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# Enhancing green infrastructure in cities: Urban car parks as an opportunity space

the activity forward.

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Keywords: Green Infrastructure Urban Agriculture Sustainable Cities Transport	Interest in radical solutions to embedding Green Infrastructure (GI) into the built environment are at an all-time high. With land value often preventing more mundane forms of GI, key actors, such as planners, developers, architects and others, are increasingly exploring novel methods for embedding the features. This innovation involves a surge in green roofs, living walls and other systems which enables nature to thrive in otherwise hostile environments. Many of these systems are embedded on or within office complexes, universities and various 'clean' buildings within cities. However, there is a nascent movement to using urban car parks to enhance GI. In this opinion piece, we reflect on the opportunity space here and the potential to upscale work around embedding GI into urban car parks: exploring good practice, barriers to implementation and recommendations for moving				

# 1. Introduction

Cities are expanding at a rapid rate, putting more pressure on land use, resources and their inhabitants (Luo and Lau, 2019; Ramyar et al., 2020). By 2050, it is estimated that many urban areas will have significantly increased their land area, with some 68% of the world's population residing in cities (He et al., 2021). As Panagopoulos (2019) argues, such changes are putting increased pressure on ecosystems and there is a need to critically reflect on mitigation measures to prevent disaster. Alongside ecological pressures, Mitchell et al. (2021) argues that such rapid urbanisation has a negative effect on city dwellers: exposing them to increased development, noise, air pollution and often segregating them from nature. In this sense, they argue that with development taking precedence in terms of land use, this results in landscapes which are not ideal for the health of city residents. However, with post-COVID planning often favouring a scaling-up of Green Infrastructure (GI) and other concepts, there is renewed interest in innovation around sustainability in the built environment (Florida et al., 2021).

GI can be described as "natural or semi natural networks of green (soil covered or vegetated) and blue (water covered) spaces and corridors that maintain and enhance ecosystem services" (Green Building Council, 2015 p.15). Traditionally, parks, allotments, trees and other assets are considered key components of urban GI (Bell et al., 2018). In

recent years these assets have come under increased pressure from development, budget cuts and associated impacts; reducing their existing impact and often preventing future expansion (Nam and Dempsey, 2019). Since the pandemic however, there has been a renewed interest in how to effectively incorporate GI into the urban fabric, with a rise in policies and other tools to enable mainstreaming (see for example Scott et al., 2018).

A major barrier to the implementation of these more creative GI systems often surrounds the weight capacity of infrastructure, accessibility and the general cost of retrofit, alongside other land use pressures. We argue that urban car parks offer a unique opportunity space here, given their ability to overcome many of these obstacles. With the post-COVID reforming of urban centres around principles such as the 15-minute concept, walkability and more efficient public transport systems, these spaces could become underutilised in the future cityscape (Florida et al., 2021); presenting an opportunity space to upscale novel GI solutions. Indeed, there are already examples of this in practice, with allotments and mini green roofs existing on some urban car park structures (see: Silva et al., 2018; Warhust et al., 2014).

With the rise in tools designed to deter cars from cities, from clean air zones to congestion charges and other interventions, urban car parks could be impacted in parts of the world by a dwindling customer base (see for example, Gonzalez et al., 2021). Indeed, Gonzalez et al.'s (2021)

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study demonstrates that residents themselves are turning away from private vehicle ownership in cities, such as Madrid, where interventions are implemented; resulting in not just public, but also private urban car parks experiencing reductions in terms of their need and value. Labee et al. (2022) demonstrate that there has been an upscaling of such measures, with concerns around poor air pollution, congestion, accidents and climate change fuelling change. Coupled with changes due to pandemic working habits, we could see more ad-hoc and infrequent use of these spaces (cf. Florida et al., 2021). We proceed to reflect on wider novel approaches to GI before focussing on the appetite for urban car parks in this context. In doing so, we provide a reflection on the need for key actors to seriously consider these assets for the mainstreaming of innovative GI solutions.

