

RESEARCH ARTICLE

# Operationalizing accessibility in environmental sustainability efforts: Challenges, barriers, and opportunities

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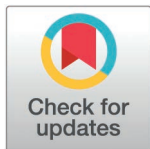
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## Abstract

There is growing recognition of the need to move towards climate justice in response to the climate crisis; that is, ensuring mitigation and adaptation responses centre equity, and promote the inclusion of marginalized or otherwise ‘equity-deserving’ groups, including people with disabilities. Despite this recognition, there is little empirical research exploring the intersection of disability in sustainable developments, and even less addressing the practical challenges and opportunities to operationalize a sustainability-accessibility mindset within existing organizations. Drawing from a systems perspective and the human rights model of disability as well as an empirical case study, this paper explores practical challenges and considerations of integrating accessibility into environmental sustainability projects through a critical reflection of our own experiences implementing a tactile and visual information system for multi-stream waste disposal units in public spaces. This article presents an illustrative example of the challenges and barriers of bureaucracy, corporate structures, and the shift of mental models that need to be considered in the implementation of promoting the inclusion of visually impaired individuals. We argue for an intersectional approach to environmental sustainability that addresses these challenges and barriers, and that is compatible with the disability rights motto, “Nothing about us without us” and the need for inclusive design for collaborative impact.

## Introduction

There is growing recognition of the need to move towards climate justice in response to the climate crisis; that is, ensuring mitigation and adaptation responses centre

restrictions on the sharing data that includes potentially identifying information and the confidentiality agreement with the focus group participants. The Wilfrid Laurier Research Ethics Board may be contacted with inquiries about those data at [reb@wlu.ca](mailto:reb@wlu.ca).

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**Competing interests:** One research partner and co-author, HS, was the founder and CEO of STIL Solutions, the social enterprise whose products were utilized in the research project discussed in this paper. Therefore, co-author HS had potential business and/or financial interest in this research and its potential outcomes. After the research concluded and at the time of writing this manuscript, STIL Solutions has closed down and the business is no longer operational. In addition, while HS was consulted on key aspects of the research, the Principal Investigator made all final research-related decisions. All data were independently analysed by the university-based research team and the manuscript was drafted by the university-based researchers. HS was provided the opportunity to provide feedback and editorial suggestions.

equity, and promote the inclusion of marginalized or otherwise ‘equity-deserving’ groups, including people with disabilities [1–5]. The need for a shift towards climate justice is recognized in the 2030 Agenda for Sustainable Development which was adopted by all United Nations (UN) Member States in 2015, including Canada. Disability issues are included in several targets under this agenda such as Sustainable Development Goals (SDGs) 10 and 11, which emphasize the social, economic, and political inclusion of people with disabilities, and creating accessible cities with universal access to safe, inclusive, and green public spaces [6]. The SDGs recognize that inclusion of people with disabilities must go together with strategies that enhance the capacities of structurally excluded, marginalized, or otherwise vulnerable groups to reduce inequality while tackling climate change.

While there has been growing attention given to this issue, ways of understanding and implementing equity and accessibility in the context of local urban sustainability transitions remain underdeveloped [7,8]. Consequently, many public environments remain largely exclusionary and inaccessible for individuals with disabilities [9,10]. For example, local-level policies/bylaws that encourage walking, cycling and public transportation may help to reduce greenhouse gas emissions, however, they may also “reflect assumptions about able [bodied] citizens capable of adopting environmentally friendly behaviors, giving little consideration to the accessibility challenges faced by people with disabilities” [9,11]. In another example, the design of many public waste disposal and recycling units are inaccessible to people with vision impairments because they use visual instructions for waste sorting and disposal (i.e., waste diversion) [8].

While some municipal actors are trying to align their local climate action planning with broad global frameworks that consider the interconnectedness of sustainability issues (e.g., the SDGs) there are challenges to translating these abstract frameworks into concrete local actions [12,13]. Consequently, interconnected issues related to climate action, accessibility, and inclusion are siloed [14,15].

Transforming our social, economic, and political systems to advance inclusive climate justice requires new mental models, more equitable participatory planning and development processes, and innovative inclusive designs [1,12]. The first Innovate4Cities conference, held in 2021, co-hosted by the Global Covenant of Mayors (GCoM) and UN Human Settlements Programme, cited a gap between stated actions and implementation of climate solutions as one of the primary areas for discussion and further research [16]. The report from this conference highlights that to overcome this implementation gap, there is a need to move past siloed approaches to an integrated systems approach (see below), and to shift the mindsets of stakeholders working to address climate change in cities towards systems-thinking [16].

This paper contributes to that discussion by presenting the successes and challenges of implementing an accessible waste diversion project within a municipal community space; we reflect on lessons learned from an integrated systems-thinking and human rights-based approach, including utilizing equitable planning and development processes and inclusive design in our project. Based on the implementation successes and challenges that we faced, we offer recommendations for researchers

interested in conducting similar community-based projects that aim to promote equity and accessibility in the context of local-level sustainability.

In this explorative study we draw from a convergent parallel mixed methods research project including surveys, focus groups and waste audits, before and after installing “WasteFinder” – a multi-stream waste management system that provides both tactile and visual information to assist individuals to sort and dispose of their waste independently and effectively in public spaces (see <https://stilsolutions.ca/products/>). This research project explored the factors that promote and/or hinder participation in waste diversion in public spaces and assessed the impact of WasteFinder on participation in and perceptions of sustainability and on waste sorting behaviour. The present paper, however, goes beyond the findings of the research project, speaking to an empirical and applied understanding of how systems thinking can be mobilized within the context of municipal governance for climate justice and used to enable transformative change. In fact, it is these reflections that we believe are the most valuable contribution of this paper.

### **Interconnected approaches for interconnected challenges—Applying a systems perspective to accessible and sustainable waste management in cities**

Municipal leaders are facing complex challenges in aligning sustainability planning and action within broad global frameworks while adopting an interconnected systems perspective [13]. An integrated systems approach, which allows for the recognition of connections among actors, non-linear effects of complex problems and interventions, and informed feedback mechanisms to strategically implement meaningful change, is increasingly recognized as necessary for addressing these complex challenges [12,17]. Systems approaches have been recognized in domains such as social change [18], development and adaptation pathways [19], urban planning [20], ecosystem management [21], organizational management [22], and more recently, climate governance [23]. This recent embrace of systems perspectives is accompanied by a movement towards a just transformation where humanity’s interdependence with natural ecosystems is recognized, and simultaneously the well-being of all people is met without exceeding the limits of the planetary systems upon which all life depends (i.e., climate justice) [7,24–27]. There is growing recognition that applying an integrated systems perspective to the climate crisis – both understanding it and addressing it – requires “acknowledging the interdependency of social justice, economic wellbeing, and environmental stewardship.” [28,29].

