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# Locative Audio Cartography for Sustainability Education: A Case Study in Green Stormwater Infrastructure

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**Abstract:**

This research explores how locative audio can extend the primarily visual cartographic practices to support environmental education, sustainability awareness, and community resilience. *Locative audio*, supported by mobile devices' GPS and spatial sensors, delivers sounds as users move through space (Behrendt, 2015; Indans et al., 2019). Through immersive, sound-based storytelling, locative audio redefines how people encounter space, transforming routine movement through a space into an active learning experience, while also improving accessibility and safety by reducing the need for continuous visual attention (D'Ignazio & Klein, 2016; Roth et al., 2018).

We developed a locative audio walking tour in Shorewood, Wisconsin, as a case study to inform the public about *green stormwater infrastructure* (GSI), nature-based practices that capture and treat stormwater directly at the source (McFarland et al., 2019). These practices offer an environmentally and economically sustainable alternative to conventional gray infrastructure in urban areas addressing flooding, runoff pollution, and ecosystem degradation while strengthening long-term resilience (Chinni et al., 2017; Meerow & Newell, 2017). Given that GSI implementation is a complex sociotechnical system predicated on iterative policy and community participation, overcoming the barrier of public knowledge gap is essential for cumulative environmental benefits (Chinni et al., 2017; Ureta et al., 2021).

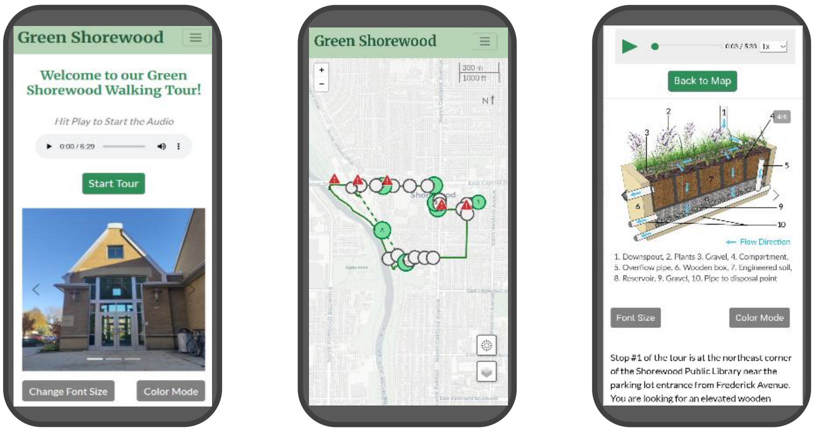


Figure 1. Green Shorewood locative audio tour interface, showing the home screen, interactive map, and stop-level educational content (*https://ntnawshin.github.io/Shorewood-Walking-Tour/*)

Using a user-centered, iterative design process, we built an open-source web app with Leaflet.js that integrates maps, images, and GPS-triggered audio narration (Figure 1). Expert and user feedback informed design cycles to improve usability by synchronizing audio with walking pace and crafting a reflective, narrative flow rather than passive listening (Nawshin et al., forthcoming). The app translates technical GSI concepts such as water-quantity control, pollution removal, and ecosystem co-benefits into relatable, place-based stories for non-experts (McFarland et al., 2019; Meerow & Newell, 2017).


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Our final prototype includes ten stops, each highlighting a distinct GSI practice that illustrates how sustainability operates across multiple spatial scales. Household practices such as *planter boxes, rain barrels,* and *rain gardens* demonstrate how individuals can capture runoff and improve local drainage. For instance, the planter boxes at Shorewood Public Library alone hold over 350 gallons of rainwater, while two rain barrels at Department of Public Works have a combined capacity of 10,000 gallons. Neighborhood-scale systems, including *bioswales, biofiltration structures*, and *permeable pavement* manage runoff from large, paved urban areas like parking lots and major thoroughfares, collectively mitigating flood risk. Community-ecosystem features, such as *stormwater trees, urban gardens and farms, nature corridors*, and *gabions* promote biodiversity, reduce heat-island effect, stabilize riverbanks and prevent erosion improving both ecological health and neighbourhood liveability. Together, these practices form a network of interconnected, nature-based solutions reshaping dense urban landscapes.

Each narration in our tour follows a consistent pedagogical arc: orienting the listener, introducing a quantifiable “hook” with concrete, memorable data, contrasting the gray infrastructure issues with the environmental or social co-benefits of green infrastructure and concluding each narration with a critical thinking or agency prompt that encourages listeners to reflect on what they learned and inviting personal action, aligning with the principles of place-based stewardship education (Great Lakes Stewardship Initiative 2016).

Figure 2. Participants walking the tour and engaging with the physical practices

To evaluate usability and educational impact, we conducted a user experience study in June–July 2025 with 18 participants aged 20–77 (Figure 2). Each completed the tour independently and responded to a post-tour survey. The results revealed a range of positive outcomes with all 18 participants describing the tour as educational and engaging, often noting the novelty of learning through sound. Key outcomes included:

• **Improved understanding** of stormwater systems and GSI’s role in reducing runoff and flooding;
• **Deeper insight** into past extreme flooding events and Shorewood’s proactive mitigation efforts;
• **Recognition** of previously overlooked features, such as biofiltration structures, stormwater trees, etc;
• **Systems thinking** linking small-scale household practices to broader watershed impacts; and
• **Motivation for action**, with several participants intending to install practices at home or join community initiatives.

These findings confirm that experiential sound mapping can foster empathy, understanding, and stewardship, moving beyond information-sharing toward active engagement. Feedback also suggested shorter or segmented narration to ease cognitive load, a refinement planned for future versions.

Moving forward, we aim to enhance accessibility, GPS precision, and audio pacing, integrate community voices, and collaborate with educators and local partners to support pedagogical goals for a multidisciplinary audience (Johnson et al., 2019). Adapting this framework for other regions such as small-island communities where land and water management are tightly linked and data scarcity constrains traditional mapping (Kaur & Gupta, 2022), will test its global transferability. The approach complements data-intensive GIS models by providing an accessible, qualitative means of capturing community perspectives which is essential for resilient planning cycles (Meerow & Newell, 2017).

This work demonstrates how blending cartography and sound can make environmental knowledge tangible and participatory. By situating sustainability learning within lived landscapes, locative audio transforms maps into experiences that cultivate belonging, care, and shared responsibility, advancing mobile cartography as a scalable tool for sustainability education and community resilience worldwide.

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