# 2. Novel approaches to GI in cities: Exploring practice

In Europe, innovation in the form of pocket parks, community gardens and more complex GI systems are increasingly becoming commonplace in urban areas (Baumont De Oliveira et al., 2021; Scott et al., 2013). Schoen et al. (2020) demonstrate the immense social value of some of these newer forms of GI, particularly community gardens, which they highlight as an important asset for urban residents. These community gardens are becoming increasingly popular in the UK, with local authorities especially favouring the model; this is partially due to strict legislation around allotments, which could restrict future development on allocated spaces (Holland, 2004; Pitt, 2014; Viljoen, 2005). With community gardens, it could be argued that this enables authorities to change space much easier and avoid the legislative constraints of the allotment model, with the latter protected under strict planning regulations in the UK. As St Clair et al. (2020) argue, the community garden model has major drawbacks, with projects often shutdown with little notice in favour of development activities. We now proceed to review a spectrum of what we designate 'radical' GI interventions, before delving into barriers and urban car parks within this context.

#### 2.1. Radical GI: Practice and benefits

Within cities there is a burgeoning movement to enable more creative solutions to embedding GI into the built environment. Repurposing leftover infrastructure is highly popular at present, such as New York City's High Line, which has influenced countless other similar approaches globally (Al-Chalabi, 2015; Svendsen, 2013). In 2022 for instance, the City of Manchester in England opened a similar space, supported by the often rural-focussed National Trust (National Trust, 2021), whilst Barcelona's 'Jardins de la Rambla de Sants' is another example here (Urban Nature Atlas, 2021). We are even witnessing private actors investing in such 'radical' GI at a somewhat large-scale, such as Peel Holding's expansion of green roofs, or Creative Apparel, a fast fashion company retrofitting living walls and a roof onto their new factory build (Creative Apparel, 2021; PLP Construction, 2018). In terms of radical GI, we adopt Mitchell et al.'s (2021) definition here, in which large-scale urban agricultural projects, green walls and roofs and other somewhat unique forms of GI features could be considered under this broad term.

As mentioned at the beginning of this piece, a driver for this investment surrounds the new to address climate change impacts, reduce emissions in cities and create more public assets (Gonzalez et al., 2021). GI is viewed as a powerful tool as part of this drive, due to its wide ranging benefits: from its immense social value, to its ability to cool heavily populated areas (Schoen et al., 2020). Indeed, Scott et al. (2021) argue that there is a desire to mainstream the concept within policy making and planning processes, in part due to climate change, biodiversity loss and other concerns, particularly within urban environments. They argue that progress has been made and, with more interdisciplinary and transdisciplinary work, GI can be mainstreamed on a wider level (Scott et al., 2021).

The radical GI international movement is flourishing, for instance, in Germany Stuttgart's authorities have introduced legislation requiring any new flat, and most pitched roofs, to have green roofs installed (Wilkinson et al., 2022). Similarly, Lawrence et al. (2022) show that rooftop urban agriculture has expanded in South Africa, with the potential to enable short food supply chains and new business ventures. The aforementioned High Line in New York City has acted as a catalyst for similar schemes globally (Lang and Rothenberg, 2017). The sky park concept has transformed part of the west side of the city, through drawing in tourists, creating new business ventures and enabling more greenery in an otherwise grey environment (Loughran, 2014).

Such ventures appear overly positive and beneficial to the city. However, with the 'famous' High Line example, Black and Richards (2020) show that it raised nearby house values by 35% and led to gentrification in the area. Adding to this, Lang and Rothenberg (2017): (1758) question the social equity of the scheme, even going so far as to warn other cities about the 'High Line effect'; in this sense, how similar green developments can lead to negative impacts on the cityscape and particularly its residents. Similar critiques have been voiced with other radical GI schemes, such as Ling 's et al. (2020) reflections on vertical greening and gentrification in Taiwan. In their work, they urge decision-makers to reflect on urban greening strategies to avoid negative impacts on communities. With the scaling-up of GI in urban areas, particularly radical models which are often aesthetically pleasing and draw in footfall, these concerns around green gentrification will certainly persist for years to come.

Despite these critiques, the benefits of GI are well-documented in the literature, particularly the social and environmental value of the practice (see for example Schoen et al., 2020). Marchi et al. (2022) show how urban greening was of immense value during the pandemic and argue that planning such spaces into the urban landscape should be a priority moving forwards. Schoen and Blythe (2020) highlight how interest in productive spaces has especially expanded, particularly due to their role during the pandemic and ability to grow food in the heart of the city. Their view alludes to the idea that key actors should be exploring ways to increase productive spaces within our city and move beyond merely aesthetic value. Whilst the above relates to more 'conventional' GI systems, Lang and Rothenberg (2017) note that newer forms, such as the High Line, require further investigation as to their value to cities.

