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Advancing neighbourhood climate action: opportunities, challenges and way ahead

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Cities are emerging as key sites for action on climate change. Within cities, urban neighbourhoods are increasingly taking leadership in addressing local effects of climate change through mitigation and adaptation programs. Bottom-up action on climate change through neighbourhood scale programs presents opportunities in terms of getting the community to partner and participate in climate action. However, neighbourhood scale programs often run into challenges in terms of limited participation, impact and resources to keep the programs running. In this paper, we advance the literature on the opportunities and challenges of neighbourhood scale climate action. We do so by analysing three neighbourhood scale programs that address climate action in Canada and in Australia. We adopt online workshops as a research methodology where volunteers from the three programs share their experiences of opportunities and ways of overcoming challenges of neighbourhood climate action. Our findings illustrate that collaborative governance between the city and the neighbourhoods, incremental community building and consolidating local resources are important for advancing neighbourhood climate action. This paper adds to the thin body of knowledge on neighbourhood scale climate action and presents ways of overcoming the challenges of bottom-up climate action.

INTRODUCTION

Cities, directly and indirectly, contribute to around 50% of global greenhouse gas (GHG) emissions[1–3]. Owing to this, cities are increasingly recognised worldwide as an optimum scale for framing policies and plans for local action on climate change[4,5]. Consequently, multiple cities across the world now have dedicated climate action plans with concrete strategies for the mitigation of GHG emissions and adaptation to the impacts of extreme weather events[5]. The focus on cities as sites of climate action has also elicited increasing interest in understanding the role of urban neighbourhoods in participating in or leading bottom-up climate action within cities[6,7]. Neighbourhood scale climate action includes efforts by urban communities to address climate change. These actions range from GHG mitigation efforts through investment in low-carbon buildings, promoting active transportation and adopting renewable sources of energy[8–10]. They also include adaptation efforts like flood mitigation measures, reducing urban heat island effects by increasing green spaces and collective water conservation measures[11,12].

Bottom-up initiatives at a neighbourhood level present opportunities for collective community action to address the impacts of climate change[13]. These initiatives bring neighbours together and build a sense of mutualism that contributes towards developing social capital[14,15]. Neighbourhood climate action is also a realisation of bottom-up democracy and decentralisation of power[16–18]. However, neighbourhood scale efforts may run into challenges in initiating and maintaining projects on climate action because of limited power, resources and agency at the neighbourhood level. Additionally, inequalities may exist in terms of which neighbourhoods act on climate change and within these neighbourhoods, which group of people participate in and benefit from climate action[19–21].

Rohe defines neighbourhoods are distinct physical and social blocks of a city[22]. On the one hand, they are composed of physical aspects like buildings, streets, infrastructure and vegetation[23]. On the other hand, they are constituted of complex social relationships between residents contributing to a shared neighbourhood identity[24]. The concept of neighbourhood remains broad and challenging to define as it is at the same time a place, a community and an administrative unit[25]. Hence neighbourhoods must be understood in the context in which they exist and are being researched[26]. As this research is located in three cities in the Global North, we adopt Rohe's definition as a working frame.

The physical and the social aspects of neighbourhoods and their interplay are at the centre of any bottom-up, neighbourhood scale endeavour from urban regeneration[22,24] and sustainability[6,27] to present day efforts towards addressing climate change through mitigation and adaptation measures[10,12,17].

Addressing climate action at the neighbourhood scale brings together two strands of scholarly knowledge. The first one is on bottom-up action towards sustainability in general and climate change in particular[28,29]. The second one is on neighbourhoods as a fundamental unit of planning and organisation in a city[16,22,30]. Based on a reading of literature on bottom-up climate action and neighbourhood planning[7], we identify key opportunities and challenges for programs aiming to address climate change at the neighbourhood scale.

Some scholars argue that within the structure of a city, the scale of the neighbourhood is optimum for bottom-up climate action. From a physical perspective, this is because a neighbourhood is large enough to have its own urban design strategy[31]. From a social perspective, this scale is easily recognisable for people and is situated where they are likely to have existing social networks and connections[22]. Furthermore, the scale of neighbourhood provides a sample of urban reality that is wide enough to

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Table 1. Opportunities and challenges of neighbourhood climate action.	
Opportunities	Challenges
Optimal scale: physically and socially tangible for residents	Sub-optimal scale: small scale and short term action
Mutualism and social capital: neighbourhoods have strong social networks	Social challenges: reproduction of socio-economic inequalities.
Realising bottom-up democracy: participate in decisions on climate change	Power and resources : largely concentrated at the city scale

encompass sustainability criteria[32]. From a multi-scalar perspective of action on climate change, the neighbourhood scale is ideally positioned for community action, between top-down action by the government and bottom-up action by individuals[13]. From an urban planning perspective, the neighbourhood scale provides an optimal environment for the development, experimentation, and assessment of diverse planning and developmental initiatives[25]. The focus on the neighbourhood scale as a site for locating climate action is also resulting in the emergence of new concepts like low carbon localism[16] and positive energy neighbourhoods[33]. Furthermore, neighbourhoods received renewed attention during the COVID-19 pandemic, when residents spent extended amounts of time within their local communities and possibly had a chance to reconnect with their immediate surroundings[34–36].

