City Climate Finance Gap Fund

GAP FUND TECHNICAL NOTES

LOW-CARBON SLUM UPGRADING

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Low-Carbon Slum Upgrading

Gap Fund Technical Note[1]

Contents

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The Need for Low-Carbon Pathways in Slum Upgrading

While the link between slums[2] and climate adaptation is well-established, it is also becoming clear that slum upgrading offers potential for climate mitigation. Close to one billion people living in slums globally face disproportionate impacts of climate change due to their disaster-prone locations, sub-standard housing and inadequate service provision; their numbers are increasing[3]. Slum sites are often in areas prone to flooding, landslides and sea level rise. Slum dwellings made of non-durable materials may not protect from strong winds. Lack of adequate open or green space for ventilation, along with lack of access to electricity may compound the urban heat island effect. Lack of infrastructure increases risk to health, productivity, and livelihoods especially in the informal economy, and slum households' limited incomes reduced their ability to bounce back after major climatic events. Although slum upgrading initiatives have improved climate resilience in many countries, the potential for climate mitigation through slum upgrading is not widely understood. Slum neighborhoods in general have a lower carbon footprint within an urban area4; however, slum conditions can contribute to greenhouse gas (GHG) emissions. Slum dwellers consume relatively less energy for many reasons: they tend to use recycled materials for house construction; with limited access to electricity and infrastructure, they consume less energy; and lastly, with limited incomes, they have relatively low affordability for household durables, appliances and transport. Still, carbon emissions generated from untreated wastewater and solid waste can be considerable. Additionally, slum neighborhoods that lack connectivity to public transport often rely on vehicles that use fossil fuels inefficiently. By providing basic services and connectivity to city infrastructure, slum upgrading can reduce carbon emissions.

Business-As-Usual (BAU) slum upgrading may increase GHG emissions. Conventional housing and infrastructure provision in slum upgrading can also contribute to carbon emissions. Durable homes constructed with cement and steel increase carbon emissions. As slum neighborhoods get connected to a city's infrastructure, the load on a city's wastewater treatment, solid waste management and electricity demand increases. Additionally, improvements in health and incomes due to slum upgrading are associated with lifestyle changes that consume more energy. A study in India found that increase in income by 10 times led to increase in carbon emissions by 4.5 times[5]. Given the popular perception that slums do not contribute significantly to GHG emissions, slums are typically not considered as an essential part of a city's climate mitigation investments. If slum

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[2] 'Slums' are defined by UN HABITAT as housing that lacks one or more of the following: durable housing structure, access to clean water, access to improved sanitation, adequate living space and secure tenure. The term 'informal settlements' is commonly used to refer to any form of housing where occupants do not have legal claim to the land and fall outside government control or regulations. Slum housing may or may not be informal. For the purpose of this note, the two terms are used interchangeably.

[3] (Satterthwaite, Archer, et al., Building Resilience to Climate Change in Informal Settlements 2020); (World Bank 2015); (UN HABITAT 2018)

[4] (UN HABITAT 2018)

[5] (Ananthapadmanabhan, Srinivas and Gopal 2007)

upgrading proceeds in the same fashion as conventional urban development, it may add on to the already high percentage, 70%[6], of carbon emissions from urban areas. The costs of doing nothing can be significant.

Adopting a low-carbon pathway in slum upgrading is critical in order to avoid the carbon lock-in associated with conventional slum upgrading and leap-frog towards carbon neutrality. Slum upgrading offers several opportunities for reducing the carbon footprint in housing and infrastructure provision. For example, housing construction using local materials will have lower carbon emissions as compared to conventional construction that uses concrete and steel transported from far away. Using solar energy and improving energy efficiency in housing reduced the dependence on grid energy. In addition, such slum upgrading measures generate many co-benefits, not only at the household and community level, such as, reducing utility costs, generating jobs, income and improving health, but also at the city level, such as, enhancing productivity and competitiveness. Limiting carbon emission in slum upgrading helps preserve a slum neighborhood's low-carbon trajectory, offering an opportunity to simultaneously meet the goals of both the Paris Agreement and the Sustainable Development Goals (SDGs).

This note has two main objectives. First, it highlights the critical need for low-carbon slum upgrading within city investments for climate mitigation. Second, it demonstrates that practical, affordable and adaptable low-carbon solutions for slum upgrading at the household level and neighborhood level are possible and have been implemented successfully in many slums in different countries. The note aims to inform urban practitioners and policy makers who are either directly involved in slum upgrading projects, or in a position to influence related policies. The following sections will discuss the entry points for low carbon development for the various approaches to slum upgrading, illustrate emerging low carbon solutions in buildings, water and sanitation, solid waste, energy, transportation and urban form, and highlight key considerations and lessons in the planning and implementation of low carbon interventions in slum upgrading.

Slum Upgrading Approaches and Entry Points for Low Carbon Development

Slum upgrading undertaken by communities, NGOs, local/national governments or donor agencies adopt different approaches depending on the types of slums in question, considering factors such as the *distance* to city center, *density* in the slum and exposure to *disaste*r risks, and *viability* of specific interventions. Such approaches include in-situ upgrading, land readjustment, high-rise redevelopment, sites and services, and when there is no other option, relocation. These different approaches to slum upgrading offer various opportunities for climate mitigation.

- **City slums**: These slums tend to have good proximity to primary and secondary infrastructure and transportation networks, due to their locations within city boundaries and

[6] (Dasgupta , Lall and Wheeler 2022)

closer to city centers. However, city slums have organic, haphazard layouts and are built at high density with no public or green open spaces. Therefore, these slums tend to create zones of relatively higher urban heat-island effect. In some locations where the land value is very high, the private sector has undertaken slum redevelopment by cross-subsidizing low-income housing with high income 'for-sale' units. Since such redevelopment involves demolition of the existing slums and rehousing the former slums dwellers in new housing on-site, it offers opportunity for climatic design of buildings, as well as planning for infrastructure and open space in the new developments. In less dense city slums, re-blocking with denser development may be possible to make available space for open space, basic services and infrastructure that can be connected to city's trunk infrastructure and grid. This will also allow slum dwellers to upgrade their homes incrementally, which may contribute to emission reduction. A World Bank study found that home improvement and expansion in Mexico have significantly lower emissions (1/15 to one third depending on the types of interventions and materials used) compared to construction of new homes[7]. Green infrastructure incorporated with open space design will mitigate the urban heat-island effect. Green building and energy efficient design with local building materials will support carbon reductions. Slum residents depend on the local construction materials markets for upgrading their houses.

- **Peri-urban slums**: Peri-urban slums are mostly less-dense, often laid out to a grid pattern ready to receive urban services when available. However, they are far from the city center and have poor connectivity to transport and infrastructure. In these scattered locations, better connectivity to transportation options is a priority, and mixed-use development will ensure walkable access to amenities and even jobs for some. Since they are less dense, land readjustment is a good approach to plan for infrastructure and meaningful public open space. Self-contained, decentralized, off-grid services such as sanitation, electricity and water would be very valuable in these locations as they allow for greater accessibility and lower costs than conventional networked approaches[8]. Green infrastructure that incorporates urban farming, while providing storm drainage and water treatment services would be suitable. Low density may also allow good exposure to solar radiation that can make solar home systems very viable. In some cases, provision of serviced sites, typically with a toilet block on a site connected to the city infrastructure networks, combine the flexibility of incremental housing and organized service provision.
- **Slums on precarious sites**: Upgrading options for slums on steep slopes and along riverbanks is very challenging. However, in many cities it may not be feasible to relocate

[7] (World Bank 2022)
[8] (World Bank 2022)

these informal settlements. For such slums, slope stabilization and preventing soil erosion with green infrastructure would be appropriate.

Table 1 below summarizes the low carbon opportunities for different upgrading approaches.

Table 1: Low-carbon slum upgrading solutions

Upgrading Approach	Types of Slums	Mitigation Opportunities
Incremental housing	City slums or peri-urban slums	Supporting production of low-carbon or recycled building materials; programs for skills development in the construction industry
In-situ upgrading	City slums or peri-urban slums	Ensuring access to low-emission building materials and technology; energy-efficient technologies for infrastructure and utilities such as, home solar systems and green infrastructure.
High-rise slum redevelopment	City slums	Climatic design of high-rise buildings; planning for green infrastructure and open space
Land readjustment	Less dense city slums or peri-urban slums	Reserving open space within slums to mitigate the urban heat island effect; regularizing street network for walkable access to amenities and jobs; opportunities for distributed infrastructure
Sites and services	Peri-urban slums	Connectivity to public transport; choice of infrastructure systems; access to low-emission building materials and technologies
Relocation	Slums on disaster-prone sites or on sites earmarked for large urban infrastructure projects	Selecting sites close to transport and infrastructure networks; design of green buildings and compact neighborhood.

Managing the risks of introducing mitigation solutions in slum upgrading may need additional institutional or operational support, that forms an entire service supply chain to ensure that these solutions 'stick'. Data availability is essential for diagnostics and evidence-based decision making. The use of low-carbon or recycled building materials or home solar systems may not be easily accepted by communities as compared to conventional building materials based on perceptions of durability and social status associated. Outreach efforts would be required to communicate the viability of new products in order to develop a market demand. Participatory approach is key to gain community support and identify financially and socially acceptable solutions. Production of innovative technologies at-scale may require support through the entire supply chain from sourcing the raw materials to production to installation to maintenance support. Investing in capacity building at city & community level would be essential. Programmatic support to implement demonstration projects, especially community buildings can be an important step for sustained acceptance and implementation of low-carbon solutions in slum upgrading.

Low Carbon Solutions in Slum Upgrading

Low carbon solutions may be incorporated in slum upgrading at two scales: household level and neighborhood level. Improving living conditions in slums is mostly an ongoing, incremental process. As household incomes increase, they may invest in a more durable roof, add ventilation, or raise their floor level to prevent flooding.

i) **Household Level:** Upgrading at household level can improve energy efficiency through choices in how the dwelling is constructed by minimizing embodied energy in building materials, as well as choices in operational energy required for heating, cooling, lighting and cooking. Recycling and reuse of household waste can reduce resource consumption. In addition, urban farming and greening, if integrated with the house design, can further add environmental benefits that mitigate carbon emissions.

ii) **Neighborhood Level:** Measures for low-carbon slum upgrading at the neighborhood level, such as efficiencies in urban form, infrastructure and public/ green spaces can also reduce carbon emissions. Mitigation solutions in buildings, solid waste, water and sanitation, energy, urban form-land use-public space, and transport and mobility have been successful in not only reducing carbon emissions but generating a host of valuable co-benefits to the communities.

Table 2 summarizes the mitigation solutions at the two levels. The following section describes these solutions in more detail.

Table 2: Low-carbon slum upgrading solutions

Sectors	Mitigation Solutions
Household Level	
Buildings	• Construction materials • EE design • Green building certification • Household RE (renewal energy)/ EE (energy efficiency) appliances
Neighborhood Level	
Solid Waste	• Solid waste collection • Recycling • Waste to fuel
Water, Sanitation & Stormwater	• Decentralized water supply • Condominial sewers

	• Decentralized sanitation & fuel • Green infrastructure
Energy	• Micro-grids with RE • EE street lighting
Urban Form, Land Use & Public Space	• Re-blocking • Mixed use • Public open space
Transportation	• Walkability • Public transportation • Renewable energy

Buildings

Housing structures in informal settlements are often made of temporary materials that offer poor thermal comfort and are incrementally consolidated into more durable housing. Due to the unplanned nature of incremental housing, buildings are poorly designed without adequate light and ventilation. Indoor air quality can be poor due to the use of bio/fossil fuels for cooking and space heating. The use of such fuels indoors also poses fire risks in slums. Meeting the housing deficit for 1 billion people in slums with conventional methods using cement and steel would result in an enormous increase in carbon emissions. Cement and steel production generate 6.5% and 7% of global CO_2 emissions per year respectively[9].

Energy-efficiency (EE) in housing during slum upgrading can contribute significantly to reducing carbon emissions in multiple ways: through use of EE building materials, through EE building design, and through green building certification. Such measures not only decrease utility bills for the households, better light and ventilation in the homes also improves health and therefore productivity. The adoption of EE housing in slums has created a need for skilled construction workers and created opportunities for job mobility for slum dwellers.

Construction Materials: Initiatives in low-carbon cement and bricks help reduce carbon emissions but these construction materials are not easily available in construction markets. Additionally, there are scattered efforts to train masons and other construction workers to use materials efficiently and correctly. Such efforts in the production of building materials and capacity building in technically correct and efficient use of materials need to be scaled up with policies and funding in order to facilitate slum dwellers to access to low-emission building materials and technology in local markets. Additionally, building materials that are locally sourced break the conventional carbon lock-in of industrial materials that are transported from distant locations. Locally sourced materials that utilize naturally occurring and biodegradable materials, or re-use and recycle materials waste,

[9] (IEA 2020)

are low-carbon building materials[10]. Hustlenomics, a social enterprise is replacing shacks with durable houses with bricks made from natural soil and construction waste in Soweto, South Africa. Interlocking soil stabilized bricks developed by the National Slum Dwellers Federation of Uganda, do not require firing and also help reduce deforestation. They are also cheaper than regular fired bricks[11].

EE Design: Passive climatic design that considers efficiency in the building envelope, insulation, fenestrations, and maximizes natural light and ventilation, ensures energy and cost savings. In Gorakhpur, India, screen brick-work techniques for improved ventilation to reduce energy consumption are also less expensive; they were estimated to be 18% less than cost of standard construction[12]. Retrofitting existing buildings with EE and renewable energy (RE) technologies are more practical where redesign is not feasible. In Barrio 31, Buenos Aires, EE housing retrofits in 4 neighborhoods for 75,000 residents that provided insulation, weather proofing, solar heating systems and LED street lighting resulted in 20% less energy, 20% less water and 20% less embodied energy in materials. Implementation was possible by training local residents in installation, maintenance and monitoring of RE equipment such as solar panels. The project built in institutional capacity building for EE as well as outreach for community behavioral changes.[13]

Green Building Certification: Certifications help endorse an approach and incentivize large-scale adoption. The CeDEL office building located in the heart of Villa 31, one of the poorest neighborhoods in Buenos Aires, received the IFC EDGE (International Finance Corporation Excellence in design for Greater Efficiencies) certification for EE in buildings and is recognized as the first milestone for a green building movement in Buenos Aires. The building achieved a predicted energy savings of 38%, water savings of 23% and 63% reduction of embodied energy in building materials[14].

[10] (World Bank 2022)
[11] (Hustlenomics n.d.); (World Bank 2018)
[12] (Satterthwaite, Archer , et al. 2018)
[13] (ESMAP, World Bank Group 2021)
[14] (Mueller 2017)

Figure 1: EDGE certified office building in Barrio 31, Buenos Aires

Source: (Mueller 2017)

Solid Waste

Informal settlements are often located near or on city landfills and lack solid waste collection themselves. While municipal waste is increasing with rise in income levels and consumerism, waste collection and disposal services are lagging. Globally 2 billion people were without waste collection services, and 3 billion people lacked access to controlled waste disposal facilities in 2018. Many municipal solid waste disposal facilities in low- and middle-income countries are open dumpsites which contribute to air, water and soil pollution and carbon emissions[15]. Burning refuse is a common practice that results in an increase of black carbon in the atmosphere. Municipal solid waste collection and treatment systems contribute to 3-9% of global GHG emissions[16]. Further, lack of adequate solid waste collection and improper disposal leads to chronic diseases in slum populations.

Lack of willingness to pay for formal waste collection services makes it difficult for governments to collect waste from densely populated and hard-to-access low-income informal settlements. Consequently, a large number of informal waste-pickers are engaged in manual collection and segregation of waste in unhygienic environments for low wages, and are unaware of safe or good

[15] (United Nations n.d.)
[16] (D'Aquino, et al. 2022)

waste handling practices. There have been successful efforts in solid waste collection and recycling in slums, as well as converting the collected waste into fuel sources. Well-planned solid waste management in slums improves air and water quality and therefore results in better health and productivity for slum residents. Such practices have not only created significant numbers of local jobs, but they also created supplementary sources of energy supply for slum residents.

Solid waste collection: Efficient and community-managed recycling measures reduce the volume of solid waste going to landfills and convert the waste into income sources. TakaTaka Solutions is a social enterprise that collects waste from households, businesses and factories in Nairobi for recycling and composting. TakaTaka Solutions charges its customers on a scale based on economic status. They also ensure reliable and professional service through new trucks with GPS tracking, trained staff, and additional options such as onsite sorting and environmental reporting. TakaTaka Solutions conducts door-to-door awareness campaigns on waste disposal practices such as educating customers on the type of bin liners to use for different types of waste. The enterprise has served over 12,000 households with 105 employees including unemployed youth and women from impoverished communities. It has collected 470 tons of waste per month, enabled recycling of 446 tons of waste per month, and produced 50 tons of compost per month[17].

Recycling: Wecyclers is a for-profit social enterprise in Lagos, Nigeria, that provides rewards-based waste collection recycling services in densely populated urban neighborhoods. Wecyclers model is designed to reward customers who are diligent in separating their waste. Wecyclers works in partnership with the Lagos Waste Management Authority and collects waste from households in previously inaccessible areas on bicycles, sorts and segregates the waste and sells it to Nigerian recyclers. The use of tricycles in its operations allows the enterprise to maneuver through narrow lanes in unplanned slum areas thereby increasing its reach to low-income customers. Wecyclers uses sorting facilities owned by the local municipal authority to undertake its waste sorting and bailing processes. Wecyclers employs local unemployed youth in its collection activities and awareness campaigns. Employees of Wecyclers have the ability to earn income in proportion to the waste they collect. Wecyclers has reached over 11,000 low-income households since 2013. The enterprise has employed 82 unemployed youth in its waste collection activities, and diverted 525 tons of waste from reaching landfills in Nigeria[18].

[17] (World Bank 2018)
[18] (World Bank 2018)

Figure 2: Solid waste recycling in Nigeria's slums

Source: (Copenhagenize Index 2019)

Waste to fuel: Diverting organic solid waste from landfills and using it to create fuel sources mitigates GHG emissions apart from reducing environmental pollution and related diseases. A study to assess the feasibility of producing electricity from biogas obtained through anaerobic digestion of 400,000 tons of food waste generated in Sao Paulo's slums estimated a potential of meeting 1.3% of the residential electricity demand and potential reduction of the equivalent of over 2 million tons of CO_2 emissions per year[19]. The Community Cooker Foundation in Kibera, Nairobi, is a social enterprise that was set up to improve the efficiency and design of community cookers, promote its uses and educate the public regarding safe and responsible methods of incinerating solid waste for energy production in densely populated areas. The community collects and burns waste to generate low-cost heat that can be used for cooking, baking, heating, and boiling water. As of 2020, 17 Community Cookers have been built. The Cooker has considerably improved the quality of life for individuals in low-income areas by responsibly minimizing waste, reducing emissions from cooking, and providing a cheaper alternative to wood fuel and charcoal. Furthermore, the Cooker is reducing youth unemployment through its labor-intensive approach[20].

Water, Sanitation & Stormwater

Slum residents rely on unsafe and unreliable drinking water supply. Woodstoves used to boil water cause indoor air pollution. Piped water distribution is limited in informal settlements and requires resources that are lacking. Most informal settlements lack connection to a sewage system and

[19] (D'Aquino, et al. 2022)
[20] (World Bank 2018)

residents often use pit latrines or engage in open defecation that spread disease. Storm drainage is mostly lacking in slums, and when it does exist, the drains are often clogged with garbage that result in stagnant wastewater and spread of raw sewage and refuse with rainwater. Untreated wastewater generates 3 times more GHG emissions than wastewater treated at a conventional sewage treatment plant[21]. Untreated wastewater not only contaminates soil and water, it also reduces dissolved oxygen in waterbodies and consequently impacts aquatic ecosystems and dependent livelihoods. Still, only about 20% of all wastewater generated globally is treated[22].

One of the key challenges in providing improved sanitation in informal settlements is safely removing waste in areas not connected to a sewage system and often inaccessible to large vehicles. In hard-to-reach slum pockets, off-grid, small scale, decentralized water supply and sanitation systems have been successful in ensuring access to basic services with minimal public funds[23]. Small-scale but networked green infrastructure systems can manage stormwater effectively in slums. Ensuring access to safe water, sanitation and storm drainage using affordable off-grid, small scale, decentralized systems result not only in improved health and productivity, but also, can provide supplementary energy sources, household savings and green jobs. Fuel from bio-gas or briquettes helps reduce harmful emissions from the use of charcoal or kerosene.

Decentralized water supply: Decentralized water treatment systems set up by social enterprises treat ground and surface water locally close to the communities they serve, and distribute safe, healthy and affordable drinking water to communities previously without access. In many countries it may take years to expand water pipelines to remote areas whereas a decentralized water treatment system can take as little as 45 days to set up. Customers may pick up the water themselves from kiosks, or have their water delivered. WaterHealth International (WHI) is a social enterprise that provides access to safe, WHO-quality affordable drinking water to underserved communities. WHI has developed a low-cost business model for the installation, operation, maintenance, and quality monitoring of community water purification systems called WaterHealth Centers. WHI has installed more than 500 WaterHealth Centers across India, Ghana, and Nigeria, providing access to safe water to more than 5 million people. WaterHealth works through a Public-Private Partnership (PPP) model to set-up a water purification plant [which can typically serve a community of population ranging from 5,000 to 20,000] where the land, raw water source, and electricity are provided by the community. WaterHealth raises the funds to procure and install the water purification plant based on a Build Operate Transfer (BOT) agreement signed with the Local Government Agency, with a concession term spanning 15 -20 years. WaterHealth also runs well conceived Social Marketing programs to change community behavior towards safe water and spread awareness about the health benefits of safe water. Studies have shown that the average

[21] (Warming 2020)
[22] (V. 2017)
[23] (World Bank 2018)

monthly savings as a result of decentralized treated water increased. The provision of clean water also cuts down the need to boil water, reducing indoor pollution and fuel costs.

Condominial sewers: Citywide sanitation that allows a combination of technical options including condominial sewer networks has emerged as a viable alternative to traditional sewer networks. Condominial sewer networks involve a simplified system of shallow sewers that serve a cluster of houses or condominium[24]. The public sewer network therefore does not need to reach each household, but merely connects to the condominial sewer point. As a result, the required length of the city sewer network is considerable shorter than that of a conventional system[25]. Installing and maintenance of condominial requires greater levels of cooperation, but they are less expensive than conventional sewers[26]. Such systems have been successfully implemented at scale in Brazilian cities including in Rocinha slum in Rio-de-Janeiro[27] and are now under pilot as a low-cost solution for Africa's urban poor[28].

Decentralized sanitation & fuel: Social enterprises have set up household or community serviced, low-cost toilets in places without public sewerage systems in collaboration with private companies, NGOs, local entrepreneurs and government agencies. The waste is transported in containers and treated at local treatment plants and often used to make fertilizer or fuel briquettes. The toilets are compact so that they can be located in the heart of densely populated areas and portable waste containers can be carried by hand or wheelbarrows obviating the need for access to roads. Companies supply and install the toilets, service them and treat the waste for a fee. For community toilets, local franchises or operators manage servicing. Companies may manufacture or procure the toilets, sell or rent the units to franchisees for operation. Sanivation has been operating in Kenya since 2014, partnering with local governments to support the research, design, implementation, and monitoring of safely managed sanitation. Sanivation rents and services in-home toilets, collecting waste once a week and bringing it to a local treatment site where it is treated using solar power and turned into fuel briquettes. Sanivation also works with municipalities to process their fecal sludge into briquettes. Briquettes made by Sanivation in Kenya which burn longer and at lower temperature have found a niche market in BBQ restaurants[29].

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[24] (World Bank 2022)
[25] (Melo 2005)
[26] (Vargas-Ramirez and Lampoglia 2006)
[27] (Melo 2005)
[28] (World Bank 2022)
[29] (World Bank 2018)

Figure 3: Sanivation toilets

Source: (Design Indaba n.d.)

Citywide Inclusive Sanitation: Initiatives in city-wide inclusive sanitation (CWIS) aim to not only ensure access to toilets to all urban residents, but also safe management of all fecal waste from capture to disposal or reuse. The CWIS approach ensures lower operational costs and environmental benefits while creating local jobs. Safe collection of fecal waste is formalized, fecal sludge is treated and combined with other waste products to make biomass briquettes that are sold to industries to replace firewood. In Kenya, counties and cities are starting to adopt inclusive sanitation across their jurisdictions. In Malindi town on Kenya's coast, the CWIS concept is being championed by the County and Municipal leadership and coordinated by the Malindi Water & Sewerage Company (MAWASCO). Malindi has embarked on a comprehensive process for planning and implementing the CWIS to achieve a financially sustainable access to safely managed sanitation for all, while creating jobs and building local capacities for a thriving sanitation economy[30].

[30] (Akinyi, et al. n.d.)

Figure 4: Left: Formalized pit emptying service providers in Malindi.

Right: Ongoing construction of fecal sludge treatment plant, Malindi.

Source: (Akinyi, et al. n.d.)

Green infrastructure: Green infrastructure or nature-based systems have been used in informal settlements to manage storm water and waste water treatment. Such systems are decentralized and can utilize incidental spaces in slums and convert hard areas into sponge-like zones to absorb and treat wastewater. Green infrastructure not only treat wastewater, but recharge ground water, and convert incidental spaces in slums into community green spaces that reduce the urban heat island effect and serve as carbon sinks. Green-blue-gray infrastructure in 10 public space projects in Kibera, Nairobi includes constructed wetlands for storm drainage and wastewater treatment, pervious paving, planted infiltration pits, swales, rain gardens and a composting toilet[31]. Similar approaches have been employed in informal settlements in other African cities, Windhoek, Gobabis and Oshikati[32], to upgrade 24 informal settlements in in Fiji and Indonesia[33], and for rainwater harvesting in 68 informal settlements in Freetown, Sierra Leone[34].

Energy

Slum households spend a greater share of their income on energy for cooking, lighting and space heating than other city residents. There is a lack of access to legal, reliable and affordable energy. Electricity is often "stolen", and as a result, utilities also lose revenue. Use of charcoal fuel or generators consume fossil fuel that are expensive, unhealthy and unsafe with a great risk of fires. Energy consumption in slums represents a suppressed energy demand and, if met, it will create very high peak demand for the utilities. The Intergovernmental Panel on Climate Change (IPCC) identifies

[31] (Mulligan , et al. 2020)
[32] (ICLEI n.d.); (Wijesinghe and Thorn 2021)
[33] (RISE 2021)
[34] (van den Berg, et al. 2020)

opportunities for renewable energy in informal settlements as a pathway to limit global warming to 1.5^{0}C[35]. Access to reliable, affordable clean energy results in reduction of black carbon from use of bio/ fossil fuels. Mitigation solutions to ensure clean energy access to slums include micro-grids with RE, EE street lighting and household RE/ EE appliances, as well as use of small Electric Vehicles (EV) in service delivery. Solar power can replace significant electricity needs as a more sustainable off-grid solution[36]. Such systems are mostly solar PV panels and new battery storage systems that enable electricity to be used in the evenings. These systems take up very little space – rooftops – and a small area for the battery. Solar home systems have not only extended productive hours for low-income families, but improved health by reducing use of polluting fuels, increased security, and increased access to information through television and radio, but also created jobs and increased incomes for people who sell, install and service them. Additionally, the use of electric two-wheelers for the last-mile and hyperlocal delivery of essential items, such as medicines and groceries, is important for informal settlements, especially when the street layouts can be irregular and do not allow the passage of larger vehicles. The use of EV in last mile delivery that make up 40% of the overall supply chain cost, results in savings in fuel[37].

Micro-grids with RE: Localized, distributed technology has become significantly cheaper than centralized, large-scale electricity systems. A micro-grid powered community center, Kibera Nairobi with rooftop solar panels is used for classrooms, internet and computers, charge battery packs for home lighting and cell phones, and pumping clean water from a well for laundry. It is to be expanded to serve a nearby school and neighborhood businesses[38]. Decentralized solar energy microgrids are being planned in Dharavi, Mumbai by the NSDF, Mahila Milan and others[39] under the Project Brighten.

[35] (IPCC 2018)
[36] (World Bank 2022)
[37] (Kumar , Nunes and Pai 2021)
[38] (Francklyn 2019)
[39] (Gaudreau, et al. 2021)

Figure 5: Micro-grid in Kibera, Nairobi

Source: (Francklyn 2019)

EE street lighting: EE street lighting has lower operating costs without compromising quality. Solar powered LED street lighting is a relatively easier initiative to implement. LED street lighting has been installed in Barrio 31 Buenos Aires, Argentina[40], and planned in slums in many Indian cities[41].

Household RE/ EE appliances: Household RE/ EE appliances provide energy access in slums at minimal capital cost. Social enterprises offer solar home systems that can be used to power small electrical appliances, lights, mobile phones etc. A wide range of solar home products and affordable prices have increased take up. Solar lighting and cooking appliances are finding acceptance in many slums. The Pollinate Group equips low-income people in Indian cities with the business acumen and financing to set up microenterprises that provide residents in slum communities with solar lights. It trains local women entrepreneurs to distribute household products such as solar lights and cooking appliances. Women entrepreneurs earn respect and meaningful income and act as role models who raise awareness about better product alternatives. They have reached more than 613,000 people across India and Nepal with access to products and empowered more than 650 women to bring positive change in their communities[42]. In South Africa, solar home systems have been installed in

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[40] (ESMAP, World Bank Group 2021)
[41] (LEDinside 2016)
[42] (World Bank 2018)

75 households in the Ruimsiq community[43]. As part of slum upgrading, solar panels have been installed on 50 houses in La Lima near Tegucigalpa, Honduras[44].

Urban Form, Land Use & Public Space

Integrated spatial planning of slums to achieve compact and resource-efficient urban growth through co-location of higher residential and job densities, mixed land use, quality public spaces and transit-oriented development could reduce GHG emissions between 23-26% by 2050 compared to the business-as-usual scenario[45]. Meaningful public spaces encourage community interaction and social cohesion. Investment in networks of streets and open public spaces also improves urban productivity, livelihoods and access to markets, jobs and public services, especially in countries where over half of the urban workforce is informal[46].

Re-blocking: Re-blocking of informal settlements through land readjustment or slum rehabilitation housing allows for open spaces not only for recreation, but also mitigating extreme temperatures. Re-blocking of informal settlements using land readjustment methods ensure more efficient use of the land itself at high density, while providing rationalized space for provision of services and community open spaces. Community-driven re-blocking in informal settlements in Thailand supported by CODI, was successfully enlarging open spaces in slums[47]. In Tangerang Municipality, Indonesia, a dynamic system analysis with data on water, electricity and waste generated, building material constructed or destroyed to manage the slum area concluded that land readjustment along with green building reduced carbon emissions by 40%[48]. Climatic design considerations in multistory housing design for slum upgrading can contribute to GHG emissions reduction in slum upgrading. A study of slum rehabilitation housing in Mumbai, India and Joao Pessoa, Brazil, showed that the Mumbai housing design with access to open and ventilated spaces in the development resulted in lesser appliance ownership and therefore lesser energy consumption[49].

Mixed use: Mixed use development can not only reduce transportation related GHG emissions, but also encourage local spending and support local economy. Providing space for businesses centers in slum upgrading provides these opportunities closer to the residence and reduces emissions from transportation. Land use policies that provide for mixed-use neighborhoods as opposed to single-use zoning must be encouraged.

Public space: Public open spaces that incorporate green infrastructure solutions in slums can function as lungs within slums. Blue-green infrastructure for flood regulation in Johannesburg

[43] (UN HABITAT 2018)
[44] (Rocha 2014)
[45] (IPCC 2022)
[46] (United Nations n.d.)
[47] (Satterthwaite, Archer, et al. 2020)
[48] (Wismansyah, et al. 2019)
[49] (Debnath , et al. 2020)

resulted in local climate moderation including wind and temperature control; domestic gardens provided food, medicine and income while communal gardens serve as public social spaces[50]. Vertical greening systems within a low-income community in Lagos demonstrated the possibility of reducing indoor air temperature by up to 2.3 deg C across wet and dry seasons[51].

Figure 6: Vertical greening in Lagos low-income neighborhood, Nigeria

Source: (Akinwolemiwa, et al. 2018)

Transportation

Slums with organic layouts can have long, winding street networks that can make reaching amenities time consuming. Peri-urban slums are typically not well connected with points in the public transport system in order to reach jobs or amenities. Slum households can spend a significant amount on transportation, mostly informal, and on vehicles that tend to use fossil fuels inefficiently and pollute heavily. With slum upgrading and consequent income mobility, lack of access to good public transportation often results in an increase in ownership of personal vehicles and consequently carbon emissions. A comparison of carbon emissions in a slum area with a non-slum area in Rawalpindi, Pakistan, found that with increasing monthly income, there was a significant increase in the use of personal vehicles in non-slum areas[52]. Low-carbon solutions for transportation reduce black carbon from fossil fuels and therefore improve outdoor air quality and health. Such systems provide affordable access to public transport, amenities and jobs. As a result, they increase household cash savings.

Walkability: Increasing the walkability of slum residents to jobs and amenities within or close to the neighborhoods avoids use of fossil fuel-based transportation. Slum upgrading must incorporate a

[50] (Adegun 2021)
[51] (Akinwolemiwa, et al. 2018)
[52] (Adnan, Safeer and Rashid 2018)

safe and accessible sidewalk network connecting to paratransit nodes, public transportation and social amenities.

Public transportation: Convenient access to public transportation for slum dwellers can reduce considerable carbon emissions from alternate, expensive, fossil fuel-based transport. The use of public transport is helping to mitigate air pollution and climate change in many cities. Data from 227 cities in 78 countries showed that only 53% of urban residents had convenient access to public transport – defined as residing within 500 m. walking distance of a bus stop or a low-capacity transport system, or within 1,000 m. of a railway/ ferry terminal. In fact, only 18% of residents in Sub-Saharan Africa had convenient access to public transport[53]. Medellin pioneered the Metrocable system in 2004 that connects slums normally inaccessible to the city center. The transportation system has demonstrated emissions reduction of 17,290 metric tons per annum in the first seven years. The project is reported under the Clean Development Mechanism of the United Nations Framework on Climate Change (UNFCC)[54]. Columbia's lead has been followed in other Latin American cities keen on efficient, green transport in poor neighborhoods, such as Mexico City and La Paz, Bolivia[55].

RE: The use of renewable energy powered transport to replace fossil fuels, in the last mile transportation connectivity, reduces GHG emissions even further. In Latin American countries, policy makers are supporting clean transport systems. In Bogota, a four-station, solar-powered cable car system in the 'TransMiCable' transportation system piloted in 2018 has demonstrated the application of RE to reduce carbon emissions in public transportation. Two solar panels on each cabin generate enough power to operate for 5-6 hours a day without using any other source of electricity. The cable car transports 20,000 residents a day from Ciudad Bolivar, a slum along the upper reaches of a hillside to the city and its bus network. TransMiCable has halved the trip time for slum residents to less than $1 per trip. Earlier, the residents spent about 2 hours a day commuting using up to 3 buses. TransMiCable has given the community known for crime and violence some to be proud about. It has reduced traffic congestion and air pollution. The government recognizes that expanding green transport and quantifying its success is urgent and is studying its impact on GHG emissions and economic growth. However, the project was not without challenges. It was tough to buy land needed to build cable-car stations and pylons. It was tough to convince the community to trust the government with a long history of neglect. Shortage of public funds may also prevent expansion of the system to other poor neighborhoods[56].

[53] (United Nations n.d.)
[54] (Collado and Wang 2020)
[55] (Moloney 2019)
[56] (Moloney 2019)

Figure 7: Solar powered gondola in Bogota slum

Source: (Barto920203 2019)

Planning & Implementing Low-carbon Slum Upgrading

The basic components for planning and implementing slum upgrading are well established. In order to ensure that slum upgrading interventions contribute to GHG emissions reductions, two additional components are important:

- It is necessary to establish a baseline for carbon emissions at the neighborhood level through available diagnostic methods in order to identify priority interventions in slum upgrading, as well as, set up a simple enough M&E protocol that can be managed by the community;
- Methods to access climate and other finance for slum upgrading.

Further, for low-carbon slum upgrading to be successful, the process of planning and implementing depends on crucial aspects, such as, commitment from the government, community participation and relevant capacity building in non-conventional technologies.

Baseline Diagnostics

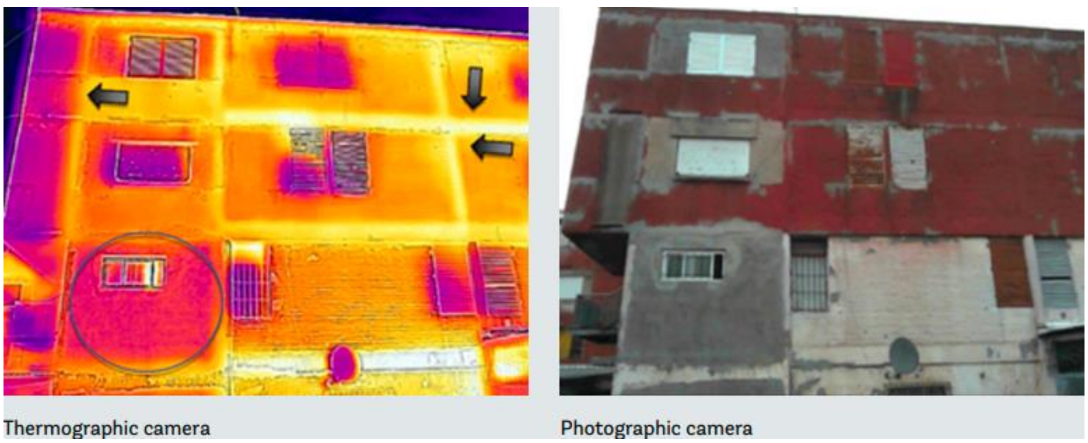
Each informal settlement has its own unique climate change vulnerabilities, socio-economic characteristics, assets and capacities. Diagnostics help prioritize interventions in slum upgrading. Typically, indicators used are GHG emissions, energy consumption, thermal comfort, monetary savings and jobs created. Diagnostic results can show potential cash savings that can be used to attract private investments in slum upgrading. Diagnostic results can also capture tangible socio-economic co-benefits that can help mobilize government commitment and community acceptance. However, diagnostics are dependent on the quality of data available and collected, such as consumption information from utilities that may not be available for informal settlements that lack services. Where data is challenging to collect, proxies and assumptions on energy consumption and waste generation are used, or household surveys are conducted with community involvement. Community engagement in data collection and analysis helps build local awareness of risks. Several tools are available to model carbon emissions at different scales of development, including the household and neighborhood levels.

Household Level

***IFC EDGE tool*:** EDGE (Excellence in Design for Greater Efficiencies) is a decision support system to model emissions from buildings and water consumption. It not only includes options of low-cost EE building techniques but also evaluates embodied energy costs of building materials.

Thermographic analysis of facades helps identify energy leakages through façade design or materials. In Barrio Mugica in Buenos Aires, it helped identify the need for weather proofing of windows[57].

Figure 7: Thermographic analysis of facades in Barrio Mugica, Buenos Aires



Source: (ESMAP, World Bank Group 2021)

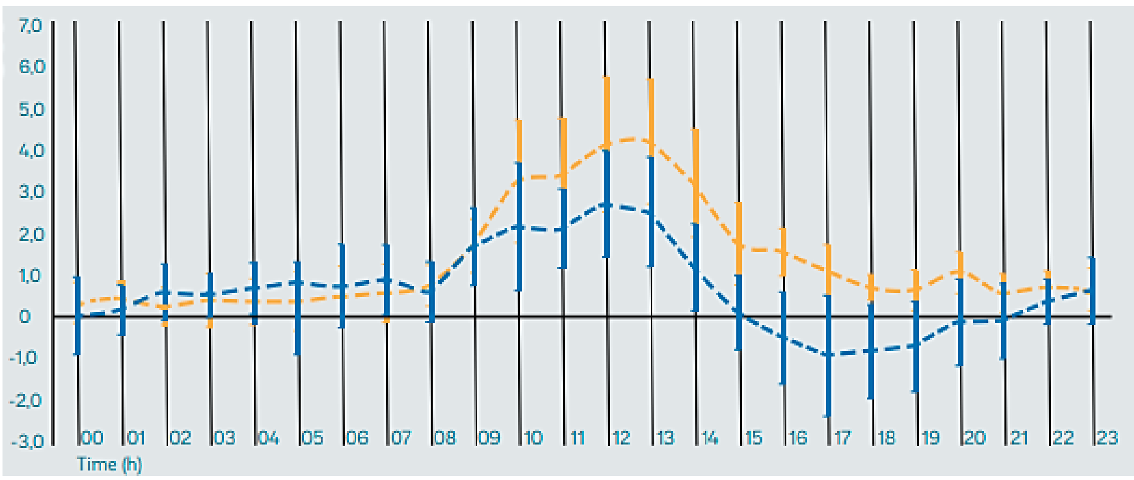
Neighborhood Level

Urban Heat Island Effect (UHIE) mapping: The urban heat-island effect can lead to an increase in demand for energy for cooling and consequently increase electricity consumption. The UHIE is caused by the interaction of several factors: i) increased heat due to the thermal energy absorption capacity of construction materials used, such as asphalt and concrete, ii) reduction of evapotranspiration due to decrease in vegetation and increase in impervious surfaces, iii) heat emission from anthropogenic sources, such as cooking activity, vehicles etc. and release of atmospheric pollutants that retain energy, and iv) obstruction of air movements due to layout of

[57] (ESMAP, World Bank Group 2021)

buildings and open spaces in the neighborhood. The UHIE mapping was used to map temperature measurements over one year and identify excess heat/ heat island effects in Barrio Mugica in Buenos Aires. The study found that on summer days, the neighborhood can have a temperature 3°C higher than nearby areas, and that areas of high-sun exposure within the neighborhood can have a thermal amplitude of up to 6°C. The results were used to propose mitigation measures such as an urban forestry program, an early warning system for heat waves and housing improvements to reflect heat[58].

Figure 8: UHIE Mapping in Barrio Mugica, Buenos Aires

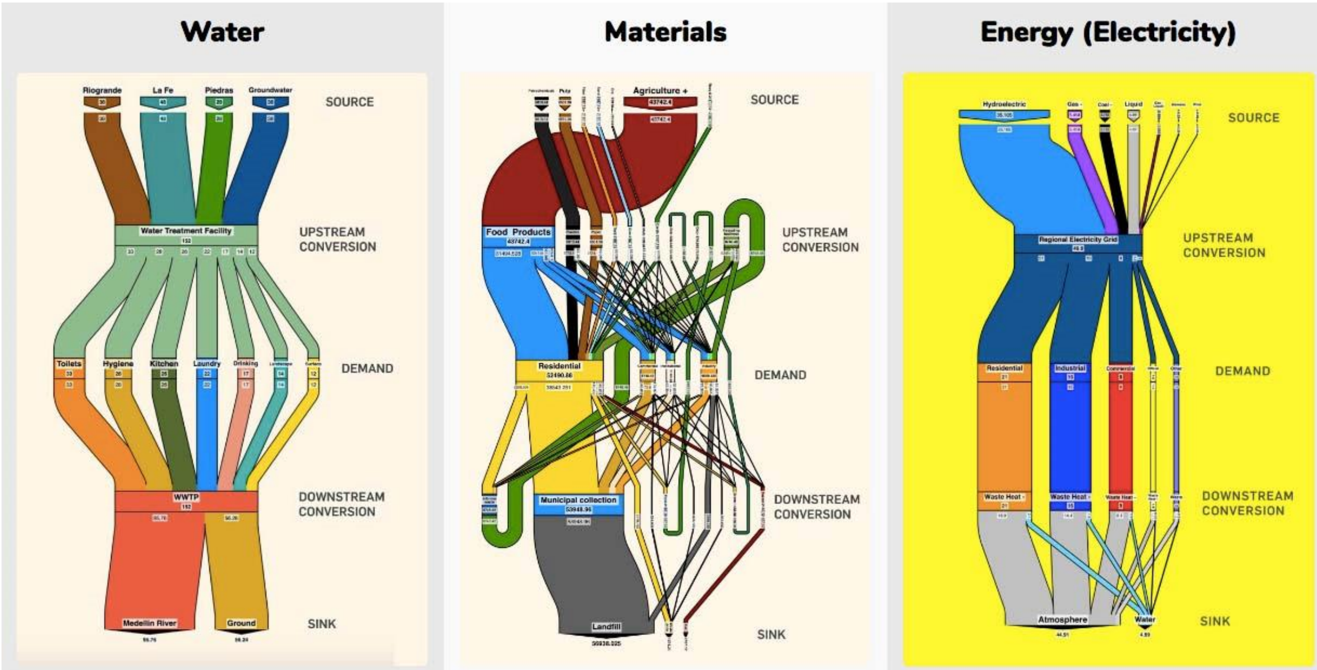


Source: (ESMAP, World Bank Group 2021)

Participatory Urban Metabolism (PUM): a neighborhood level tool for communities to analyze and monitor material and energy flows of urban systems. Consumption of resources including energy and the production of waste including GHG emissions can be used to assess informal settlements. Piloted in Cairo, Casablanca, it has been successfully used in Cusco inner-city and Medellin Communa 8 with informal neighborhoods to develop Neighborhood Sustainability Plans[59].

[58] (ESMAP, World Bank Group 2021)
[59] (Eberlein 2018)

Figure 9: Water, materials and energy metaflow charts for Medellín



Source: (Eberlein 2018)

Life-cycle Assessment (LCA): Comprehensive analysis of resource consumption (self-help housing, household energy consumption and transportation) in Isidro Favela, Mexico City using LCA methodology found that natural gas or LPG used for water heating was the most significant contributor to GHG emissions since families use inefficient heaters[60].

Urban Performance (UP): The Urban Performance tool is used to model urban growth scenarios to represent urban form, urban footprint, mobility infrastructure, urban amenities, water and energy consumption, energy generation and climate hazards. Different scenarios can be modeled and compared through spatial, environmental, climate risk, social and economic indicators. Comparison of three urban growth scenario modeling results, BAU, Urban Plans and Climate Smart, in three cities in Mongolia (Ulan Bataar, Erdenet and Darkhaan) using the UP methodology showed that, raw coal burning for heating in *ger* areas (slum like low-income neighborhoods) contributes to 80% of air pollution in winter. Planned and Climate Smart Scenarios reduce PM10 emissions related to heating by more than 90% when raw-coal burning in ger areas was replaced with processed coal or electricity. Improving thermal insulation in ger dwellings can save up to 28.4 GWh a year[61].

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[60] (Reyes 2021)
[61] (World Bank 2022)

Finance

Explicit financing mechanisms for low-carbon slum upgrading are hard to come by. However, it is possible to put together funds for low-carbon slum upgrading from different sources and using different approaches.

- ***Managing incremental cost***: A number of interventions have little or no significant additional cost. Managing incremental costs with reduced operating cost, behavioral change and passive building design measures can go a long way to make implementation of low-carbon slum upgrading solutions a reality.
- ***Sector specific grants and subsidies***, especially for uptake of relatively new RE technologies, like solar home systems can support implementation of some mitigation solutions.
- ***Land-based financing*** *can help* cross subsidize slum upgrading through land value capture mechanisms.
- ***Support to community-led climate fund***: Community-based initiatives have succeeded in procuring funds for climate mitigation initiatives. In Da Nang, Vietnam, seed funding from GIZ was obtained in partnership with the city government and Association of Vietnamese Cities (ACVN) for a community-led climate fund in Hoa Hiep Bac Ward. The fund was managed by the community for upgrading and strengthening housing, adaptation of income generation activities, planting trees and purchasing shared back-up generators[62].
- ***Climate finance***: Formal mechanisms of climate mitigation finance are typically not designed to facilitate low-carbon slum upgrading, as illustrated in the case of Cape Town later in the note. New mechanisms are needed to increase subnational access to climate financing mechanisms and link the finance to the needs of informal settlements, such as through bundling of projects, diversification of existing funding instruments and development of new ones, and the involvement of intermediary organizations.

Planning & Implementation Process

The process for planning, financing and implementation of low-carbon slum upgrading depends upon several aspects.

- ***Commitment.*** A local champion, such as the city administration, has to be very convinced that a low-carbon approach is necessary. It is important that city administration recognizes the dependence of the city on services offered by slum dwellers for city growth and competitiveness. Improving living conditions in informal settlements with low-carbon solutions ensures greater workforce productivity with less resource consumption. City

[62] (UN HABITAT 2018)

mitigation efforts typically consider quantitative indicators, such as, GHG emissions reductions and number of jobs created. However, in order to promote low-carbon slum upgrading, it is necessary to appreciate the additional value of qualitative co-benefits generated, such as, health, savings and income at the household level, and air quality at the neighborhood level.

- ***Finance.*** Sector-specific incentives are typical. Access to climate finance for slum upgrading can be challenging since it requires additional know-how of benchmarking a baseline and setting up a monitoring and reporting system.
- ***Collaborative approach.*** An agency must be identified to coordinate planning inputs amongst various municipal departments, seek finance and oversee implementation. In countries that have national slum upgrading programs, coordinating with national agencies is necessary to allow transfers from national budgets.
- ***Stakeholder coordination.*** Clarity in roles and responsibilities of all stakeholders ensures smooth implementation. Community engagement is very critical because unless the community is convinced about the benefits from low-carbon solutions, community buy-in for unfamiliar technologies to be installed in their homes and neighborhood, especially since that may require behavioral changes, is challenging. A participatory approach is key to gain community support and identify financially and socially acceptable solutions.
- ***Information.*** Introducing new approaches depends on information, in particular to conduct baseline diagnostics, assess availability of low-carbon solutions in the city, especially those provided by local social entrepreneurs, and gauge community acceptance.
- ***Capacity Building***. Huge investments in capacity building are necessary both at the institutional level and the community level in order to develop, produce, implement, maintain and monitor new solutions**.** Training of professionals, contractors and workmen is required for green building, energy efficiency and renewable energy solutions.

Box 1 describes the initiative of EE retrofitting housing in Cape Town, South Africa, illustrating what it takes for low-carbon slum upgrading to be successful[63].

[63] (ESMAP 2012)

Box 1: Planning & Implementation of EE Retrofits in Kuyasa Settlement, Cape Town

The EE retrofitting project provided energy access to 2,309 poor households in Reconstruction and Development Program (RDP) housing by installing solar water heaters (SWH), ceiling insulation and Compact Fluorescent Lamp (CFL) lighting. With a budget of US$ 4.67 million, the project reduced energy consumption by 34% and CO_2 emissions by 33% annually. The project is the first Gold Standard Clean Development Mechanism (CDM) project with the United Nations Framework Convention on Climate Change (UNFCC). It was nominated for the World Clean Energy Awards and recognized by the Renewable Energy and Energy Efficiency Partnership (REEP) as a model project for national replication.

Commitment: Despite many challenges, long term commitment from all stakeholders towards improving the housing conditions for low-income communities endured. The project was the brainchild of a Dutch NGO, SSN (SouthSouthNorth) that aimed to remove EE market barriers for low-income communities using CDM. SSN motivated key Kuyasa residents who facilitated access to the site and eventually convinced the City of Cape Town since the project aligned with the City's existing targets of improving energy access in low-income neighborhoods - 10% SWH installation by 2010 and 10% renewable energy by 2020.The City backed the project despite an assessment of a negative internal rate of return. The City was convinced that the environmental and socio-economic returns would outweigh financial costs. The City's gamble paid off. The project generated substantial co-benefits. Insulated ceilings increased thermal comfort and reduced energy needs, so much so, the residents eliminated the need for paraffin space heaters and indoor air quality improved. Apart from savings with reduced paraffin and electricity use, 76% reported relief from respiratory illnesses from paraffin fumes. Additionally, elimination of paraffin heaters from homes reduced the risk of fires. By managing typical energy consumption patterns, the project helped defer new electricity capacity investments and reduced peak demand for the utility. The project created 87 local jobs. Half of the trained residents are full time green industry technicians or entrepreneurs with opportunities in the region.

Finance: The funds were cobbled together from several sources: i) municipal and provincial government grants and loans, ii) NGO funds for project design and savings validation required to register the project under CDM, iii) community contribution, and iv) sale of carbon credits under CDM. Grants and loans included: Department of Environmental Affairs and Tourism (DEAT) grant by positioning the project as part of the National Government's Expanded Public Works Program (EPWP) to create employment; contribution from Western Cape Provincial Department of Housing; and South African Export Development Fund (SAEDF) loans to be recovered from community contribution and sale of carbon credits. Revenues from sale of Certified Emission Reduction (CER) credits under CDM would be available only post project completion over a 21-year period. The greatest challenge was to finance capital costs for the technologies, which was met with the SAEDF loan.

Collaborative approach: The project was a collaborative effort of the City of Cape Town, SSN, and Kuyasa residents.

Box 2 (continued)

Stakeholder coordination: The NGO developed the project concept over 3 years and presented it to the community via townhall meetings. It conducted a successful pilot in 10 houses to prepare baseline documents for project registration as a CDM. Its relationship with the community ensured complete access to the sites for conducting measurement and verification needed. The community was actively engaged in the planning, financing and implementation stages with regular meetings, periodic community updates and a steering committee. This not only created a strong sense of project ownership, but also community solidarity. The residents became strong stakeholders and project proponents. SAEDF was the main implementing agency. The City and SAEDF selected local contractors to oversee EE retrofits, monitor and maintenance.

Information: Information for baseline diagnostics required for CDM registration was generated through the pilot. CDM grants carbon credits for reductions against a pre-project baseline energy consumption level. Improving quality of life for Kuyasa residents was expected to result in increased energy consumption. Therefore, CDM rules were interpreted to allow for GHG reductions against an inflated baseline equivalent to a home already serviced with conventional heat, warm water and lighting. Monitoring and evaluation of the proposed technologies in the pilot developed confidence in all stakeholders. Information on locally available technologies identified locally manufactured SWHs for the project. In order to build community acceptance, extended outreach was conducted with information on expected benefits for the community, such as, cash savings, improved air quality and health, thermal comfort, greater productivity, jobs mobility and increase in household income.

Capacity building: 30% of project cost was allocated to local skills development and job creation. Local contractors and unemployed residents were trained to become carpenters, plumbers and electricians needed to install and maintain RE and EE technologies. Kuyasa residents were also actively engaged in implementation of retrofits. Residents, particularly women, were trained in the use and maintenance of SWHs and CFLs.

Conclusion: Low-carbon Slum Upgrading as an Essential Part of a City's Climate Goals

Slums should be seen as an asset to achieve a city's climate goals. Slum upgrading is typically not an integrated component of a city's climate action plan. Low-carbon slum upgrading can accelerate transitions to the city's carbon neutrality goals and adaptation plans. In some cities, 30-40% of the population lives in slums. If we aggregate the impacts of low-carbon slum upgrading of all the slums in a city, the overall contribution to potential GHG emissions reduction in comparison to "business-as-usual" slum upgrading, can be quite significant. Limiting carbon emission in slum upgrading helps cities remain in a low-carbon trajectory, while improving the living conditions and livelihoods of the most vulnerable population. Climate mitigation produces socio-economic co-benefits, i.e., household saving, job creation, improved health, air and water quality, reduced deforestation. Low-carbon slum upgrading creates inclusive city assets with transformation of slums into vibrant neighborhoods, ensures better health outcomes, productivity and participation in the city's workforce, supports socio-economic mobility and consequently enhances city productivity and competitiveness. Finally, it can be adopted at multiple levels, the household and the neighborhood, as well as, through multiple entry points in sector specific solutions.

There are a few cities that are taking the step to be more explicit about prioritizing slums and adopting slum upgrading as part of their climate strategies and plans. For example, the Buenos Aires Climate Action Plan 2050 identifies slum upgrading as one of the priority actions. The 2019 Durban Action Plan identifies the need to prioritize vulnerable residents while balancing emission reduction strategies and creating job opportunities. The goal is to become carbon neutral by 2050 using green energy, address flooding, waste management and water conservation[64]. At the neighborhood level, there have been some efforts to develop Neighborhood Sustainability Plan for informal settlements. In Tegucigalpa, Honduras, slum residents worked with municipal authorities to identify, negotiate and agree on climate change adaptation solutions that were both legally and technically feasible, financially and socially acceptable. In Cusco, Peru and Medellin, participatory waste audit and community-based waste management are steps towards a neighborhood sustainability plan. However, in order to generate substantial carbon mitigation benefits from slum upgrading, low-carbon slum upgrading must be scaled up and become an essential component of a city's climate action goals.

[64] (eThekwini Municipality n.d.)

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