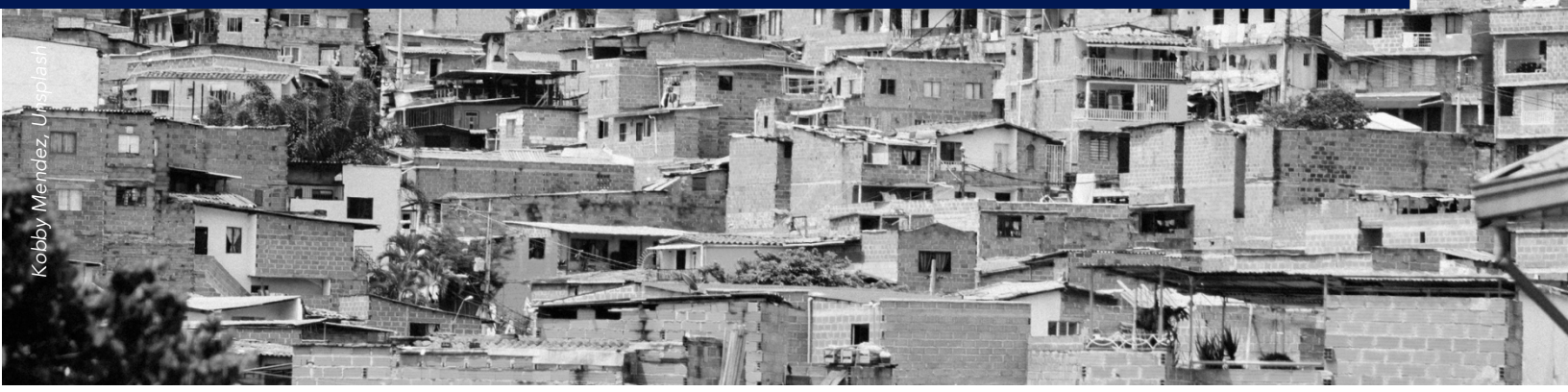
Realising the Multiple Benefits of Climate Resilience and Inclusive Development in Informal Settlements

2019



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Executive Summary

Climate change will worsen many existing shocks and stresses, in addition to creating new challenges in informal settlements ('slums')[1]. Climate and disaster-related risks in cities cannot be addressed without upgrading informal settlements; likewise, upgrading will be futile unless the impacts of climate change are taken into account and incorporated.

Due to low incomes, fewer assets, and limited voice in governance, residents of informal settlements often lack the capacity to cope with climate risks. Additionally, recognising that informal settlements are not a homogenous group and individuals can be characterised by age, gender, occupation and disability etc, is crucial for policy interventions. Oftentimes, these individuals are likely to be more vulnerable than others and therefore should be considered in upgrading, to ensure an equitable distribution of benefits across an informal community.

This report explores how upgrading informal settlements can simultaneously help in achieving climate resilient, inclusive and low carbon development leading to multiple benefits. Upgrading is a process of improving living conditions in informal settlements, often by providing shelter and services while supporting economic development via stronger links with the 'formal' city. Interventions can range in scale and levels of community participation, and they may vary in scope from single-sector projects (e.g. water-taps, electrification) to multi-sectoral programmes. Along with analysing the benefits of key upgrading actions, the report offers a case study of a holistic intervention currently planned in Nairobi's informal settlement of Mukuru.

This report identifies ten particularly promising upgrading actions with potential to foster multiple benefits and advance several Sustainable Development Goals (SDGs). These interventions are specific to the context of Mukuru and are:

1. Increasing the efficiency of solid-waste management
2. Increasing the diversion of food waste, organics, and recycling with benefits for livelihoods
3. Cooler housing design
4. Provision of green space
5. Maintaining high-density neighbourhoods
6. Mixed-use development
7. Pedestrianisation
8. Increase cycling
9. Solar power for street lighting
10. Liquified Petroleum Gas (LPG) stoves for cooking

[1] The term 'slum' usually has derogatory connotations and can suggest that a settlement needs replacement or can legitimate the eviction of its residents. When used here, it refers to settlements characterised by some or all of the following: 1) a lack of formal recognition by government; 2) absence of secure tenure; 3) inadequate infrastructure and services provision; 4) overcrowded and sub-standard dwellings; and 5) location on lands that are unsuitable for occupation.

The above initiatives have significant potential to yield multiple benefits, as highlighted in Section 2 and Appendices 1 and 4, such as:

Social benefits; such as including the promotion of gender equity, community pride and social cohesion between local actors.

Health benefits; such as from improved air quality, increased physical activity and reduced vector diseases.

Climate benefits; such as through reducing CO_2 emissions (e.g. *a potential of 218 metric tonnes & 808 metric tonnes CO_2 reduction from residents cycling and walking to work in Mukuru respectively)* and adapting to local climate risks.

Economic benefits; such as through protecting assets such as houses and enhancing livelihoods through potential costs savings of up to 80% from switching to LPG from charcoal as cooking fuel.

Environmental benefits; such as through lower emissions and improved air quality.

The study of Mukuru also provides **several key considerations and recommendations** for international, national, local policymakers and NGOs as outlined in Section 4**.**

The key lessons learned from Mukuru are:

Integrated Upgrading; Mukuru's integrated plans and governance structure helped the government understand how a neighbourhood can be transformed using multi-sectoral strategies to foster resilience, rather than a single housing solution.

Federated grassroots organisations; Linking grassroots organisations with residents to support each other and share a multiplicity of experiences can make residents feel empowered to undertake improvements in their own settlements.

Devolved local government; A democratic and adequately resourced local government can secure national interventions in informal settlements and bridge the gap between national government and grassroots organisations in need of support.

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1. Introduction

Upgrading informal settlements will be an essential part of achieving resilient, inclusive and low-carbon urban development. Climate change will worsen many existing shocks and stresses, in addition to creating new challenges in informal settlements ('slums'). Upgrading these informal settlements can not only mitigate climate risks but also provide multiple socioeconomic and development benefits simultaneously.

Informal settlements vary widely, but they are often located in areas exposed to several natural hazards (Revi et al. 2014). Worldwide, an estimated 880 million people live in informal settlements, which are typically home to 30–50% of urban residents in the Global South (UN-Habitat 2016). These areas are already experiencing climate risks often linked to inadequate shelter, services or infrastructure, as well as facing small- and larger-scale disasters (Satterthwaite and Bartlett 2017; Pelling et al. 2018). Due to low incomes, few assets, and limited voice in governance, many residents of informal settlements lack the capacity to cope with such risks. Climate- and disaster-related risks in cities cannot be addressed without upgrading informal settlements; and upgrading will be futile unless the impacts of climate change are taken into account and incorporated.

Addressing climate-change-related risks and fostering resilience are vital in informal settlements, as recognised by the latest report by the Intergovernmental Panel on Climate Change (IPCC). It highlights the extent of climate change that is anticipated in coming decades, concluding that 'global warming of 2°C is expected to pose greater risks to urban areas than global warming of 1.5°C' (IPCC 2018, p.180). Additionally, it notes that the 'extent of risk depends on human vulnerability and the effectiveness of adaptation for regions [,] informal settlements, and infrastructure sectors (energy, water, and transport)' (ibid.). The IPCC's explicit identification of informal settlements as a key factor shaping climate-related risk, as well as the imperative to limit warming to 1.5°C, highlights the need for practical interventions in these neighbourhoods.

This report explores how upgrading informal settlements can contribute to climate resilience and inclusive development with multiple benefits, using findings from across the Global South and a case study in Mukuru, Nairobi. Upgrading is a process of improving living conditions in informal settlements, often by providing shelter, services, and tenure security while supporting economic development via stronger links with the 'formal' city (Satterthwaite and Mitlin 2014). Interventions can range in scale and levels of community participation and may vary in scope from single-sector projects (e.g. water-taps, electrification), to multi-sectoral programmes that include land tenure regularisation.[2] Residents of informal settlements face substantial risks in the face of climate change, but the following discussion will show how upgrading can strongly promote urban climate resilience. It identifies actions that can be taken by municipal governments and NGOs to deliver

[2] Although it can take different forms, 'secure tenure' is defined as the 'right of all individuals and groups to effective protection by the State against forced evictions' (Durand-Lasserve and Selod 2009, Payne *et al.* 2009). For Thailand's Baan Mankong upgrading programme, see Boonyabancha (2009); for Brazil's land tenure regularisation, see Fernandes (2011).

upgrades with multiple benefits, simultaneously achieving inclusive, climate-resilient urban development.

In particular, this report examines the potential benefits of improving infrastructure and services (i.e. clean energy, transport, solid-waste management), upgrading housing, and enhancing neighbourhoods through mixed-use development. It focuses on strategies that can address the interlinked issues of climate mitigation, adaptation, and inclusive development in informal settlements.

We identify ten particularly promising upgrading strategies, with potential to foster multiple benefits and advance several Sustainable Development Goals (SDGs) as outlined below:

Sustainable Development Goals;

SDG 1 no poverty
SDG 3 health
SDG 5 gender equity
SDG 6 water and sanitation
SDG 7 clean energy
SDG 8 decent work and economic growth
SDG 9 resilient infrastructure
SDG 10 reduced inequalities
SDG 11 sustainable cities
SDG 13 climate action
SDG 17 partnerships for development

Section 2 synthesises the existing evidence around the benefits of upgrading informal settlements, taking a global perspective. Section 3 then discusses a specific case study in Mukuru, Nairobi, Kenya, where these benefits are put to the local test. Section 4 offers considerations and key policy recommendations before concluding remarks in Section 5. The appendices contain further detail on the literature review and case study.

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2. The Benefits of Climate-Friendly Development: The Existing Evidence

There is plenty of evidence already in existence that climate-friendly development has multiple benefits. We reviewed the existing research to identify the evidenced benefits and the actions that have led to these outcomes. A summary of these actions and beneficial outcomes is provided in this section, and full details of the literature review can be found in Appendix 1 while the evidence for the significance of these improvements in the case of Mukuru is provided in Appendix 4.

Benefits of Waste Management

- Upgrading interventions that foster mitigation and climate adaptation such as enhanced solid waste management can increase households' incomes and their ability to afford engagement in health-promoting behaviours.
- SWM can also reduce environmental and health risks. Blocked drains from uncollected waste can lead to flooding which in turn, provides breeding sites for mosquitos and other disease vectors in stagnant and contaminated water. Having an efficient system to collect, sort and manage waste can therefore prevent these risks leading to a cleaner environment and improved health for residents.

Benefits of Improved Housing

- Interventions to upgrade shelter and infrastructure (particularly water, sanitation, drainage, and paths) can help to reduce the impacts of flooding and heatwaves in informal settlements.
- Introducing alternative housing materials can foster adaptation (lowering internal temperatures and reducing vulnerability to extreme weather) while also reducing greenhouse gas emissions, creating jobs (through the building materials industry), and enhancing safety in informal settlements.

Benefits of Neighbourhood Upgrading

- Green infrastructure can promote environmental health and inclusive development such as fostering water resilience, creating green jobs, improving air quality, and promoting social cohesion.

- Densification offers benefits in terms of reduced travel to work times and emissions, as well as benefits related to the agglomeration of economic activities, which are often recognised as a feature of high quality and thriving neighbourhoods.
- Mixed-use neighbourhoods have been recognised for their contribution to poverty reduction and are optimal for low-income households as they can foster the livelihoods of families with mixed-income sources.
- Further economic and health gains may include enhanced recreation and physical activity (helping to reduce chronic disease); groundwater recharge and reduced flood risk; stress relief and lower rates of depression.

Benefits of Inclusive Transport

- There is strong evidence that improved non-motorised and public transport provision will benefit informal settlement residents, whilst also generating several benefits for climate mitigation and air quality.
- Key benefits of improved access to transport include economic (reduced congestion and travel times, improved efficiency etc.); environmental (e.g. reduced air pollutants and noise); health (enhanced physical activity and improved air quality); and social, (e.g. enhanced community sociability and reduction in community severance).

Benefits of Clean Energy

- With enhanced access to clean energy, there are several potential health benefits and also opportunities to promote economic productivity, gender equality, and climate change mitigation.
- Improved access to LPG and solar energy can simultaneously promote jobs and time savings, reduce emissions, and enhance health and well-being.
- Improving access to clean energy and reducing fire risks via upgrading can offer multiple benefits for inclusive development, health, and disaster resilience.

See Appendix 1 for details of the benefits under each sector and the actions implemented.

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3. Testing the Benefits on the Ground: Mukuru, Nairobi

The previous section summarised the global findings of the existing research literature, showing that multiple benefits result from climate-resilient development interventions. Our aim was to test these apparent benefits locally, on the ground, using a pilot case study.

The Setting

The case study took place in the informal settlement of Mukuru, in Nairobi, Kenya. Mukuru's population is estimated at 100,500 households, with an average of three people per household.

The settlement faces several environmental, health and disaster risks. Nairobi will likely experience more frequent heat spells due to climate change. Projections predict that Nairobi's mean daily maximum temperatures will increase by 0.5 to 2°C, with an increased frequency of heatwaves (UCT et al. 2017, pp. 2–3, 7). Furthermore, Nairobi's informal settlements such as Mukuru already experience higher temperatures (largely due to limited vegetation and other surface properties (Scott et al. 2017).