Howarth et al. (2020) demonstrate how key actors are also realising the wider benefits of these systems, with concepts such as social prescribing becoming more prominent within our cities. Social prescribing allows for individuals suffering from certain health conditions to be prescribed nature, which in turn generates more revenue for formal projects and has positive health outcomes for those involved (Bell et al., 2018; Howarth et al., 2020). In the UK, there has been a significant focus on this approach, with the likes of DEFRA investing millions into projects such as the upscaling social prescribing initiative (DEFRA, 2020). Nevertheless, as Mitchell (2021) highlight in their spatial analysis of social prescribing projects in the UK, the majority of these schemes still reside outside of urban centres and more work is needed to embed them into the city context.

# 2.2. Urban car parks and GI

Despite a move away from private transport in many cities, car parks still litter our urban landscapes across the globe. Within the UK, the RAC (2020) estimates that there are 20,000 car parks, providing some 3–4 million spaces. In the US, it is estimated that around one third of the land area of cities is taking up by parking bays, with some 800 million spaces in total (Fast Company, 2021; Rossenblum et al., 2020). As outlined in the introduction, there is already work ongoing on how we can rethink the use of urban car parks, either in their entirety or small sections of the development. Whilst we realise that these spaces will not reap the same benefits as retrofitting an office block and the energy savings associated with a green roof, it may be advantageous to encourage certain GI approaches within these spaces.

An example here can be seen with the concept of Urban Agriculture (UA) and creating more food secure cities. Evidence shows that a major barrier here is the availability of space in centres and yet the immense social, environmental and often economic value of even the smallest projects (Milbourne, 2011). Indeed, waiting lists for traditional UA spaces are so severe, evidence shows that some urban residents are resorting to guerrilla gardening and other informal activities to grow produce and to feel connected with nature (Reynolds, 2008). This vision for using car parks as key enablers for food production is already being realised, with projects such as Birmingham's multi-storey car park urban farm pioneering practices at scale (see BBC News, 2023).

Urban car parks may not merely be viewed as assets for enhancing community-focussed GI schemes, but also as an opportunity space for smaller-scale improvements. In this context, there is evidence of an increasing appetite for more sustainable, and often greener, materials within car park construction, such as those shown in Fig. 1. For example, flooding and storm water run-off is often an issue due to the impermeable surface of concrete and other materials used in car park construction (Abebe et al., 2018). Eraslan and Secme (2018) developed the idea of using a permeable surface, such as asphalt in car parks, to create a GI-enhanced infrastructure. However, with cars parking for longer durations, the stability of this material needs to be researched and critically evaluated. The issue of the Urban Heat Island effect (UHI) is discussed by Eraslan and Secme (2018) as they suggest that GI such as green roofs and walls insulates buildings, therefore, creating a more sustainable and energy efficient car park. Further supporting Eraslan and Secme (2018), Goode (2006) also researches how the UHI is a product of an urban setting and that GI-enhanced car parks can reduce this phenomenon. In the UK, there are examples of new car parks adopting GI, such as with Northern Roots and their use of natural materials during the construction of their eco-park scheme (see Northern Roots, 2021).

Opportunities are already being realised with regards to using urban car parks in innovative ways and not merely the greening of assets for purely aesthetic purposes. Open car parks enable more conventional GI systems to flourish, perhaps in raised beds or other systems, with little restrictions due to natural light (Warhust et al., 2014). Multistorey or more closed car parks may be more restrictive in this regard, but evidence shows that high-tech systems, such as hydroponics, could offer bypass the lack of natural light in these spaces (see for example Freight Farms, 2022). The appetite for high-tech has expanded rapidly within cities, with projects such as Farm Urban and their underground growing systems, demonstrating the future potential in urban environments (Farm Urban, 2022). As Caputo et al. (2020) argue, we are witnessing a range of policy tools, funding and general support from key actors to expand the practice, with space being one of the few constraints to the systems. In the context of urban car parks, particularly those with poor natural light, there is an opportunity space here to consider high-tech options to bypass the restrictions; particularly systems, such as those



**Fig. 1.** a multistorey car park in Cornwall, England featuring natural elements (author's own).

by Freight Farms, which are ready made and can be adapted into the urban fabric with relative ease. Such spaces could also be viable assets for rooftop space, given their ability to hold substantial weight and usually high-level of accessibility through elevators for instance.