Given that the lives of residents are often socially linked to their immediate surroundings, a collective neighbourhood identity and bonds lend themselves as a foundation for climate action[37,38]. Existing social networks within the neighbourhood may provide support to climate action projects[9,39]. Social capital, or the advantages that residents draw from being part of a social group, could help mobilise people for climate action projects[14,15,40].

By engaging residents as active participants in responding to climate change, neighbourhood climate action is recognised by some as a means for actualizing bottom-up democracy in a city[16]. This pushes the multi-scalar perspective further to include neighbourhoods in climate action planning. Existing literature presents multiple means by which residents participate in climate action: from informal projects[17,18] to formal integration in the city's planning system[16].

A counterargument to the neighbourhood being an ideal for climate action is that neighbourhood projects are often small-scale and short-term, failing to create tangible impact[17,41]. Furthermore, urban planning is often within the purview of the city governments, making neighbourhood scale action an informal and sporadic activity[18]. This ties back to a larger debate on the optimal scale for a large-scale global problem like climate change[42]. With no formal mandate to act on climate change, neighbourhood scale activities remain volunteer led projects creating limited local impact[43,44].

All neighbourhoods in a city are not equal nor are residents within the same neighbourhoods (Wittmayer et al.[45]). Existing literature points out that vulnerable neighbourhoods often lack resources for organising climate action projects[19,20,46]. Among neighbourhoods where climate action is organised, only dominant interests and voices within the community might be represented[40]. Neighbourhood climate action thus runs the risk of recreating socio-economic inequalities that exist within the city as well as within neighbourhoods themselves[47].

The power and resources for neighbourhood planning have traditionally been concentrated at the city level[22,48]. While climate change creates new expectations of bottom-up action from neighbourhoods, there is a mismatch when it comes to the power and resources available at the neighbourhood level for such action[49,50]. Tax collection, building and development bylaws formulation and budget allocation largely happen at the city level[22]. Furthermore, data and knowledge needed to frame climate action might not exist at the neighbourhood scale[51,52]. Resources to collect and analyse this data might also be missing

at the neighbourhood scale. There are also instances when neighbourhood climate action clashes against the developmental mandates being set at the city and regional scales[24,53].

Table 1 below summarises the contrasting opportunities and challenges identified for climate action at the neighbourhood scale. While the identified opportunities make a case for neighbourhood scale climate action, the challenges pull in the opposite direction. We do not know enough on how the opportunities and challenges framework plays out in practice as well as what are some potential ways of overcoming the identified challenges? To deepen our understanding of neighbourhood climate action and to explore ways of overcoming existing challenges, we analyse the experience of three neighbourhood action programs in Canada and Australia.

Building on a recent literature review on neighbourhood climate action[7], we advance the current knowledge on the challenges and opportunities of locating climate action at a neighbourhood scale. We do so by presenting three case studies of neighbourhood climate action programs. These include the Green Leagues program in Edmonton, Canada, Resilient Streets program in Victoria, Canada and Ecoburbia in Fremantle, Australia (see the Methodology section for theprogram description). We adopt online workshops as a research methodology inviting the key-representatives of neighbourhood climate action programs to present the opportunities and challenges of their programs as well as to share and deliberate upon potential ways forward to overcome the challenges of acting on a neighbourhood scale. Our research is driven by three key questions:

What opportunities and challenges are identified by neighbourhood climate action programs?

How were those challenges overcome?

What lessons can be learnt for advancing neighbourhood climate action based on the experience of the selected programs?

Our findings build upon the opportunities and challenges identified in academic literature as well as presents ways in which neighbourhood scale programs navigate the challenges and work towards initiating and sustaining climate action.

RESULTS
Based on our analysis, we identified three main opportunities that can be used as useful starting points for neighbourhood climate action.

Optimal scale
First, several participants discussed a variety of reasons why neighbourhoods are an optimal *scale* for local level climate related decision making and implementation. For example, one of the Sustainability Directors (SD) of the Green Leagues program mentioned how communities are the *"nexus for everything that happens in society"*, thus any meaningful urban climate action framework must accommodate community interests. Another SD emphasised how the community leagues, of which the Green Leagues program is a part, have now existed for decades which makes them more reliable from residents' perspective compared to other organisations at different scales of governance. A SD highlighted how the neighbourhoods present a unique opportunity for entry points for new action, since the possibilities of

community league specific actions are largely missing from climate action across cities:

"I would say that the scale at which they (community leagues) operate, which is the neighbourhood scale, that is a very important and an unrepresented scale at urban level when we talk of energy transitions".