Mukuru is also prone to flooding due to its close proximity to the flood-prone Ngong River, resulting in problems such as mosquito-breeding and diseases; property destruction; limited mobility; burst latrines and water pollution (Boit 2014, pp.67–68). Casualties and building collapses have also resulted from flooding.[3]

See Appendix 2 for details of the local context and risks of the case study location.

Methodology - Why Mukuru?

The Mukuru case study draws heavily upon the authors' engagement with the Muungano Alliance and their understanding of the potential of a community-driven process of development. The Alliance is comprised of Muungano wa Wanavijiji, a federation of women-led savings groups based in informal settlements (hereafter Muungano); SDI-Kenya, a technical assistance NGO; and a community-led finance facility called Akiba Mashinani Trust.[4] We focus upon Mukuru because it is where the Alliance secured the commitment of Nairobi County (the local government) in 2017 to declare a Special Planning Area (SPA) as shown in Map 1 in Appendix 1. The SPA generates a multi-sectoral upgrading plan for Mukuru, co-produced by residents and the County.

Under Kenyan legislation, Nairobi's County Government is legally required to develop an integrated plan to redevelop the area within two years.

[3] See '10 killed as heavy rains hit Nairobi Monday night', *The Standard,* available at: www.standardmedia.co.ke/article/2000161938/10-killed-as-heavy-rains-hit-nairobi-monday-night. We offer thanks to Bernard Majani for sharing his database of media mentions of flooding in Mukuru.

[4] See https://www.muungano.net/about

Engagement with Mukuru, Nairobi

One of the key successes of the work in Mukuru was the engagement with the community. Under Kenyan legislation, Nairobi's County Government is legally required to develop an integrated plan to redevelop the area within two years. With the County's commitment to upgrade Mukuru, the Muungano Alliance began to intensify its engagement with residents. Alongside continuing mobilisation of women into savings groups, the Alliance began to strengthen neighbourhood associations to provide a platform for citizen engagement**.** In Mukuru, neighbourhood associations led in developing the SPA plans, while the predominantly women-led savings groups build the capacity of all residents to participate.

Participatory consultations were held across the SPA, aiming for a final plan by August 2019. A set of eight consortia, were set up mirroring the County's departments, with 42 organisations from academia, government, private-sector, and civil society. These consortia synthesised data from Mukuru and generated policy briefs to inform future upgrading strategies. To date, each consortium has completed a situational analysis, community consultation and prepared potential interventions to address sectoral needs. The fifth stage will be the presentation of the plan to the Nairobi County in August 2019.

Community mobilisation is coordinated by the Muungano Alliance, who work with the County Government to brief other decisionmakers, share issues arising from grassroots consultations, and develop next steps. The authors have worked for many years with the Muungano Alliance. This longstanding engagement in which multiple local engagements based upon a shared commitment to inclusive, gender-sensitive development has enabled the researchers' exposure to a range of activities and perspectives.

This report has been informed by a site visit to Mukuru, and multiple discussions with Muungano leaders, SDI-Kenya professionals, local experts, and stakeholders such as the National Treasury, the Ministry of the Environment, Adaptation Consortium at the Ministry of Development for Northern Kenya and other Arid Lands and the National Environmental Management Agency.

The participatory approach, along with work of the eight consortia and the Alliance, have been the key to the success so far in Mukuru.

Sectors and Actions

Below we outline the key sectors of focus where actions were implemented in the upgrading of Mukuru. To determine these sectors and actions a participatory approach involving the local community and the County government was followed. The initial setup of the eight consortia synthesised data from Mukuru and generated policy briefs to inform future upgrading strategies. Following these briefs, intense engagement with the community, through the Muungano Alliance, between the consortia, was instrumental in co-developing a list of ten actions. These were agreed to be development imperatives with strong potential to strengthen climate resilience in informal settlements.

Waste

Inadequate solid waste management and open dumping are two of the key challenges identified in the Mukuru area. Both actions - **increasing the efficiency of waste management**, and **increasing the diversion of food waste, organics, and recycling** – aim to address the problem and provide additional benefits listed below in the table.

Housing

Extreme heat and floods are the main climate hazards experienced in Mukuru. **Cooler housing design** aims to address the extreme heat issues whereas the **provision of green spaces** aims to address both extreme heat and flooding in addition to other benefits.

Neighbourhoods

A further potential to generate benefits in Mukuru for climate change resilience and broader development goals is that of densification, with measures to secure a more compact city. **Maintaining high-density neighbourhoods** offers benefits in terms of reduced travel to work times (and emissions) as well as benefits related to the agglomeration of economic activities.

Mixed-use development helps in creating stronger local economies through different employment opportunities and ensuring equitable and inclusive development. Local enterprises and self-provisioning (i.e. enterprises that enable domestic goods to be provided at a lower cost, such as street foods or tailoring) are particularly important for women as their gendered responsibilities mean they need income-generating opportunities close to home.

Transport

Efforts must be made to ensure that Mukuru's non-motorized transport (NMT) is improved, including **increased pedestrianisation and cycling**. Even though the formal commercial or industrial employment opportunities are quite far from Mukuru, 60% of employment opportunities are in the informal sector (World Bank 2016). Many of these are in informal settlements, and Mukuru has close proximity to industrial areas. NMT provides an array of benefits ranging from GHG reductions to health benefits.

Energy

Solar power for street lighting will help in improving energy access in Mukuru, apart from providing benefits such as reduced GHG emissions, improving air quality, providing a safe environment for residents at night.

The SPA energy consortium has proposed the introduction of **LPG stoves for cooking** to replace charcoal and paraffin. Use of LPG would reduce the cost of fuel by 66% as compared to kerosene and by ~80% as compared to charcoal. Even though LPG is a cost-efficient lower-carbon fuel alternative, it is a fossil fuel. Therefore, choosing to invest in it still locks in future emissions, especially if no zero carbon alternatives are considered in the long term. We would instead recommend pursuing electrification with a low carbon grid mix and/or

contextualised renewable energy solutions (i.e. solar cookstoves) as the long term means to deliver climate and social benefits even if LPG is used as a transition fuel.

Table 1: Summary of actions, immediate benefits, adaptation contribution and wider benefits related to informal settlement upgrading

Sector	Actions	Immediate benefits (outputs) and SDG links	Contribution to adaptation (outcomes)[5]	Wider benefits and links SDGs links (impacts)
Waste	Increasing the efficiency of waste management	Health (SDG 3): reduced risk of drowning, injuries, skin infections, or other illnesses linked to flooding and poor solid-waste management. Assets: reduced loss of assets.	Better management of runoff will reduce exposure to flooding. May reduce residents' vulnerability to floods, particularly when combined with other infrastructure (e.g. adequate roads, water/sanitation, or drainage).	Livelihoods and assets (SDG 1 no poverty; SDG 8 decent work): reduced flood risk to homes and other assets; improved livelihoods for informal waste collectors if they are integrated into formal service provision. Inclusive development by creating work for local youths (SDG 10 reduced inequality). Coproduction with government or private providers (SDG 17 on partnerships) to achieve sustainable cities and communities (SDG 11). Better-quality environment, with benefits for local pride and social solidarity.
	Increasing the diversion of food waste, organics, and recycling	Reduced GHG emissions (SDG 13) from composting, re-use, recycling.	May reduce residents' exposure to floods (by severing the links between poor solid-waste management and flooding).	As above, can enhance youths' livelihoods and develop partnerships with service providers.

[5] According to the IPCC, exposure is 'the presence of people, livelihood, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.' And vulnerability is 'the propensity or predisposition to be adversely affected' and includes both 'susceptibility to harm and lack of capacity to cope and adapt'.

Sector	Actions	Immediate benefits (outputs) and SDG links	Contribution to adaptation (outcomes)[5]	Wider benefits and links SDGs links (impacts)
Housing	Cooler design	Health benefits & lower GHG emissions: reductions in heat stress with ensuing health gains, as well as lower electricity consumption due to cooler design.	Cooler design reduces exposure to higher temperatures.	Health: Reduced internal temperatures for vulnerable residents (elderly and children) and those with pre-existing health conditions particularly vulnerable to heat-related illness. Gender equity (SDG 5): Women, who, typically shoulder their households' care burdens, have reduced care duties. Livelihoods and assets: Improved conditions for local enterprises, especially benefiting women who are more likely to work at home (or elsewhere in the settlement) – promoting gender equity.
Neighbourhoods	Provision of green space	Health benefits & lower GHG emissions due to reduced temperatures, lower flood risks, and enhanced air quality. Potential for enhanced physical activity in green areas.	Reduced exposure to high temperatures due to cooling effects of vegetation and shading. Reduced exposure to flooding as green spaces enable infiltration and slow runoff, as well as retaining excess water. Health benefits can reduce vulnerability.	Livelihoods and assets: Potential for urban agriculture, with benefits for food security (SDG 2 zero hunger); other provisioning possibilities. Better-quality local environment. Coproduction: Environmental agencies may be interested in partnerships, enhancing local governance; management of green space can strengthen Community Based Organisations (CBOs).
	Increased density – but trade-offs related to rising temperatures must be managed carefully	Time savings: reduced travel to work times.	Students, workers, and other residents less vulnerable to potential increased costs for motorised transport (stemming from efforts to discourage fossil fuel use).	Livelihoods and assets: Proximity to inner-city can improve access to livelihoods and enhanced education/skills. Social inclusion via in-situ development and limited relocation, retaining a strong sense of place (SDG 10 reduced inequality). Quality of life: Reduced travel-to-work times can create time for leisure, family, or productive activities. Reduced GHG emissions & health benefits due to increased physical activity, especially if non-motorised transport promoted.
	Mixed-use development	As above, reduced travel to work and lower GHG emissions.	As above, residents less vulnerable to potential increased costs for motorised transport	Livelihoods: Stronger local economies. Gender equity: As above, can especially benefit women (more likely to work near home).

Sector	Actions	Immediate benefits (outputs) and SDG links	Contribution to adaptation (outcomes)[5]	Wider benefits and links SDGs links (impacts)
Transport	Pedestrianisation	Reduced GHG emissions through preventing a switch to motorised transport. Health benefits from continued exercise while reducing the injury risks to users.	All-weather paths and cycle routes are less susceptible to flooding and can better maintain service access. Reduced vulnerability due to better access to emergency services (SDG 9 resilient infrastructure).	Livelihoods: Improved local economies from higher 'footfall'. Greater pride in local neighbourhood from improved connectivity. Improved mobility within and beyond the neighbourhood (particularly key for people with disabilities), thereby promoting access to work or education.
	Cycle paths			
Energy	Solar power for street lighting	Emissions savings over grid electricity.	Reduced vulnerability to increases in price of grid electricity.	Livelihoods: Local employment may be created to manage solar power systems. Potential for feed-in tariffs enabling streetlights at minimal cost, helping to enhance safety (SDG 16 on peace and security).
	LPG stoves*	Reduced GHG emissions compared to charcoal and paraffin. Health benefits due to improved indoor air quality and lower fire risk.	Reduced vulnerability to rising prices of grid electricity and/or to increases in charcoal and paraffin prices.	Livelihoods and assets: Reduced expenditures and greater productivity; lower risk of lost assets from fire. Gender equity: Women typically at greater risk of respiratory illness due to unclean cooking fuels and gendered responsibilities.

Further detail on the benefits and considerations of each intervention is provided in Appendix 4.

*Even though LPG is a cost-efficient lower-carbon fuel alternative, it is a fossil fuel. Therefore, choosing to invest in it still locks in future emissions, especially if no zero carbon alternatives are considered in the long term. We would instead recommend pursuing electrification with a low carbon grid mix and/or contextualised renewable energy solutions (i.e. solar cookstoves) as the long term means to deliver climate and social benefits even if LPG is used as a transition fuel.

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4. Lessons Learned and Recommendations

This section discusses the learnings from the study. The first part of the section talks about what worked in Mukuru exclusively, and the second part combines the recommendations for a variety of stakeholders based on the literature review as well as the Mukuru case study.

What worked in Mukuru?

Based on experiences in Mukuru, three key elements of successful interventions can be emphasised; 1) integrated upgrading, 2) city-wide federating, and 3) devolved local government.

Integrated upgrading

Mukuru's integrated plans and governance structure helped the government understand how a neighbourhood can be transformed using multi-sectoral strategies to foster resilience, rather than a single housing solution.

At the national level in Kenya, informal settlements are viewed narrowly as a housing issue and are the responsibility of the Ministry of Transport, Infrastructure, Housing and Urban Development. This is a key limitation as informal settlement upgrading or climate resilience is hindered if the focus of the area is only on housing. By contrast, the SPA's emphasis is upon developing holisti

c, joined-up plans with local government. The eight SPA consortia, as shown in Figure 1, have been mapped against the Nairobi County Government's departments, which helped to show each department that they had a contribution to make within respective SPA areas. Mukuru's integrated plans helped the government to look at upgrading differently; no longer do they envision just a housing solution, but rather understand how a neighbourhood can be transformed using multi-sectoral strategies to foster resilience.