Municipalities and the actors that comprise them play a vital role in climate change mitigation and adaptation, influencing approximately 40% of Canada’s greenhouse gas emissions [30,31]. Municipalities govern climate action directly by wielding jurisdiction over land use planning, inter-city transportation, residential and commercial waste diversion, infrastructure, and buildings, and they work with civil society, other levels of government, and the private sector to develop community-wide responses to climate change [32, 33, 34, 35]. Local authorities, therefore, have dual responsibilities “to transform within their own organisation and to act as a catalyst for transformation locally” [36]. From a systems perspective, local-level transformation should move toward addressing both ecological and social viability in an interconnected way, highlighting the relationship between sustainability and social equity issues [2]. However, too often, environmental initiatives focus narrowly on environmental goals without considering social justice and equity, thus creating an equity gap/deficit [28]. Several examples from the literature demonstrate that popular mitigation and adaptation responses can exacerbate inequities for equity-deserving groups [37]. For example, Teeklucksingh [38] found that racialized immigrants have been excluded from the growing green economy and green jobs in the city of Toronto, Canada, thus contributing to the marginalization of racialized immigrants in the broader labour market.

Among equity-deserving groups, people with disabilities – their experiences, perspectives, and rights – have often been excluded from local-level environmental sustainability initiatives [9,39–41]. For example, there has been a tendency to ignore or insufficiently consider accessibility concerns in the design and construction of sustainable transit, bike lanes, houses, buildings, communities, and neighbourhoods – including a lack of consultation and meaningful inclusion of people with disabilities themselves in local-level planning [11,42–47]. As a result, people with disabilities are often faced with inaccessibility

of built and social environments, which leads to difficulty performing everyday tasks such as intercity transportation and participating in sustainable practices in the community [43,48]. Moreover, people with disabilities are often more vulnerable to the risks and hazards associated with climate change; people with disabilities will also have additional barriers to escape and respond to extreme weather such as floods, heatwaves, and wildfires [39]. These risks and consequences are especially severe for people with disabilities that experience intersecting forms of discrimination and exclusion including women, youth, Indigenous peoples, racialized and 2SLGBTQI+ communities, older people, and other marginalized groups [40,49–51]. It is also predicted that climate change will increase the overall incidence and prevalence of impairments leading to disability due to both disease and injuries that may result from extreme weather events or conflict [49], which further emphasizes the urgent need for addressing the exclusion of people with disabilities from sustainability initiatives.

Municipalities are being urged to address equity gaps and deficits through an approach that centres accessibility and social justice in climate action planning and implementation [1,5,7,52]. Lack of a systems perspective and the absence of actors from equity-deserving groups in decision-making are often the root causes of the equity gaps. One example of this shortcoming is public waste sorting and disposal; the design of many public waste disposal units poses physical and functional barriers for individuals with disabilities to sort and dispose of their waste independently, including the height and width of the disposal unit, the location of openings or lids, and how the streams of waste are differentiated (i.e., with visual signs or clues) [8]. This example can be seen as a microcosm of not including people with disabilities in the design of our sustainability initiatives and more broadly our built social environments [8,48]. Policy makers and practitioners have paid relatively little attention to disability issues in the context of sustainability, rendering the needs of people with disabilities largely “invisible” in climate mitigation and adaptation efforts [9], and highlighting the need for more inclusive practices. Adopting a systems perspective would strengthen municipal systems themselves and the actors that they are comprised of and serve. In municipalities, as systems that connect shared actors through mutual value creation of a good public life and public services, “value is defined as the increase in overall system viability [...] and is co-created by purposeful actors through mutually beneficial collaboration [...]” [12]. In other words, when municipalities focus on collaboration and inclusion of diverse community members (i.e., stakeholders) such as individuals with disabilities and members of other equity-deserving groups, they strengthen the system as a whole. Stronger interconnectedness among diverse actors across the system improves its overall viability, and its value. Key characteristics of service eco-systems are a) that they are nested in multiple layers of other systems (e.g., the municipality within provincial regulatory systems and policies) and contain sub-systems themselves (e.g., organizations of people such as communities); b) that the systems parts are highly interconnected (e.g., green gentrification and lack of affordable housing); c) are emergent because the interactions of these systems layers and components are non-linear and very difficult to predict (e.g., the COVID-19 pandemic and its impact on the implementation of the system featured in this article); and d) their form and emergent properties are fundamentally determined by a multitude of socially generated and relatively durable rules, norms, beliefs, and values (institutions), and interdependent collections of complementary institutions (institutional arrangements) [12]. Moving toward the ecological and social viability and justice of a city therefore requires recognizing and acting adequately upon the complex interactions of actors and other components across all system levels. While easily stated, implementing this in practice is quite challenging because it requires a shift in mental models and a re-alignment of systems components while prioritizing equity and justice, that is, a system transformation.

To better understand this shift in mental models we now present two theoretical perspectives that embody mentalities which contribute to the systems thinking perspective we previously introduced.

## Integration from a theoretical perspective

### Human rights model of disability

The human rights model of disability defines disability in accordance with the UN Convention on the Rights of Persons with Disabilities (UNCRPD) as, “long-term physical, mental, intellectual or sensory impairments which in interaction with

various barriers may hinder [an individual's] full and effective participation in society on an equal basis with others" [53]. The human rights model conceives people with disabilities as diverse rights-bearing citizens and embraces substantive and transformative conceptions of equality that address the physical, economic, institutional, and social barriers that undermine their rights and dignity [54]. This perspective also considers the multiple identities that people with disabilities hold, and intersecting forms of oppression related to their sex, gender, age, race, or other characteristics. Finally, a disability rights perspective focuses on the barriers that people with disabilities face in society and multi-level solutions through which they can be dismantled.

The UNCRPD - which has been ratified by Canada - notes that achieving accessibility involves the identification and elimination of obstacles and barriers in the built environment, and information, communications, and other services. Thus, the inaccessibility of municipal waste sorting and disposal systems undercuts their effectiveness and reinforces social inequities by limiting opportunities for a share of the population to contribute to sustainable practices.