# 3. The case of Manchester: Exploring the potential of scaling-up

# 3.1. Pilot study methodology

This piece aims to provide a critical reflection on the opportunities and barriers to using urban car parks for enabling GI activities in the built environment. Following our reflection on the potential from a desktop perspective, we now reflect on a pilot exploration in Manchester. This pilot aimed to ascertain views towards enabling practices explored through the secondary data, prior to engaging key actors on the ground. As Table 1 shows, the latter included an array of major car park companies, planners, local authority officials and others. The core focus here was to critically investigate the practicalities and possibilities of translating theory into practice at scale in a cityscape which was amongst the fastest growing in the UK. Data collection started in 2019 and stretched into 2020; due to pandemic restriction, some of the later interviews were conducted by distance methods, such as Teams and Zoom.

Grounded Theory's point of saturation was used as a tool to determine the sample in each category, with the research team ceasing data collection when no new knowledge was generated through discussions (Glaser and Strauss, 1967). The larger sample for the city residents and wider stakeholder group was due to the methods used in this context, with the aim of ascertaining broader views to changes to the urban landscape through the car parks. It was crucial here to gain an insight from the public and private sectors, alongside the general population; in this sense, exploring trends from a variety of perspectives, such as those who own the assets, to users and government decision-makers. Participants were recruited through a combination of meta gatekeepers, such as resident associations, to adopting a snowball method to connect with the key actors involved in the study, such as the car park owners.

Thematic analysis was the core analysis method through NVivo, allowing for themes to be generated from the interview and focus group data. Through content analysis, we were able to generate an array of meta themes, which we delve into in more depth in the next sections. These themes ranged from health benefits, to financial concerns and the aesthetics of the assets; we proceeded to group these into meta categories of opportunities and barriers for the discussion element of this paper. We now proceed to reflect on these discussions from Urban Residents (UR), Car Park Owners (CPO), Authority Officials (AO) and other stakeholders; with the latter, we refer to such respondents by their occupation, given the breadth of interviewees in this category from various sectors.

# 3.2. Reflecting on opportunities and barriers

Manchester is undergoing drastic change with population growth

#### Table 1

an	overview	of th	e data	from	the	pilot	study	in	Manchester
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Interview group	Method	Number in sample
Car park owners - CPO (e.g. private car park companies, smaller organisations)	Semi-structured interviews	7
Authority officials - AO (e.g. planners, environmental health officers, policy officers)	Semi-structured interviews	7
Urban residents (UR) and other key stakeholders (e.g. community groups, social enterprises)	Semi-structured interviews and focus groups	53

fuelling development in the city (Silver, 2018). As Rose and Silver (2020) argues in a more recent piece, the city's rapid development is reducing access to quality GI, with private development favoured over community-focussed initiatives. Fig. 2 provides an indication as to the dearth of formal green space within the urban centre, with only a few pocket parks and other assets existing within the inner ring road. The local authority has responded with the aforementioned viaduct park project and a new £ 1 billion park scheme in the North of the city; such schemes are still funded through private development investments and could take over a decade to be realised (Manchester Evening News, 2020). Manchester, like many other UK cities, has a wide array of urban cars parks, with the Manchester Evening News (2020) estimating that there are over 30,000 spaces alone in formal lots. The city offers an opportunity to evaluate the potential of opening up some spaces to meet the demands of the local residents and provide creative solutions to enabling GI in a place focussed on major development. More recently, the focus on a clean air zone in the city demonstrates the potential impact on its car parks and the need to rethink how these spaces could be utilised (see Clean Air GM, 2022).

