This highlights the need for continuous and comprehensive monitoring to ensure accountability and compensation, particularly as South Africa seeks to transition to a sustainable economy.

Germany: In Germany, the energy transition away from carbon-intensive energy sources requires updated cross-border monitoring policies to ensure community health and safety from both new and historic sources of air pollution. Despite stringent national regulations, which are notably

more rigorous than those in the U.S. (Wing 2024), significant monitoring gaps persist in industrial areas. While public monitoring networks exist at pollution hotspots, they often fail to measure all relevant pollutants and lack sufficient spatial density for continuous localised assessment, leaving fenceline communities vulnerable to health risks (Hodges 2024). Regulatory frameworks frequently rely on mean values rather than capturing dangerous peak concentrations, and face challenges from temporary exceptions like Germany's LNG Acceleration Act. Cross-border sources of pollution remain particularly under-monitored, highlighting the need for improved oversight. As Germany shifts from coal to renewables and LNG, community-level monitoring has revealed gaps in regulatory oversight within supply chains connecting Germany to external energy and industrial sources. Localised air quality data has been instrumental in advocating for stricter emissions controls and more transparent reporting from industrial facilities.

Analysis: Challenges, Opportunities, and Metrics for Success

Technological Empowerment and Public Perception

Leading low-cost air quality sensors offer significant potential to empower communities by providing real-time data on local pollution levels. While weather apps and websites provide AQI readings, they often lack the precision needed for localised monitoring. These sensors enable grassroots communities, especially those near industrial sites and petrochemical plants, to identify pollution hotspots and advocate for regulatory action. However, integrating these sensors into formal regulatory frameworks faces challenges

due to concerns over data accuracy and legal defensibility. Public perception also poses a barrier; scepticism about the validity of sensor data and political polarisation around environmental issues can undermine community-driven monitoring efforts.

To address these challenges, governments need to standardise sensor data collection and certification processes across borders, enhancing credibility and fostering broader acceptance in policymaking. This standardisation will ensure that localised monitoring efforts are both accurate and reliable, making them integral to effective cross-border environmental management.

Regulatory Gaps and the Need for Localised Standards

Existing regulatory frameworks often fail to address the specific needs of communities living near pollution sources. In the United States, broad national standards overlook highly localised pollution, leaving marginalised communities unprotected. For instance, with rapidly changing energy sectors, communities near pollution sites and along supply chains, such as near ports, suffer from present-day effects of pollution. These gaps highlight the need for developing localised air quality standards that can more effectively target pollution in specific neighbourhoods. Implementing such standards would ensure that vulnerable populations are adequately protected.

Community Involvement and Sustaining Engagement

Although air monitoring should not be the sole responsibility of ordinary citizens, community-driven data can be vital to enhancing the accuracy and relevance of air quality monitoring. Communities possess unique knowledge and insights into local pollution sources and impacts, making their involvement crucial for effective monitoring programmes and air monitoring design. However, sustaining long-term community engagement is challenging, especially when current policies limit the use of sensor data in regulatory processes. To address this, investments in community training and resources are necessary. By improving data literacy and providing tools for effective advocacy, communities can maintain their involvement and drive meaningful policy changes.

Opportunities for Scale and Robust Data Collection

One of the most promising opportunities lies in the widespread deployment of low-cost sensors. Expanding these monitoring efforts, if accurate and durable, can significantly enhance the robustness of the data collected, providing a more comprehensive picture of air quality across entire regions. In South Africa, the U.S., and Germany, increasing the use of sensors could provide critical evidence to challenge harmful polluters and protect public health. The broader and more reliable the data, the harder it becomes for detractors to dismiss community-driven findings, thus reinforcing the credibility of such initiatives.

Implementation Challenges: Regulatory Hurdles and Data Privacy

Regulatory agencies often resist incorporating supplemental data sources, like low-cost sensors, into formal decision-making processes due to concerns about accuracy and potential legal challenges. At times, the scientific and technological advancements happen faster than it is possible to make regulatory changes. This resistance is particularly pronounced in regions with strong industrial interests, where agencies may face pressure to disregard data that could lead to stricter regulations. Overcoming these hurdles requires the development of standardised procedures for data collection and documentation, ensuring that sensor data is scientifically valid and legally defensible. Additionally, protecting the privacy of individuals and communities involved in monitoring efforts is crucial. Establishing transparent data-sharing protocols will build trust among stakeholders and encourage broader participation in environmental monitoring.

Metrics for Success

The success of community-driven air quality monitoring initiatives can be measured through several key metrics:

- Air Quality Improvement: A measurable reduction in pollutant levels in monitored communities, indicating the effectiveness of monitoring and regulatory interventions.
- Health Outcomes: A decrease in respiratory and cardiovascular diseases linked to air pollution, demonstrating the public health benefits of improved air quality management.
- Community Participation: Increased engagement in monitoring and advocacy efforts, reflecting the sustainability and impact of community involvement.
- Policy Changes: The adoption of new regulations that incorporate community-driven data, signalling the successful integration of non-traditional data sources into formal air quality management frameworks.

Conclusion

To create equitable and effective air quality monitoring systems, it is imperative to update policies and provide communities with the necessary technology. This approach addresses immediate public health concerns and contributes to broader goals of environmental and climate justice and sustainable development. By overcoming regulatory hurdles, improving ways for the public to engage in design and planning for air monitoring, and generally expanding monitoring efforts to address highly localised air pollution, low-cost air quality sensors can become a powerful tool in ensuring that all communities, regardless of socioeconomic status, are protected from the harmful effects of air pollution. Collaboration across sectors – policymakers, academia, communities, and the private sector – as well as sustained investment, and a commitment to placing communities at the centre of air quality management are essential to realising this vision – with governments and directly impacted communities playing a pivotal role.

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