Operationalizing accessibility in environmental sustainability

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

Alicia Bevan[1,#a¶], Alexis Buettgen[1,¶*], Manuel Riemer[1,#a¶], Brittany Spadafore[1,#a], Hillary Scanlon[2,#b], and Stephanie Whitney[3,#c]

[1] Department of Psychology, Wilfrid Laurier University - Viessmann Centre for Engagement and Research in Sustainability (VERiS), Waterloo, Ontario, Canada

[2] Faculty of Philosophy, University of Oxford, Oxford, United Kingdom

[3] Faculty of Mathematics, University of Waterloo, Waterloo, Canada

[#a] Current Address: Department of Psychology, Wilfrid Laurier University - Viessmann Centre for Engagement and Research in Sustainability (VERiS), Waterloo, Ontario, Canada

[#b] Current Address: Faculty of Philosophy, University of Oxford, Oxford, United Kingdom

[#c] Current Address: Faculty of Mathematics, University of Waterloo, Waterloo, Canada

*Corresponding author

Email: a.buettgen@gmail.com (AB)

¶ These authors contributed equally to this work. MR was the Principal Investigator and provided supervision for the research activity.

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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 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 (UN General Assembly, 2015 [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 (e.g., Jodoin, Ananthamoorthy, and Lofts 2020 [9]; Morris et al. 2018 [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" (Jodoin, Ananthamoorthy, and Lofts 2020, 98 [9]; see Fenney Salkeld 2016 [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) (Jensen and Nielsen 2001 [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.

We draw from an exploratory sequential 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. 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.

Interconnected Approaches for Interconnected Challenges – A Systems Perspective

Municipal leaders are facing complex challenges in trying to align their sustainability planning and action within broad global frameworks from an interconnected systems perspective [13]. Bosch and colleagues 2013, p117 [17] stress that "it has become crucially important for decision makers and managers involved in the management of any system to be equipped with the necessary capabilities and skills to make good policy and management decisions". Multiple authors point to the ability to effectively apply an integrated systems approach as a key capability for managing today's complex challenges (e.g., Bosch et al. 2013 [17] ; Posselt et al. 2022 [12]). An integrated systems approach enables the recognition of effective connectivity among actors in networks, non-linear effects of problems and interventions, the behaviour of feedback, and strategically direct change where it makes the most difference [12]. Systems science 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]. System approaches that recognize humanity's interdependence with natural ecosystems have

become increasingly embedded in sustainability and resilience principles and practices across various disciplines [24,25]. This recent embrace of systems perspectives is accompanied by a movement towards a just transformation where 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; Dreyer, 2022 [7]; Olsson, Galaz, and Boonstra 2014 [26]; Scoones et al. 2020 [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].

Considering a systems approach, Posselt and colleagues (2022) [12] propose that municipalities could be seen as service ecosystems defined as "relatively self-contained, self-adjusting systems of resource-integrating actors that are connected by shared institutional logics and mutual value creation." [29]. Within service ecosystems, "value is defined as the increase in overall system viability […], and is co-created by purposeful actors through mutually beneficial collaboration […] [12]. 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; 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, that is, a system transformation. To apply these ideas more concretely, in the next section we will employ the example of accessibility in the context of developing environmentally sustainable waste management for members of the public at the municipal level.

Applying a Systems Perspective to Accessible and Sustainable Waste Management in Cities

Municipalities 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 [32,33]. In addition, they work with civil society, other levels of government, and the private sector to develop community-wide responses to climate change [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, this 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]. Not addressing this connection and instead narrowly focusing on environmental aspects without considering aspects of social justice and equity has resulted in an equity gap or deficit [28]. That is, popular mitigation and adaptation responses are often exacerbating existing inequities for equity-deserving groups (see Anguelovski et al. 2016 [37]). For example, Teeklucksingh (2019) [38] found that racialized immigrants have been excluded in the

development of the green economy and green jobs in the city of Toronto, Ontario, Canada and exacerbated the marginalization of racialized immigrants in the broader labour market. While Toronto is considered a leader in green economic development, racialized and immigrant green jobseekers have been excluded because they lack the cultural knowledge, contacts, and expectations of the dominant groups in Canada. The focus of this paper, however, is people with disabilities as an equity-deserving group that warrants further attention and discussion in the context of an intersectional and accessible approach to local-level sustainability.