Talking about the foundations of the Ecoburbia program, the presenter described how the neighbourhood scale can be most useful to consider while planning for emergencies and extreme events, since often the community members can provide the quickest response before formal help arrives. They said:

"In some sort of crisis, whether it be bushfires, floods, [the] majority of the help within the first 48 hours most often comes from within your geographic community, within one kilometre from your house".

Mutualism and social capital as co-benefits

The second opportunity that the participants described was that many of the community level actions can have *co-benefits* that can be seen in terms of positive benefits in terms of social well-being of residents. A presenter from the Resilient Streets program pointed out the following:

"Climate related challenges intersect with other challenges, so we are looking to build resilience not just to acute stresses and weather events, but also to other challenges such as social isolation, social equity and health challenges".

Bottom-up democracy

The third opportunity, building on co-benefits, is also key in making community climate actions more socially rooted, thus strengthening local democracy in the city. Participants noted that harnessing volunteers, providing small financial grants as well as facilitating social events regularly can promote more connectedness between neighbours, which can be a crucial factor during emergencies as well as in fostering long term community resilience. A participant in the Resilient Streets program described the variety of actions that have been initiated to foster more community connectedness:

"We engage neighbours through workshops to learn about ideas, and then we offer support through small grants to remove financial barriers for people to take action….Many local activities such as block parties are foundational strategies for building neighbourhood resilience".

"When we first started Resilient Streets, our first project was building up a program called transition streets… ..this is a deeper dive into sort of neighbours choosing to come together to learn about opportunities for energy transition".

In analysing the workshops, we find that three categories of challenges emerged across the sessions – social, scale, and power and resource challenges. The following section explores these in detail.

Sub-optimal scale

Currently, our workshop participants noted that city processes and procedures are a barrier to implementing climate action in communities. One participant highlighted the challenges in getting approvals for these actions, saying:

"It has been difficult to make [adaptation and mitigation projects] happen because the city process is cumbersome".

Further, internally, city processes that are not integrated can also slow down the progression of climate action. This internal inaction has meant that we see a silo-ing of the best intentions and initiatives, which are not necessarily having an integrated and joint approach.

Finally, capacity, and specifically the capacity of neighbourhood volunteers to undertake advocacy under current governance structures, also came up as a challenge to implementing climate actions. As one workshop participant said

"[t]here is only so much volunteer capacity to advocate for specific things".

Current processes and procedures may intentionally or unintentionally limit climate action at the neighbourhood level because people in communities have *"limited capacity for advocacy".*

Social challenges

Based on our workshops, we found that socio-cultural challenges posed a significant role in the implementation and success of neighbourhood climate action work. Politics at the provincial, municipal, and local levels all influence people's willingness to accept and undertake different neighbourhood climate action work. Participant narratives suggested that competing socio-political interests can lead to inaction or slow the progress of implementing these actions. A workshop participant who had worked to install solar panels on their community league building in Edmonton highlighted this challenge, saying

"one of the people who has very strong connections with the current government, sent me an email congratulating me personally, but said I prefer to burn fossil fuels".

The quote highlights that neighbours, like cities, might have divergent political orientations[54] that in turn might influence their support or dissent for neighbour climate action.

We also found that a key determinant of neighbourhood climate action is the social and behavioural norms that are dominant within communities. In the cases we studied, the social norms, specifically present within western cultures were a barrier to implementing actions that are considered to be beneficial to climate change adaptation and mitigation. As a result, the activities and methodologies prominent in neighbourhood climate action work often push against social norms and, as described by one participant,

"tendency in western cultures to look for technological solutions to social problems".

One workshop participant spoke to the shift in behaviours that is necessary to enact meaningful climate action that neighbourhood organisations intend to undertake:

"There are so many cultural shifts that are needed because right now I feel that I would have a hard time convincing my neighbour to share even a lawn mower with me because my neighbour might not want to be beholden to me".

The case of the Ecoburbia program in Australia was also faced with similar challenges. The group has since worked to overcome

them by building relationships between community members prior to discussing climate-related actions.

Power and resources

With power traditionally concentrated at the city level, neighbourhoods have experienced both financial and informational challenges when undertaking or planning for climate action.

Because *"[t]he idea of planning at the neighbourhood level is new to Canada,"* often these neighbourhoods lack power within current city processes to initiate, plan and execute projects. Thus, they do not have the autonomy to undertake climate actions or there is ambiguity over the neighbourhood's role in such actions. One workshop participant in Edmonton suggested that instead of telling the neighbourhood what the project or upgrade will be we should examine:

"How [can we] shift conversation in neighbourhoods to allow people to participate in that early process of deciding what is important and creating buy in that way".