Figure: The eight SPA planning consortia of Mukuru (seven consortia + coordination & community organization) (Source: UC Berkeley/SDI Kenya/Muungano wa Wanavijiji Alliance)

Federated grassroot organisations

The SPA's second key element is federated grassroots organizations that can negotiate and partner effectively with city governments or service providers. Once these organisations are linked together, residents can support each other and share a multiplicity of experiences. Neighbourhood associations and savings groups in Mukuru have regular exchanges with other local groups. Fellow residents have seen the emerging solutions in Mukuru, including waste recycling and neighbourhood clean-ups. This helps residents to feel empowered to undertake improvements in their own settlements. As additional residents begin interacting with officials and negotiating with local politicians, they can ensure that they learn from the experiences of others and that they pool information. The key driver in the case of Mukuru has been **the community organisation** to mobilise informal settlement upgrading, including to address climate resilience.

Devolved local government

A third element is that of democratic and adequately resourced local governments. Kenya's 2010 constitution created and strengthened the County government, devolving key local responsibilities such as health and education. The Alliance believe that the opportunity to re-plan Mukuru largely emerged because the Alliance was dealing with a devolved level of government, which brought decision making closer to the people. It is often difficult to secure national interventions in informal settlements, even though half of Kenya's urban population is living in slums, as many national politicians do not represent urban constituencies and are far removed from the issues on the ground.

Recommendations

Based on the literature review on upgrading informal settlements, and the experiences of the study in Mukuru, we are able to make several key policy recommendations below. Recommendations for stakeholders in the upgrading process e.g. Mayor and city policymakers, National and International Stakeholders and NGOs are summarised with detailed explanations, as well as recommendations on data-collection in an informal settlement context.

For national and international policymakers

Recognise the potential benefits of upgrading for climate resilience, and meeting development imperatives in informal settlements

Using a 'resilience' lens in upgrading informal settlements can help to resolve tensions between development and environment agendas, and instead encourage holistic actions in these areas. While early definitions of 'resilience' narrowly focused on returning systems to their prior levels of functioning (which may have been inadequate, particularly in the Global South), a more developmental understanding of resilience can be used in support of

upgrading such as the case of Mukuru where the eight SPA consortia were able to link up with Nairobi County Government's departments to demonstrate neighbourhood upgrading as a holistic multi-sectoral strategy.

Proactively finance interventions developed in partnership with local government and local civil society organisations that can simultaneously foster climate, health, and socioeconomic benefits in informal settlements.

There is limited climate funding allocated for informal settlement upgrading, and Colenbrander et al. (2018) note that climate adaptation funds are again rarely directed at the local level. However, the potential of local level funds to address urban development imperatives, as well as to foster climate change adaptation, is widely recognised (Satterthwaite and Mitlin 2014). In Kenya, the Muungano Alliance's work has demonstrated the effectiveness of such funding and also how community-managed funds can recycle money through savings and loans (Weru et al. 2017). National and international policy makers should therefore look to build partnerships with local governments and civil society organisations to channel finance to more targeted local interventions.

Develop financing mechanisms to integrate upgrading with urban resilience strategies.

Finance should be provided at a scale appropriate to need; Though the case of Mukuru is still in development and the SPA upgrading plans are limited to the settlement area only, other SDI affiliates, particularly the Indian Alliance, have showed how to scale-up from NGO project financing to large-scale urban development interventions. Since the late 1980s, the Indian Alliance has secured just under US$18 million in development assistance. It has used these funds to negotiate additional finance and to gain the support of India's government agencies. Their total investment in innovative approaches to addressing the shelter needs of the lowest-income Indian residents has been almost $100 million, with US$56 million from government subsidies and market subsidies as a result of government policies. These funds have provided "sanitation for more than 163,000 households, shelter for over 86,000 households and income generation loans for almost 8,500 households" (Patel et al. 2018, page 85).

Partner closely with residents and grassroots organisations.

Residents of informal settlements typically lack voice or meaningful participation in urban planning, and top-down interventions may only further marginalise these communities (Reckien et al. 2017). Residents of informal settlements may also experience limited trust and social cohesion, reflecting the heterogeneous composition, high levels of poverty, and development pressures in some neighbourhoods (Rashid 2009). Successful intervention requires urban governance that responds to local catalysts. It is essential for policymakers to partner closely with residents and grassroots organisations, so that upgrading fosters social inclusion and does not exclude informal households (Dobson 2017).

For mayors and urban policymakers

Use upgrading as an entry point for promoting inclusive urban development (SDG 11) and several other SDGs:

Develop complementary strategies in informal settlements to reduce risks – including climate-related risks.
Many challenges in cities of the Global South can overlap with each other, thus it is neither analytically nor practically possible to engage with a single agenda in isolation. However, there are significant commonalities and potential synergies between them which can be used as entry point of informal upgrading. Efforts to reduce poverty and disaster risks, as well as to adapt to climate change, should all focus on local risks and their root causes (even if they differ in their lenses for viewing such risks). In the case of Mukuru, improved waste management interventions are not only to increase adaptive capacity and reduce flooding in the settlement but also provide a means of livelihoods for residents.

Develop programmatic interventions that respond to the scale of need in informal settlements, particularly as the population in these areas will likely grow in the future.
The importance of implementing scaled-up interventions will be particularly vital in the context of growing populations in informal settlements. Meanwhile, it is widely recognised that efforts to formalize the informal have exacerbated cities' social marginalization and economic exclusion (Banks et al., 2019). Informal workers in the Global South, who typically have low and erratic incomes, cannot easily meet the requirements of formal banks or utilities that expect regular repayments. More positively, this report has illustrated how upgrading can address several SDGs (poverty reduction, clean energy etc.) and promote inclusive, climate-resilient development in informal settlements.

Recognise that the solution to informality is not formality, and inappropriate interventions will exacerbate the difficulties faced by the most vulnerable residents.
Upgrading interventions should include the full participation of residents as they can bring their perspectives into what is needed for the community. As follows:

- It keeps residents and their social networks in place, while displacement is associated with lost social ties that are essential to promote access to jobs, services, and community cohesion.
- Strong local participation and local ownership makes it more likely that the resultant improvements will address residents' key needs. Building grassroots organisations, such as those needed for designing and implementing participatory upgrading initiatives, like Muungano, can support project maintenance in the future.
- Strong local ownership increases the likelihood that residents will subsequently invest in improvements, helping to reach more people and ensuring that state funds are targeted to needy households.

Interventions need to be contextually rooted and tailored to local risks.

The Mukuru case study exemplifies just one approach to upgrading informal settlements and reflects local political relations and particular risks. For instance, improved housing can reduce GHG emissions and disaster risks, but benefits may be difficult to realise in areas dominated by rental housing and absentee landlords (Gilbert 2016, Lines and Makau 2017).

For local organizations and NGOs in the Global South

Raise awareness at the grassroots level of the essential links between adaptation, mitigation, and inclusive urban development.

Although there is growing awareness of climate change in urban areas, community leaders and ordinary residents often know little about how to address such risks in informal settlements. Thus, there is a need to develop specific, replicable approaches to support climate resilience in these neighbourhoods.[6]

Develop pilot initiatives to protect communities at risk that can enhance livelihoods, social capital, and climate resilience in informal settlements.

Pilot initiatives can demonstrate the potential for local action; accelerate the processes of learning and resolving problems; and catalyse more substantive interventions as Mukuru has demonstrated.

Residents must be organised and empowered to secure inclusive engagements.

Fostering social capital, improved governance, and social inclusion via upgrading is heavily contingent upon the planning processes utilised. Residents must be organised and empowered to secure inclusive engagements with public authorities (Lines and Makau 2017). If residents can work with official actors to co-produce participatory upgrading strategies, there is a possibility to achieve transformative changes in governance (Mitlin and Bartlett 2018).

For both policymakers and local organisations

Partner closely with residents to develop locally appropriate, inclusive, upgrading interventions in informal settlements.

- **Organise**; A key primary foundation of securing the SPA status was the ten-year history of organizing in Mukuru (see Lines and Makau 2017). Given the rising real estate speculation as land prices increased across Nairobi prior, tenants in Mukuru faced heightened vulnerability and Muungano began to mobilise the community. At first,

[6] See also Dodman, D., Archer, D., & Satterthwaite, D. (2019). Responding to climate change in contexts of urban poverty and informality. Environment and Urbanization 31(1), 3-12 and other articles from this issue on more inclusive approaches to climate adaptation.

Muungano feared that residents would not be interested in participating in local savings groups but would merely wait for the County governments to deliver. However, residents rapidly realised that nothing would change if they were not organized.

- **Document and collect data**; Secondly, the documentation of living conditions and evidence about the "poverty penalty" (AMT et al. 2017) was key in informing the necessary interventions. The Muungano Alliance collaborated with academics to document residents' living conditions, their lack of access to public services, levels of income, and household expenditure to provide evidence and a case for development in the settlement. Further data recommendations are provided below.
- **Engage with local government**; In the third stage, Muungano engaged Nairobi County officials to present this evidence and demonstrate the scale and depth of development deficits in Mukuru. The local community's engagement with higher government (the local council) allowed evidence sharing and eventually secured the commitment. Governments should therefore partner closely with residents to gather data in informal settlements (Beukes 2015) and use this to design policy interventions.

Find innovative ways to link climate resilience to local plans.

Finding innovative strategies can help to embed climate change action, while also advancing cities' existing priorities. For cities in the Global South, recent risk-reduction strategies have begun with multi-partner governance arrangements "that have taken advantage of opportunities to creatively link new agendas to existing goals, plans, and programmes. These emergent framings [can incorporate] social justice concerns [as] a critical dimension of inclusive and equitable development and risk reduction" (Pelling et al. 2018, p.11, emphasis added).

Data collection recommendations

Improved data collection and detailed data on multiple scales on informal settlements.

There is a need for more detailed data, on multiple scales, on informal settlements' key climate-related vulnerabilities, access to infrastructure, and service provision. Improved data-collection is necessary when designing interventions in informal settlements, and findings can subsequently assess how upgrading can and does foster resilience. Community-led data collection can strengthen local organisations and enable them to participate more effectively in democratic decision-making (Patel et al. 2012). Collecting baseline and ongoing data will enable monitoring and evaluation following the upgrading interventions.

Below are several recommendations on data-collection in urban areas that focus on understanding risks at an informal community level:

- Household-level data on access to infrastructure and services in informal settlements (e.g. solid-waste management, fuel mix, transport patterns). Together with geographic information system (GIS), data findings can identify structures at risk.
- Neighbourhood-level data on green infrastructure, quality of roads/footpaths, maintenance of drainage and water/sanitation networks, fire outbreaks, and access to emergency services.
- Past impacts of extreme weather (e.g. floods, heatwaves, water scarcity, landslides) with attention to health, livelihoods/assets, and gendered burdens, while also identifying any particularly vulnerable groups
- Climate scenarios, presented with appropriate levels of uncertainty and downscaled to the city or informal settlement level, can aid local decision-makers in identifying actions with the greatest developmental and climate adaptation benefits.

Pablo García Saldaña, Unsplash

6. Conclusion

Conclusion

Alongside the need to respond to climate-related risks there exists a range of other development imperatives linked to the SDGs within informal settlements. Upgrading informal settlements is a way for policymakers to address both aspects simultaneously. Through an extensive literature review and on the ground case study, this report has demonstrated how upgrading can deliver resilient, inclusive, low carbon development and support multiple socioeconomic benefits.

The large body of existing research from all across the globe amply demonstrates the multiple benefits of upgrading informal settlements (see Section 2 and Appendix 1). Furthermore, the case study in Mukuru, Nairobi, shows how this would work on the ground, bringing a wide range of benefits and impacts to a specific local context (see Section 3 and Appendix 4). Though the actions implemented in Mukuru are context specific, the ten actions provide a suite of strategies that can inspire other cities how to foster climate resilience while advancing SDGs and addressing broader development needs. These actions provide a wealth of socioeconomic benefits from improved health and increased safety, to reduced congestion and risk, enhancing resilience, equity and quality of life (see Table 1).

Recommendations and conclusions from the literature review and case study are summarised for policymakers, local organisations and NGOs to support future upgrading efforts (see Section 4). Data collection recommendations are also stressed in order to understand the localised context of climate risks and to implement relevant actions.

By taking into account the lessons learned and recommendations set out in this report, cities can support informal communities to realise the benefits of climate resilience through upgrading. With Over 880 million people living in informal settlements across the Global South (UN-Habitat 2016; Satterthwaite et al. 2018), and these numbers expecting to increase, a multi-pronged strategy that meets the need for low-carbon development and improved living conditions in informal settlements is critical to achieving climate safe, prosperous cities and delivering the Paris agreement and SDGs.

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Appendix 1: Literature Review

This literature review uses the existing body of research to introduce key climate-related challenges for informal settlements in the Global South, and the benefits of informal settlement upgrading in the context of essential climate action. Along with identifying key research gaps, we note opportunities to promote inclusive development and gender equity via upgrading – as it is essential to recognise the gendered nature of shelter, access to infrastructure, and livelihood patterns in informal settlements (Jabeen 2014; Chant 2013).

The review is structured so as to explicate the discrete benefits associated with upgrading informal settlements, which were summarised in Section 2.

While the review will discuss potential benefits on a sectoral basis, it is important to note that multi-sectoral upgrading may help to realise far-reaching gains for climate resilience in informal settlements.

Benefits of Waste Management

Climate change represents a key threat to urban livelihoods but upgrading can offer several opportunities to foster resilience and inclusive development in informal settlements, particularly through investing in waste recycling and composting.

Perhaps most significantly, the stable income through hiring informal workers in waste management can reduce low-income urban residents' vulnerabilities to shocks and stresses, including those linked to climate change. The ability to invest in improvements that can enhance adaptation to extreme weather, alongside households' ability to afford a high-quality diet and to engage in health-promoting behaviours, are key assets that can promote climate resilience (Moser and Stein 2011).

Improved SWM can significantly help to reduce flooding risks while promoting environmental health and climate resilience more broadly. In the absence of regular rubbish collection, uncollected solid waste (particularly plastic bags) often blocks drains and can result in burst sewers (Ziraba et al. 2016). Blocked drainage can provide breeding sites for mosquitos and other disease vectors; water contamination can only amplify the health risks of flooding (ibid. p. 8). When drainage channels are clogged with solid waste, their capacity for storage or conveyance is considerably reduced, thereby inducing floods, and research has confirmed the links between blocked drainage and localised flash floods in informal settlements (Lamond et al. 2012). It will be essential to maintain drainage systems in informal settlements over time and to holistically manage downstream and upstream wastes (ibid. p. 194).

Adequate SWM can also lead to substantial GHG reductions (Koop and van Leeuwen 2017, pp. 391–2). In the Global South, waste is directly responsible for 10–15% of overall emissions, primarily due to food waste and organics decomposition (UNEP 2015, p.12). But waste diversion and utilising this organic material for compost and energy recovery (through

anaerobic digestion) can offer significant benefits, such as enhancing local environmental quality, lowering GHG emissions, and reducing drainage clogging.

In many cities of the Global South, most municipal solid waste is not formally collected. Estimates for Nairobi suggest that just 50% of solid waste is collected (von Blottnitz 2010, APHRC 2017) and informal waste collection is pervasive. More generally, informal recyclers in the Global South can divert at least 10% of urban waste (UNEP 2015, p. 177). In Delhi, informal waste recyclers collect 15–20% of the city's total waste by weight, generating major benefits for climate mitigation as well as local livelihoods (Chintan 2009).[7] Furthermore, Ahmedabad has successfully incorporated informal waste-pickers into formal service provision, generating benefits for resource recovery, social inclusion and reduced stigma of these workers, while also costing less than high-tech SWM interventions (Oates et al. 2018).

Benefits of Inclusive Waste Management

Benefits of Improved Housing

Housing is a key asset for informal settlement residents, and it is one of the most significant factors shaping risk and resilience to climate change (Moser and Stein 2011).[8] Dwellings are essential sites for promoting safety and security as well as reducing disaster risks; numerous strategies for reconfiguring shelter can foster these benefits and support climate adaptation. For instance, there are opportunities to reduce the heat stress linked to the rising frequency of heatwaves (due to climate change and urban heat island effects) by using building materials that reduce internal temperatures, in addition to ways of maximising ventilation via building designs (Jabeen 2014). Potential interventions may include the use of reflective paint to reduce heat absorption; higher ceilings to increase ventilation; extending roofs to improve shade; and adjusting the orientation of dwellings, all with a cooling effect (Wamsler and Brink 2014).

Although there are several household-level responses in informal settlements that can reduce heat or flooding risks, these are best seen as coping strategies and will be insufficient for promoting resilience. In an analysis of household responses to heat in Dhaka's informal settlements, Jabeen et al. (2010) note that residents often increased their power consumption (for fans and electricity), but this was unmanageable for the poorest households: 'Extremely poor families often traded off between a light and a fan[,] as they pay vendors in terms of the number of points rather than total kilowatt hours used' (p. 426). Meanwhile, Dhaka residents can reduce flood risk by raising plinths and constructing small walls at the dwelling entrance, thereby lowering the risk of floodwaters entering the house

[7] Based in Pune, SWaCH is India's first wholly owned cooperative of self-employed waste collectors (see https://swachcoop.com/). See also Chikarmane, P. (2012). Integrating Waste Pickers into Municipal Solid Waste Management in Pune, India, WIEGO Policy Brief, and for more on WIEGO's work with waste-pickers see http://www.wiego.org/informal-economy/occupational-groups/waste-pickers

[8] Housing is often referred to as 'shelter' in reflection of the reality that dwellings, tenure, and services must be taken equally into account.

(ibid.). But flood risk is often closely related to housing or settlement location, and many informal settlement households live in flood-prone areas, particularly to secure affordable sites (Olthuis et al. 2015). Without collective action, residents' interventions will likely have only a minimal effect on improving shelter and what is instead necessary is neighbourhood-level investments with zoned areas, such as the special planning area in Mukuru (see Appendix 2).

Upgrading shelter and infrastructure (particularly water, sanitation, drainage, and paths) can help to reduce flooding and address other climate-related risks in informal settlements. For instance, more intense precipitation will likely reduce the safety of water and sanitation provision in informal settlements. Although residents of informal settlements can sometimes access piped water, their supplies are often intermittent and contaminated (Kumpel and Nelson 2014). Rising water-tables can make intermittent supplies particularly hazardous, as low pressure in the pipes leads to contamination and polluted water enters the network. Additionally, informal settlements typically have inadequate sanitation, and many residents rely upon pit latrines (Satterthwaite et al. 2015). But limited latrine-emptying services in informal settlements (especially in narrow paths or other inaccessible areas), combined with the costs of such emptying, means that there is a well-established practice of allowing pit latrines to 'flood-out' during the rainy season (Jenkins et al. 2015). While this is not caused by climate change, additional precipitation may increase the number of times that this practice occurs, while greater frequency or intensity of flash floods may extend the area over which the contaminated water will travel.[9] Meanwhile, if limited water supplies are further constrained by drought due to climate change, this may result in urban water shortages, exacerbate the intermittent nature of the piped water, and prevent water-borne sanitation in informal settlements.[10] But by upgrading shelter, there are vital opportunities to adapt to heat and floods while also supporting access to risk-reducing infrastructure and services.

Building materials can have significant environmental impacts, while also influencing comfort and safety. Informal housing is often built with low-quality materials (e.g. scrap-metal doors or roofs), which often fails to provide adequate protection from extreme weather. Moreover, in South Africa, residents of informal settlements may lack adequate gates or other ways to deter criminal entry (Meth 2017). Dense, often inflammable housing units in informal settlements are at elevated risk of arson; limited access by police or emergency services may only compound these areas' vulnerabilities to crime (ibid., p. 16).

Green infrastructure (GI) has been defined as 'the means through which vital ecological and biodiversity-related functions (e.g. habitat provision and landscape connectivity) and most nature-derived human benefits are delivered' (Lindley et al. 2018, p. 4). As well as improving water and air quality, GI can improve thermal comfort and reduce risks from floods by enabling infiltration and slowing surface water runoff (Demuzere et al. 2014). There are few

[9] Flooding may also cause difficulties for sky-loos (eco-sanitation in which the toilet facilities are elevated to enable the compost to be easily removed). If sky-loos flood, their contents will need to be safely removed and disposed of as faecal sludge, since water prevents the safe decomposition of faecal matter (personal communication, Dr Beth Chitekwe-Biti, SDI's deputy director).

[10] This may also cause higher prices for domestic water supplied by vendors, which is already a significant expense for many residents of informal settlements (Kjellén and McGranahan 2006, Mitlin and Walnycki 2016).

other well-documented good practices in African cities; many cities lack baseline data on GI; and there is only limited municipal capacity or broader awareness of the benefits of green space in the Global South (du Toit et al. 2018, pp. 256–7). Here, we briefly review the benefits of GI for urban climate resilience, as well as identifying potential tensions and trade-offs that policymakers will need to bear in mind.

There are multiple benefits that GI in housing can promote environmental health and inclusive development such as fostering water resilience, creating green jobs, improving air quality, and promoting social cohesion (Raymond et al. 2017a, b). Possible indicators to measure GI's impacts can be economic (e.g. lower energy demand, enhanced property values), environmental and health-related (carbon sequestration, temperature reduction, enhanced air quality), and social such as greater accessibility and more equitable distribution of green spaces (ibid.). Further economic and health gains may include enhanced recreation and physical activity (helping to reduce chronic disease); groundwater recharge and reduced flood risk; stress relief and lower rates of depression (ibid., also World Bank 2016).

Residents of informal settlements often have limited access to or degraded levels of green infrastructure, but they may especially value its provisioning services and other benefits. For instance, provision of food and fuelwood are considered key benefits of Nigeria's urban forests; there is also ample evidence on the use of medicinal plants in Ghana and South Africa, often amongst low-income households (du Toit et al. 2018, Lindley et al. 2018). In Dar es Salaam's flood-prone informal settlements, residents noted that green spaces had vital links to livelihoods, outdoor recreation, tourism, and psychological comfort (Roy et al. 2018, p. 287). Furthermore, Durban has successfully combined green roofs, enhanced fire management, and other interventions with efforts to promote jobs for low-income residents (Roberts et al. 2012). Additionally, surveys with 550 residents of Kampala's informal settlements near wetlands uncovered several benefits of wetlands, such as free or affordable water (23.2%), as well as cooler breezes and lower temperatures (19.6%) (Bosco Isunju et al. 2016a). But these areas were often degraded and polluted, with floods and related hazards leading to children drowning, proliferation of vermin or other disease vectors, and stress amongst parents (Bosco Isunju et al. 2016b, p. 282). With urban densification and privatisation of GI often leading to diminished access by low-income residents, there is a key need to enhance access to these multi-functional yet rarely prioritised assets.

When seeking to realise these benefits, urban policymakers will need to recognise potential trade-offs and the importance of equitable access to GI in informal settlements. For instance, rising property values after GI interventions may negatively affect low-income households, and residents of informal settlements in ecologically degraded areas may be evicted to make way for GI or other climate-related initiatives (Raymond et al. 2017, p.47; Colenbrander et al. 2017).[11] Categorising its services and benefits is difficult, since GI is multi-functional, multi-scalar, and affected by multiple interactions and broader contextual factors (Demuzere et al., 2014, p. 108). As a result, conflicts or trade-offs may arise between different GI objectives,

[11] Similarly, in their review of urban ecosystem-based adaptation, Brink *et al.* (2016) argued for future research with greater focus on *social* benefits and more sensitivity to power relations and urban inequalities, especially as residents of informal settlements may be negatively affected by land-use and other planning measures.

such as between supporting food production (provisioning services) and flood reduction (regulating services) in urban floodplains (du Toit et al. 2018, p. 257). Nevertheless, there are important possibilities to improve access or restore green spaces in informal settlements, with further potential to create jobs, as exemplified by Durban's 'tree-preneurs' afforestation initiatives (Roberts et al. 2012).

Benefits of Low-Carbon Housing

Efforts to create eco-friendly building materials may offer several benefits for climate and inclusive development.[1] For example, in the Ugandan town of Jinja, SDI's federation has developed a building materials workshop that produces low-cost ecological building materials such as precast slabs, t-beams, and laadis (precast mini-slabs), which utilise less cement but still provide effective insulation (Dobson et al. 2015, p. 615). These materials can reduce dependence upon wood for firing bricks and generate incomes for local people, who are trained to produce the materials.[2]

Soil-stabilised blocks (made with local materials) have been developed as an environmentally friendly building material but cannot always be produced, as they depend on soil type. Meanwhile, in the Indian state of Kerala, an upgrading partnership has utilised indigenous bricks with alternating gaps to improve ventilation, alongside novel features such as rat-trap bond masonry (using vertical bricks to create hollow spaces, thereby enhancing insulation) and filler slab roofing that has lowered the use of steel and concrete (Gillard et al. 2018, p. 9).

Such strategies can promote adaptation by reducing internal temperatures and vulnerabilities to heatwaves, as well as reducing GHG emissions, strengthening livelihoods for builders and home-based workers, bringing potential benefits for gender equality as women are predominantly home-based workers (Chen and Sinha 2016), and enhancing health, safety, and disaster resilience by replacing low-quality shelter materials.

[1]See also the Building Advisory Service and Information Network (http://skat.ch/wp-content/uploads/2017/01/basin.pdf)

[2]This also builds on extensive SDI experiences in Malawi, the Philippines, South Africa, Tanzania, Zambia, and Zimbabwe.

Benefits of Improved Housing

Social | Health | Climate | Environment

Benefits of Neighbourhood Upgrading

Many dwellings are utilised both for residential and business purposes; there is also a widespread prevalence of small shops and production units in informal settlements. For instance, informal areas around a market in Mbare (Zimbabwe) were home to many working in the market and informal enterprises[12] (e.g. workers making small plastic bags for traders selling from market stalls). Neighbourhoods may also develop a specialist activity (e.g. iron-work for construction), while other enterprises develop to serve local residents. Such

[12] 'Informal' workers are unregulated and lack social protections; many residents of informal settlements also work in the informal economy. See www.wiego.org/informal-economy/about-informal-economy.

enterprises typically include traders selling essential foodstuffs broken down into low-cost, small units, and some vendors specialise in fruit and vegetables, typically travelling on a daily basis to wholesale markets (Githiri et al. 2016). Other services may include salons, tailors, and kiosks selling mobile phone cards or electricity to charge phones (Gulyani 2006 for Nairobi). More broadly, mixed-use neighbourhoods offering employment opportunities close to home can reduce travel-to-work times (and costs), while also assisting women as their gendered responsibilities often keep them close to home (cf. Chen and Sinha 2016).

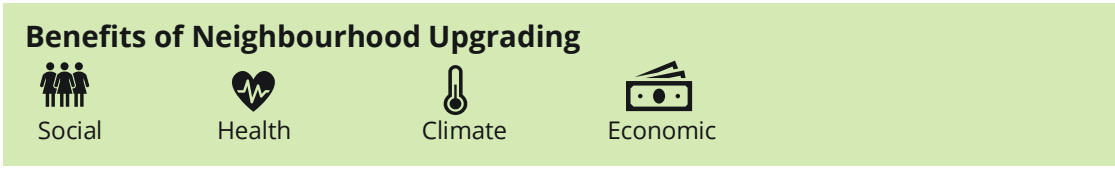
Travel is a major contributor to urban emissions, and ensuring that employment, services, and retail are located in places that reduce the need for long journeys by private transport will help to reduce GHG emissions. Dense urban centres often have lower household carbon footprints, as a result of this increased accessibility (Jones and Kammen 2014). Zoning requirements can also take into account environmental health needs and the desirability of separating potentially dangerous activities from residential areas. There is no simple answer to the best mix of enterprises and dwellings, with solutions needed to reflect local socioeconomic contexts and priorities. More generally, grid infrastructure (e.g. roads, water, sanitation) can 'lock-in' a pattern of urban development, with significant consequences for long-term energy use and the costs of providing basic services (Mehrotra et al. 2018, p. 502). But upgrading can offer a vital opportunity to 'lock-in' lower-carbon and more socially inclusive patterns of land-use, infrastructure, and housing provision in informal settlements.

Although few epidemiological studies exist on the links between cardiovascular mortality and the built environment, there is good evidence that residential density and a highly walkable environment are associated with increased physical activity, as well as with lower blood pressure, lower prevalence of diabetes, and the reduction of other risk factors for cardiovascular disease (Nieuwenhuijsen 2018, p. 433).[13] Meanwhile, research in the Lancet found that combining active travel and lower-emission motor vehicles in urban areas will provide the largest health benefits, particularly with respect to preventing heart disease (Woodcock et al. 2009). The authors recommend interventions to increase the appeal and safety of walking or cycling, such as enhanced streetscape design, properly enforced speed reductions, and diverting investment from motorists to NMT (ibid., also Stevenson et al. 2016). Although these benefits of compact planning and active transport are increasingly recognised, realising their possibilities in informal settlements will require the development of holistic, joined-up upgrading strategies.

Combining active transport and compact land-use strategies can create an array of health, economic, and social benefits, which will require joined-up plans and targeted NMT initiatives. Compact land-use strategies and active transport may achieve both adaptation and mitigation benefits by avoiding trips or shifting away from motorised transport (see Mehrotra et al. 2018), in turn enhancing air quality and lowering temperatures (with respiratory health benefits), supporting physical activity (reducing chronic disease), and also lowering emissions (LSE Cities and C40 2016). There is strong potential to simultaneously

[13] Models generated by Stevenson *et al.* (2016) found that compact city strategies resulted in health gains for six cities (including Delhi and Sao Paulo) thanks to lower rates of diabetes, cardiovascular disease, and respiratory disease, with overall health gains of 420 to 826 disability-adjusted life-years (DALYs) per 100,000 population.

achieve transport, health, and land-use benefits if these cross-cutting interventions are carefully coordinated across government departments (ibid., p. 40). The benefits on inclusive transport interventions are further discussed in the next section



Benefits of Inclusive Transport

Nairobi's predominant transport options are walking or using a 14-seater minibus (matatu). These are both essential for low-income and informal residents, but these modes are often unsafe and rarely a policy priority. Regarding the modal split, private cars account for only 15% of all trips in the city, while walking comprised about 45%, public transport (including matatu) about 40% and cycling just 1% (Nairobi City County Government 2015, p.3). Despite having adopted a non-motorised transport (NMT) policy in 2015, a mere 20% of Nairobi County's transportation budget is allocated to NMT and public transit, even as 80% of residents utilise these modes (Campbell et al. 2019, p. 87; also, Cummings and Obwacha 2018). There is extensive evidence that pedestrian safety is a major health concern in Nairobi, although few studies analyse travel patterns for residents of the city's informal settlements. Similarly, the literature on the climate and health benefits of NMT or public transport usually adopts a citywide lens, rather than focusing on informal settlements.[14] But there is strong evidence that improved NMT, compact land-use strategies, and public transport provision will likely benefit informal residents, while also generating several benefits for climate mitigation and air quality.

Nairobi's pedestrians are at elevated risk of road traffic injuries (RTI), and with informal residents being more likely to walk, safer NMT would likely have equitable impacts. Research by JICA found the highest rates of walking amongst low-income Nairobi residents (earning under USD $23/month in 2013), with 56% of these residents' trips per day being by foot (cited in World Bank 2016, p. 89). Pedestrians and street vendors in Nairobi are currently at increased risk of being killed or suffering serious injuries. In 2014, Nairobi's road accidents data indicated that out of 723 fatalities, as many as 507 (70%) were pedestrians, followed by 101 passengers (14%) (Nairobi City County Government 2015, p. 5).[15] There is a clear need for improved pedestrian safety measures benefiting street vendors and other informal residents, who depend heavily upon walking for work, school, or other essential activities (cf. Ogendi et al. 2013). Furthermore, as discussed below, upgrading paths and roads will be vital to support health and livelihoods in informal settlements.

Improved access to NMT and public transport can promote physical activity while lowering air pollution levels; equitable planning strategies can promote such gains in informal

[14] See also C40 (2018) for analysis of improved bus provision, including the health, social impacts, and economic benefits stemming from reduced premature mortality (due to reduced air pollution, reduced road traffic fatalities, and savings in commute times).
[15] Based on data from Kenyatta National Hospital (Kenya's national referral hospital located in Nairobi), over 40% of the hospital's total injury cases were due to RTI, with over 2,900 traffic-related injuries from January 2014 until May 2015 (Botchey *et al*. 2017a, p.S49). Over 52% of Kenyatta National Hospital's patients presenting with RTIs were pedestrians (Botchey *et al*. 2017b).

settlements. Key benefits of improved access to transport may include economic (reduced congestion and travel times, improved efficiency etc.), environmental (e.g. reduced air pollutants and noise), and social such as enhanced community sociability and reduction in community severance (Mehrotra et al. 2018, p. 507). Realising such benefits will also depend upon the design and implementation of interventions, which should also reflect how travel patterns can vary based on residents' gender, disability, incomes, and other axes of difference. For instance, in a 2004 survey with over 1,500 residents of Nairobi's informal settlements, women were far more likely to walk than men (62% vs. 48%) (Salon and Gulyani 2010, p. 650).

Benefits of Inclusive Transport


Social


Health


Climate


Economic

Benefits of Clean Energy

Residents of informal settlements typically use a mix of energy sources ('fuel stacking'), which is often hazardous and may contribute to ill-health as well as fire outbreaks. Although energy provision is usually considered a national policy concern or rural priority, many low-income urban households cannot access clean, reliable, or affordable energy sources (Westphal et al. 2017; Singh et al. 2015). Households in informal settlements regularly utilise solid fuels for cooking, and their stoves may be unsafe (e.g. unstable, leaky) with risks sometimes compounded by temporary building materials and lack of enclosure around open fires (WHO 2011, p. 38). Additional risk factors may include unsafe electrical wiring and overcrowded or congested housing in informal settlements (ibid.; also, Figueroa 2016). There are further risks of electrocution and respiratory ill-health linked to unclean cooking fuels, particularly for women and children (WHO 2016). But with enhanced access to clean energy, there are several potential health benefits and also opportunities to promote economic productivity, gender equality, and climate change mitigation.

The health and gender-inequitable burdens of unclean energy sources are rarely analysed in informal settlements, but there is clear evidence of the health risks from solid fuels and injuries linked to burns. The WHO estimated that in 2016, household air pollution (HAP) from solid fuels led to 4.3m premature deaths globally, including 16,600 deaths in Kenya.[16] Worldwide, exposure to HAP (including from unclean cooking fuels) accounts for 18% of all ischaemic heart disease and 33% of the total disease burden from respiratory infections (Prüss-Ustün et al., 2016, pp. 14–15). Burns is the cause of another 268,000 deaths annually from exposure to fire, heat, or hot substances, with most cases in the Global South (ibid., p. 77).

Research in Nairobi's informal settlements has confirmed women and children's particular health burdens linked to unsafe energy, among women and children (particularly girls) who

[16] See www.who.int/gho/phe/indoor_air_pollution/burden_text/en/ and GBD 2016 Risk Factors Collaborators, Supplementary Appendix 2, p. 2728.

utilise solid fuels when cooking.[17] In 2013, the average $PM_{2.5}$ concentration in Viwandani was 67 μg/m^3, over six times the WHO's $PM_{2.5}$ guidelines of 10 μg/m^3 annually (Egondi et al. 2016).[18] Although it is difficult to disentangle the causes of air pollution (given the nearby factories and other potential sources), unclean cooking fuels likely contribute to elevated $PM_{2.5}$ levels. Based on research in the settlements of Viwandani and Korogocho from 2003–2012, as many as 30% of women's injury-related deaths were due to exposure to smoke/fire/flame, as compared to just 12% of men's injury-related deaths from the same risk factor (Mberu et al. 2015, p.17; data for residents aged 15 and older). Complementary research in Kibera found that among the 2,723 residents suffering burns from 2006–2011, the incidence was 3.8-fold greater in children under five years old than amongst older residents (Wong et al. 2014). Women in Kibera were at significantly higher risk of burn injury than men of the same age (ibid., p.4).[19]

But clean energy can offer significant benefits for gender equity, as well as supporting health, air quality, and GHG mitigation (Gordon et al. 2014; WHO 2016). Meanwhile, improved access to liquefied petroleum gas (LPG) and solar energy can simultaneously promote jobs and time savings, reduce emissions, and enhance health and well-being. Rosenthal et al. (2018) argue that, as compared to improved biomass stoves, instituting LPG cookstoves will generate greater improvements in disability-adjusted life-years (DALYs) and more significant GHG reductions.[20] Westphal et al. (2017, p. 21) also note that LPG can reduce cooking time by 50%

Benefits of Clean Energy

In November 2017, SDI's India Alliance inaugurated a rooftop solar PV system on a large-scale, government-financed informal housing complex in Mumbai. The solar PV system installed makes use of enabling net-metering policy and a capital subsidy, incentivising the tapping of Mumbai's vast rooftop solar potential and making energy more affordable for residents.

In another set of equitable, climate-sensitive strategies, Brazil has promoted energy-efficient fridges, lightbulbs, and solar water heaters for low-income households. From 2008–10, Brazil's Efficient Community Program donated efficient appliances to low-income residents (totalling over 25,000 efficient fridges and 500,000 fluorescent lamps); it also conducted educational outreach and employed local youth as agents to promote behaviour change (GNESD 2014, pp. 38–40).

Offering several socioeconomic and climate benefits, solar water heaters have significantly reduced households' bills (by up to 30%), while also advancing the objective of dignified, high-quality housing as demanded by Brazilian social movements (Bulkeley et al. 2014). Research after electrification in Ahmedabad's informal settlements found that beneficiaries valued electricity not only for the convenience and night-time lighting, but also for improving safety, enhancing incomes, and supporting education (Parikh et al. 2012, p. 482).

See http://knowyourcity.info/2017/12/inauguration-solar-energy-project-mumbai-slum-housing-project/.

[17] About 18% of the global burden of ischaemic heart disease is attributable to HAP, alongside 26% of stroke burden; for countries with widespread use of solid fuels, the 'mean population attributable fractions [for chronic obstructive pulmonary disease] often exceeded 30%, with *higher values for women than for men*' (Prüss-Ustün *et al*. 2016, p. 61, italics added).

[18] See also www.who.int/gho/phe/indoor_air_pollution/burden/en/.

[19] Less than 1% of burn victims from Kibera were hospitalised (Wong *et al.* 2014), underscoring the need for settlement-based studies rather than relying on hospital-based research.

[20] DALYs are a combination of the sum of the years of potential life lost due to premature mortality and years of productive life lost due to a disability.

(vs. traditional biomass cooking), thereby enhancing productivity and freeing up women's time for other activities. Improving access to clean energy and reducing fire risks via upgrading can offer multiple benefits for inclusive development, health, and disaster resilience. After a fire outbreak in an informal settlement, an upgrading project in Durban incorporated fire-resilient construction materials, fire detectors, and improved access ways (Dobson 2017, p.79). This multi-pronged upgrading strategy not only supported fire resilience but also facilitated access to emergency services during other disasters in the settlement. In another energy intervention with multiple benefits, Uganda's slum-dweller federation has produced affordable, ecological briquettes made largely of food waste (matoke, or plantains) that replace unclean charcoal previously used for cooking, which had clogged drainage and thereby exacerbated flooding risks in informal settlements (Dobson et al. 2015, p. 615). Matoke briquettes are cheaper for consumers than charcoal and help prevent deforestation linked to charcoal production. Creating further benefits for local economic development and environmental health, the briquettes are produced locally by federation members, who began rooftop water-harvesting to produce the bricks and also engage in clean-ups to help access matoke peels (ibid.). More broadly, these initiatives underscore the inextricable links between adaptation, mitigation, and inclusive development as well as the need to develop locally rooted upgrading initiatives with community residents to simultaneously advance multiple agendas.

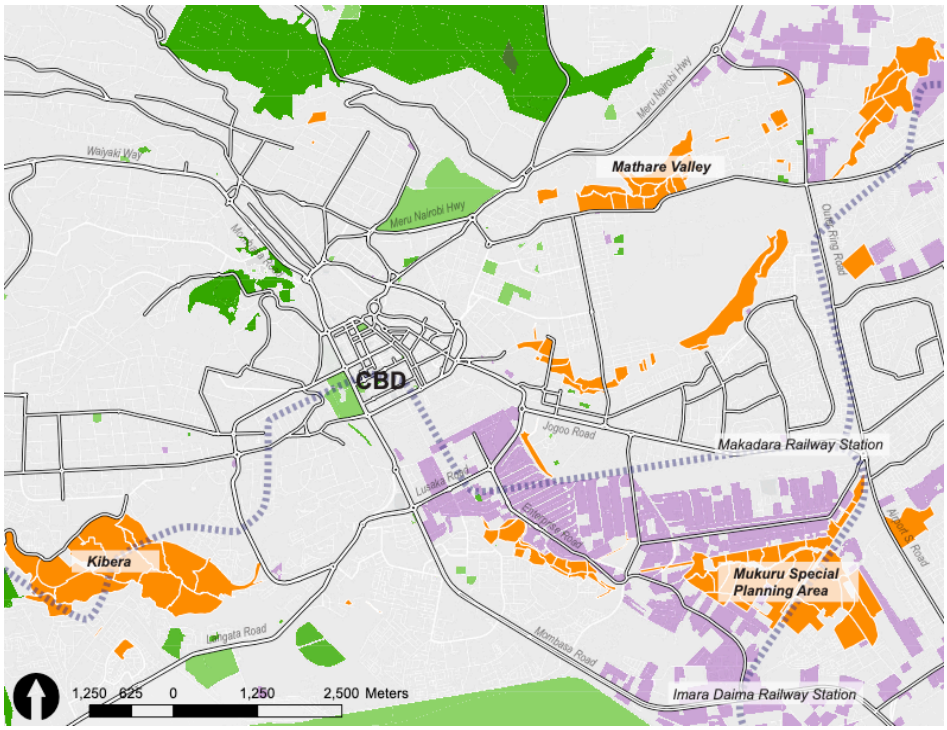
Benefits of Clean Energy

This appendix provides additional information for Section 2.

Appendix 2: Local Context and Key Risks in Mukuru, Nairobi

Context: the Muungano Alliance, the SPA and the political framework

This case study analyses the ongoing plans to upgrade Mukuru where the Muungano Alliance is spearheading a participatory planning process as explained in section 3.



Map 1: Nairobi's informal settlements, including Mukuru Special Planning Area (SPA)

Muungano is a social movement initially launched in Nairobi's informal settlements around 1996, before spreading nationwide in the early 2000s (Lines and Makau 2017). Although its emergence directly responded to evictions by the Kenyan government, Muungano has also developed collaborative government partnerships and precedent-setting strategies to catalyse inclusive interventions, such as community-led upgrading in Nairobi's informal settlement of Huruma (Weru 2004). The movement currently has around 100,000 members across Kenya, and in 2001, Muungano became a member of SDI.

Like other SDI affiliates, the Muungano Alliance has an extensive track record of grassroots data collection, including detailed inventories, household enumerations, and city-wide profiles of Kenyan informal settlements. Vibrant savings groups[21] and in-depth data gathered by residents themselves, as well as a recognition of the need to develop inclusive

[21] In *Muungano* and other SDI federations, group members save on a daily basis and meet regularly with their fellow participants, 'creating a sense of shared identity... the structure of savings groups allows members to access short-term loans …[This] prepares communities for medium and large-scale financial management necessary in the slum upgrading projects … Often regarded as the cornerstone of SDI, these savings groups link together to form "federations".' (see SDI's website: http://knowyourcity.info/our-practices-for-change/).

government partnerships, have underpinned and orientated the Alliance's activities within and beyond Mukuru.

Map 2: SPA informal settlements of Mukuru: Kwa Reuben, Mukuru Kwa Njenga, and Viwandani (credits: SPA Health Consortium 2018, p. 10; Muungano Alliance)

Nairobi has several other upgrading projects,[22] but the SPA is distinguished by its scale, governmental support, and multi-sectoral participatory approach. Kenya's Physical Planning Act (2012) defined a 'Special Planning Area' as having 'unique development and environmental potential while also raising significant urban design and environmental [social, economic, and physical] challenges.' The elevated levels of pollution, hazardous service provision, and lack of prior interventions in Mukuru (AMT et al. 2017, UC Berkeley et al. 2017), as well as its central location and vibrant livelihoods, all helped to motivate the SPA declaration.

The SPA was enabled by Kenya's progressive Constitution, but challenges remain in implementing the rights and decentralisation reforms enshrined in the Constitution. The 2010 Constitution established rights to key economic and social rights, including to 'accessible and adequate housing', 'reasonable standards of sanitation', and the 'highest attainable standard of health.'[23] Furthermore, it instituted 47 county governments with directly elected governors and county assemblies; county governments were granted additional responsibility for county-level planning and service delivery (World Bank 2016). County governments are now expected to provide housing, water, sanitation, and storm-water management (Housing Consortium 2018). However, counties face persistent challenges with raising sufficient own-source revenues, and their budgets have 'barely covered their inherited recurrent expenditures and liabilities' (World Bank 2016, p. 15). Funding for the SPA's implementation is still to be determined, but the SPA has already been made a statutory obligation of the county government (Makau and Weru 2018).

[22] For UN-Habitat's upgrading in Kibera, see https://unhabitat.org/books/un-habitat-and-the-kenya-slum-upgrading-programme-strategy-document/ and the World Bank's KISIP http://projects.worldbank.org/P113542/kenya-informal-settlements-improvement-project-kisip?lang=en.
[23] See full text of 2010 Constitution available at www.kenyalaw.org/lex/actview.xql?actid=Const2010.

Participatory planning session as part of Mukuru SPA (credit: Muungano Alliance)

Climate change and overlapping risks in Mukuru

Mukuru's population is estimated at 100,500 households, with an average of three people per household, and the settlement faces several environmental health and disaster risks. Approximately 90% of residents in Mukuru are tenants who rent rooms; most dwellings are single- or double-storey shacks built of mud, galvanised iron sheets, and/or waste materials.[24] There are a small number of high-rise buildings ('tenements'), which provide rooms at a slightly higher cost. In total, 22,871 structures have been identified in Mukuru, of which 1,261 are 'permanent' (i.e. with 'modern' building materials) and 21,610 are 'temporary'.

Fire in Mukuru has been linked to the use of low-quality (often illegal) electricity connections and paraffin lamps; risks are only heightened by high-density shacks and inadequate access to emergency services. Based on a survey with 264 households in Mukuru Fuata Nyayo (62% were female respondents), the leading cooking fuels were paraffin (46%) and charcoal (33%), with just 14% using gas and 6% electricity (University of Nairobi and Red Cross 2016, p. 21). Over 90% had experienced a fire at the neighbourhood level, and 54% had experience with fires at the household level (ibid., p. 22). Leading causes of fires were illegal/faulty electricity (43%), careless use of electronics (30%), or stoves (13%) (ibid., p. 24). There have been large-scale fires, including a March 2015 fire in Kayaba that left 693 residents homeless and 8 injured (ibid., p.22), but no comprehensive statistics on fire incidence are available.

Although located at an altitude of 1800 m above sea level, its name translating as 'cool waters' (reflecting its proximity to the Nairobi River), Nairobi will likely experience more frequent heat spells due to climate change. Daily maximum and minimum temperatures already show statistically significant warming trends over the past three decades (UCT et al. 2017, pp. 2–3). Projections suggest that by 2040, Nairobi's mean daily maximum temperatures may be

[24] Rental housing is widespread in Nairobi's other informal settlements and elsewhere in the Global South (Gulyani *et al.* 2018, Gilbert 2016).

0.5 to 2°C warmer than at present; the frequency of daytime and night-time heat spells are projected to increase in the second half of the century (ibid., p.7). Furthermore, Nairobi's informal settlements already experience higher temperatures (largely due to limited vegetation and other surface properties), with a mean temperature of 1.8° to 3.1°C above the main Dagoretti weather station (Scott et al. 2017). Meanwhile, the city typically has two rainfall seasons (long rains from March until May, short rains from November until December), but models disagree regarding future rainfall, with some projections indicating a rise in rainfall in the second half of the century (UCT et al. 2017).

Flooded path and dense iron-sheet shacks in Mukuru (credits: Marisa Asari, UC Berkeley)

Mukuru has unusually low levels of vegetation, even compared to Nairobi's other informal settlements (Scott et al. 2017).[25] Lower levels of vegetation are strongly correlated with higher temperatures, and unsurprisingly Mukuru's average daytime temperatures exceeded those of other settlements or the Dagoretti weather station. The authors conclude that temperatures in Mukuru 'regularly exceed temperatures at [Nairobi's central monitoring station] by several degrees or more' (ibid., p. 15). Although this data was gathered in 2015, an unusually hot year, heatwaves in Nairobi are likely to become more common with climate change (ibid.).

Flooding in Mukuru has multiple causes, including the settlement's low-lying location, poor infrastructure, inadequate solid waste management, and degraded wetlands. Mukuru is located along the low-lying banks of the Ngong River, and the riparian zone is at elevated risk of flooding and landslides.[26] Furthermore, degradation of Nairobi's wetlands, impervious surfaces, and the ensuing surface runoff have led to a greater concentration of sediments, which can block Mukuru's already poor drainage (HIA 2018, pp. 31-32). Mukuru's meagre solid waste management may again exacerbate the risks of floods by clogging drainage (see Photo 3). Although there are no detailed economic studies of flooding impacts in the SPA,

[25] 'Mukuru, the neighbourhood [that was] hottest during the day, has the lowest measured vegetative fraction (0.09), half of that in Kibera (0.189)' and also lower than that of Mathare (0.12) (Scott *et al.* 2017, p. 13).
[26] Mukuru's close proximity to the Ngong River increases vulnerability to flooding, which may be worsened by climate change. The SPA may have to address this, including the challenge of some potential displacement of residents (with thanks to a reviewer for this comment).

research in Gatope (a flood-prone area in Mukuru Kwa Reuben) found that floods regularly resulted in mosquito-breeding and diseases; property destruction; limited mobility; burst latrines; and water pollution (Boit 2014, pp.67–68). Casualties and building collapses have been recorded due to flooding: on 12 May 2015, at least ten people were killed in Mukuru Fuata Nyayo after a building wall and mosque partially collapsed following six hours of heavy rainfall.[27] There are also suggestive findings of the negative impacts of Mukuru's floods upon education: in March 2018, floodwaters reached 50cm in Embakasi Girls Secondary School, and 500 students could not attend school during the two-day closure (HIA 2018, p. 36).

Flooding in Mukuru (credits: Marisa Asari, UC Berkeley)

This appendix provides additional information for Section 3.

[27] See '10 killed as heavy rains hit Nairobi Monday night,' *The Standard,* available at www.standardmedia.co.ke/article/2000161938/10-killed-as-heavy-rains-hit-nairobi-monday-night. We offer thanks to Bernard Majani for sharing his database of media mentions of flooding in Mukuru.

Appendix 3: Approach, Methodology and Limitations

Conceptual Approach

Climate change risk is a function of hazard, exposure, and vulnerability. Adaptation requires addressing one or more of these elements of risk. The key goal of the adaptation strategies and actions is to reduce the risk faced by the people. This study is concerned about the adverse consequences of climate change and conscious that informal settlement dwellers are frequently blamed for 'urban problems' irrespective of whether or not they are actually responsible. Hence, acting on, and being seen to act on, the causes of climate change as well as adapting to the consequences of climate change have emerged as key priorities.

In informal settlements, all three functions – hazard, exposure, and vulnerability – are important. But there is little that can be done directly on the hazard in the short and possibly long term (e.g. changing precipitation, rising temperature, rising sea-level although the latter is not relevant in Mukuru). Therefore, adaptation efforts need to focus on either reducing exposure (e.g. through protective infrastructure that reduces flooding, through better housing design that reduces internal temperatures) or reducing vulnerability (e.g. through increasing their ability to cope and adapt).

At the same time, the nature of upgrading introduces other interventions relevant to the achievement of the SDGs. Upgrading on the scale of Mukuru involves the comprehensive introduction of infrastructure.

Equally significant to urban form is the need to allow for the potential of increasing affluence and additional consumption related to that affluence. Hence, it is not just a question of providing a suitable built environment for today but preparing for predictable changes in behaviour. This means, for example, thinking about the form of building that allows for natural cooling even if households have too few resources to invest in fans at present. The physical form has to be credible in the context of recognised behaviours that exacerbate GHG emissions, as well as adapting to the increased risk of exposure to the negative effects of climate change.