From a disability rights perspective, the motto "Nothing about us without us" is used to communicate that no law, policy, program, or intervention affecting people with disabilities should be decided without the full and direct participation of people with disabilities. The motto expresses the conviction that people with disabilities know what is best for them. The active involvement of diverse people with disabilities in the development of provincial, national, and international policies such as the Accessibility for Ontarians with Disabilities Act (AODA), Accessible Canada Act (ACA) and the UNCRPD are excellent examples of how the principle of full participation can be put into practice. It is important that local-level sustainability and climate action efforts follow these policies as well.

## Inclusive design

Inclusive design integrates equity and diversity in the design process. It is an approach that considers the full range of human diversity with respect to ability, language, culture, gender, age, and other forms of human difference. Inclusively designed spaces and places can be used and enjoyed by all. Our understanding of inclusive design draws from the dimensions articulated at the Inclusive Design Research Centre (IDRC). According to the IDRC website, 'inclusive design' is distinct from 'universal design' which is achieved through a one-size-fits-all approach whereas inclusive design uses a one-size-fits-one approach [55]. The IDRC website suggests that universal design has become associated with a constrained categorization of disabilities, whereas inclusive design stresses the multi-faceted aspects of the individual such that their needs may arise from many factors which all need to be taken into account in the design of any physical or virtual space. However, like universal design principles, inclusive design also aims to design integrated systems that work for everyone, including people with disabilities.

The three dimensions of the inclusive design framework are: 1) to recognize, respect, and design for human uniqueness and variability with an emphasis on self-determination and self-knowledge; 2) use inclusive, open and transparent processes, and co-design with people who have a diversity of perspectives, including people that cannot use or have difficulty using the current environments; and 3) realize that you are designing in a complex adaptive system. Inclusive co-design is an iterative process where at each iteration the design team asks, 'Who is still missing?' The goal is to trigger a cycle of inclusion by leveraging the innovation benefits of designing for needs at the margins.

While there are legal obligations outlined in the AODA, ACA and UNCRPD for municipalities to make adjustments and modifications to improve access for people with disabilities, it is less expensive and more efficient to address considerations of accessibility in the initial concept and design, than to retrofit and incur greater cost later on [56]. The practice of inclusive design offers citizens a way to actively participate in the iterative design and growth of communities that meet their needs.

Kurt Lewin famously stated that nothing is so practical as a good theory [57]. A theory is an explanation and a set of ideas about how something works. It goes beyond what is immediately observable or intuitive. As such, it can provide useful guidance to practitioners, especially for complex challenges such as the integration of equity and accessibility with

climate action. Applying theory adequately in a practice setting, however, is not straight-forward and requires an iterative process of reflection and action. When the rubber (the theory) hits the road (the specific practical context), there can be significant implementation challenges. Below we present our own reflection on the experience in implementing and testing an innovation that is grounded both in a human rights model and reflects the application of inclusive design. We will first present the methods and results of the explorative study followed by our reflections on the challenges in implementing and testing the innovation. We recognize that the empirical study has certain limitations regarding traditional scientific criteria of rigour. However, we do believe there is great value in what we found and it provides important context for our reflection on implementing and testing the innovation.

## Methods

### Ethics statement

All research methods were reviewed and approved by the Wilfrid Laurier University Research Ethics Board under #6518. For the focus group, written signed consent was obtained via email prior to the focus group. For the survey, written consent was obtained either in person if they completed the survey in person or electronically as part of the Qualtrics survey if participants completed it online.

The main purpose of this explorative study was to investigate the user experience and the impact of the WasterFinder system on users of a public community space both with and without disabilities. WasteFinder is a system invented by a person with a visual impairment to make waste sorting in public spaces more inclusive for visually impaired individuals (i.e., WasteFinder; see also Research Context below). The reasoning to target all eligible users of the public space was that from a systems and universal design perspective it is important to ensure the implementation of WasterFinder did not lead to any negative impacts on any of the users and to assess if there may have even been positive impacts on users other than those with visual impairment (e.g., improved perceptions of the inclusiveness of the community space). To explore this experience and impact we used a pre-post convergent parallel mixed methods design including surveys, focus groups, and waste audits. Our research questions were: RQ1) What are the experiences of users (both with and without disabilities) of a municipal community space with the WasterFinder system? RQ2) What are the impacts of the WasteFinder system on users' perceptions of sustainability, inclusivity, and accessibility of the community space? RQ3) What are the impacts of the WasterFinder systems on the waste sorting behaviour of users of the community space?

Given that our study presents the first systematic investigation of the WasterFinder system in a public space and this happened under the specific conditions of the COVID-19 pandemic, a secondary purpose of this research was to gain insight into the implementation process of the WasteFinder system from a systems perspective. As such, a fourth research question (RQ4) was: What is the experience of implementing the WasterFinder system in a public space during the public health restrictions of the COVID-19 pandemic? To answer this question, our team kept notes about the implementation process and engaged in group reflections using a systems perspective while also considering a human rights and inclusive design lens. A description of our observations is included in the result section (see Implementation Observations) while the results of our reflections are embedded throughout the discussion.

### Research context

Our project took place in a mid-sized city in Ontario, Canada from August to November 2021. The city is recognized for their leadership in public engagement, social inclusion, and equity in climate action planning. The project was led in partnership with city staff, researchers from the Viessman Centre for Engagement and Research in Sustainability (VERiS) at Wilfrid Laurier University, and Sustainability Through an Inclusive Lens (STIL) Solutions – a Canadian social enterprise that produces “WasteFinder”. STIL Solutions was founded and is operated by a woman with vision impairment (our co-author HS), to bridge the gap between sustainability and accessibility. WasteFinder is a tactile and visual system that

surrounds the floor area around waste disposal units with “Vicinity Indicators” which let individuals know when they are within a certain distance of the bins. It can be felt distinctly underfoot even when using mobility devices. Once in the vicinity of the waste disposal unit, “Stream Indicators” help the user determine where to place their waste using raised symbols on the floor, so the user never needs to touch a waste disposal unit (i.e., in search of braille or other tactile indicators) or get close enough to the waste disposal unit to read its signs. The Stream Indicators use simple shapes that are easily detected underfoot or through a mobility device. The Stream Indicators are depicted below in [Fig 1](#), [Fig 2](#), [Fig 3](#) and [Fig 4](#) shows the whole WasteFinder including Vicinity and Stream Indicators (Images from the former STIL Solutions website (now closed down): [www.stilsolutions.ca](http://www.stilsolutions.ca)).