Currently, workshop participants in Edmonton highlighted the process that must be undertaken when following established governance structures.

"It is basically residents coming together and making their voices known to the city administration and beyond, is the only way to get ideas forward […] neighbourhoods are not legal [entities] in any shape or form in the Canadian context".

Without shifts in this governance structure, neighbourhoods are restricted by the city processes and procedures, resulting in delayed action and disempowered community members.

A major challenge for neighbourhoods looking to implement climate actions was the lack of data and information at the neighbourhood scale. As one research participant noted the city typically does not either collect data or make it publicly available at the neighbourhood scale, possibly owing to privacy and confidentiality concerns. Thus, as our participants noted

"[d]ata is a big challenge" that needs to be addressed because *"[i]f people don't have the information [from cities] then those decisions aren't going to get made".*

Workshop participants also noted the role of money and finances in actualizing climate action. Funding at both the city and neighbourhood level have an impact on the feasibility of these projects. In one of our workshops, the participants highlighted the need to *"remove financial barriers [in order] for people to take action".*

However, some participants suggested work-arounds to these constraints. This is evident in the following quote from a community organiser: *"money is a resource that you might not even need."* Furthermore, speaking to the issue of power at the neighbourhood scale they offered an alternative vision saying that *"permission needs to be granted by the people who are impacted, not the city [government]".*

The workshops opened a space for participants to put forth ways to overcome barriers of climate action at the neighbourhood scale drawing from their experience. Here we summarise the key themes that emerged during the workshops.

Collaborative governance

To overcome the problem of scale, participants suggested utilising scalar dynamics at the city level, given that the city has greater capacity and organisational power. This was indicated by the Green Leagues program as they explained that they:

"Would love to see the city drive some of it [climate action], and say like these are all of the categories where we could do better on climate intervention and kind of treat the best climate strategies as standard, rather than as an upgrade to be advocated for [at the neighbourhood level]".

The Green League program advocated for the city to create better opportunities for neighbourhoods to engage in climate action, specifically through educating neighbourhoods of their options during city-led processes. For example, during city government-led neighbourhood renewal projects, our research participants suggested that we *"need to make sure people are educated about options and what they mean"* – the community league can work with the city government and *"say look we also want either [energy] efficient options if they're not there or if they are there we want people to understand why they are there, what benefits those have as opposed to others, and at what costs".*

Incrementally building community

A common theme among several participants' responses was the necessity to adopt an incremental approach at the community level to overcome challenges. The participants noted that this approach can be an effective way in exploring possibilities and range of adaptation options, as well as to validate initial ideas that may have potential to scale up at a later stage. Participants described how local block level social events can be a useful *"foundational strategy for building neighbourhood resilience"*, having potential to develop *"social connectedness between people within the community"*. Local household communication is key to achieve the above, and can spark other varying scales of actions. A participant from Edmonton reflected on the importance of informal discussions to spark important discussion on risks and possible solutions:

"You get people together with these topics that even if it's totally tangentially related, and just get people in the same room, sitting together and then maybe someone really likes the Coyote talk, so they come to the next one on flood mitigation and insurance policies and they find that really interest.. …I think it is just about giving people all the different options they can to get them interested".

This was further explored in the Ecoburbia, Australia program, as they worked to incrementally build community through social activities saying that at the beginning of their program they"

"Weren't talking openly about climate change, about peak oil and resource depletion, about sharing resources. None of those things were spoken about out loud, but they were still there in the activities we had".

Given current governance structures and city processes, Edmonton's Green League program emphasised that *"proactive engagement of bringing together"* communities may be important instead of waiting for the city government to do so when a decision needs to be made. If relationships aren't built before, it may become challenging to come to a consensus. Thus, all programs highlight the importance of building connections in communities as a way of building resilience to future risks posed by climate change.

Consolidating local resources

Overcoming volunteer capacity challenges was a recurrent theme in the workshop. A participant from Ecoburbia noted that they overcame challenges with capacity and volunteer burnout by creating a street coordinator system to distribute information to 350 more effectively. The system was developed after the

program leaders delivered flyers for events by hand to all houses and they needed a more efficient system to deliver flyers on each street. After putting out a call to the community, 16 people volunteered, establishing the current street coordinator system which Ecoburbia participant described as:

> "When we have a flyer, I get them copied, we put them on a table out the front of my house. Each of those people know how many they need, and then they distribute that flyer to the area. It's like a telephone tree in many ways".

The system has also increased the capacity to organise future events as within the current organisational structure "using those street coordinators we have a meeting once a year [...] and someone volunteers to organize some sort of activity every month".