Efforts to develop an urban form that reduces the likelihood of GHG emissions have a further dimension. A recently recognised element of climate risk is that from inappropriate climate change policies (either maladaptation or inappropriate mitigation policies). In this regard, some of the more 'mitigation' focused outcomes discussed here can also reduce risk – because they mean that Mukuru residents are not at risk from inappropriate policies (e.g. that would distribute the costs of mitigation inequitably, or that simply impose additional burdens on low-income residents).

In summary, the proposed actions will cover those areas traditionally understood as relating both to adaptation and mitigation. Adaptation is about dealing with immediately adverse consequences of climate change. Meanwhile, mitigation-related actions are prioritised by federations to reduce the challenges faced by future generations, avoid informal settlement

dwellers being adversely treated due to 'irresponsible' actions that exacerbate climate change, and protect informal settlement dwellers from policy actions that might increase their living costs and other difficulties.

Limitations

We acknowledge several limitations to this study that reflect the still-incomplete SPA plans; the evolving understanding of SDI's federations about how climate change may influence upgrading; and limited data about many potential impacts of upgrading.

With an emphasis on tacit and local knowledge, SDI federations consistently learn by doing. In the absence of finance to enable climate change precedents, there remain certain gaps in their knowledge about what they want to do and how they want to do it. Furthermore, there are many uncertainties about the development process in Mukuru; plans are being developed but are not fully in place. The actions are currently being developed as the strategy and components of the SPA emerge. But the period associated with the SPA will only end in August 2019, and many activities are yet to be decided. Thus, uncertainties exist in terms of assessing the present conditions and potential actions.

When we have to predict the outcomes of actions that bear upon changed behaviours in the future, the estimates are even trickier. Moreover, it remains unclear how SPA plans will be realised, including how it will be financed and what conditionalities may be required.

Some benefits are indirect and especially challenging to quantify, however, we selected indicators that can be readily gathered in other informal settlements. Potential gains in mental health or other intangible benefits may be substantial (e.g. lower stress and enhanced well-being due to improved living conditions and reduced disaster risk), but our framework has focused more narrowly on a few key indicators that are more easily quantifiable. Adaptation also requires households to deal with post-disaster trauma; reducing or avoiding trauma is a key potential benefit of upgrading that nevertheless will not be quantified below. For instance, homeowners in Iloilo (the Philippines) who experience floods have highlighted the benefits of having a flat roof that they could occupy as the floodwaters rose, since their children needed to believe that they were safe Although upgrading can reduce flooding risks by improving water, sanitation, and hygiene (WASH), internal drainage and solid waste management (as discussed below), there are other interventions needed to address flooding that extend beyond the scale of informal settlements.

The discussions identified a suite of potential interventions linked to the Muungano Alliance's priorities for upgrading of Mukuru. We spent three months exploring the feasibility of these actions. In many cases, data was not available. In some cases, the benefits appeared to be present, but it was difficult to measure them. In other cases, the scale and nature of the benefits were not clear.

Appendix 4: Technical Details

This section provides further detail on the analysis of the benefits of upgrading informal settlements, broken down into the ten discrete intervention actions identified by the methodology.

Increasing the efficiency of waste management

Waste management reduces methane (along with other emissions). It also reduces the risks of flooding (with associated benefits by improving health and retaining household assets), and it can create jobs. Waste management has positive health impacts beyond the reduction in flood risk, and by improving the appearance of the neighbourhood it builds self-respect and potentially reduces prejudice and discrimination.

The analysis prepared by SDI-Kenya suggests that per capita waste in Mukuru is 1.47 kg per day. However, comparing this figure to other analyses suggests that this figure is too high.[28] For the following assessment, we have selected the figure of 0.8 kg per person per day, with 50% organic waste.

If there are 100,500 households in Mukuru, three people per household and 0.8 kg per person per day in waste with waste being 50% organic, then the annual estimate for waste in Mukuru is 88,000,000 kg; or 88,000 metric tonnes of waste with 44,000 metric tonnes in food waste.

Landfills' impact on climate change is due to their emissions of CO_2 and CH_4, along with several other gaseous components. These gases are the by-product of anaerobic decomposition of organic waste, characteristic of conventional landfills, and tend to accumulate within the landfill (Lou and Nair 2009, 3792).

The processes by which waste leads to emissions are complex.[29]

- emissions continue for some years after the waste is first deposited.
- emissions are sensitive to characteristics of the waste itself (the amount of organic matter) as well as external factors such as weather.

Therefore, approximate estimation for greenhouse gas emissions from solid waste is difficult. Moreover, Wangyao et al's (2010) analysis of the emissions calculated from the IPCC model and those observable at sites in Thailand demonstrate yet further complexities with considerable discrepancies in some cases and close alignment in others (page 257). Hence

[28] Njoroge *et al* (2014) estimate that Nairobi's residents produce 1.2 kg of waste per capita per day, with between 50 and 60% being organic. Khamala *et al.*'s (2013) research suggests a higher percentage of organic waste in Nairobi's low-income neighbourhoods (64%). The National Environment Management Authority (NEMA) (2015) suggests a lower figure in Nakuru County of 0.5 kg per person per day (with 51% organic waste), and von Blottnitz (2010) suggests that Nairobi's residents produce between 0.2 to 0.8 kg per person per day.

[29] UNFCCC reporting requirements demonstrates the need for a considerable amount of information: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/reporting-requirements/crf-tables-for-sbsta-39

Further technical requirements as elaborated by the IPCC are here: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

even if we could have obtained a figure of estimated emissions produced from a "model," we would have to be cautious. Wangyao *et al* (2010) highlight the sensitivity of emissions to seasonal variation, as well as the difference between emissions from sanitary landfill (greater) than open dumping (lesser) due to more favourable conditions for anaerobic decomposition in the former, and the significance of the depth of solid waste deposition.

Emissions can be reduced by improved waste management as well as recovery, re-use, and recycling. A variety of solutions have been put forward, of which the simplest for organic waste is composting with aerobic decomposition.

Of the 0.4 kg per person per day, or 44,000 metric tonnes a year, of organic waste, between 44,000 and 83,600 metric tonnes of CO_2 equivalent will likely be released into the atmosphere. However, the relationship between organic waste and emissions is complex and can only be estimated. Inadequate solid waste management (SWM) also exacerbates flood risk; based on recent flooding (including spring 2018), one-third of Mukuru's structures are at risk of some flood damage.

There is an urgent need for SWM strategy that ensures universal collection and safe disposal of Mukuru's waste, which can reduce its negative environmental impacts (e.g. open burning, clogged waterways) and also mitigate GHG emissions. This could be achieved through Nairobi County and the Muungano Alliance developing plans to improve access to affordable SWM services (municipal, private, or community-managed), and through Nairobi County developing strategies either to treat waste on-site or to remove for safe disposal.

Increasing the diversion of food waste, organics and recycling

Youth unemployment is high in Nairobi, and waste recovery, recycling, and re-use can generate jobs for young people living in the SPA.[30]

Composting can significantly reduce GHG emissions, although such reductions will depend on the precise waste composition and composting process utilised. Aerobic composting – if done properly – emits 0.12–9 kilograms methane per tonne of treated waste and 0–0.43 kg N_2O-N per tonne of treated waste (Sánchez et al. 2015 quoted in Annepu et al. 2018). Composting of the 44,000 metric tonnes of organic waste in Mukuru is likely to reduce emissions significantly.31 If the nearby riparian reserve is used for Muungano-led composting, then this activity reduces the need to transport Mukuru's waste, a further source of GHG emissions, and helps to secure this green space for community activities. As an illustration of what can be achieved, a recycling and composting programme in Tangerang Selatan (Indonesia) reports a reduction of approximately 700 tonnes CO_2 equivalent against a total waste volume of 2,200 tonnes (of which 900 tonnes were organic) over a 16-month period (Annepu et al. 2018, p. 568).

Annepu et al. (2018) note that composting in the global South has had limited success due to the inability to produce high-quality compost. While they argue that landfill gas-to-energy

[30] A Mukuru youth group is already interested in plastics recycling but cannot currently realise their plans due to the lack of reliable electricity provision (underscoring the need for multi-pronged upgrading interventions).
[31] However, the experience of other SDI affiliates highlights the difficulties in building up the market for compost, even with the help of the authorities.

is the most cost-effective strategy to reduce emissions; they recommend recycling of materials, and elimination of waste dumps is a priority.

Reducing food waste and better managing other organic waste will limit the need to transport waste; lower maintenance costs; and extend the disposal site's operational lifetime. Additionally, increasing food waste recovery will enhance recycling efficiency, help to recover nutrients, and improve soil quality.

Cooler housing designs

The benefits of reduced energy consumption thanks to cooler housing designs are multiple but difficult to measure in Mukuru at present. Mukuru residents do not currently appear to be spending money on reducing temperatures in their dwellings. Hence, it is not possible to assess the scale of the problems associated with over-heating, nor do we have data on heat-related stress and related illness in Mukuru. As Scott et al. (2017) report excessive temperatures in Mukuru, it is likely that poverty and low incomes have meant that expenditure on cooling energy has not taken place at scale, despite the need.

What is clear is that in the future (with electrification and rising incomes linked to upgrading), shelter designs are needed that can reduce energy demand while also minimising the risk of heat-stress and exposure to extreme temperatures. The cost of such housing improvements, and the related energy savings cannot easily be estimated, but the potential for cost-savings of climate-related housing improvements on household expenditure has been noted in other projects (for São Paulo, see Bulkeley et al. 2014).

There is a lack of data about current expenditure on cooling and housing designs have not yet been developed in Mukuru (due to the sequencing of other SPA plans), but the potential of such designs to reduce heat stress should be carefully considered. These design strategies will need to take account of the opportunity to promote cooling; possible improvements may include building alignment, changes in building materials, higher ceilings, amended window designs, overhangs, balconies, and use of alternative building materials.

Provision of green space

The significance of green infrastructure is increasingly recognised in studies of climate change adaptation, notwithstanding the difficulties in quantifying benefits.

Scott et al. (2017) studied temperatures in informal settlements in Nairobi, including Mukuru, and report increased temperatures in Mukuru relative to the surrounding area. They argue that urban areas have higher temperatures than rural areas and informal settlements are 'potentially highly vulnerable to heat exposure due to lack of information on heat wave occurrence and risk, inadequate access to routine health services, limited access to potable water, limited household ventilation and lack of access to cooling centers' (ibid., p. 17). The lack of vegetation in Mukuru is, they suggest, particularly significant in explaining high temperatures in this area.

High relative temperatures appear to be correlated with mortality more strongly than are low relative temperatures,[32,33] but the researchers are cautious about causality. Higher rainfall is also associated with mortality. The upgrading of Mukuru offers opportunities to change these relations through the provision of infrastructure and the re-design of the neighbourhood.

The potential of green space to reduce local temperatures and reduce flooding risks is widely recognised and can be assumed to also reduce heat stress in Mukuru. Research in other African cities suggests that planning for increased vegetation has significant positive local climate impacts and can potentially reduce local temperatures by more than the predicted increase in temperature due to global climate change (Cavana et al. 2014; Lindley et al. 2015).[34]

The benefits of green infrastructure (or green space) in Mukuru appear to be concentrated in three areas. First, the cooling effect can offer relief from extremes of heat. Second, well-being effects are generated both by the opportunity for physical exercise and the pleasure of seeing vegetation. Third, there is potential for reduced risk of flooding and better management of floodwaters, with reduced damage to property or associated health impacts. The benefits of green space and related ecosystem services in four informal settlements in Dar es Salaam are categorised by Roy et al. (2018) into four: supporting (nutrient recycling), provisioning (food, fuel), regulating (coastal erosion, temperature), and cultural (recreation, spiritual, educational).

Planning for Mukuru will need to take account of the need for green space, and strategies to improve local green spaces (e.g. tree planting) should be developed.

Maintaining high-density neighbourhoods

Densification – taking measures to secure a more compact city – offers benefits in terms of reduced travel-to-work times (and emissions) as well as benefits related to the agglomeration of economic activities.

Bird et al. (2017) estimate that the average population density of 'slums' in Nairobi was 28, 200 people per square kilometre in 2009, a 51% increase in just ten years. Mukuru's population density is 108,128 people per square kilometre.

In sum, Mukuru is already a compact neighbourhood. The Muungano Alliance has committed to ensuring that all current residents are included in the SPA interventions. This pledge will provide an opportunity to develop systems that can prevent gentrification. The SPA's infrastructure plans are being developed on this basis, and affordable housing options

[32] Egondi *et al*. (2012) use Nairobi Urban Health and Demographic Surveillance System data for approximately 60,000 households over the period 2003 to 2008. These authors found that increasing temperatures (above 75th%ile) were significantly associated with mortality in children and non-communicable disease (NCD) deaths (*ibid*., p. 23). With respect to female NCD and pneumonia deaths in relation to rainfall, mortality increased by 3% for each 1 inch (25 mm) increase in the amount of rainfall. The relationship of rainfall to the increase in NCDs and pneumonia (accumulated over one month) was 12% and 24%, respectively.

[33] The mortality-related impact of low temperatures is potentially linked to the fuel used for heating. While less relevant for climate change, this highlights the inter-connected nature of impacts in informal settlements.

[34] As noted above, research in Nairobi's informal settlements has documented the health risks of heat stress (Egondi *et al.* 2015, Scott *et al.* 2017).

will be developed enabling all residents to remain in Mukuru (but in safer, more secure dwellings).

An exemplary high-density neighbourhood in Mukuru, which demonstrates how to support high-quality local livelihoods and efficient energy provision, can advance inclusive, climate-friendly urban planning with lessons for other cities in the Global South.

Mixed-use development

Mixed-use development is widely considered to be optimal for informal households. This is because it recognises that households have mixed sources of income and that these mixed sources can foster more secure livelihoods. It includes both home-based enterprises and separate proximate workspaces (either for retail trade and/or service provision to consumers or wholesaling activities and production). Typical enterprises in Mukuru include grocery/vegetable vendors; bars, pubs, and hotels; charcoal vendors; tailors/ dressmakers; barbershops and hair salons; kiosks; and shops.

Drawing on the research for the Mukuru SPA (2016), we can identify 22,871 structures in Mukuru of which 4,244 (18.5%) are dedicated to business use and 2,698 (11.8%) are mixed-use. In terms of employment, data indicates that 46.5% of adults currently work in Mukuru or in the adjacent industrial zone. The major occupations for men in Mukuru are casual workers[35] (22%), industrial worker (14%) and businessperson (10%) whereas among the females the main occupations are unemployed (36%), housewife (26%), and businessperson (20%).

Evidence from focus groups and other data suggest that, at present, transport is not a significant expenditure for Mukuru households, and this is consistent with the occupations in Mukuru. About 9% of all working age adults in Mukuru are industrial workers. All of these are employed in the zone adjacent to Mukuru with a maximum distance to walk of 4 km. A further 16% are casual workers and a high percentage of these may be employed in the industrial sector. Across the sample of working age adults, 16% are businesspeople and 5.5% are artisans. These workers are likely to all work in Mukuru or on the periphery of the settlement. Hence, they are unlikely to have significant travel to work, although they may shift from walking to bicycles and motorised vehicles if and when incomes grow.

In terms of GHG emissions, it is likely that mixed-use neighbourhoods can reduce emissions from the transport of goods and services. Residents of such neighbourhoods do not have to travel outside of the settlement to secure essential goods and services on a daily or weekly basis. The productive and trading enterprises in the SPA are typically supplying goods and services internally to Mukuru residents. Hence, these goods and services are not transported out of the area (with consequences for emissions). While businesspeople and artisans are unlikely to have significant travel-to-work costs (either in income or emissions), they may transport goods into Mukuru in their production and/or retailing, but this is likely to have a lower emission load than individual journeys outside of the settlement.

[35] 'casual worker' category referred to those employed on a daily or weekly wage in low-skill, on-demand jobs such as offloading goods within the industrial zone, supporting the construction workers (sweeping waste and/or passing materials), and paper cutting if a machine breaks down

The complexities of measurement are related to what will be secured in terms of strengthening mixed-use neighbourhoods, how it will affect economic development, how it will impact on emissions-related activities (e.g. travel), and how the emissions of these activities might change (e.g. potentially matatus converted to run on electricity).

There is a need for facilitating mixed-use development in Mukuru, including space for formal and informal enterprises, as well as access to core public services (e.g. healthcare, education). This integrated approach underpins the current SPA plan; there are evident GHG emissions benefits in ensuring that commuting distances remain limited and journeys optimised.

Pedestrianisation and increased cycling

Distances within Mukuru extend to approximately 3 km from one corner of the settlement to another 'as the crow flies. The settlement shape can be simplified as a triangle (refer to map 2 in Appendix 2).

The World Bank's Kenya Urbanisation Review (2016) highlights that – at present – 41% of trips in Nairobi are made by walking and 28% by matatu (ibid, p. 84). A 2016 study by the Muungano Alliance analysed the ownership of vehicles in Mukuru. Respondents reported that car ownership was less than 1%, motorcycle ownership was less than 3% and bicycle ownership was 4.8%. The very low ownership of bicycles appears to be reflected in the current prioritisation of pedestrian needs.

What is evident from this analysis is that – rather than replacing motorised transport – efforts have to be made to ensure that Mukuru's residents carry on walking or shift to bicycles both for journeys within Mukuru and for those beyond. Mukuru residents' benefit from their proximity to the industrial area and Nairobi's central business district, while in wider Nairobi figures suggest that only 11–20% of formal commercial or industrial employment opportunities can be reached within the hour using these two transport modes (ibid, p. 82).

Planning for the Mukuru SPA has placed considerable emphasis on the provision of walkways and cycle paths. The structure of the plan for pathways and roads favours non-motorised transport (NMT), with 33% of planned provision being 3-metre pedestrian pathways that are inaccessible for motor vehicles (excluding motorcycles) but suitable for cycling. The next level of road provision – 42% of planned provision – provides roads that are 5.5–6.5 meters in width, intended for cars as well as bicycles. A third, arterial level will have provision for either wider pavements or cycle tracks. Community consultations to date have found that the number of people who want to walk exceeds those who want to cycle and there is no demand for additional provision for bicycles. Hence at present wider pavements are planned alongside arterial roads. When cycle routes through the neighbourhoods are identified, cycle paths may be added.

To assess the benefits that may arise as a result of encouraging NMT is complex. However, based on the data about vehicle ownership in Mukuru (Muungano Alliance 2016), and making some modest assumptions about the switch to motorised transport (and the

potential to deter this switch), it is possible to suggest potential savings of about 1,000 metric tonnes of CO_2 equivalent annually.

For simplicity, we assume identical mode shift to the C40 study (Arup, 2017). Let's assume that one-third of Mukuru's population crosses the settlement every day and taking into account the uneven coverage of footpaths and the possible location anywhere in the area that is a distance of 2 km. They travel and return meaning a distance of 4 km. That means that each day there is a distance of 360,000 to 402,000 km travelled within the settlement depending on the household size of 2.7 or 3 persons. Let's take the average of 380,000. Let's assume that the structure of the new road network is such that all those journeys have to be made on foot, bicycle or motorcycle. But without the new road structure, 20% of them would be made by motorised transport. So, the benefit of the SPA is that 20% of travellers are prevented from shifting to motorised transport (bus, matatu, car) at some indefinite point in the future – say 76,000 km a day. For let's assume an identical mode shift to the C40 study. And let us assume that at present 10% of Mukuru's adult population travel 7 km to the city centre each day at present, that at this indefinite point in the future all of these would shift from walking to matatu or car. And that investment in cycle paths halves the number who shift. So, if we assume that there are 200,000 adults in Mukuru then 10,000 people will travel by cycle (or walk) who would otherwise have travelled by motorised transport (bus, matatu, car). And the distance they travel is 7 km there and 7 km back or 140,000 km. See Table 3 for a summary of these findings drawn from a C40 study of cycling in Nairobi (Arup 2017).

Table 3: Reduction in CO_2 possible from encouraging non-motorised transport

	Cycling - C40	Pedestrianisation	Cycling
Mode shift	Estimated to be 12.5%, which means that of all the trips currently undertaken 12.5% on the hypothetical 10.4 km of cycle lane would have been taken by alternative modes of transport if the bike lane did not exist.	One-third of people make a 4 km walking journey every day. 10% of these are prevented from switching to motorised transport.	10% of the adult population travel to the city centre every day. Half of these are persuaded to cycle rather than switching to motorised transport.
No. of daily trips	1,000 trips per day	9,452 trips a day	10,000 trips a day
Average length of trip	10.4 km	4 km	14 km
Est. ↓CO_2/year based on identified mode shift for 2016	60 metric tonnes	218 metric tonnes	808 metric tonnes

Source: Arup (2017)

There are also anticipated health benefits (e.g. from continued physical activity, avoided air and noise pollution) due to limited use of motorised vehicles.

Solar power for street lighting

SDI-Kenya is working with the Strathmore Energy Research Group (SERG) on projects to improve energy access in Nairobi. SERG are members of the SPA's energy consortium. This summary draws on their inputs and previous work with SDI Kenya to estimate the provision of street lighting to the Kibera Railways Relocation Project.

At present, there is no street lighting in Mukuru, making the settlement dangerous at night and reducing opportunities for street trading. Even if installed, grid lighting will not function during power outages. There is the potential to shift away from grid electricity and towards solar in the provision of streetlights, bringing key benefits for health and well-being. A saving of 54 to 63 metric tonnes of CO2 equivalent per year might be secured, depending on the bulbs used with grid electricity. Where there is currently no grid provision, there are cost savings of approximately US$ 500 per light from the installation of solar streetlights, rather than conventional street light poles. This saving does not include the cost of electricity needed to power conventional lights. Nairobi County should, therefore, consider providing solar street lighting for Mukuru as the benefits in terms of increased safety and security are already evident. In informal settlements, there are additional benefits of extending trading hours for local enterprises.

LPG stoves for cooking

The SPA energy consortium has proposed the introduction of LPG to replace charcoal and paraffin. This analysis draws on earlier work including the Mukuru situational analysis and research for PayGo Energy, a new company in Nairobi that is also part of the SPA energy consortium (www.paygoenergy.co). The consortium has summarised the situation as follows:

LPG is considered as the close alternative to kerosene use. Based on studies from Dalberg (2018) and Malla et al. (2014), it would cost Ksh. 2,400 (USD 24) to cook three traditional meals a day of ugali, vegetables and meat for 30 days a month with kerosene and Ksh. 3,600 (USD 36) using charcoal as compared to Ksh. 800 (USD 8) when using LPG. The upfront costs of buying and refilling the LPG cylinder and buying the burner is hindering the adoption of LPG, with the majority of Mukuru residents preferring to use kerosene even if they are aware of its health hazards.

There is interest in encouraging a switch to LPG, replacing the current mix of charcoal and kerosene. 83% of Mukuru's residents currently use charcoal and paraffin, which are expensive and linked to respiratory disease or other health risks. Emissions are currently estimated at 97,500 metric tonnes CO_2 equivalent a year, which could fall to 10,600 metric tonnes if 85% of households using kerosene and charcoal switched to LPG. A comparison of usage and equivalent emissions for the three main fuel sources is made in Table 4.

These estimates have been prepared with the assistance of PayGo Energy, a new company in Nairobi that is also part of the SPA energy consortium (https://www.paygoenergy.co). The following assumptions have been used:

Table 4: Comparison of fuel sources[36]

Fuel source	Equivalent CO_2 kg emissions per 3-person household per year	% of households currently using fuel source
LPG	106	15%
Paraffin	132	45%*
Charcoal	2237	40%*

* 83% use both charcoal and paraffin; estimated split based on information about primary fuel use

Therefore, the use of charcoal emits 21 times $C0_2$ kg emissions and paraffin emits similar (slightly higher) $C0_2$ kg emissions as compared to LPG. This is currently based on 15% share of LPG. The emissions saving would of course significantly increase with the increased use of LPG. The financial implications of a shift to LPG from charcoal are estimated to be positive for households, although, any price estimates are dependent on multiple assumptions. Also important to affordability considerations is that PayGo use smart Wi-Fi technology to monitor gas consumption, enabling their customers to pay daily for gas consumed, and this can help to overcome the difficulties posed by upfront costs.

There are also related health benefits in terms of reduced indoor air pollution, but no precise data is available on this. Relevant agencies should work with PayGo and other enterprises to expand access to LPG and to other clean fuels.

Even though LPG is a cost-efficient fuel alternative, it is a non-renewable source. Therefore, we don't recommend cities to move to LPG, rather explore cleaner and renewable sources.

[36] Data on emissions is drawn from cleancookstoves.org, www.icbe.com, and the University of Exeter. Data on fuel efficiency is from the World Bank and Dalberg. We recognise that transportation and treatment may also result in emissions, but we have not analysed this aspect due to a lack of data.

Summary: The interrelating benefits

Potential Pathways between Upgrading, Climate Resilience, and Inclusive Development

Sector	Actions	Immediate Outcomes	Wider Benefits
Waste	Increasing the efficiency of waste management		Health Benefits Reduced Income Poverty Increased Adaptive Capacity Increased Dignity and Wellbeing Increased Household Income Reduced Damage to Assets and Property
	Increasing the diversion of food waste, organics, and recycling		
Housing	Cooler design		Health Benefits Increased Adaptive Capacity Reduced GHG Emissions Reduced income Poverty Reduced Damage to Assets and Property
	Green space		
Upgraded Neighbourhoods	Increased density/ Compact		Reduced Income Poverty Increased Household Income Increased Dignity and Wellbeing Increased Adaptive Capacity Reduced GHG Emissions
	Mixed use development		
Inclusive Transport	Pedestrianisation		Health Benefits Reduced Income Poverty Increased Household Income Reduced Damage to Assets and Property Reduced GHG Emissions Increased Adaptive Capacity
	Cycling paths		
Energy	Solar power		Health Benefits Increased Adaptive Capacity Reduced Income Poverty Reduced GHG Emissions
	LPG Stoves		

Key

If implemented using participatory approaches and official partnerships, these ten initiatives have further potential to foster social inclusion and more responsive governance. Their developmental impact can be understood through five contributions. They can:

- Protect existing individual and community assets.
- Bolster incomes, thus enabling households to acquire additional assets.
- Improve health and well-being by providing basic services and improving local environments.
- Enhance physical mobility and connectivity, in turn fostering employment, strengthening social networks, and promoting access to emergency services.

Improve political outcomes by establishing grassroots partnerships with official actors, and amplifying residents' voices and organisational capabilities to negotiate for equitable interventions.