A growing body of research indicates that people with disabilities – their experiences, perspectives, and rights – have often been excluded from local-level environmental sustainability initiatives (e.g., Engelman, Craig, and Iles 2022 [39]; Jampel 2018 [40]; Jodoin, Ananthamoorthy, and Lofts 2020 [9]; Jodoin, Savaresi, and Wewerinke-Singh 2021 [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 the inaccessibility of built and social environments, which leads to difficulty performing everyday tasks such as intercity transportation, as well as participating in sustainable practices in the community (e.g., Bhakta and Pickerill 2016 [43]; Gossett et al. 2009 [48]). In addition to the exclusion of people with disabilities from past and present sustainability initiatives, people with disabilities are often more vulnerable to the risks and hazards associated with climate change. Climate change is predicted to increase the incidence and prevalence of impairments leading to disability due to both disease and injuries that may result from extreme weather events or conflict

[49]. 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 [40,50].

Municipal waste sorting and disposal is an overlooked example where a lack of systems perspective and the absence of people with disabilities in decision-making has resulted in an inaccessible sustainability action. The design of many public waste disposal units poses a barrier to waste sorting and disposal for people with vision impairments and other disabilities; there can be many physical or functional barriers to independently sorting and disposing of one's waste, 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]. The inaccessible design of waste bins can be seen as a microcosm of not including people with disabilities in the design of our built social environments [8,48]. Policy makers and practitioners have paid relatively little attention to disability issues in the context of sustainability actions, rendering the needs of people with disabilities largely "invisible" in climate mitigation and adaptation efforts [9]. Public waste sorting is one example where people with disabilities are neglected and/or adversely affected by the design of environmental and sustainability focused policies, programs, and projects. There is evidently a need for an approach that centres issues of accessibility and social justice in climate action planning and implementation [1,5,7,52]. This in turn requires a shift in the mental models of climate change actors towards a system perspective [16]. To better understand this shift in mental models we are now presenting two theoretical perspectives that embody

Commented [BA1]: Remove the International Disability Alliance (IDA) reference from the reference list and replace it here with (e.g., Jodoin et al., 2023; Wolbring & Leopatra, 2012) Full references below:

Jodoin, S., Buettgen, A., Groce, N., Gurung, P., C., Kett, M., Keough, M., Macanawai, S., Muñoz, Y., Powaseu, I., Stein, M.A., & Stein, P. (2023). Nothing About Us Without Us: The urgent need for disability-inclusive climate research. PLOS Climate, 2(3). https://doi.org/10.1371/journal.pclm.0000153;

Also add: Wolbring, G., & Leopatra, V. (2012). Climate Change, Water, Sanitation and Energy Insecurity: Invisibility Of People With Disabilities. *Canadian Journal of Disability Studies*, *1*(3), 66-90. https://doi.org/10.15353/cjds.v1i3.58

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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 significant 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

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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 (1951) [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.

Project Overview

Our project took place in a mid-sized city in Ontario, Canada from April of 2020 to November of 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 shown in Figures 1, 2 and 3. Figure 4 shows the whole WasteFinder including Vicinity and Stream Indicators.

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.

Methods

We used an exploratory sequential mixed methods research design, including surveys, focus groups, and waste audits pre- and post- installation of the WasteFinders. We made efforts to align our methodological approach 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. The main objectives of this research were (1) to explore the factors that promote and/or hinder participation in waste diversion in a public space and (2) to assess the impact of the WasteFinder on participation and perceptions of sustainability, inclusivity, accessibility. 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. During both the pre- and post-installation periods, participants were approached by members of the research team and invited to complete a paper or online survey. 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. Post-installation questions aimed to compare

awareness and understanding of accessibility and inclusion post-installation of WasteFinder and assess participants' experience with WasteFinder. Participants were also asked to leave their contact information if they wished to participate in a focus group (detailed below). The pre-installation survey was completed by 106 unique participants, and the post-installation survey by 78 unique participants; two participants completed the survey at both timepoints, resulting in 184 survey responses completed by 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 to 39 (43.4%, n=46), with the second largest age group being 60+ (24.5%, n=26), followed closely by people aged 40 to 59 (20.8%, n=22), then people aged 18 to 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 to 59 (28.2%, n=22), followed by people aged 18 to 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).

The pre-installation focus group aimed to understand participants' experiences of accessibility and inclusivity of sustainability at the community space. The post-installation focus group aimed to compare participants experiences with accessibility and sustainability following the installation of WasteFinder. Findings from the focus groups were used to supplement and compliment findings from the surveys. Focus group participants were recruited among participants in the survey, through local disability groups, and through the networks of the research team.