#### 3.2.1. Benefits of scaled-up transformation

There was agreement across the various groups in Table 1 with regards to the core benefits of opening up such spaces. Private car park owners mentioned the marketing benefits and connection to communities, allowing them to build partnerships with potential clients. With the former, several owners felt that it would make their car parks more attractive, particularly through tools such as green walls or living roofs; creating a safer image of the spaces and helping them to standout from

competition. With regards to working with communities, the owner of one of the largest private car parks mentioned how such changes could help to 'support people's physical and mental wellbeing' (CPO1). This was echoed by others, with a smaller car park lead mentioning how cumulatively this could help to create a 'higher quality of life' (CPO2) for urban communities, whilst another added to this by explaining it helps the spaces to 'blend into their surroundings' (CPO3).

In a similar manner, in terms of the broader key actor group of planners and environment officers, they alluded to the idea that it could lead to more GI creation and positive impacts on communities. An Environmental Health Officer argued that such enhancements 'could encourage better health and wellbeing' (AO1). In this case, AO1 was alluding to the concept of social prescribing and opening up of spaces for more innovative activities in a highly restrictive built environment. A local authority planner agreed with this, stating that It could help to 'create healthier environments' (AO2), particularly if this was scaled-up across Manchester, specifically for urban communities which have been impacted significantly during the pandemic. This was a strong focus from this particular stakeholder group, who also argued that air quality could be impacted and green community schemes, such as UA, could be upscaled. Connecting again with the private stakeholders, a planner mentioned how such activity could enabled 'cleaner places' (AO2) and transform the often negative images of urban car parks. The cumulative impact of scaling up was a focus in this group, with the decision-makers recognising the opportunity if this practice was widespread.

The wider stakeholder groups focused on how this could enable them to address land acquisition in the centre. A social enterprise lead mentioned how 'a main thing for me is getting the land, even just for a



Fig. 2. Formal greenspaces in Manchester City Centre (Contains OS data © Crown copyright [Mapbox / OpenStreetMap] [2022]).

#### A. Evans and M. Hardman

short time... I could do quite a lot with those spaces'. In this sense, the social enterprise lead was referring to using raised beds for food growing purposes. They argued that it was very difficult to do this in the centre of Manchester, despite a large amount of interest from residents and the broader community alike. This was echoed by other interviewees and focus group participants in the wider group: 'there could be more incredible edible type projects' (UR5), 'all added together it could make quite an impact' (small green business CEO), 'the top levels are never used... there's so much space for pocket parks and other green schemes' (voluntary sector lead).

'It'd be more pleasant to look at and possibly more calming'

(UR1)

'Anything that enhances our environment is beneficial to everyone'

(UR3)

'I feel the benefits of green infrastructure would balance out the reasons why a car park is used... using a car emits pollution, whilst a green roof mitigates pollution, they balance each other out. The green roof makes you feel that little bit better about using a car'

(UR8)

'Car parks tend to be very stark, with the only non-solid structure being accumulated litter'

### (UR14)

'People aren't using the car parks as much, the clean air zone will come in soon'

# (UR30)

'I believe that green car parks will improve our chances of creating a more sustainable environment and helping us all in the future'

# (UR11)

In a similar manner to the other stakeholder categories, the wider group were optimistic around the opportunities with using such leftover space, particularly in a city in which land use overly favoured development (see Silver, 2018). Comments ranged from the health benefits to the aesthetic changes and mitigation measures of converting car parks at a broad level. Our pilot shows that residents, community groups, business leaders and social enterprises were keen on the concept, particularly given the post-COVID focus on scaling-up GI and lack of access to such spaces during the height of the pandemic. Many were realistic about options in such spaces, with a preference for raised beds and food growing; potentially enabling more radical practices, such as high-tech systems or green roofs, if initial pilots were successful. This is captured through UR40, who explained that 'we just look over a grey car park, the idea of growing food there sounds exciting... there aren't any allotments in the centre really'.

# 3.2.2. Core challenges

In a similar manner, there was a broad consensus around the key challenges facing the use of this infrastructure. As with the secondary data, all stakeholders mentioned the issue around multistorey facilities and a lack of natural light: 'the raised beds would have a hard time, unless it was on the top floor' (Incredible Edible scheme lead), 'I don't see how things could grow there' (CPO4), 'I mean they aren't the nicest of places to hang out' (UR16). There was also an appreciation that utilities might be an issue, particularly for sites which aimed to be productive. Whilst mundane spaces require access to water supplies, high-tech projects often require a lot of energy and thus this might not be feasible in all urban car park sites.

Another core challenge identified across the groups related to the cost element, particularly around insurance, utilities and general access. A highly experienced green social enterprise lead commented on utilities being the largest obstacle 'water is important, I'm not sure how that would work'. He continued to question how these facilities would be installed and who would pay for their use, particularly with regards to the cost of insurance, soil and labour. This barrier was echoed by some of the car park owners interviewed, with one suggesting 'we are not in the position to be looking at spending money unless it is absolutely necessary' (CPO3). This hesitancy around cost was also mentioned by the key decision-maker stakeholder group, with a planner capturing the views of many, 'cost is a big thing and maintenance would be needed which would rack up the bills' (AO2).

Despite the cost barrier, the wider stakeholder group, in particular the residents, voiced support for innovation and a willing to pay more if car parks could focus more on GI innovations: 'I think that not only would it look more appealing [but] I'm happy to pay a little extra for something if I know it's helping the environment' (UR1). This willingness to pay more was echoed by others in the focus groups and interviews:

'I would need to be reassured that any car parking fees were going towards supporting the environment around me. I would be glad that they we aware of the importance of climate change and the strategies towards improving air quality'

# (UR7)

There was an explicit focus on the potential bureaucracy involved from those stakeholders who coordinate GI schemes. As St Clair et al. (2020) show, sites with temporary leases can cause friction in communities and the process for establishing even the simplest of spaces can be costly and overly lengthy. Linked to this, this stakeholder group were aware of vandalism issues, having experienced much of this already on their more 'traditional' GI schemes: 'car parks aren't the nicest of places, things will just get stolen' (social enterprise lead), 'you get all sorts of dodgy people in car parks' (small green business CEO). Although more modern car parks were viewed as perhaps being more secure in this context, allowing for tools and equipment to be left on site.

# 3.2.3. Reflecting on the opportunities and barriers

Our pilot qualitative exploration provides a series of discussion appoints around the retrofit of urban car parks for GI activities. In Table 2, we attempt to capture the key findings through reflecting on the focus group and interview data collected.

If such work was to be upscaled, we urge key decision-makers to ensure accessibility and social value is at the heart of their work. As the earlier background sections demonstrated, green roofs and similar projects are on the rise globally (Wilkinson, 2022). However, we argue that the vast majority of these are inaccessible to general members of the public and urban residents: this is perhaps through a lack of appropriate infrastructure, to support those with disabilities, to the health and safety risks around the general population accessing roof spaces. Urban car parks offer an opportunity space here in that many are equipped with good access, through elevators for instance. Many are also open to members of the public and therefore much easier to access in general. Alongside this, top levels of multi-storey car parks are often equipped with safety tools to enable the general public to gain access, without the need for qualified health and safety officers. If managed correctly, this could provide additional opportunities in the cityscape for populations to access these more creative GI solutions.

# 4. Moving forwards: Using forgotten spaces for GI

This viewpoint paper aimed to provide an insight into the appetite from a range of key stakeholders with regards to utilising urban car parks for GI activities at a broader scale. Our opinion here centres on the need to be more innovative with regards to these landscapes, particularly in congested cities such as Manchester. With the city's urban population due to triple in the next few years (Silver, 2018), there was

#### Table 2

a summary of the opportunities and barriers according to each stakeholder group.

Stakeholder group	Opportunities	Barriers
Car park owners	<ul> <li>Marketing tool</li> <li>Enhance social impact and sustainability work</li> <li>Potential cost saving (e.g. energy savings through living wall schemes)</li> </ul>	<ul> <li>Cost implications (e.g capital investment)</li> <li>Maintenance responsibilities</li> <li>Potential conflict through lease and insurance issues</li> </ul>
Key decision- makers	<ul> <li>Social, environmental, economic and health benefits could be significant</li> <li>Allows for innovative GI in congested cities</li> <li>Cumulative impact potential of large retrofit</li> </ul>	<ul> <li>Lease conditions and legal requirements</li> <li>Cost for initial setup and ongoing maintenance</li> <li>Impact of emissions and other pollutants on schemes (particularly food growing)</li> </ul>
Social enterprises / GI businesses	<ul> <li>Provides opportunity space in the heart of cities</li> <li>Ease of access and potential for significant impact</li> <li>Generation of revenue through partnerships with car park owners</li> </ul>	<ul> <li>Limits with regards to activities (e.g. raised beds for growing)</li> <li>Costs, particularly of ongoing maintenance</li> <li>Utility access</li> </ul>
Urban residents	<ul> <li>Excited by the aesthetic, health and wider sustainability benefits</li> <li>Allows for access to GI, which otherwise would be far away from homes</li> <li>Acts as a connector between often fragmented urban communities</li> </ul>	<ul> <li>Hesitancy around consuming produce grown in such areas</li> <li>Vandalism and general perception of car parks</li> <li>Issues around contamination</li> </ul>