**Fig 1. WasteFinder Organic Stream Indicator.**

<https://doi.org/10.1371/journal.pclm.0000486.g001>



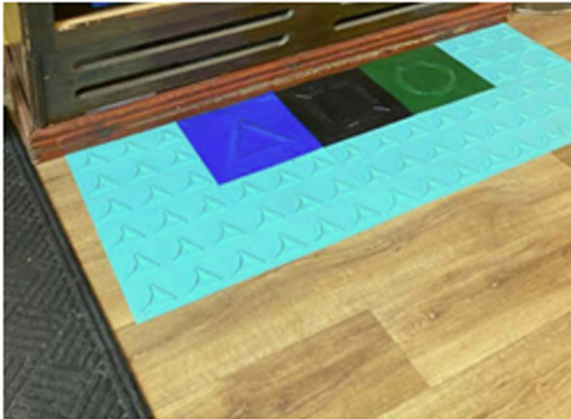
**Fig 2. WasteFinder Garbage Stream Indicator.**

<https://doi.org/10.1371/journal.pclm.0000486.g002>



**Fig 3. WasteFinder Recycling Stream Indicator.**

<https://doi.org/10.1371/journal.pclm.0000486.g003>



**Fig 4. WasteFinder system including three stream indicators and surrounding floor tiles.**

<https://doi.org/10.1371/journal.pclm.0000486.g004>

The partnering city purchased and installed three WasteFinders in a popular community space to explore how they impacted the ability of people with disabilities to participate in waste sorting and disposal as well as how the system impacted community awareness of accessibility and waste sorting behaviour. Prior to and after the installation of the WasteFinders, the research team examined pre- and post- waste diversion behaviours of community members as well as their perceptions and awareness of accessible and sustainable features at the community space. The community space was accessible by bus, public transit, bike, and cars, with accessible parking available. The space inside had two main levels connected by stairs and elevators.

### Research design and approach

For this explorative study we used a convergent parallel mixed methods research design [58], including surveys, focus groups, and waste audits pre- and post-installation of the WasteFinders. The pre-data collection was conducted August to September 2021, and the WasteFinders were installed at the end of September. The post-date collection was conducted approximately one month after the installation, from the end of October to the beginning of November 2021.

We made efforts to align our community-engaged research approach [59] with the “Nothing about us without us” disability rights motto by meeting with STIL Solutions, an accessibility advisory committee, and a non-profit for people living with vision loss on several occasions to inform the research design. We also worked closely with the founder of STIL Solutions and the city during the planning and implementation of the research.

### Procedures

**Pre-Post Surveys.** Pre-installation surveys were collected during the peak hours of the opening time of the public community space on two consecutive Saturdays at the end of August and beginning of September. Post-installation surveys were conducted on two consecutive Saturdays at the end of October and beginning of November. Potential participants were approached by members of the research team (one faculty member, one postdoc, one research associate, and three research assistants; with always at least two people present at a time) and were provided with the option to complete either a paper version immediately on site or take home a flyer to complete the survey online (see Participants). Participants were approached at the second level of the facility in relative proximity to the waste sorting stations.

Pre-installation survey questions aimed to establish a baseline level of awareness and understanding of accessibility and inclusion of sustainability practices at the community space (RQ2). The survey also included a self-report question on their waste-sorting behaviour (RQ3). Post-installation questions aimed to compare self-reports of waste-sorting behaviour

as well as awareness and understanding of accessibility and inclusion post-installation of WasteFinder. In addition, the survey included questions about participants' experience with WasteFinder (RQ1). Participants were also asked to generate an anonymous ID that would allow to link pre-post survey responses, answer some basic demographic questions, and provide their contact information if they wished to participate in a focus group (detailed below). Participants were told that for each completed survey we would be donating \$2 CAD to the Canadian National Institute for the Blind (CNIB).

**Pre-Post Focus Groups.** Focus groups were held online over Zoom and lasted approximately 90 minutes. Prior to starting the focus group conversation, participants were reminded about the confidential nature of the focus group and asked to agree to some basic ground rules. The pre-installation focus group aimed to understand participants' experiences of accessibility and inclusivity of sustainability at the community space both from the perspective of somebody with a disability and those without (RQ2). The post-installation focus group aimed to compare participants experiences with accessibility and sustainability following the installation of WasteFinder (RQ1 and RQ2). Participants received a compensation in form of a 10\$ CAD gift card for each focus group and another \$10 CAD bonus if they attended both focus groups. Findings from the focus groups were used to supplement and compliment findings from the surveys.

**Pre-Post Waste Audits.** To have an objective measure of waste sorting behaviour (RQ3) three waste audits were conducted to assess the level of waste diversion pre- and post- installation of the WasteFinders. The audits measured the weight and composition of each waste stream (i.e., recycling, garbage and compost) at three identified waste disposal units. The first two waste audits established the baseline weight and composition of each of the waste streams prior to the installation of the WasteFinders. The third waste audit measured the weight and composition of the four waste streams following the installation of the WasteFinders. To enable the waste audits, the maintenance staff at the community facility deposited the waste they collected during the day in differently coloured bags (one colour for paper recycling, one for green waste, one for other recycling, and one for landfill waste) in one secured location. Members of the research team trained in waste sorting then conducted the audits and noted on observations sheets any items that were not correctly sorted (e.g., a soda can in the green waster bin) and the weight of each bag.

All procedures were reviewed and approved by our accessibility advisory committee and the research ethics board of the university of the principal investigator (see ethics statement above).

## Participants

**Surveys** Potential participants included all visitors of the community space who were at least 18 years old between August to September (pre-installation) and October to November (post-installation) in 2021. On a typical Saturday, this community space would have approximately 10,000 visitors during the day. However, during the COVID-19 constrictions when this study took place, the capacity was limited to half, and even less people visited the second level where data were collected because of the planned installation of the WasterFinders there. Exact numbers of the target population of eligible participants are not available. Anybody present during the four hours of data collection 18 years and older was eligible to participate.