In addition, three waste audits were conducted to assess the level of change in proper waste sorting/disposal 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.

Analyses

Qualitative data were analysed using thematic analysis [58]. Quantitative data were analysed using SPSS for descriptive statistics. The two strands of data were integrated in the research design and then during interpretation to connect the qualitative with the quantitative data. Quotes from the qualitative data were compared to results from the statistical analyses of the survey data and waste audits. 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 through integration of data strands [59]. The connected data was interpreted within the scope of the study's purpose: to implement and evaluate the process and impacts of WasteFinder in a particular community space.

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.

Results

Based on post-installation survey responses, the majority of participants (75.8%) found WasteFinder beneficial and easy to use (n=33); this included participants who self-identified with and without disabilities. 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). Half (50%) of participants who used WasteFinder said it influenced how they sorted their waste (n=34). For example, one participant said they felt WasteFinder "Forces individuals to sort their waste and become more aware.". Over two-thirds (67.6%) of surveyed participants who interacted with WasteFinder agreed it was 'equally easy to use for anyone who may visit the [community space]' (n=34); in comparison, 38.5% of surveyed participants agreed the pre-existing waste disposal units at the community space (i.e., pre-installation of WasteFinder) were 'equally easy to use for anyone that may visit the [community space]' (n=104). Our findings suggest that WasteFinder reduced common barriers to sorting and disposing of waste; participants noted fewer barriers to waste disposal after the installation of WasteFinder. While WasteFinder was generally easy to use, participants noted that there was still "[c]onfusion over what materials can be put into different receptacles". Several 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"). Participants also noted that the bins were too high for people in wheelchairs and were difficult to find in the 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 market (47.2%, n=50 and 50%, n=39, respectively), with the waste disposal units being the most noted feature in both surveys (mentioned 39 and 32 times respectively). Survey respondents were also asked if they perceived the community space as accessible and inclusive to anyone who may visit; in the post-installation survey (i.e., after the installation of WasteFinder), 59.8% of respondents (n=77) said 'Yes' or 'Definitely yes'. For a related but slightly differently worded question in the pre-installation survey, fewer respondents (39.6%, n=106) said 'Yes' or 'Definitely yes'; however, this discrepancy could also be due to specific language used in the pre-installation survey.[1] Overall, many survey respondents found the community space accessible, and many identified specific features of the public space that promote accessibility (e.g., ramps, handrails, automatic doors, spaciousness).

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 of WasteFinder. There was an increased rate of compost

[1] The pre-installation survey (n=106) 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?'. 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 suggested 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).

457 materials diverted from landfill (26.17% diversion rate relative to 21.59% pre-
458 installation); however, the audit also found a decreased rate of recycling materials
459 diverted from landfill (30.98% diversion rate relative to 39.98% pre-installation).
460 Contamination and capture rates for both compost and recycling systems during pre-
461 and post-installation of WasteFinder were comparable (55.2% pre-installation, and
462 66.5% post-installation). Moreover, diversion rates for recycling and compost were
463 negligible pre- and post- installation of WasteFinder.

464 ***Implementation Context***

465 The empirical research produced some interesting findings regarding public perceptions
466 of the accessibility and effectiveness of WasteFinder and the local community space.
467 Below, we reflect on the process of implementing the WasteFinders in an established
468 municipal 'system'.

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

478 Prior to installing the WasteFinders, the internal project champion left their
479 employment at the city. At the time, the project had not yet been reassigned to an
480 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-10 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 allow for 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. 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 (1995) [60] 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 (see Wielopolski and Bulthuis 2022 [61] for example).

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). During data collection our research team had many positive conversations with patrons about WasteFinder. Our research also triggered conversation with patrons 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 patrons 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 [12,62]. 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 (see Vargas, Paucar-Caceres and Haley 2021 [63]). 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 [64]. 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 [2,6,7,36,65]. Much of this literature has focused on racial and socio-economic inequalities (e.g., Anguelovski et al. 2016 [37]; Rice et al. 2019 [66]) 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

651 others, to the physical environment, to information and communications, and to other
652 facilities and service open or provided to the public in rural and urban areas. Upon
653 reflection of our process, we found we did not provide adequate information and
654 education about the right to accessibility and recommend that future initiatives
655 explicitly identify and remove all obstacles and barriers to accessibility throughout the
656 implementation process. This identification and elimination of barriers could have been
657 resolved through a more inclusive design process including our planning team
658 comprised of people with disabilities and operations staff working at the community
659 space and the everyday maintenance of WasteFinder and waste disposal units. Future
660 initiatives should proactively address the existing and evolving challenges and barriers
661 to accessibility in local waste diversion activities by continually asking who is still
662 missing the from discussion and design of sustainability efforts.

663 **Conclusion**

664 Our experiences point to the necessary identification of the multiple nested layers
665 within local-ecosystems (e.g., the municipality within international, national, and
666 provincial regulatory systems and policies – UNCRPD, ACA and AODA) and sub-
667 systems themselves (e.g., the organizational hierarchy including senior leaders,
668 managers and operations staff; individual community members accessing public
669 spaces). Our reflections highlight the interconnectedness of these multiple layers and
670 the potential consequences of excluding groups in the design and implementation of
671 accessible waste diversion. We reflect on the emergent nature of the pandemic to
672 highlight the need for inclusive design in emergency and crisis responses even when
673 these situations may be difficult to predict. Thus, we recommend future initiative take a
674 strong human rights and inclusive design approach in their efforts to promote and move

675 towards climate justice that explicitly include the full and direct participation of people
676 with disabilities.

677 When we wrote the proposal for this study, we had a difficult time finding
678 empirical studies that investigated the accessibility of sustainability solutions and
679 climate actions. Research in this area is only now slowly starting to pick up. Further, the
680 2021 Innovate4Cities, one of the most influential recent conferences on moving climate
681 action and sustainability at the local level forward, clearly highlighted an
682 implementation gap between ambitious goals and the actual observed practice. A clear
683 call for more research to support local governments in the needed sustainability
684 transition followed. A need for shifting mindsets and integrated system thinking was
685 also identified. Applying system thinking in practice can be as challenging as the
686 complex problems it is trying to address, therefore highlighting the need for applied
687 research in real world contexts. The WasteFinder developed by STIL Solutions, and our
688 partnership, provided a great opportunity to address some of these research needs. Our
689 experience in implementing this in a specific public space managed by a local
690 municipality during the context of major pandemic offered useful insights into the
691 challenges one can expect when trying to promote more inclusive sustainability
692 solutions in a time when emergency responses will become increasingly a normality.
693 Scholars of social and technological innovations highlight the importance of
694 experimentation and learning from failure to develop solutions that are adaptive and
695 resilient (see Schreuder and Horlings 2022 [67]; see Strasser, Kraker and Kemp 2019
696 [68]). We hope that our own learning from the challenges of translating theory into
697 action in this project provides insights for others trying to carry out similar initiatives.

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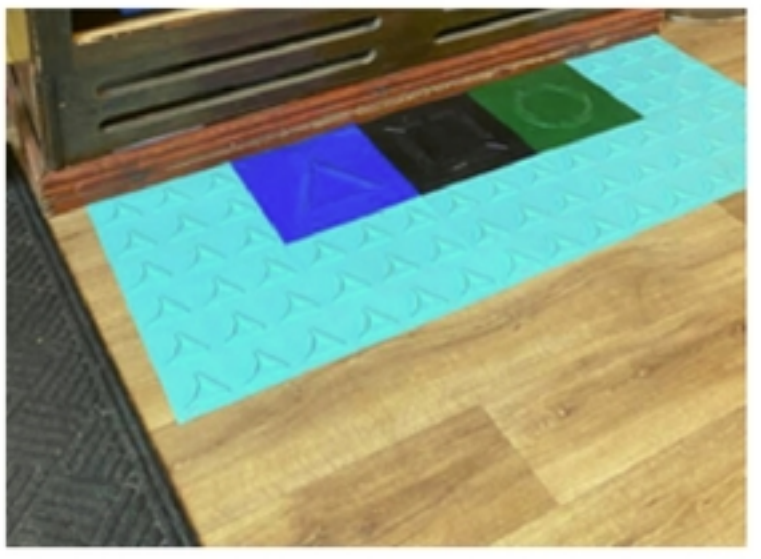
Figures

Figure 1: WasteFinder Organic Stream Indicator

Figure 2: WasteFinder Garbage Stream Indicator

Figure 3: WasteFinder Recycling Stream Indicator

Figure 4: WasteFinder system including three stream indicators and surrounding floor tiles



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