

Article

Slum Regeneration and Sustainability: Applying the Extended Metabolism Model and the SDGs

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Abstract: This paper examines the extent to which slum redevelopments have been successful in improving the sustainability of human settlements. Sustainability is measured in two ways: through the Extended Metabolism Model that looks at resource consumption, wastes, and liveability outcomes; and, through the framework of the Sustainable Development Goals (SDGs). The study compares the sustainability of informal slum settlements in Addis Ababa with high-rise slum clearance apartments; such clearance is the model mostly used for the world's informal settlements. The results show very little difference in resource consumption and waste produced but show liveability outcomes are mixed: Economic benefit is substantially improved in the high-rise areas due to becoming part of the formal economy, but community networks and trust are substantially lost when people transfer from the slums. This paper suggests that slum policy could be shifted from the Modernist high-rise slum clearance approach to a more organic, community-based renewal of the slums themselves in which infrastructure for energy, water, and waste can be brought in. New technology that fits into community-based governance structures allows such infrastructure to be a viable option, as well as enabling formal economic benefits. Some hybrid approaches may be needed in many slum improvement programs.

Keywords: apartments; high-rise; metabolism; SDGs; slums; sustainability

1. Introduction

Sustainability is a concept that needs to be applied to all human activity, especially cities. Its application requires various models and tools to enable cities to see how they can integrate economic, social, and environmental goals into their long term future. In this paper, we use two tools: the Extended Metabolism Model framework and the Sustainable Development Goals framework, which are outlined below before they are applied to slum regeneration in Addis Ababa, as a demonstration of how this critical issue can be given a sustainability perspective.

In 2003, there were an estimated 1 billion slum dwellers in the world; by 2020, this figure is projected to double to two billion people [1]. Urbanisation is a global phenomenon, sometimes leading to the dramatic growth of cities and urban districts which can stretch the ability of the city to provide sufficient adequate housing. In developing countries, informal urbanism emerges as a substitute for a formal city growth to address these massive rural-urban migration movements. Currently, an estimated 72% of urban dwellers in Sub-Saharan Africa are living in such informal slums [2]. With only an estimated 24% of the population living in urban areas, East Africa remains the least urbanized sub-region in Africa, so if that changes the amount of informal settlement in Africa may grow even faster [3].

As an example of this phenomenon, approximately 80% of Addis Ababa's three million inhabitants live in the city's slums ("Yedekeku Menderoch") or other types of informal settlements [4–6].

These settlements are characterised by substandard housing conditions and a lack of essential services, as developing cities like Addis Ababa do not have the necessary financial resources in their residents, cities, and national economies to provide better settlements [7].

There has been an evolution in policy responses to the challenge of slums over the past 40 years. Slum relocation and clearance were the conventional solutions based on a primarily negative outlook of slum settlements and a strong commitment to a modernist approach of building high-rise complexes to replace them. This approach was tried and rejected in most developed cities [8] but has now been adopted almost universally in developing country informal settlements. The obvious problem that has emerged is that the bulk of slum relocation high-rise has been pushed to the outskirts of cities, where many economic and social services are not easily available [9]. This paper will look at the evidence of sustainability outcomes in Ethiopia as a way of pursuing an alternative approach to slum improvement.

Like other cities in the developing world, many Ethiopian cities fail to accommodate growth within formal, planned urban framework dwelling policies and strategies. Thus only informal settlements result and without formal addresses and approvals to improve their condition there is no access to suitable financing to enable better housing or to enter the formal economy in terms of employment [6,10,11].

The Ethiopian government, in collaboration with its development partners, have thus begun to adopt policies and introduced a number of programs to solve the problems of present slums as well as prevent emerging new ones. However, it is not clear that they are actually improving the lives of those living in slum settlements, and thus this paper has been motivated to investigate what is happening in both old slums and new slum clearance housing, to try and seek some clarity on how to move forward.

Perhaps the biggest issue underlying the slum policies and programs is whether slum clearance is able to help on all levels of environmental/physical health, socio-economic health, or community health. Without both aspects being covered, the policies will be unbalanced and could do more harm than good [12]. Sustainability is obviously about how to integrate these factors in all developments [13].

The paper explores the extent to which the slum redevelopments have been successful in improving the socio-economic and physical quality of human settlements and improving the living conditions of the residents. Such issues require a sustainability framework to assess the outcomes.

2. Sustainability Frameworks

The main reason for the particular framing of the data collection was to see how sustainability relates to informal settlements using two theories. The first is to apply the Extended Metabolism Model of Newman [14], which has been posited as a way to examine the notion of sustainable development in cities [13]. This model is increasingly used for developed cities seeking to create a more circular metabolism [15] but has not been applied to emerging cities.