The pre-installation survey was completed by 106 unique participants, and the post-installation survey by 78 unique participants; only two participants completed the survey at both timepoints, resulting in 184 survey responses completed by a total of 182 unique participants across the pre- and post-installation data collection periods. Demographic variables were relatively comparable across both surveys. Respondents of the pre-installation survey were most likely to be between the ages of 25–39 (43.4%,  $n=46$ ), with the second largest age group being 60+ (24.5%,  $n=26$ ), followed closely by people aged 40–59 (20.8%,  $n=22$ ), then people aged 18–24 (11.3%,  $n=12$ ). The post-installation survey found 29.5% of the sample to be between the ages of 25 and 39 ( $n=23$ ), with the second largest group aged 40–59 (28.2%,  $n=22$ ), followed by people aged 18–24 (20.5%,  $n=16$ ), and 19.2% of the sample aged 60+ ( $n=15$ ). Across both surveys, the majority of participants described themselves as Native English speakers (73% pre-installation,  $n=100$ ; 83.3% post-installation,

n = 78). Pre-installation, 7.9% of survey respondents identified as a person with a disability (n = 101), compared to 12.8% of respondents for the post-installation survey (n = 78).

**Focus Groups.** Focus group participants were recruited among participants in the survey, through local disability groups, and through the networks of the research team. To be eligible they had to be at least 16 years old and a user of the public community space. The aim was to have a mix of people with disabilities and without. Unfortunately, we encountered difficulties in recruiting focus group participants during this time of the pandemic. For the first focus group we had four participants, three of whom were people with disabilities. For the second focus group we had three participants, two of whom had participated in the first focus group, and one new participant, a relative of a person with a visual disability. Given the small sample size, we decided not to collect and report demographic data to protect the confidentiality of the participants. The exception is disability status given the importance of that to the research focus. Despite these low participant numbers, we still find the information shared by the participants still quite valuable in supplementing the information from the surveys and decided to include it ([Table 1](#)).

## Analyses

The survey data were analysed in SAS 9.4 using descriptive statistics (frequency and percentages) to describe the experiences with WasteFinder (RQ1) and, where appropriate, Chi-Square test of difference to assess the impact of the presence of the WasteFinder system on visitors of the community space (RQ2 & 3). This test was selected given that the variables were of categorical nature (dichotomous and ordinal) and the pre- and post-survey samples were independent (with the exception of two individuals) [60]. With the achieved sample sizes (106 and 78 respectively) and an alpha level of .05 there is power of .8 to detect a minimum a difference in proportions between pre- and post-survey samples in the range of .19 to .24 depending on the proportion at the pre-survey (calculated with the statistical software G\*Power 3.1.9.7 [61]).

Qualitative data were analysed by two members of the research team using thematic analysis [62]. For this purpose, the researchers followed the standard steps indicated by Braun and Clarke [62] to familiarize themselves with the data, code the data using both deductive and inductive codes, generate, define, and name themes. The developing themes

**Table 1. Survey & focus group participants.**

| Survey Participants        | Pre-Installation<br>August–September 2021<br>(N = 106) | Post-Installation<br>October–November 2021<br>(N = 78) |
|----------------------------|--------------------------------------------------------|--------------------------------------------------------|
| Age [blank]                | 0 (0.0%)                                               | 2 (2.6%)                                               |
| Age 18–24                  | 12 (11.3%)                                             | 16 (20.5%)                                             |
| Age 25–39                  | 46 (43.4%)                                             | 23 (29.5%)                                             |
| Age 40–59                  | 22 (20.8%)                                             | 22 (28.2%)                                             |
| Age 60+                    | 26 (24.5%)                                             | 15 (19.2%)                                             |
| Native English [blank]     | 5 (4.7%)                                               | 0 (0.0%)                                               |
| Native English Speaker Yes | 100 (94.3%)                                            | 65 (83.3%)                                             |
| Native English Speaker No  | 1 (0.9%)                                               | 13 (16.7%)                                             |
| Disability status [blank]  | 5 (4.7%)                                               | 0 (0.0%)                                               |
| Disability status Yes      | 8 (7.5%)                                               | 10 (12.8%)                                             |
| Disability status No       | 93 (87.7%)                                             | 68 (87.2%)                                             |
| Repeat Participants        | NA                                                     | 2 (2.6%)                                               |
| Focus Group Participants   | September 2021<br>(N = 4)                              | November 2021<br>(N = 3)                               |
| Disability status Yes      | 3                                                      | 2                                                      |
| Repeat Participants        | NA                                                     | 2                                                      |

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were discussed as a research team before being finalized. Overall, we identified three themes. These include *challenges and barriers to implementation and use*, *positive experiences with WasteFinder*, and *recommendations for future implementation*. The themes were then interpreted and merged with the survey results and an integrated mixed-methods write-up was generated and presented in the result section below. Points of contention and areas of convergence between the qualitative and quantitative phases were dissected in the final analysis phase to develop an overall understanding related to our three research questions through integration of data strands [63].

## Results

**RQ1 (experience of users).** Based on post-installation survey responses, 81% (n = 34) of the post-survey respondents reported that they have encountered the WasteFinder sorting system. The majority of these participants (75.8%; n = 25) found the system easy to use; this included participants who self-identified with and without disabilities. All percentages in this section are valid ones (i.e., not counting missing observations). When prompted in the survey, several participants – including those without visual impairments – noted specific features of WasteFinder that made it easy to use, including its colour-coded system, the floor tiles, and the use of additional visual cues/illustrations (i.e., posters with pictures posted by the waste disposal units). Likewise, one focus group participant with low vision liked that they did not need to get their face close to the receptacles to see where to divert their waste. They said, “I don’t have to stick my nose right down there to find something...the domes will tell me.”

Half (50%; n = 17) of the participants who encountered the WasteFinder said it influenced how they sorted their waste. For example, one survey participant said they felt WasteFinder “Forces individuals to sort their waste and become more aware”.

While many survey participants indicated that WasteFinder was generally easy to use, participants noted that there was still “[c]onfusion over what materials can be put into different receptacles”. Several survey and focus group participants noted there was not sufficient instructional signage to support them in effectively sorting their waste, and noted issues with existing signage (e.g., “too small, not posted in convenient locations”). Some focus group participants also said there was a need for more accessible information about how to use the WasteFinder system to encourage more usage and awareness of the system. Survey participants also noted that the bins were too high for people in wheelchairs and were difficult to find in the community space. The majority of focus group participants said that these challenges included a lack of way finding indicators or other accessible forms of information sharing (e.g., audible announcements, large print, braille) about the existence and location of the WasteFinder system inside the community space.

Many focus group participants also said that waste receptacles were often placed in crowded areas, possibly to encourage the general public to dispose and divert their waste properly. However, these busy crowded areas around the waste receptacles were a deterrent to users with disabilities because they felt unsafe navigating these spaces or being physically pushed by a crowd of people. As one participant said, “The crowding in general is a deterrent to trying to find the recycling section...I’ve been caught up in a crowd and moved from the spot I was standing because the crowd pushed me to a different place.” This challenge was discussed as something that is not easily solved.

**RQ2 (impacts on perceptions of community space).** The surveys also inquired about perceptions of accessibility and inclusion of sustainability practices at the community space more broadly. The survey asked participants if they were aware of any features in the community space that promoted or encouraged sustainability. In both the pre- and post-installation surveys, approximately half of participants said they were aware of some sustainability features at the community space (47.2%, n = 50 and 50%, n = 39, respectively; difference not significant), with the waste disposal units being the most noted feature in both surveys (mentioned 39 and 32 times respectively). The pre-installation survey (n = 106) also posed the question ‘In your opinion, to what degree has [the community space] met Ontario’s commitment to create an accessible Ontario, as well as promoting accessibility and equitable access to services and facilities?’. Of the respondents, 39.6% (n = 42) said yes or definitely yes. It is possible that the specificity of the phrase “Ontario’s commitment to

create an accessible Ontario” left respondents uncertain about the standards to which we were referring, as indicated by the 46.2% of respondents who answered ‘Neutral/not sure’. In the post-installation survey, we addressed this by changing the wording of the question to “In your opinion, do you feel [the community space] is equally accessible and inclusive to anyone that may visit?”, to which fewer respondents indicated ‘Neutral/not sure’ (25%,  $n = 77$ ). For this question, 59.7% ( $n = 46$ ) said yes or definitely yes. While this difference could be due to the change in the accessibility of the waste system, the lower number in those who were uncertain limits a statistically certain conclusion. Moreover, the majority of focus group participants indicated that the community space has numerous accessibility barriers and risks including a lack of tactile wayfinding floor tiles and accessible information for navigation within the space (e.g., audible announcements, large print and braille signage). Participants indicated that they were not able to easily find the WasteFinder system because of these accessibility challenges and barriers in the larger community space. For example, in the pre-implementation focus group, blind users said they were dissuaded from recycling because of the inaccessibility of waste receptacles.

A similar question asked directly about the accessibility of the waste sorting. Almost two thirds of the participants in the post-survey who had encountered the new waste sorting system (67.7%,  $n = 23$ ; 53.5% of the total sample) agreed the new waste system at the community place was ‘equally easy to use for anyone who may visit the [community space]’; in comparison, only 38.5% ( $n = 40$ ) agreed that the pre-existing waste disposal units were ‘equally easy to use for anyone while 22 individuals (21.2%) disagreed. At the post-survey only 4 individuals disagreed (the remainder were either unsure or had missing responses for this question). A statistical difference test was not conducted in this case because only those who had encountered the new system at the post-survey were asked about it (8 people reported that they had not encountered it). Overall, focus group participants indicated that the implementation of the WasteFinder system had a positive impact on their perceptions of sustainability, inclusivity and accessibility of the community space. Participants expressed appreciation for the development and evaluation of the WasteFinder system as a means toward improving waste diversion and accessibility. One participant said, “when you make it accessible for one group that actually makes it more accessible for everybody”. Participants described the WasteFinder system as a means of raising awareness and an indicator of the importance of making waste diversion accessible to all. Another participant commented, “having these physically present reminders of how to make recycling and garbage disposal accessible [is an] important system and reminder [to] start getting people thinking in this direction”. Likewise, another participant said the WasteFinder system “is something different. People are used to seeing recycling systems, but this looks different. And I think that that raises the profile of recycling...I think that that also spells out something that’s important.”

In addition, focus group participants also discussed the monetary and moral value of the system. They said the WasteFinder System reflects the ideals of equity, and well-being and that “The WasteFinder System is worth the monetary cost. People’s health and well-being, and their inclusion in society is worth what these types of systems may cost in monetary value. So, there is...huge value in equity.”

Focus group participants recognized that educating people on what and how to divert waste is “a long and complicated process”. Regarding this process, one participant said, “The [WasterFinder] tiles were a first step for greater accessibility”. Participants suggested that municipal staff need to be engaged and educated on the system to promote greater implementation and uptake in more municipal spaces. One participant said that considerations of municipal operations is critical to improving sustainability, inclusivity, and accessibility of municipal community spaces. One participant said there is a need to conduct training, “to have the staff aware of the fact that people [with disabilities] want to use their recycling bins. So, I think it does have a lot to do with their operations.”

**RQ3 (impact on waste sorting behaviour)** Participants in both surveys were asked how often they sort their waste in the community space. At the pre-survey, 84.2% ( $n = 85$ ) reported that they ‘always’ or ‘often’ sort their waste while at the post-survey it was 86.7% ( $n = 65$ ), a non-statistical difference.

Several focus group participants observed users without disabilities paying closer attention to their waste diversion when they approached bins with the WasteFinder system. One participant said, “I feel like it slowed people down a bit.

And it made them pause before they just kind of threw something in the garbage.”. Another participant said, “Several people stopped and read the signs, and then connected the signs with the tiles on the floor.”

An analysis of the waste audit also suggests that there may not have been a meaningful change in waste sorting as a result of the installation of WasteFinder by the time of our post-assessment. A total of 151.6 pounds of waste was generated at the community space over the three data collection days. The waste audits found some variability in diversion rates pre- and post-installation. There was an increased rate of compost materials diverted from landfill (26.17% diversion rate relative to 21.59% pre-installation); however, the audit also found a decreased rate of recycling materials diverted from landfill (30.98% diversion rate relative to 39.98% pre-installation). Contamination and capture rates for both compost and recycling systems during pre- and post-installation of WasteFinder were comparable (55.2% pre-installation, and 66.5% post-installation). Moreover, diversion rates for recycling and compost were negligible pre- and post- installation of WasteFinder. Contamination was also present at all three time points and did not differ in a meaningful way.

### Implementation observations

*RQ4 (experience of implementation)* The empirical research produced some interesting findings regarding public perceptions of the accessibility and effectiveness of WasteFinder and the local community space. Below, we reflect on the process of implementing the WasteFinders in an established municipal ‘system’.

At the time of the project’s inception, the city’s sustainability manager, who will subsequently be referred to as the ‘internal project champion’, was essential for sparking the initial partnership between STIL Solutions, the city, and the research team. The champion advocated for the project at the city, including procuring the three WasteFinders, and they ensured the manager of the community space and other relevant staff (e.g., representative from accessibility and inclusion services) were engaged with STIL Solutions and the research team. The city, STIL Solutions, an accessibility advisory committee, a non-profit organization for people living with vision loss, and the research team met on several occasions to inform the implementation of the study.

Prior to installing the WasteFinders, the internal project champion left their employment at the city. At the time, the project had not yet been reassigned to an alternative upper management leader within the municipality and the sustainability management position was not filled until the project was almost complete. In addition, as we later learned, there was no clear internal project plan in place within the city. This left the project somewhat in limbo. The manager at the community location became our main contact so that we could proceed. This manager and their staff were still amenable to the project moving forward, but there was no longer an internal project champion, leaving the roles and responsibilities of the city staff not clearly defined. It was challenging for the manager of the community space to prioritize this project above their existing scope of work, especially with the evolving changes and challenges during the COVID-19 pandemic.

Due to the pandemic (and, to a lesser extent, the loss of our internal project champion), the implementation of the WasteFinders was delayed by several weeks. As part of the agreement between STIL Solutions and the city, the city was responsible for installing the WasteFinders with support from STIL Solutions. Installation included the indicator and stream tiles, as well as an information poster explaining the WasteFinder system. The implementation itself was done by STIL Solutions in partnership with the manager of the community space (i.e., the installation site), as well as their custodial team. The research team supported the implementation. The first WasteFinder was installed by STIL Solutions in August 2021. The second and third WasteFinders were installed in October 2021 by staff at the community space. The manager of the location, with support from the research team, communicated with the custodial staff about the WasteFinders and the objectives of our research project.

The waste disposal units and associated WasteFinders were moved around as needed by staff across the four data collection days. Functionally this was necessary to accommodate capacity limits as the community space adapted to changing COVID-19 pandemic restrictions; however, the original locations of the waste disposal units and WasteFinders were specifically chosen for optimal accessibility for people with disabilities. Further, the system is intended to be

installed and remain in the same location. Waste bin signage was designed to be installed alongside the WasteFinders to ensure that members of the public could dispose of their items in the appropriate bins. These were designed based on pre-installation findings of the most incorrectly disposed of items from the waste audits, and with agreement from city staff, were intended to be posted above the WasteFinders in a more visually accessible location. However, due to communication and coordination logistics, posters were either installed sequentially or not at all. As noted in our research findings, this affected the ability for community members to effectively use the system and dispose of their waste.

These challenges were further exacerbated by the unique historical context in which the WasteFinders were installed. This research was conducted 1.5 years into the COVID-19 pandemic (August 2021), such that implementation of the project required frequent adjustments to abide by public health requirements in the province of Ontario. This required the research team to be ready for implementation, or ready to pause the project, as the health restrictions/safety measures in public spaces changed. This made it difficult to operate according to schedule as well as have adequate intervention and installation time to ensure all intervention pieces were in place for a sufficient amount of time.

## Reflections and discussion

The implementation of WasteFinder in this context provided some important lessons learned for inclusive design of sustainability initiatives. In this section, we will share our reflections on the findings and the implementation context using the theoretical considerations presented above.

### Emergence

Our project was significantly affected by the emergent nature of the COVID-19 pandemic. The implementation of WasteFinders and our data collection process was delayed and interrupted when public spaces were closed as part of province-wide mandates to reduce the spread of COVID-19. The community space in which we were operating was rearranged for health and safety purposes (i.e., to facilitate social distancing) which included moving the waste disposal units. These units were built on wheels, making them easy for city staff to move. It is more difficult, however, to move the WasteFinder floor tiles around once they have been installed; as such, the tiles were not consistently moved with the bins or delayed being installed while waiting for a more stable location to be settled. This likely contributed to our participants noting that the WasteFinder sorting systems were difficult to find. These kinds of emergent responses to the COVID-19 pandemic compounded the existing complex challenges that local governments already faced. Indeed, implementing an initiative that addresses the intersection of sustainability and accessibility/inclusion – specifically an initiative that embraced a systems approach – was already a challenging task for the city and the research team prior to the impact of the COVID-19 pandemic. The emergent interaction of the municipal system itself with other systems (in this instance, the Ontario provincial government system and its associated COVID-19 pandemic public health measures) resulted in additional unforeseen challenges and complications. Our experience speaks to the need for anticipatory system thinking and adjustable planning and processes within the system of interest itself but also considering related systems [12]. Our example highlights the potential unintended consequences of not considering and/or not adapting to the emergent nature of systems – including its interactions with other systems. In our example, emergency response measures that did not adequately consider the needs and priorities of the participation of people with disabilities in public spaces resulted in the failure of the consistent use and maintenance of WasteFinders. Here, we suggest that effective community resilience requires an integrated approach to mitigation and adaption with a clear equity lens.

### System change, not just new technology

Rogers [64] championed the idea that the adoption of innovations requires a complex social process to make it a success. WasteFinder is an important innovation that was carefully developed and tested in its design process; our study,

however, was the first real systematic test of its implementation in a public place. This test was made possible by municipal staff who were well versed in integrated system thinking and saw the value of increasing the accessibility of sustainability solutions in the city. Staff also had previous positive engagements with both the founder of WasteFinder and the lead researcher, which made collaborative work easy. However, the departure of the internal project champion made it apparent that we had taken an insufficient approach to systems thinking. The municipality is a complex system itself with sub-systems, specific organizational structures, rules, and power relationships; we relied heavily on the enthusiasm and support of our champion but did not ensure that this initiative was embedded within the system structure of the municipality in a way that allowed for seamless transition in the case of staff turnover. For example, there was nobody within the corporate leadership who championed this project or even knew about it; further, knowledge dissemination was insufficient among the research team and the maintenance staff at the community space that held the WasteFinders (explained in more detail below). Additionally, there was no clear internal written project plan or an officially signed terms of reference that somebody in an interim or succession role could pick up to easily support the project. Thus, even though we embraced a systems perspective, we failed in adequately understanding the true complexity of the system that we tried to implement the technological innovation within. This is a critical shortcoming in a system that is known to be risk adverse and slow in adopting innovations [65].

### Inclusive design in practice

In many ways, implementation of WasteFinder applied principles of inclusive design. The system was developed by a person with a visual impairment to increase her ability to adequately participate in waste diversion. The system was designed to make waste streaming more inclusive of people with visual impairments and other disabilities while also providing benefits to other, non-disabled, community members. The benefits of an inclusively designed product realized benefits for all. For example, the majority of survey participants – regardless of disability status – reported that they found WasteFinder beneficial and easy to use. The visual cues the tiles provide alert users of the waste units to pay attention to the sorting. This would have been further aided if the informational signage, that the STIL team carefully designed based on the initial waste audit, would have been installed according to plan (this was an implementation challenge and not a design flaw). Here our findings suggest that there is a need to address accessibility from a broader, system level perspective to examine spaces and places to all accessibility challenges and barriers. The WasteFinder system could have been more effective with a more fulsome integration into the community space.

During data collection our research team had many positive conversations with users of the community space about WasteFinder. Our research also triggered conversation with users about accessibility and sustainability at this community space more broadly, which we then shared with the manager. As such, we conclude that there is a clear value for all users in implementing accessible waste diversion and other environmentally sustainable initiatives using an inclusive co-design/universal design.

Moreover, our planning meetings included the municipal sustainability manager, a municipal accessibility/inclusion coordinator, the manager of the community space where WasteFinder was installed, people with disabilities, allies with expertise in accessibility issues, and the research team. However, as we asked ourselves: ‘Who is still missing?’ we found that we did not include senior municipal leaders, or maintenance and operations staff working at the community location. These staff were responsible for the maintenance and movement of waste disposal units but not included in the planning and implementation of the WasteFinders. Our experience has shown that considerations of who is missing in the design of an initiative is relevant to both the outcome (i.e., that the design itself is inclusive) and the implementation process. This includes people at all levels of the organizational hierarchy. We believe that involving more senior leaders within the city, as well as the operations staff at the community space, in the planning process, could have reduced our implementation challenges and promoted sustainability of our initiative. This includes scenario planning for the adjustments that would be necessary to respond to public health measures in the context of a pandemic.

From a systems thinking perspective, we recognize the importance of shifting mindsets or mental models for inclusive, accessible, and just sustainable initiatives [12,66]. We may have oversimplified or even overlooked the complex network of stakeholders within the municipal system and instead focused too much of our efforts and communications towards our internal project champion. While the internal project champion and their leadership was necessary for championing the project, we should have considered leadership and stakeholder networks themselves through a systems perspective [67]. In relation, we believe that we should have invested more time to raise awareness and appreciation for accessibility among municipal staff. It is one thing to simply be told of a new way of doing waste sorting and disposal, but there is additional education required to deeply understand the meaning and importance of accessibility. A deep commitment to values and principles of inclusion are especially critical in times of crisis [68]. Previous research argues that understanding disability rights – including the right to accessibility – is central in all-inclusive COVID-19 and climate change preparedness [3,9]. This commitment could have been further strengthened if this initiative would have been linked to everyday operational processes, key strategic goals of the city and been endorsed officially by top leadership.

## Human rights

Our research resonates with previous literature arguing that municipalities and local governments should identify and pursue synergies between the realization of human rights and sustainability initiatives [2,6,7,36,69]. Much of this literature has focused on racial and socio-economic inequalities [37,70] and there is a dearth of knowledge on the implications of urban sustainability efforts or the efforts to promote the formal and substantive equality of people with disabilities in cities. As local environments move forward with plans toward climate justice, it is critical that we know more about the potential contributions of people with disabilities and the types of practices that can yield transformative change. Without an explicit focus on creating opportunities for persons with disabilities, the goals of a movement toward social justice and sustainability will remain difficult to accomplish.

Taking a human rights approach means enabling people with disabilities to participate fully in all aspects of life, including active participation in sustainability and climate solutions. With relevance to our study, accessibility is defined under Article 9 of the UNCPRD as ensuring people with disabilities have access, on an equal basis with others, to the physical environment, to information and communications, and to other facilities and service open or provided to the public in rural and urban areas. Upon reflection of our process, we found we did not provide adequate information and education about the right to accessibility and recommend that future initiatives explicitly identify and remove all obstacles and barriers to accessibility throughout the implementation process. This identification and elimination of barriers could have been resolved through a more inclusive design process including our planning team comprised of people with disabilities and operations staff working at the community space and the everyday maintenance of WasteFinder and waste disposal units. Future initiatives should proactively address the existing and evolving challenges and barriers to accessibility in local waste diversion activities by continually asking who is still missing the from discussion and design of sustainability efforts.

From a human rights perspective, it is also important to note that while our findings suggest that there was no meaningful change in waste sorting behaviour, participants did highlight that WasteFinder promoted a higher level of accessibility of the waste sorting system at this community space. Human rights-based approaches are not about the most economical solution but about those that enable to inclusion of otherwise marginalized individuals and groups. According to Agyeman and Evans, a ‘just’ sustainability is “the need to ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems” [1].

## Conclusion

Our experiences point to the necessary identification of the multiple nested layers within local-ecosystems (e.g., the municipality within international, national, and provincial regulatory systems and policies – UNCPRD, ACA and AODA) and sub-systems themselves (e.g., the organizational hierarchy including senior leaders, managers and operations staff;

individual community members accessing public spaces). Our reflections highlight the interconnectedness of these multiple layers and the potential consequences of excluding groups in the design and implementation of accessible waste diversion. We reflect on the emergent nature of the pandemic to highlight the need for inclusive design in emergency and crisis responses even when these situations may be difficult to predict. Thus, we recommend future initiatives take a strong human rights and inclusive design approach in their efforts to promote and move towards climate justice that explicitly include the full and direct participation of people with disabilities.

When we wrote the proposal for this study, we had a difficult time finding empirical studies that investigated the accessibility of sustainability solutions and climate actions. Research in this area is only now slowly starting to pick up. Further, the 2021 Innovate4Cities, one of the most influential recent conferences on moving climate action and sustainability at the local level forward, clearly highlighted an implementation gap between ambitious goals and the actual observed practice. A clear call for more research to support local governments in the needed sustainability transition followed. A need for shifting mindsets and integrated system thinking was also identified. Applying system thinking in practice can be as challenging as the complex problems it is trying to address, therefore highlighting the need for applied research in real world contexts. The WasteFinder developed by STIL Solutions, and our partnership, provided a great opportunity to address some of these research needs. Our experience in implementing this in a specific public space managed by a local municipality during the context of a major pandemic offered useful insights into the challenges one can expect when trying to promote more inclusive sustainability solutions in a time when emergency responses will increasingly become a normality. Scholars of social and technological innovations highlight the importance of experimentation and learning from failure to develop solutions that are adaptive and resilient [71,72]. We hope that our own learning from the challenges of translating theory into action in this project provides insights for others trying to carry out similar initiatives.

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