DISCUSSION

We began this research by setting out the existing opportunities and challenges of neighbourhood scale climate action (see Table 1). To build upon these challenges and opportunities-as well as to identify ways forward of overcoming these challenges- we have presented inputs from three neighbourhood scale climate action programs- two in Canada and one in Australia. In this section, we synthesise the findings from literature as well as the inputs from our workshop participants to derive key assertions for advancing neighbourhood scale climate action.

The opportunities of the neighbourhood scale in being tangible and recognisable for residents clash against its challenges of shaping and sustaining climate action programs[17,22]. The workshop participants point toward utilising the existing scalar opportunities and utilising multi-scalar dynamics to overcome these challenges. Developing a collaborative governance model between the neighbourhood and city scale programs is a way forward in this regard. Here the city programs may benefit from the close knit structures of the neighbourhood scale and the neighbourhood programs can draw on the expertise and financial resources at the city scale to sustain their programs. The Green Leagues program and the Resilient Streets Program attempt to build on collaborative governance structures with their respective city administrations.

Mutualism and social capital are described as the foundation of building climate action programs in a neighbourhood[24]. However neighbourhoods are not homogeneous entities and neither are neighbourhood-based associations, and thus disagreements may exist regarding climate change and climate action projects[9]. The idea of a community cannot be taken for granted in the neighbourhood context in the Global North. The workshop participants pointed towards the idea of incremental community building as a foundational strategy for a climate action program. This involves engaging in a range of activities that may or may not be related to climate action to build a sense of community in the first place. In turn, community building is also described as a positive co-benefit of bringing people together on climate action projects.

Scholarly literature recognises a mismatch between the expectations of bottom-up action on climate change and the power and resources available at the neighbourhood scale for realising it[49,50]. This was confirmed by the workshop participants who have worked with the consolidation of available resources and expertise to start climate action programs. This is also closely linked to the themes of collaborative governance and incremental community building as ways of laying the foundation of climate action programs. In the absence of dedicated budgets and formally recognised institutional structure or incorporation within the city's climate governance structure, it is useful to begin with small-scaled actions that are not capital and labour intensive, but instead rely on individual and group leadership that can emerge from communities, who can come up with creative ideas that can require micro-financing. An incremental approach can be useful in providing data that resemble pilot projects to the city and other larger institutions, which can consequently devise methods to scale up successful projects and actions.

Figure 1 below summarises the key opportunities and challenges identified in literature as well as ways forward identified by workshop participants.

As we drew from the experience of three neighbourhood scale climate action programs located in different contexts. There were noticeable similarities and differences in approach and context. Across all three programs, the central approach appears to be similar – small activities, such as community movie nights or potlucks, are important building blocks for developing the community and a place-based attachment necessary for building
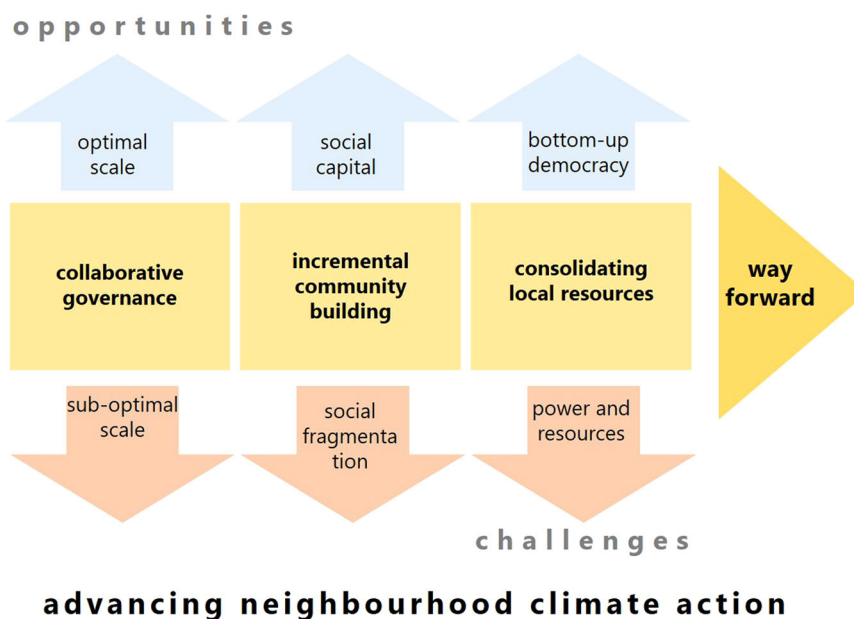

Fig. 1 Key opportunities, challenges and way for forward for advancing neighbourhood climate action.

community resilience. In creating a sense of community, by allowing people to know and care for each other, the aim of these programs is to teach people to learn to work together with the intent that they will act on this together when climate change or extreme weather events happen. At the same time, these programs should be understood as complementing larger city-scale climate action plans and programs, and not substituting them[55].