The other major framing is the Sustainable Development Goals, which have been set up and recognized by global consent but have not yet been researched to see how they are integrated and can provide perspective on how future cities can become more sustainable with their complex issues of economic development, environment, community, and equity [16,17].

2.1. Urban Metabolism and Slum Settlements subsection

Abel Wolman [18] used the concept of urban metabolism for the first time in his work entitled "The Metabolism of Cities". He defined the urban metabolic necessities of a city as "all the commodities and materials needed to sustain the city dweller at home, at work and at play" [18]. See Figure 1.



Figure 1. Energy and material flows in urban areas. Source: [19].

More recently, the metabolism context has been used in the reporting of environmental information in Australia, where researchers have started to link urban metabolic measures to liveability, where liveability is about the human requirement for health and well-being, including both individual, social amenity, and community wellbeing. Liveability ensures that the economic and social dimensions of sustainability are incorporated with the ecological dimensions [20].

The Extended Urban Metabolism Model was developed by Newman [14] to illustrate how sustainability can be applied to cities. See Figure 2.

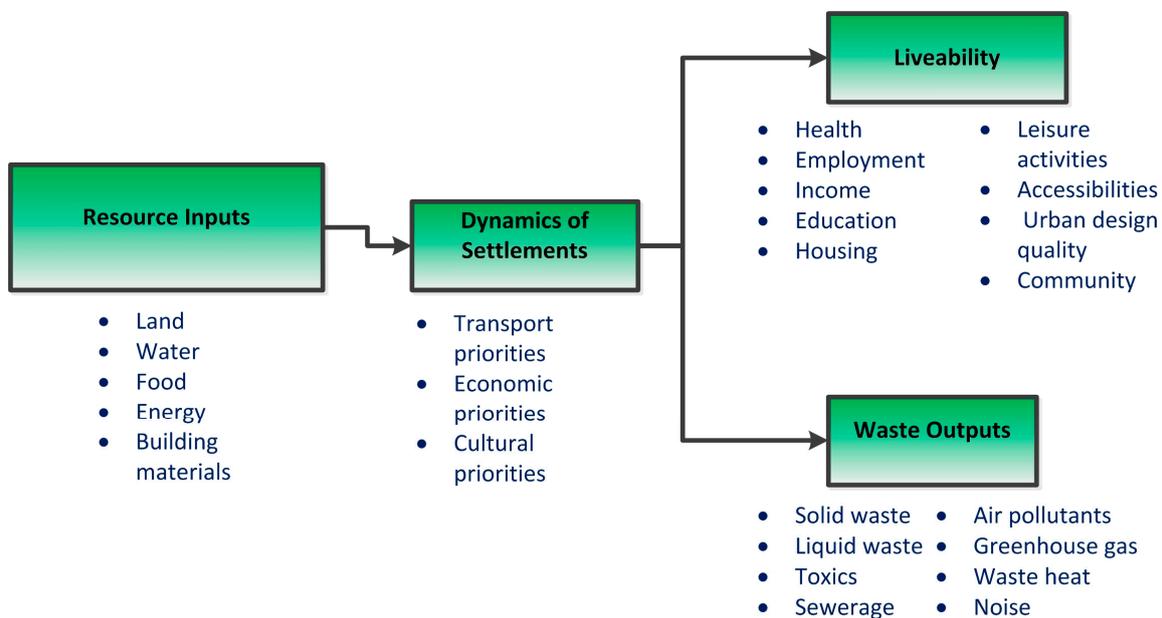


Figure 2. The extended metabolism model. Source: [14].

The model views cities as systems that require inputs of key resources that are drawn into the urban processes, which then convert them into waste through metabolism, as in all living systems, but also into anticipated liveability outputs. Newman argues that “... cities are more than a mechanism for processing resources and producing waste; they are about creating human opportunity” [14]. Therefore, to achieve sustainability, urban planners should not only aim to reduce

material and energy flows (inputs and waste outputs) but also to increase the liveability of the city, which is understood as an increase in social amenity, health, and well-being of citizens. This covers the whole gamut of socio-economic outcomes being sought in cities.

The model explicitly, therefore, attempts to show how all aspects of human life in cities need to be considered when assessing the outcomes of development in cities. For developing countries, especially in settlements, this means more considerable efforts to increase the living standards of poor people, the majority of whom live in slum settlements.

The Extended Metabolism Model can also be used to assess future directions in cities [21] and show how they may even become regenerative, not only in terms of energy but also for water, food, and biodiversity [21–23]. Each of these elements needs an understanding of urban stocks and flows, which can be provided through an urban metabolism analysis [15].

The paper will attempt to shed light on the sustainability of informal settlements by using the Extended Metabolism Model.

2.2. Sustainable Development Goals and Slum Settlements

The Sustainable Development Goals were established through a UN process for application at a national level but have now begun being applied to cities. Cities offer both great opportunities and profound challenges; thus, how urbanisation processes are managed is critical, especially how they manage the rapidly growing urban poor in their slums. It is timely and crucial to consider how cities can execute an ambitious universal agenda like the Sustainable Development Goals (SDGs), including Goal 11 on cities: “make cities inclusive, safe, resilient and sustainable” [3].

Agreed in 2015, with implementation now in progress, the SDGs are an ambitious agenda, setting 17 goals and 169 targets in areas of critical importance: people, planet, prosperity, peace, and partnership. Furthermore, Habitat III—the major global summit on sustainable urban development that took place in Quito in October 2016—also discussed how to implement the SDGs in urban areas, providing an opportunity to align these two major global processes.

The advantage of SDGs is that they represent a more holistic approach to urban solutions rather than isolated, sector-specific tasks. In this way, SDG11 can be seen as an acknowledgement that the urban problems are interrelated and must be resolved by integrated approaches. Access to essential infrastructure facilities such as efficient waste management, access to clean potable water, and energy access for all is fundamental for promoting better health and reducing sicknesses. Thus, it is needed for economic development and equity. Appropriate sanitation and drainage services can minimise health risks, enhance environmental quality, and prevent flooding and other related threats associated with climate change. In order to achieve such integrated goals, multi-scale planning, execution, and implementation require that governments have adequate, financial, human, and institutional resources available [1]. However, they also need the right way to think about how to approach solutions and sustainability can help with shaping this thinking, especially if projects are evaluated in terms of sustainability frameworks like the SDGs.

2.3. From Millennium Development Goals to Sustainable Development Goals

Though the slums had been part of the global sustainable development agenda since the Millennium Summit (and indeed before), their incorporation in the MDGs was limited by poor formulation and their lack of coherence under an exclusively environmental rubric. Target 7D aimed at improving the lives of 100 million slum dwellers. Though in some cases it has been achieved, progress on slum improvement and reduction has been negatively offset by overwhelming slum growth [24].

While the lives of 220 million slum dwellers have been improved, the total number of slum dwellers has increased, and it is estimated that 863 million people are now living in slums. The number is projected to double by 2030, and thus urban poverty eradication stays an enormous challenge to be addressed [25]. This increased inequality and exclusion is a consequence of the failure of public and private investment in pro-poor urban and housing development.

Learning from the MDG experience, it is important to continue efforts for improved living standards in slums towards sustainable, inclusive, and adequate housing for all. The target will be owned by national and local authorities developing rights-based, gender responsive, and results-based national housing and slum upgrading strategies and programs formulated with full participation. In particular, cities must strengthen the capacities of women, youth, and vulnerable groups so that they may function as agents in the improvement of living standards and the realization of the right to adequate housing without unlawful forced evictions.

Sustainability, as suggested by the SDGs, is only achieved through adopting comprehensive, integrated solutions that provide better outcomes for a range of goals. Successful responses should be based on acknowledging varied forces behind different types of slum settlements and the need to apply a range of policy tools (social, economic, physical, and community) altogether. For such combined integration to be effective, they must be enclosed by long-term strategies to achieve wider societal goals based on the principles of sustainability. A positive slum upgrading and renewal should therefore not be about merely providing housing and infrastructure but rather about prioritizing economic, social, and community activities that are needed to turn around downward trends in an area. Such an approach can indeed lead to urban regeneration at a precinct level and impact the overall urban fabrics of cities.

The most significant thing about the SDGs is that they take these integrative approaches and apply them to all areas of development need, including cities. Thus, the SDG 11 to “make cities inclusive, safe, resilient and sustainable” has a series of targets that need to be assessed in an integrative way in order to evaluate the success of any urban development policy. Thus, these targets for SDG 11 will be used to assess the policy of slum clearance in emerging cities such as Addis Ababa.

3. Policies for Slum Improvement

3.1. History

Until the 1970s, the traditional method of governments to deal with slums was neglect and clearance in order to build modernist high-rise towers following the tradition established by Le Corbusier and the CIEE movement [26,27]. By doing this, governments seemed to destroy more low-income housing than they built, which, with a growing urban population, was very difficult [28]. Later, in the 1970s, however, slums were recognised as urban realities that require an adequate solution. This recognition began to follow the trends of the developed world, which had begun to oppose the modernist tradition through authors such as Jane Jacobs [8], who helped to begin a more organic approach to urban renewal.

The first reference point of modern slum upgrading in the third world appears to be John F. C. Turner’s writings. In his book, *Freedom to Build* [29], he argued, based on field observations in Latin America, that the response to slum challenges was not in their total clearance, but in enhancing the environment; if governments could improve the sanitary conditions and environmental quality of slum areas, then residents, given their resourcefulness and organizational skills, would progressively improve their houses, especially when encouraged by security of tenure and access to credit.

From 50 years of upgrading settlements, it is now known that most cities are growing based on an informal logic following a pattern reverse to what most planners are trained to. This has led to shifts in policy doctrine since the 1970s from emphasizing repression, resettlement, eradication, and evictions based on land acquisition, land banking, and conventional housing projects to an approach of integration into housing policies in the 1980s providing for land tenure regularization, sites and service, and housing finance, and, in the 1990s, to combined approaches along with programme designs endeavouring to deliver infrastructure improvements. See Table 1.

Table 1. Summary of slum upgrading theories.

Phase	Decade	Focus	Instruments
Modernization and urban growth	The 1960s–early 1970s	Physical planning and production of shelter by public agencies	Blueprint planning; direct construction (apartment blocks and core houses); eradication of informal settlements
Redistribution with growth/basic needs	The mid 1970s–mid 1980s	State support to self-help ownership on a project-by project basis	Recognition of informal sector; squatter upgrading and site-and services; subsidies to land and housing
The enabling approach	Late 1980–early 1990	Securing an enabling framework for action by people, private sector, and markets	Public-private partnership; community participation; land assembly and housing finance; capacity building
Sustainable urban Development	Mid 1990s onwards	Holistic planning to balance efficiency, equity, and sustainability	As above with more emphasis on environmental management and poverty alleviation

Source: Adapted from [30].

3.2. Urban Renewal or In Situ Upgrading?

For the last six decades, governments in emerging nations, especially African countries, have implemented a number of approaches to solving the problem of slums. The argument is over whether urban renewal or on-site upgrading is as old as the process of urbanisation, particularly the urbanisation of poverty and slum growth. Those in favour of clearance and resettlement believe that the economic value of the evacuated land is higher and that this option creates a win-win situation in which the poor get alternate serviced land and get to live in good quality environments [31–33]. Those against clearance and resettlement believe that resettlement distances people from their livelihoods and shocks them into poverty [34,35].

Generally, it can be said that the progression of policies regarding urban renewal has been evolving from total clearance and eviction approaches to a softer, more economically, socially, and environmentally sustainable approach. As pointed out by Forster [36], more focus is given to issues like improvement of the well-being of the community, preservation of invested capital, promotion of economic development, preservation of cultural heritage and traditions, preservation of the environment, as well as an extension of democratic process [36]. However, they have not related the upgrading of slums to sustainability or to new technologies for achieving smart, renewable settlements. This work is a major motivation behind the research reported here.

The paper endeavours to explore the sustainability of slum settlements by taking a critical look at alternative approaches to solving the problem through two sustainability frameworks. One such approach, which we have called the Modernist approach, was traditionally used to clean up old areas using standard high-rise building, not just because of the need to provide better housing and economic outcomes but also because modernist high-rise buildings were seen to be a preferred way of building cities. The other approach, which we have called the Organic approach, is a more in situ approach that respects the informal settlement for what it is and suggests it would be better to shift to a more community-based renewal of the slums themselves in which infrastructure for energy, water, and waste can be brought in, economic opportunities created, and the social structure of the community maintained.

It has been challenging to resolve the controversy between such approaches because of a lack of data on their impact on changes in incomes, livelihoods, and other socioeconomic and cultural conditions of low-income households [31]. This is particularly the case in Ethiopian cities. While deciding on the Modernist approach of clearance and relocation, the planners and policy makers in Ethiopia lay greater emphasis on estimating real costs incurred in land procurement and provision of basic urban services without estimating losses accruing to the household and city economy in the process of resettlement [36–38]. On the other hand, resettlement through relocation of households to faraway places in the city can trigger economic shocks and social disruptions of the inhabitants [39,40]. This paper attempts to help by providing data on the differences in these outcomes comparing informal slums with high-rise relocation projects.

4. Research Design and Methods

The research method for this paper is based on a case study approach using the city of Addis Ababa in Ethiopia. A case study approach has been argued as being a valuable tool for gaining deeper insight into complex social phenomena, as it allows the opportunity to focus on attributes such as social, economic, physical, and community cohesion. This is what the paper seeks to do, to provide an integrated sustainability assessment of slum settlement approaches.

The research is based on interviews, and household survey data that aims at exploring the sustainability of current and improved slums in Addis Ababa. A mixed method is used to collect data, as it is considered suitable for gathering information from different groups of participants including households in slums, government officials, researchers, and community leaders. The primary data gathering was done in December 2014 and secondly in 2016 in five selected informal settlements in Addis Ababa. Household surveys were conducted with 250 respondents from the slums in total. Primary data was collected from the selected sites by using a combination of household questionnaires, participant observation methods, and household mapping to obtain qualitative and quantitative information. A stratified random sampling method was adopted to select the sample size for primary data collection.

4.1. Research Location and Description

Addis Ababa is the only large African city with no colonial legacy. It was established upon the fabric of an indigenous settlement. The indigenous urban structure hosts an urbanity featured by a ‘mixity’—as it is commonly called in Addis Ababa—of economies, social strata, and functions [41].

Addis Ababa is the capital city of Ethiopia and home to an estimated 3 million inhabitants, or about 30 per cent of the Ethiopian population [38]. It is one of the world’s fastest-growing cities (4 per cent per year), due to both rural exodus (40 per cent of the annual population increase) and fast-paced demographics [1]. Due to its location in the centre of the country, as well as the relative neglect of other urban areas, the city accounts for most of the social and economic infrastructure of Ethiopia [1]. Yet, Addis Ababa faces great challenges in terms of development, notably in the areas of housing, infrastructure, and employment [42]. Also, inadequate governance prevents the municipality from addressing these issues in an efficient manner.

Three current slums and two high-rise condominium apartment sites were selected for the study:

- Slums: Taliyan Sefer, Arat Kilo, and Tora Bora;
- High-rise apartment sites: Ginfle and Yeka Ayat;
- Households from Arat Kilo had been resettled in Ginfle and in Ayat.

Of the three slum settlements, Tora Bora was the most recent slum; 10 years had passed at the time of data collection, while Taliyan Sefer and Arat Kilo slums were the oldest slum sites. The general description of the research sites are presented below (see also Table 2).

Table 2. Selected sub-cities and settlements showing geographical locations.

Sub City	Name of the Settlement	Geographical Location
Addis Ketema	Taliyan Sefer	Inner city old slums
	Arat Kilo	
Arada	Ginfle	Inner city high-rise apartments (condominiums)
Akaki Kaliti	Tora Bora	Newly formed slums located at the outskirts of the city
Yeka	Yeka Ayat	High-rise apartments located at the outskirts of the city

Source: Authors own data.

4.1.1. Arat Kilo (Arada)

This slum settlement is a socially mixed residential place, where formal and informal structures coincide. Diverse typologies, ranging from single detached house and cluster housing to poor dwellings, can be found. Additionally, the age, construction quality, and infrastructural provisions of the buildings vary but are substandard overall.

4.1.2. Taliyan Sefer (Addis Ketema)

This slum settlement is part of the old inner centre and is dominated by a combination of deteriorating residential dwellings and commercial activities. It comprises the biggest market place of the country, Merkato, and the express bus port. Within Addis Ketema, Taliyan Sefer is one of the most densely populated areas, with approximately 700 inhabitants per hectare.

4.1.3. Tora Bora (Akaki Kality)

This site is located on the periphery of Addis Ababa city and contains both types of informal and formal residential areas. Most of the land used by this informal slum was originally set aside for agricultural purposes.

4.1.4. Ginfle (Arada)

This is a slum clearance high-rise apartment in Arada sub city, which is located in the inner city of Addis Ababa, just located a short walking distance from the Arat Kilo slum. Most of the people living here were former residents of Arat Kilo.

4.1.5. Yeka-Ayat (Yeka)

The slum clearance Yeka-Ayat high-rise apartments are situated in the Yeka Sub-city administration, located in the Eastern part of Addis Ababa periphery. It is a new set of dwellings and most residents are slum dwellers that came from different parts of the city.

4.2. Extended Metabolism Model Indicators

The Extended Metabolism Model was selected as an analytical framework because it enables us to study the metabolism and liveability of slums combined, while the other metabolism models focused only on inflows and outflows of resources. This model has been applied previously by Alma Arief [43] as a framework to integrate economic, social, and environmental goals in slum dwellers living along the Ciliwung River in Jakarta, Indonesia [15]. Its application to the slums of Addis Ababa was based on the model's indicators set out in Table 3. Only the indicators provided were possible to be measured in the slums of Addis Ababa.

Table 3. Indicators of extended urban-metabolism model.

Human Settlement Domains	Indicators
Resource inputs	Land
	Water
	Food
	Energy
	Building materials
Resource outputs	Solid waste
	Liquid waste
	Sewerage
	Air pollutants
	Greenhouse gas Waste

Table 3. Cont.

Human Settlement Domains	Indicators
Liveability	Health
	Employment
	Income
	Education
	Housing
	Leisure accessibilities
	Urban design quality

Source: [13].

4.3. SDG Indicators

A general literature review and site visits provided important background information on the renewal and upgrading process. Site visits were frequently made to obtain first-hand data about the areas undergoing upgrading or renewal. After the general site visit, consultation was carried out with local planners and some researchers from local universities to identify suitable case study neighborhoods.

Due to the interrelated nature of the SDGs, improving the slum dwellers' living conditions contributes to the achievement of many of the approved goals. This study used the seven targets from SDG 11 to evaluate the two slum development models: organic slum development model based on community approaches and the Modernist slum clearance high-rise development model. The targets are listed below in Table 4 and these were evaluated based on the data collected from the extended metabolism assessment of the two types of slums in Addis Ababa.

Table 4. Indicators used in analysis of goal 11. "Make cities and human settlements inclusive, safe, resilient, and sustainable".

Target
11.1 By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums.
11.2 By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and the elderly.
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management in all countries.
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.
11.7 By 2030, provide universal access to safe, inclusive, and accessible green and public spaces, in particular for women and children, older persons, and persons with disabilities.

Source: Authors own data based on SDG indicators.

5. Results

5.1. Extended Metabolism Model

Table 5 sets out the results from the Extended Metabolism data collection the Addia Ababa slums compared to the slum clearance high rise housing estate.

Table 5. Metabolism and liveability of slum settlements and high-rise apartments.

Metrics	Slum Settlements	High-Rise Settlements
Resource inputs		
1. Water (L/household/day)	261	186
2. Energy MJ/Household/day		
Electricity	3.10	2.60
Kerosene	58.00	54.00
Charcoal	2.10	0.12
Gasoline	4.01	7.03
Diesel	3.37	2.45
Total	70.58	66.02
Waste outputs		
1. Solid waste	3.1 kg/household/day	2.6 kg/household/day
2. Liquid waste	341 L/household/day	260 L/household/day
3. Air waste (CO ₂)		
Electricity	726	402
Kerosene	4321	3902
Charcoal	123	12
Gasoline	210	490
Diesel	213	180
Total	5593	4986
Liveability		
1. Economic	30% employed in private business, government, and NGOs	45% employed in private business, government, and NGOs
	30% self-employed (informal activities)	43% self-employed (informal activities)
	29% unemployed	7% unemployed
	3% pensioners	5% pensioners
	Average income Br10,560	Average income Br17,600
2. Housing	Constructed from wood and mud Cooking and sleeping take place in same room	Constructed from concrete blocks Separate bed and kitchen rooms available
	70% government owned	100% privately owned
	No bathrooms; pit latrines and communal electric meters	Privately owned bathrooms and electric meters
	43% wish to live there with minor improvement 30% need everything unchanged	50% wish to live there
3. Education	67% primary school and below	30% primary school and below
4. Community	High level of community	Low level of community
	80% happy to live there	50% happy to live there
	95% feel secure	7% feel secure
	93% enjoy access to at least one informal borrowing or lending network	42% enjoy access to at least one informal borrowing or lending network
	97% trust neighbours	34% trust neighbours 60% have social tie to previous communities

Source: Authors own data from 2016 field survey.

5.1.1. Metabolism

The slightly surprising results for resource consumption and waste production show very little difference between the informal slums and the high-rise projects. See Table 5. Energy, water, and waste are very informal in the first case but residents still find ways to consume, either legally or illegally. However, the consumption is very small by any comparison with other urban residents in cities across the world [13]. The management of the waste in the informal settlements is generally very dependent on local communities. In terms of the climate change agenda, the greenhouse gas emissions from both settlements are not very different, though the high-rise residents do increase their transport emissions, probably because of the new location being less central. Below, we discuss how a different approach is possible, explaining how the metabolism can be managed better within an Organic approach and using the SDGs as the framework.

5.1.2. Livability

The economic outcomes from the new high-rise development are significantly better than the informal slums, probably because the residents are given a formal address and hence can access the formal economy both in terms of banking, education, and employment. See Table 5 and Figure 3. It is critical that this element is maintained in any slum management policy, as it is a major step in providing people to end extreme poverty and also in furthering the development of the whole city.

Slums play an important role in building the city economy, in particular through the hard work of new migrants and their work in the informal sector, which is a vibrant support to the city’s economic system. The total contribution to employment by the organized sector in Addis Ababa was only 30%, with the balance coming from the unorganized sector, which is said to account for 70% of total employment [44]. Thus, any disruption in the informal sector has implications for the city and its functioning. By providing a formal address and an upgrading process in either the Organic in situ approach or the Modernist high-rise approach, the economic outcomes are likely to be similar.

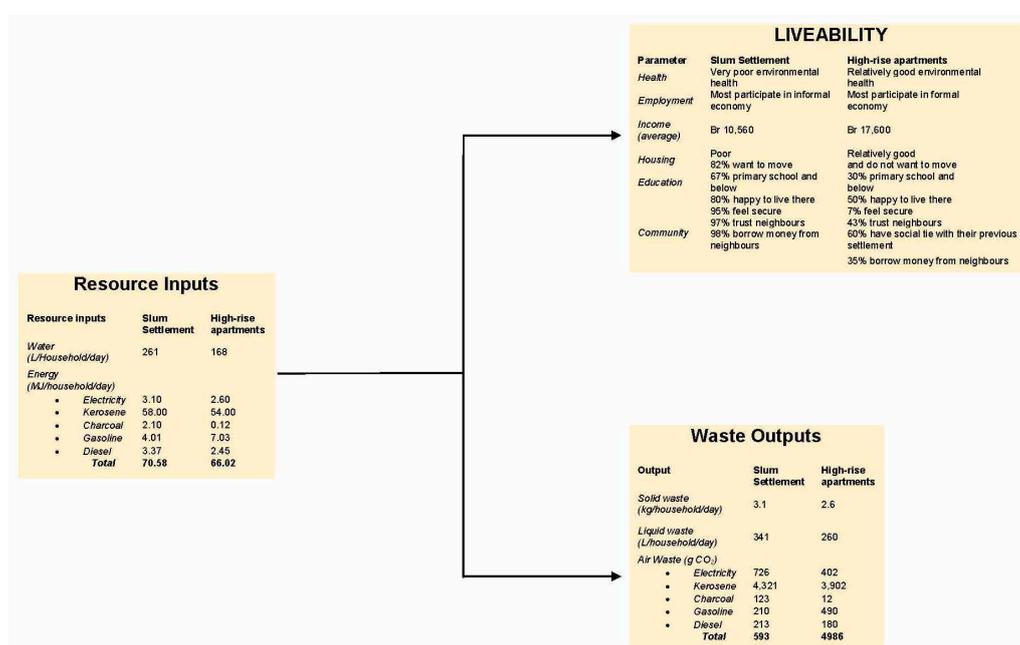


Figure 3. Extended Metabolism of Addis Ababa slum settlements. Source: Authors own data.

However, the biggest difference between the slums and the high-rise projects is the astonishing difference in community trust and networks between the two settlement types. In the slums, people feel secure and borrow tools and money from their neighbors, but this happens much less in the high-rise projects. There are ways this can be understood in terms of design where simple, walkable links are available between slum houses, but in high-rise the units are separated with little consideration of the need for community. There are architects who do find ways of building more community into high-rise developments [45–47], but, as outlined below, it may be a better approach to create Organic in situ development that builds on the social capital in communities whilst enabling better metabolism and better economic outcomes.

5.2. SDG Results

The difference between the two approaches—Organic and Modernist—is outlined in more detail to explain the difference in the two approaches, and then these are assessed using the SDG 11 targets.

The Modernist approach is well understood, with a paradigm that entails a clean slate with high-rise architecture enabling a large number of people to have a formal house, with good

infrastructure for energy, water, and waste provided through a centralized utility system. As shown above, this works with metabolism and economic outcomes but does not work with community outcomes. Any other approach would need infrastructure and design that can maintain the metabolism, the economic outcomes, and the community outcomes in an integrated way.

The Organic approach seeks to do this by using a community-based approach to infrastructure and design. The approach uses new technology for energy, water, and waste infrastructure designed to fit within the fabric of the tightly knit slums; it not only improves the economic situation of the slum dwellers, but it is sensitive to the social infrastructure within the organic structure of the slums [48]. This social capital is likely to be a significant contributor to the ending of extreme poverty through its highly inclusive mechanism; it can also be linked to more participatory governance in general [49]. This approach is being developed to manage shared photovoltaic systems in precincts and has been called Citizen Utilities [50]. The same approach can also be used to assist with water and waste management. Both can be upgraded as a local, distributed, community-based approach rather than a highly centralized mechanism, as has been the way in the past. This approach can use a range of small-scale local water and waste systems that can be mostly self-sufficient but also link to the city-wide grids for resilience and reliability [49,51].

With energy, water, and waste systems part of the same Citizen Utility and requiring a strong community-based decision-making approach, the Organic approach will require a formal tenure system to underlie the whole settlement. Such formal recognition of housing titles will enable the formal access to employment, schools, and banking systems to enable house upgrading in situ. Economic development will follow these factors.

The Organic Model is therefore likely to provide economic, social, and environmental opportunities that are more integrated than the Modernist option. The two models are therefore assessed in comparison to the SDG 11 Targets to see how they compare in their ability to provide a more inclusive, safe, resilient, and sustainable settlement. In Table 6, these 7 Targets are examined in terms of their application as shown in the Addis Ababa case study.

Table 6. Results of Sustainable Development Goals (SDG) analysis.

Goal 11. Make Cities and Human Settlements Inclusive, SAFE, Resilient, and Sustainable. Target	Organic Community-Based Infrastructure in Situ Slum Development Model	Modernist High-Rise Slum Clearance Development Model
11.1 By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums	Housing already affordable and can be upgraded by owners when given tenure Basic services all available through community utility	Housing subsidized and thus limited. Basic services available through centralized system
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Transport more available as most slums are close to economic activity. Walkable street designs. Need to upgrade for disabled access	Transport depends on location; many high-rise slum clearances placed on urban fringe without good transport
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Inclusive community already exists and can use as basis for infrastructure management and planning	Poor community inclusion. Planning is imposed
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Many old slums are approaching cultural heritage status and can be restored accordingly	Little potential

Table 6. Cont.

Goal 11. Make Cities and Human Settlements Inclusive, SAFE, Resilient, and Sustainable. Target	Organic Community-Based Infrastructure in Situ Slum Development Model	Modernist High-Rise Slum Clearance Development Model
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Disaster management can be significantly improved by community governance system. Water vulnerable settlements will need special care	Little potential
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Waste management and air quality improved by community infrastructure.	Waste management and air quality usually better.
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Green spaces needed within and around slums as it regenerates organically	Green spaces usually part of high-rise developments

Source: Authors own data based on SDG indicators.

Table 6 suggests that the Organic Model is likely to have better outcomes overall. The cultural target is quite revealing of the fundamental issue behind the two models. It raises the question of whether these slum settlements that have been patched together as temporary shelter but are now in some cases 50 or so years old, some even older, should be seen as a kind of cultural heritage that needs to be built with and improved rather than seeing them as having so little value that they need to be cleared. Organic settlements that have been built over millennia and are now seen as cultural heritage obviously had a similar evolution; at some point, people began to build on their structures and make them more durable [52]. History adds layers of materials and technologies to make them work better. This Organic approach can now be applied to slum settlements by dismissing their image issues, seeing them as potential regeneration sites, adding the community-based infrastructure of the 21st century, and creating more inclusive, safe, resilient, and sustainable habitat for 1 billion people.

6. Conclusions

Sustainability has been applied to slum settlements in Addis Ababa using two different sustainability frameworks. Together they show that economic and environmental improvements may be achieved in slum improvements based on slum clearance and high-rise housing in the Modernist tradition. However, the social cohesion of slum communities is lost, and therefore an approach based on more Organic approaches may be more sustainable in the fuller sense of this term. New small-scale technology for infrastructure and building may enable this approach. In reality, some slums are not able to be upgraded, as the material basis of the structures cannot be improved. Thus, sometimes a hybrid of the Modernist and Organic approaches is likely to provide the best option. However, the key issue is to have an Organic approach as the core policy guiding all the interventions.

The Organic Model based on in situ slum upgrading is an instrument that promises to promote empowerment, integrated urban development, and social cohesion, as well as the environmental upgrading and economic development so eagerly desired. This is a more compelling approach against the backdrop of ever-increasing urban unemployment, poverty, and widening socio-economic inequalities, as well as the lack of government funds for large scale Modernist interventions.

Institutional mainstreaming of the Organic approach to slum improvement will require planners and city policy makers to recognize the value in slum settlement patterns and seek to build on the social capital that exists inside the urban fabric. It will require demonstrations of how new technologies

for infrastructure upgrading can make it possible to maintain the community and unleash a process of upgrading that is self-sustaining rather than requiring massive government intervention, as seen in the slum clearance programs. This would make slums into significant contributors to the future sustainable city.

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