wide recognition for the need to be innovative around opening up spaces for GI projects. The rise of GI strategies, in conjunction with recent changes to the UK's planning system, could offer an opportunity to expand these practices within urban car parks. With the latter, the upscaling of tools, such as neighbourhood planning, could result in more opportunities for the retrofit and creative use of such infrastructure (see UK Government, 2020).

Our opinion piece highlights how urban car parks can become important assets in the fight against climate change, from cooling the city to creating havens for green space within the city. Furthermore, the spaces could help to advance inclusivity within the radical GI agenda. Many current schemes under this broad term, such as green roofs, are often inaccessible to general members of the public: perhaps due to safety reasons, a lack of accessible infrastructure or other reasons. Indeed, such schemes are often prevented from even starting due to weight capacity issues and the costs associated with retrofitting rooftops. In this context, urban car parks could help to provide more accessible, cheaper spaces for rooftop cultivation; creating short food supply chains and centres of immense social, environmental and economic value within often congested landscapes.

Of particular note, our opinion piece highlights the desire from an array of sectors: residents, car park owners, authority figures and other organisations, for the more creative use of urban car parks. Table 2 captured these views in a broad manner, but it demonstrates that through collective action such transformation can happen, perhaps with minimal financial commitments in comparison to other projects. As the literature demonstrated, more radical forms of GI are often expensive, even the simplest community garden or green roof can be costly (St Clair et al., 2020). Based on these findings from Manchester, we believe that:

- Urban car parks can be important assets for growing the GI movement within complex cityscapes.
- Policy officials, planners and other key actors should explore pilot projects to connect together groups and car park owners.

- There could be significant social, environmental, economic and health value through adapting the infrastructure.
- Our opinion piece shows that there is an appetite from a variety of stakeholders in this area, with benefits for each.
- Barriers, such as cost, access to utilities and other elements can be overcome through the implementation of correct models (e.g. raised beds or high-tech systems).
- Through using urban car parks, it could enable more inclusive forms of GI in the cityscape.
- There may still remain barriers to implementation, from the retrofit of ageing infrastructure to enabling access to resources for UA activities.

It must be noted that this is a viewpoint paper derived from a pilot study and provides a snapshot of the opportunities and barriers within a UK setting. Whilst Manchester's case is relevant for a number of other global contexts, a weakness of this piece is that we only focus on one city. A major barrier to generalising this research is that cities worldwide are adopting varying strategies with regards to urban car parks. In some cases, such as the US, although there have been efforts to mainstream other mobility choices post-COVID, the car still dominates urban centres and thus these assets are still in high demand (Greene et al., 2022). Recent policy movements to restrict usage in some US cityscapes, such as New York City, could lead the way for less used car parks to play a more pivotal role in urban GI strategies (see for example, New York State, 2023). We therefore urge for more focussed case study research to allow for these localised contexts to be explored in-depth; tailoring solutions based on the different landscapes in question. We also encourage a more critical lens on the scaling-up of car park use in this regard, exploring potential negative impacts, such as green gentrification.

With key actors increasingly aiming to explore the enhancement of radical GI, we feel that our pilot investigation showcases the immense potential in this area. Our reflections on the opportunities and barriers highlight lessons to be learned and offer evidence to mainstream practice. Through collaboration, such sites can become important assets in urban environments: offering spaces for social prescription, community food growing and perhaps even important sites for small business creation. Only through collaboration and innovation can these spaces be transformed. We hope that our study illuminates the potential in this area and need for urgent action, along with more research into this growing area.

# CRediT authorship contribution statement

**Evans Alicejane:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. **Hardman Michael:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

# **Declaration of Competing Interest**

none.

# Data availability

The data that has been used is confidential.

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