Participants pointed out that it is very important that all stakeholders recognise the historical and institutional context within which discussions and actions are carried out. Participants emphasised during the workshops that the Community Leagues "*need to look at their own history, on programs that have worked in the past*" which can help identify useful starting points that can be leveraged for future actions and programs. Understanding context is useful in knowing how a particular neighbourhood and its institutional structure is unique, what decisions were made in the past, and which actors and actions played an important role in leading planning and environmental actions. This will help understand what specific actions and governance options might work in that context, thus avoiding a 'one-size-fits-all' approach that assumes that neighbourhood scaled actions can be uniform. Incorporating various local stories that describe past risks, events can aid in developing an understanding of the community perception and biases that might exist.

We adopted workshops as a co-creative research methodology. We found it a useful tool for understanding different experiences of neighbourhood climate action projects. This is particularly helpful in developing the third dimension of our research i.e. way forward based on the experiences of the participants. However, we also acknowledge a positive bias in our research design towards neighbourhoods that have on-going programs on climate action. This might be because of a certain socio-economic status of these neighbourhoods that make it possible to run such programs. This limits us in contributing towards discussions on socio-economic variability in neighbourhood climate action. Future study designs can opt for neighbourhoods where such programs do not exist or have not been successful to contribute to a discussion on socio-economic challenges in neighbourhood climate action. This can be done by adopting socio-economic profile as a criterion for selecting neighbourhoods.

Neighbourhood climate action presents significant opportunities for planning and governance for local climate change effects. However, its small scale and limited power often raise questions about its efficacy and sustainability. Drawing from the experience of three neighbourhood climate action programs we recommend collaborative governance, incremental community building and resource consolidation as the foundational steps to overcome some of the recurrent challenges of working at this scale.

METHODOLOGY
The data for this research was collected as part of a one-year collaborative project on neighbourhood climate action between urban planning researchers working on climate adaptation and mitigation and a neighbourhood climate action program called Green Leagues in Edmonton, Canada. The objective of the project was to co-create knowledge on identifying the opportunities and challenges of neighbourhood climate action, drawing from the experience of existing programs, as well as develop ways of overcoming the identified challenges.

The Green Leagues, the collaborator in this project, started in the year 2016 as part of an initiative by the Edmonton Federation of Community Leagues (EFCL). EFCL is an umbrella organisation for 161 neighbourhood associations called Community Leagues (CL) in Edmonton, Canada[56]. The Community Leagues are not-for-

profit organisation established under the Societies Act of Alberta[56]. Edmonton is the capital of the province of Alberta in Canada. It has a population of approximately 1 million people spread across 403 neighbourhoods (both residential and non-residential)[57]. The City of Edmonton's Change for Climate program is the City's call to climate action and is informed by the City's Energy Transition Strategy[58]. The City of Edmonton does not offer a neighbourhood based climate action program, although it does offer grants for supporting community scale action on climate change[59]. The Green League program has been the recipient of this grant.

The Green Leagues program plays an important role in shaping bottom-up, neighbourhood climate action in Edmonton[9]. The Green Leagues program assists Community Leagues across Edmonton in their efforts to address climate change through mitigation and adaptation actions like switching to solar energy, conducting energy efficiency audits of community buildings, community gardening and creating awareness about sustainable water and waste reduction practices[9,60]. The Green Leagues program is led by an Energy Transition Officer (ETO), based at the EFCL, working with representatives on neighbourhoods known as Sustainability Directors (SD).

At the time of this research, there were 21 active SDs in Edmonton whom we reached out to. Eight SDs collaborated in this research representing the experience of their respective neighbourhoods in Edmonton. These SDs were key-informants in this research, contributing through their experience of having worked at the neighbourhood level. As the SDs were selected through convenience sampling, based on their willingness to participate, the inputs are representative of the participating neighbourhoods, rather than neighbourhoods across Edmonton.

This paper extends earlier collaborative research with the Green Leagues which identified the most common opportunities and challenges of neighbourhood scale energy transitions[9]. We build on this collaboration to design the current research as the Green Leagues were expanding to focus on climate mitigation and adaptation and extend the scope of the research to find solutions to common challenges. This project received the ethics approval by the Research Ethics Board of the University of Alberta (Project ID: Pro00113873).

Identifying neighbourhood climate action initiatives
To build on the experience of the Green Leagues program, we identified ten neighbourhood action programs across the globe through an internet-based search. We wanted to find programs similar to the Green Leagues to form a basis for comparative dialogue. We used the search string "neighbo*rhood", "climate action", "program", "bottom-up" on the Google search engine. We read through the websites of the displayed programs and purposively selected programs if they:

a. Worked at a neighbourhood scale: We established this through reading the program description on the websites and included programs that explicitly located themselves at the neighbourhood level.
b. Worked on adaptation and/or mitigation measures for climate change: while there are multiple neighbourhood scale programs, we included programs that focused on climate action, as is the focus of the Green Leagues program.
c. Adopted a bottom-up approach: we selected programs that explicitly worked with or were initiated by neighbourhood residents. This excluded city run and city led programs.
d. Had contact information available on the internet.
e. Were conducted in English: the reason for this was to have a common language for participation in the workshops planned as part of this research.

We restricted our initial search to ten programs as we were working within the frame and budget of a one year program. We also limited ourselves to neighbourhoods located in the Global North countries as our theoretical foundations as well as our collaborating program, Green Leagues, were located in the Global North. We then reached out to the program contact points via email for participation in this research. Two programs agreed to participate in the research. We further cross-checked the relevance of including these programs with our research partners, the Green Leagues Program. Here we present a short introduction of the invited programs:

Ecoburbia, Australia

Located in a suburb of Fremantle in Australia, Ecoburbia started in 2013 as an citizen-led program focused on creating more resilient communities in response to the challenges presented by climate change and peak oil[61]. Started by Shani Graham and Tim Darby, Ecoburbia functions as a community hub, micro-farm, and urban infill development site[62]. Ecoburbia's building has been retrofitted with sustainable solar power sources and water collection and dispersal systems. Ecoburbia is described by its creators as a hub committed to educating the community in which it is located and building resilience through workshops and events[62]. The Ecoburbia program defines itself as a bottom-up community program and works independent of the City of Fremantle.

The City of Fremantle is located 25 minutes from the capital of Western Australia, Perth. It has a population of 31,930[63]. In May 2019, Fremantle declared a climate and biodiversity emergency and, subsequently, in March of 2021, adopted the City of Fremantle Climate Emergency Position Statement[64]. This statement sets out the City's desire for action to be taken by all levels of government to mitigate the projected effects of climate change[64]. The City of Fremantle has eight neighbourhoods and, since COVID-19, has worked to provide funding and support for the development of neighbourhood resilience[65]. Specifically, during the pandemic, the City initiated the Neighbour to Neighbour program that worked to build community connectivity. This work has continued through the creation and distribution of Neighbourhood grants. Currently, the City does not have a neighbourhood climate action program, and its resilience work at the neighbourhood scale is focused on public engagement and community workshops.

The resilient streets program, Victoria, Canada

The Resilient Streets Program is part of the Building Resilient Neighbourhoods (BRN), which is a collaborative effort launched in 2012 to build resilient communities and neighbourhoods in the Greater Victoria region in British Columbia, Canada[66]. The program aims to strengthen street level connections between households, build relationships between neighbours, and promote cooperation and mutual support during emergencies. The program is financed through Building Resilient Neighbourhoods which is a non-profit society[66]. The Resilient Streets Program's initiatives include multiple public events such as celebratory gatherings (potlucks and fests), rooftop gardening, wall mural paintings, local scaled street interventions (such as landscaping and traffic calming), tools sharing and skills exchange, as well as sharing individual and household stories with the community through an online platform. The program is operationalized through various awareness workshops and micro-grants (financing) which act as kick starters to small scale projects initiated by the residents[66]. The Resilient Streets Program helps neighbourhoods to access funding offered by the City of Victoria[66].

The City of Victoria is the capital of the province of British Colombia in western Canada. It has a population of 94,000 people. Victoria declared a climate emergency in 2019 and addressed climate mitigation and adaptation through its Climate Leadership Plan[67]. The City of Victoria has thirteen neighbourhoods and has a Neighbourhood Team that is working to build neighbourhood capacity. Currently, the City offers grant funding for neighbourhood scale projects and has designed a guidebook to help communities create Neighbourhood Led Action Plans[68]. The City is also taking action to encourage neighbours to build connections through block parties and working to create Neighbour Hubs, which are public gathering spaces for community members during emergency events. The program representative who participated in our research and drew from her experience of working across neighbourhoods in Victoria.

Workshop as a research method

A workshop is defined as a "means an arrangement whereby a group of people learn, acquire new knowledge, perform creative problem-solving, or innovate in relation to a domain-specific issue"[69]. Workshop is a co-creation research methodology (Wittmayer et al.[70]) that aims to add to the participants knowledge about a certain domain as well as produce data about the domain in question[69]. Collaborative workshops may serve as catalysts for co-creating new knowledge on ideas and inspiration through exchange among the participants[71]. Workshops, conducted in an online environment, gained relevance as a method of data collection in social sciences during the COVID-19 pandemic[72].

For our research, we designed and conducted four online workshops between May and October 2021 on Zoom, during the height of the pandemic. The workshops were collaborative in nature[69], with the researchers leading the workshops while remaining open to the participants' inputs. The first three workshops were spotlight workshops where each of the participating programs presented their work and ongoing projects. The presentation provided an impulse for a discussion on the opportunities and challenges of the project. As well, it led to participants sharing their own experiences from engaging in neighbourhood climate action activities. The first three workshops used a question and answer format (either through the audio or chat function in Zoom). The final workshop was a synthesis workshop where Sustainability Directors from the Green League program, who had participated in the previous workshops, reflected on the information shared from the previous workshops as well as developed pathways for moving forward. We used Miro, an online collaborative whiteboard, to collect participants' inputs. The research team summarised the key challenges identified through literature as well as the first three workshops and worked towards co-creating solutions to overcome these challenges. The participants provided examples of where and how they had overcome these challenges. This was followed by inputs from other participants. Table 2 summarises the structure, objectives and the participation in the four workshops.

Data analysis

The workshops produced 4.5 hours of recordings that were transcribed and transferred to NVivo, a qualitative analysis software. We adopted a thematic analysis approach to analyse the data[73]. We first deductively coded the transcripts on six broad themes of opportunities and challenges identified through the literature review (see Table 1). Further, we inductively coded the transcripts for elaborating upon the opportunities and challenges of neighbourhood climate action. These were coded as sub-categories in the code book (see Supplementary Table 1). Finally, we inductively added the additional theme of 'solutions' that the participants shared with regard to the challenges that they identified. The solutions were then linked back to the six coded categories of opportunities and challenges.

Table 2. Structure objectives and participation in online workshops.

Date (2021)	Title of the workshop	Structure	Key objectives	Number of participants
May 26	Yes, energy transition in my backyard	30 minutes presentation on the Green Leagues program and projects followed by a 30 minutes discussion with the participants in a question-answer format.	Identify the key opportunities and challenges of the Green Leagues program. Identify ways in which the Green Leagues program overcame challenges.	Presenters: 2 SD: 8 EFCL representatives: 1 Research team: 3
June 22	Let's talk community: Ecoburbia	30 minutes presentation of the Ecoburbia program and projects followed by a 30 minutes discussion with the participants in a question-answer format.	Identify the key opportunities and challenges of the Ecoburbia program. Identify ways in which the Ecoburbia program overcame challenges.	Presenter: 1 EFCL: 1 SD: 7 Research team: 4
August 10	Resilient Streets program	30 minutes presentation of the Resilient Streets program and projects followed by a 30 minutes discussion with the participants in a question-answer format.	Identify the key opportunities and challenges of the Resilient Streets program. Identify ways in which the Resilient Streets program overcame challenges.	Presenter: 1 EFCL: 2 SD: 5 Research Team: 3
October 13	Co-Creating Neighbourhood Climate Action Strategies	Interactive 1.5 hours workshop where the research team collected inputs from the participants.	Collect inputs on participants regarding the 6 opportunities and challenges identified in literature. Collect input from the participants on ways they have/can overcome the identified challenges	EFCL: 2 SD: 7 Research Team: 3

In accordance with the ethics approval of this project (Project ID: Pro00113873), we adopted a two-step procedure to establish informed consent from the participants. First, a recruitment email regarding the project was sent along with the invitation to participate in the events. The email stated that the workshops were being organised as part of a collaborative research project and the inputs provided might be used for academic purposes. On the day of the workshop, we reiterate the information from the recruitment email verbally before starting the session. We also obtained verbal consent to record the session. Participants were requested to turn off their cameras if they did not wish to appear in the recording. Participants could withdraw consent within two weeks of the event by writing to the research team members. We have identified the participating programs with their consent, however, we have kept the identities of the participants anonymous.

Limitations

We identify three limitations in our research design. First, the data was collected as part of a one-year project, limiting the amount of time that we could allocate for workshops and the number of programs that we could invite. Second, given that this research was conducted during the COVID-19 pandemic restrictions, we were limited to the use of digital means of communication for inviting participants (emails) and conducting the workshops (Zoom). Finally, our participants were largely volunteers from the neighbourhood organisations and had competing demands on their time from their jobs and household responsibilities. We selected a one hour long format during lunchtime based on a pre-workshop survey with the participants on the best suitable time and duration.

Reporting summary

Further information on research design is available in the Nature Research Reporting Summary linked to this article.

DATA AVAILABILITY

Video recordings generated during the workshops have been made internally available to the workshop participants but cannot be publically shared as they contain identifying information of the participants. Condensed code sheet for the transcripts is provided under Supplementary Table 1.

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Funding acquisition, conceptualisation and methodology: N.J., S.A. Data collection, processing and summarisation: H.A., D.P., N.J. & S.A. Writing drafts: N.J., H.A., D.P., S.A. Editing and Finalising: N.J., S.A., H.A., D.P. Project administration: N.J. Supervision: S.A. All authors have read and agreed to the published version of the manuscript.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION