Addis Ababa City Government Plan & Development Commission | The London School of Economics and Political Science | LSE Cities | Alfred Herrhausen Gesellschaft | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Technical Report 1.3 | Urban Housing and Retrofitting

Sustainable Building Materials

Exploring green construction options for new housing in Addis Ababa

A Technical Report commissioned by the Addis Ababa Urban Age Task Force

URBAN AGE

Addis Ababa Urban Age Task Force

The purpose of the Addis Ababa Urban Age Task Force (AAUATF) is to support the City of Addis Ababa in advancing its strategic development agenda. The Task Force's work builds upon the Addis Ababa City Structure Plan (2017–2027), exploring opportunities for compact and well-connected urban growth that can be delivered through integrated city governance.

In addition to advisory activities and capacity building, it identifies strategic pilot projects to address complex urban challenges around housing, urban accessibility, green and blue infrastructure, and urban governance.

The AAUATF is a partnership between the Addis Ababa City Plan and Development Commission (AACPDC), LSE Cities at the London School of Economics and Political Science, the Alfred Herrhausen Gesellschaft, and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

urbanagetaskforce.net/addisababa

This publication has been supported by

BURO HAPPOLD

On behalf of

Federal Ministry for Economic Cooperation and Development

Addis Ababa Plan and Development Commission
Halle Gebresilasie Avenue
Addis Ababa
Ethiopia

LSE Cities
London School of Economics
and Political Science
Houghton Street
London
WC2A 2AE
United Kingdom

lse.cities@lse.ac.uk
lse.ac.uk/cities

@LSECities
LSE Cities
LSE Cities

Published by the Addis Ababa Urban Age Task Force, 2022.

Report Authors
Buro Happold
Hannah Langmaack, Consultant, Cities, Buro Happold, Berlin, Germany
Peter Scheibstock, Senior Consultant, Cities, Buro Happold, Berlin, Germany
Thomas Kraubitz, Director, Cities and Head of Sustainability and Climate in Europe, Buro Happold, Berlin, Germany

Supported by
Nebyou Yonas, Assistant Professor at EiABC, Addis Ababa University, Addis Ababa
Esther Moltie, Policy Advisor Urban Development, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany
Dalia Lüttgert, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany
Anastasiya Shadkhina, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany

Supervision
Anka Derichs, Senior Strategic Urban Development Advisor, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany

AAUATF Working Group
Urban Housing and Retrofitting
Ricky Burdett, Director, LSE Cities/Urban Age, London, UK
Timnit Eshetu, CEO, Construction Enterprise, Addis Ababa City Administration, Addis Ababa, Ethiopia
Brett Herron, Former Member of the Mayoral Committee: Transport & Urban Development, Cape Town, South Africa
Philipp Rode, Executive Director, LSE Cities and Urban Age, LSE, London, UK
Kecia Rust, Executive Director and Founder, Centre for Affordable Housing Finance in Africa, Johannesburg, South Africa
Elias Yitbarek Alemayehu, Ethiopia Architect and Associate Professor, EiABC, Addis Ababa University, Addis Ababa

Production and Design
Elaine Beebe, Copy Editor
Emily Cruz, Project Manager, LSE Cities
Lizzy Garlan, Publication Coordinator, LSE Cities
Yasmin Lennon-Chong, Graphic Design
Atelier Works, Template Design

Image credit (front cover): Charlie Rossier

Contents

Glossary

Term	Definition
CEB	Compressed earth blocks
CO_2e	CO_2 equivalent
EiABC	Ethiopian Institute of Architecture, Building Construction and City Development
GHG	Greenhouse Gas Emissions
HCB	Hollow concrete blocks
LSE	London School of Economics and Political Sciences
MJ	Mega Joule
OPC	Ordinary Portland Cement
RHA	Rice husk ash
SCMs	Supplementary cementitious materials

Report Disclaimer

1. Introduction

As the construction sector is a significant contributor to climate change, changing industrial and societal practices is central to a successful transition to sustainable construction globally. Constructing a new building not only involves a highly resource-intensive process, but also entails paying a heavy upfront toll in terms of carbon emissions. In addition to operational emissions caused by fossil energy consumption, embodied carbon stemming from the extraction, processing or manufacturing, transportation, construction or installation, and disposal of materials makes up a high share of a building's climate impacts.

In Ethiopia, the construction industry is responsible for approximately 2% of carbon emissions (Climate Watch, 2016). The country recently has been undergoing a rapid economic growth which has been attributed mainly to the building construction boom. The construction industry is expected to continue to flourish, since developing an international competitive construction industry is among the prioritised development goals for the Ethiopian government to achieve the status of a middle-income country by 2025 (Ministry of Urban Development and Construction, 2012; Taffese and Abegaz, 2019). This is likely to affect the carbon emissions related to the sector significantly. This situation is further exacerbated by poor management of building materials and generated wastes in building construction sites. In the Ethiopian construction industry, wastage of materials is more than twice as much as in countries of the Global North (Taffese and Abegaz, 2019).

Renewable, sustainable and local materials with low-carbon footprints hold enormous opportunities and enable carbon reductions on a large scale. To keep the global temperature rise to 1.5°C above pre-industrial levels, potentials of sustainable construction materials need to be explored further and sustainable practices implemented in the sector. To draw on the leverage of low-carbon construction, the quantifiable impacts in terms of reduced CO_2e emissions need to be explored further and reliable studies on CO_2e reductions of climate friendly materials are scarce.

1.1 Aim of the study

This study aims to provide recommendations for materials to be used in the context of a residential building designed by the Ethiopian Institute of Architecture, Building Construction and City Development (EiABC) at the Addis Ababa University, under the Addis Ababa Urban Age Task Force (AAUATF), to support the decision-making process of developers, architects, and the municipality of Addis Ababa. The proposed sustainable, low-carbon construction material alternatives are based on specifications given in the report "Benchmarking of construction and materials costs for new high-density, mixed-use, mixed-income housing and urban development projects for inner Addis Ababa" (CAHF, 2020).

1.2 Context of the pilot project

The London School of Economics and Political Sciences (LSE) conducted a study and prepared a draft report for the Addis Ababa Plan Commission and AAUATF titled "Implementing Addis Ababa's Structure Plan – informing pilots for strategic interventions". The study resulted in a concept referred to as the Addis Ababa City Block Project. The concept of the Addis Ababa City Block entails a vertical stack of narrow frontage housing units and horizontally stacked apartments. The development is modelled on Ildefons Cerda's Barcelona Perimeter Block but adapted to Addis Ababa's culture and the principles and objectives of the Addis Ababa City Structure Plan (2017-2027). It revolves around densification, connection to the ground and income generation as an internal cross-subsidy between low- and high-income groups. Overall, the City Block Project aims to respond to high density requirements and to enhance urbanity through a mix of income groups, social and green spaces. The expectation is that this project initiates further concepts and improvements of housing that would better serve the interests of the various stakeholders of the city.

The City Block pilot project is planned in two areas in Addis Ababa, Zones 1 and 2. Zone 1 lies in the south of the Sengatera area in the centre of the city, comprising a mix of commercial, residential, institutional and other land uses, including hotels, embassies, university departments, an international stadium and the La Gare railway station. The Zone 2 sites are earmarked for high-density mixed-use development in the Structure Plan, but the current actual zoning of the various parcels that make up the total area is not stated. The sites are currently covered by about 2,900 Kebele[1] and informal houses.

A river runs through the eastern side of both sites, but it is not known to what extent associated flood lines and possible protected water courses and wetlands would restrict the developable area of the sites (CAHF, 2020).

[1] Kebele is the smallest administrative unit in Ethiopia, comparable to a neighbourhood or a ward; usually part of a larger district.

The concept in its current draft form comprises:

- One level basement for parking, storage, machine rooms, electrical switchgear, etc.
- Ground floor plus three floors with vertically stacked duplex affordable home-based enterprise (HBE) and rental units
- In total about 850 residential units comprising of
  - Middle-income residential apartments on floors four to seven
  - High-income residential apartments on floors eight and above
  - Affordable rooms with shared communal ablution, cooking, dining and recreational spaces for students and others on floors four to 16 in the box-shaped spaces on the four corners of the block
- Market commercial and retail space on ground and floors one to three in the box-shaped spaces on the four corners of the block
- A variety of social and green spaces as indicated in the concept, but not designed yet in detail (3,000 m^2 social space, 2,500 m^2 playground, 2,854 m^2 green and recreational space).

1.3 Considerations on general design

Sustainability of a large-scale housing development such as the City Block is primarily dependent on integration of several spheres: spatial, environmental, economic and social sustainability, as well as institutional sustainability. Sound policy and governance structures are required to implement projects of such scale, especially when resettlements of informal dwellers form part of the project's development (Bredenoord et al., 2014). Integration of those aspects into the development process at an early stage is indispensable for its overall sustainability and the development's long-term success. While this study focuses primarily on sustainable material use, other spheres of sustainability will be discussed in the section below.

In general, compact settlements such as the envisaged City Block, with short distances between public modes of transportation, education and employment facilities as well as to public and open spaces, are considered an important aspect for sustainable neighbourhoods. Apart from increasing a project's financial viability and having other economically desirable effects, compact and dense settlements diminish environmental impacts through efficient resource use, for example, by reducing soil sealing and distances in transportation.

Increase of density in the area implies different impacts for either low- and higher-income settlements. S.B. Patel (2007) suggests that while in more affluent areas, higher densities could result in an increase of available living space per capita, in poorer areas, it could stress existing

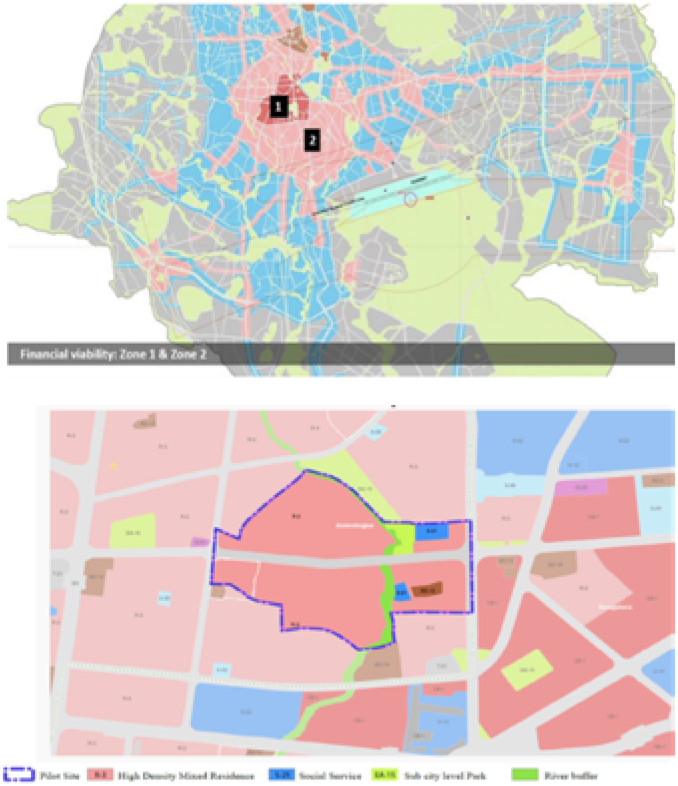

Figure 1: Implementing Addis Ababa's Structure Plan - informing pilots for strategic interventions

Land use map of Zone 2 sites for subsidised affordable housing development

Source: SME Lab (2019)

basic services and community facilities and reduce availability of open, public and green space per capita. The high density can lead to a lack of quality of public spaces and overcrowding of social spaces. Trade-offs between economic efficiency and quality of space must be assessed carefully.

Nevertheless, redevelopment of the site and potential temporary resettlement of current informal dwellers requires a careful process design. While the City Block aims to enhance quality of dwellings in the area after finalisation, it is important to consider alleviation of socio-economic backgrounds of low-income dwellers beyond their housing units. If the redevelopment of the site includes resettlements from informal dwellers away from the original location – also if only temporary for time of the construction – the process needs to be carefully planned and monitored. Studies show that relocation of informal dwellers, often to a city's periphery due to cheaper land price, increases distance to workplaces, educational and healthcare facilities. Combined with insufficient transportation or higher cost of transportation, daily expenditures of low-income households could significantly rise (Patel and Mandhyan, 2014; Patel et al.; 2015). Also, high density can lead to increased traffic congestion around the site, exposing residents to higher levels of pollution, depending on availability of public transport connections. Significant uncertainty surrounds any quantitative interpretation of alleviation regarding urban green, income inequality, health, and well-being especially in context of such large-scale developments in countries of the Global South (Ahlfeldt and Pietrostefani, 2019).

Further, it needs to be considered that especially for informal dwellers that have been accustomed to live in more "horizontal", high-density, low-rise settlements, a high-rise development could prove a constraint. Extensive consultation of local communities could support dwellers getting used to the shift, also instructing on potential maintenance of collective areas in the building (Gill and Bhide, 2012).

The most used construction materials in the Ethiopian building construction sector are cement, sand, coarse aggregates, hollow concrete blocks and reinforcement bars (Taffese and Abegaz, 2019). These materials also are prime sources of waste generation during construction. Studies on example projects in Ethiopia show that cement, hollow concrete blocks (HCB), and reinforcement bars (rebars) are the major consumers of energy and major CO_2e emitters and account for more than 90% of the embodied energy and CO_2e emissions (ibid). Studies have shown that the wastage of materials such as sand, cement or rebars ranges between 13% and 18% of total building materials (Taffese and Abegaz, 2019). This shows how the arising waste of the construction materials intensifies the embodied energy and the subsequent CO_2e emissions considerably.

Figure 2: Proposed design/layout of the City Block

Source: Elias Yitbarek Alemayehu (2020)

Figure 3: Proposed integration of city blocks into existing urban context

Source: Elias Yitbarek Alemayehu (2020)

2. Construction materials for the pilot project

The proposed sustainable, low-carbon construction material alternatives are based on specifications given in the report *Benchmarking of construction and materials costs for new high-density, mixed-use, mixed-income housing and urban development projects for inner Addis Ababa* (CAFH, 2020). It must be noted that the Benchmarking report does not provide detailed specifications on materials and makes assumptions about literature and project articles. Table 1 on the following page considers the materials given in the report, and proposes sustainable alternatives, as well as provides additional recommendations that are relevant for building design and circular approaches. Findings from the GIZ study *Climate and Employment Impacts of Sustainable Building Materials in the Context of Development Cooperation* (2021) have been integrated in the material alternatives and recommendations in Table 1.

Table 1: Materials proposed for the City Block and sustainable alternatives

		Assumed materials	Sustainable alternatives (CAFH 2020)	Other recommendations (GIZ / Buro Happold)
Site	Social and green spaces	*Hard and soft landscaping, playground equipment, etc.*	Locally sourced materials, upcycled materials for playground equipment Stormwater management: Permeable pavements allow better drainage of high rainfall during the rainy season	High density scheme maximises site utilisation while providing open and green spaces at the same time
Substructure	Basement	*Reinforced concrete column pads and wall footings*	Reinforced concrete using supplementary cementitious materials (SCM) such as fly ash (FA)	Optimise ground beams, aim to reduce excavation, minimise basement size and depth. Beneficially use excavation waste on-site to avoid transportation eg, for landscaping
Super-structure	Structural frame	*Conventional in-situ reinforced concrete frame consisting of columns and flat slabs*	Reinforced concrete using supplementary cementitious materials (SCM) such as rice husk ash (RHA), fly ash (FA) or others	Lightweight structural options, optimisation of structural grid and avoiding dead loads as well as prefabricated components can make construction more efficient and reduce waste
		Beams where required over large spans		Optimise beams structurally, lightweight structural options
	Internal divisions	*Solid non-load-bearing block walls*	Reinforced straw bale Compressed earth blocks Recycled bricks	Allow for flexible floor layouts to adapt to future uses
	Ground floor market retail	*Glazed shop fronts and security grilles*		Locally sourced, reused metal parts for grilles and glazing
	All other elevations	*Solid block walls*	Reinforced straw bale Compressed earth blocks	Design for end-of-life, disassembly
		Solid block non-load-bearing infill walls	Reinforced straw bale Compressed earth blocks	Design for end-of-life, disassembly
Shell / Skin	Roofs	*Flat reinforced concrete slabs*	Slabs using SCM-based concrete such as rice husk ash (RHA), fly ash (FA) or others	Lightweight / prefabricated roof slabs
	External wall finishes	*Cement plaster and durable paint generally*	Clay plaster	Consider façade replacement options/repair and detailing to allow end-of-life recovery Designing finishes for durability and resilience, and end-of-life material and component recovery
Finishes	Floor finishes	*High grade glazed ceramic and/or porcelain tiling, carpeting, medium grade glazed ceramic tiling, and natural stone cobble paving*		Use of recycled or recycling surface materials (tiles)
	Internal wall finishes	*Plaster and paint generally, with glazed ceramic tiling in wet areas*	Clay plaster	Non-toxic materials
Building services	Stair, walkway and balcony balustrading and handrails	*Anodised aluminium grid*	Timber	Designing for durability and end-of-life material and component recovery
	Electrical installation	*Timber*	Incoming mains, mini-subs, switchgear, energy-efficient power and lighting, including area lighting for pavements and courtyard as per load requirements	Develop a repair/maintenance strategy Provide space for future adaptations and additional cables
	Water and sanitation	*Fitted bathrooms and kitchens, with water-saving fittings, grade and facilities appropriate to end-user market*		Prefabricated bathroom pods and risers Rainwater harvesting: use of rainwater for toilets

3. Assessment of suitable construction materials

The main potential for designing the City Block Project more sustainably lies in replacing or partially replacing conventional concrete elements such as structural elements and non-load-bearing block walls with renewable alternatives or reducing the amount of highly carbon-intensive materials such as cement, steel, or aluminium.

With Portland Cement emitting between 600 to 900 kg CO_2e/t depending on the type of processing and energy used (Fennel et al., 2021; Imbabi, 2013), conventional concrete with around 15% cement emits around 100 to 300 kg CO_2e/m^3 (NRMCA, 2008). As the current design envisages a reinforced concrete frame construction, the main paradigm to avoid a large proportion of carbon emissions compared to the baseline design is to reduce the volume of cement used. Key strategies are to (i) replace concrete elements with renewable substitutes where possible, (ii) reduce volume or thickness of structural elements (eg, thinner floor slabs), or (iii) substitute parts of the cement with SCM, which has a significant impact on the embodied carbon of the development. Contrary to carbon emissions from concrete and steel, sustainable material such as timber or straw bales function as carbon sinks, storing carbon during the lifetime of a building and even beyond, if recycled and repurposed.

This section looks further into the previously identified materials suitable for the local context of the City Block Project and assesses in what way the materials could have a positive impact on the overall sustainability of the project in the context of Addis Ababa. This will include a relative comparison of the CO_2e balances of the suitable building materials/mix of building materials, impacts of resource consumption, integration of local circular economy or transport. Further, it will be assessed how the identified materials could impact local employment opportunities and the wider market. Value chains for the most suitable construction materials will be included where possible to reflect complexities and interconnected processes and show possible positive and negative effects on employment opportunities. In addition, this section includes a relative comparison of the costs of the suitable building materials/mix based on the available background documents.

3.1 Supplementary cementitious materials

With the significant number of concrete slabs, beams and walls envisaged in the current City Block design, supplementary cementitious materials (SCM) could be used partially to reduce cement in concrete elements. Industrial or agro-based cementitious material hold a great potential due to their wide local availability in Ethiopia, their nature as industrial by-products and their low cost.

Fly ash (FA) is a by-product of coal combustion eg, in coal power plants, steel production and also in waste incineration. Due to its cementitious properties, it is widely used as SCM. FA could be considered as a viable option for reducing the cement amount in the project, as FA is already available in Ethiopia due to the country's large coal industry. By repurposing FA in concrete production, the current practice of disposing toxic FA in landfills is avoided (Abebaw and Vadivu, 2020).

It must be noted though that FA has limited and only regional availability and represents a by-product of carbon intense industries which are connected to a variety of adverse environmental impacts. Furthermore, with energy and steel production globally moving towards more sustainable processes, increasing demand, and reducing availability could result in shortages for construction industry. This means FA and other SCMs from industrial by-products can provide a regional source that could be used while coal-power plants are still operating, using a diversity of available sources.

Agricultural by-products such as rice husk ash (RHA) are a renewable alternative to be used as pozzolanic material in blended cement or incorporated directly in concrete mixtures. Depending on the composition and proportional usage of RHA in concrete, the incorporation of RHA as an SCM in conventional concrete can enhance the compressive strength. Positive effects of the utilisation of RHA as an SCM are:

- RHA is a cheap waste material with no higher value for alternative use.
- RHA requires less energy than cement for its production.
- The use of RHA as cement replacing materials reduces the carbon footprint.
- Optimising RHA as an SCM can contribute to decreasing air pollution through controlled burning of the husks and benefits the environment from eliminating the disposal of wastes (rice husk) onto land.

While rice production in Ethiopia has been increasing since the early 2000s, it is still considered as one of the minor crops in Ethiopian agriculture. Teff, maize, wheat and sorghum are among the cereal crops used as the staple food crops in Ethiopia. However, the recent trends in the area and production of rice along with its high compatibility with traditional consumption habits shows that rice is becoming one of the staple foods (MoARD, 2010). A wide regional availability for the use of rice as a source for SCM would need further assessment. The largest crop grown in the country is Ethiopian teff, used to prepare the country's most popular food, injera. Teff husk and straws are by-product from teff mills, considered as organic waste, with large quantities being disposed or burnt causing environmental issues. It has been shown that teff straw ash functions as an agent for pozzolanic reactions in concrete, allowing for partial cement replacements (Woldemichael, 2020). The use of teff straw ash currently remains in experimental stage, with current research exploring compressive strength of concrete (ibid).

3.1.1 Sustainability opportunities

Partial replacement of conventional concrete elements through cement alternatives (SCMs) could affect the emission reduction of the overall project beneficially. Rice husk, an SCM based on agricultural waste arising from rice mills in the milling process of paddy, is abundantly available at virtually zero costs. Studies showed that the production of RHA is highly sustainable, with a value of embodied energy of -26 MJ per kg of RHA, with the negative sign indicating that energy is produced in the overall process. Comparing the embodied energy of RHA with that of Portland Cement (OPC) ranging between +4.6 MJ/kg (Hammond and Jones, 2008) and +6.4 MJ/kg (IFC, 2017) shows the potential for more sustainable building materials when incorporating RHA with OPC. Studies showed that replacing 20% of Portland Cement with RHA in concrete can result in a CO_2e reduction of 24% in the concrete production chain. This value can only be obtained if RHA is produced in a fluidised bed at low temperatures and is also dependent on the transport of RHA to the construction site (He, Kawasaki, Achal, 2020).

Apart from FA obtained through coal combustion, FA from municipal solid waste incineration (MSWI) plants also has potential in cement replacement for projects in Addis Ababa. A study from Simegn, Abebe and Worku (2020) utilising FA from Addis Ababa's Reppie Waste to Energy Plant has shown that replacement of cement with up to 15% of MSW FA provided satisfactory compressive strength for the required concrete grade (ibid). Further, synergies between MSWI plants and cement production plants have been explored, utilising FA as raw material for low-carbon cement manufacture and benefiting from heat in the incineration process, to be used for clinkering (Zhang, et al. 2021).

At present there are no studies on the behavior of recycled concrete using SCMs. It can be assumed that SCM concrete would behave similarly to normal concrete, which means it could either be crushed and used as aggregates or reused with new SCMs and cement.

3.1.2 Employment opportunities

Production of agro-based SCMs could have positive impacts on local value chains, as it is a waste product which is not commercially used yet. Since rice or other agricultural by-products can be used to produce SCMs, the product is not locally or regionally restricted. Further, grain husk is produced as a by-product already and therefore does not have to compete with other agricultural uses.

For every 1000 kg of milled rice paddy, ~200 kg (20%) of rice husk is produced, which results in approximately 50 kg of rice husk ash. Considering the potential and growing importance of rice as a food source in Ethiopia, rice husk ash presents a great potential for additional incomes of a previous waste material (Paul et al., 2019). Manufacturing is completely dependent on the production of the respective crop and subject to seasonal fluctuations. The production of supplementary cementitious materials does not require complex and technical machinery and could therefore strengthen local SMEs or even local farmers to generate more income. More complex technical knowledge is necessary when mixing and allying concrete using SCMs in construction projects.

To date, limited research has focused on the production and processing costs of these waste materials (Martirena and Monzo, 2018). In general, these waste materials must be treated from their source to the stage where these are ready to use in concrete as partial binder replacement. All this information is needed to assess the lifecycle impact of these (potential) SCMs and to improve their production methods where possible (Paul et al., 2019).

RHA can substitute from 5% to 25% of cement in a concrete mixture, depending on the application. Depending on the content, the addition of RHA to concrete causes an increase in compressive strength. Studies showed a compressive strength development up to 365 days about 13% higher strength in 10% RHA concrete than in control mix of OPC. Durability of concrete is often found to improve with RHA as partial cement replacement (Paul et al., 2019). These have mostly been tests under laboratory conditions as a lack of real-life applications of RHA cement replacement in high-rise buildings continues to exist. The cement industry is large enough to support the use of a significant amount of the RHA produced. Especially in developing countries, cement production is still growing at high rates, which makes this market sustainable for the long term (He, Kawasaki, Achal, 2020). At present, only a few studies have conducted cost analyses on the application of agro-waste, mainly RHA in cement. A complete economic analysis with most agro-wastes is not reported, which is necessary for their future application in construction. Industrial additives to concrete such as FA or ground granulated furnace slag still build a barrier towards market uptake of agro-based SCMs because their implementation in construction projects is already established and cost-effective. Coal FA is currently mostly used in the cement industry as it is an accepted cement admixture. Coal FA producers are typically large power plants or industries with more leverage to promoting use of coal FA, currently leaving agro-based alternatives behind.

3.2 Straw bale

Straw bale construction is especially suited for solid non-load-bearing block walls in the City Block Project. When using straw bales as an insulation filler between supporting structures, the position and thickness of the structural elements must be adapted to the needs of the project, while the placement distance between them depends on the size of the chosen bales. In-fill buildings typically consist of stacking rows of bales on a raised footing or foundation, with a moisture barrier or capillary break between the bales and their supporting platform. For partition walls with reduced bearing capacity of the walls, straw bales can also be used without load-bearing structures made of wood or other materials.

- Straw is a cheap by-product or waste material from agricultural uses of grain, rice and wheat.
- As a natural and renewable material, straw reduces the environmental footprint of the building throughout its lifecycle.
- It is readily available, and it can be obtained from both near and far sources and is a lightweight material so can be transported sustainably and economically viably.
- Once constructed, the airtight straw layer is long-lasting and fire-resistant and can withstand flames at 1,050°C for more than two hours. Straw insulation is packed densely enough to keep warm air in yet permeable enough for humidity to escape, creating a healthy and comfortable indoor climate.
- Straw structures can be pre-assembled on wooden beams with modular elements, reducing construction time.

Straw is an abundant by-product widely available in the country due to Ethiopia's agriculture-heavy economy. Ethiopian crop residues largely stem from barley, teff and wheat straw, fava bean, field peas residues and natural pasture hay. Parts of straw are used as cattle fodder, while there is already a tradition of using straw as construction material for buildings (Suttie, 2000). According to Hjort and Widén (2015) straw has been utilised traditionally in housing construction, when wooden structural frames have been filled up with a clay-straw mixture. While shortage of timber and the challenge of deforestation in the country do not allow application of timber on large-scale housing programmes, utilisation of straw for non-load bearing elements and insulation can be considered as a sustainable, low-cost option for the city block.

3.2.1 Sustainability opportunities

The embodied energy of straw construction depends on the type of construction, processing and transport to construction site. Therefore, no general value can reflect the embodied carbon of straw buildings. Studies showed ranges between 0.0014 MJ/kg and 0.4 MJ/kg straw (various values depending on analysis type with different parameter) (Sertyesilisik, Yilmaz, Sertyesilisik, 2021). The use of locally available straw can further reduce embodied carbon, carbon emissions, energy and transport cost as well as support the local economy.

The carbon sequestration of wheat ranges between 165kg and 300kg CO_2e/m^2 per m^2 (Gan et al., 2014). These values depend on crop residue decomposition, applied inorganic nitrogen and phosphorus fertilisers, nitrogen leaching losses, pesticide use, fuel consumption in various farming operations and fossil energy consumption in manufacture, transport, storage and delivery.

Houses constructed with straw generally do not require any additional wall insulation, as R-value for straw bale walls ranges between R-17 and R-65 (Sertyesilisik, Yilmaz, Sertyesilisik, 2021). Studies show that straw bale construction, when used properly, also provides better sound insulation than most materials (Vanova et al., 2021. The straw insulation is packed densely enough to keep warm air in yet permeable enough for humidity to escape. This creates a healthy and comfortable indoor climate, with estimates suggesting a saving of one tonne CO_2e per year on heating and cooling compared to conventional buildings (RIBA, 2021). Straw sequesters carbon and retains it for the lifespan of the building product. At the end of its life, it can be safely composted.

3.2.2 Employment opportunities

Examples show that straw bale constructions can have a very positive impact on local communities and gender equity, as in development projects mainly women were trained into leadership positions for lime stabilised plastering. Projects of straw bale construction further enhanced community capacity building through increasing skills and income (Re-Alliance, 2021). The building method is straightforward and people without previous building experience can participate in the design and construction. Through training and use of local labour, people are empowered to build durably with straw and lime. Going forward they can maintain their buildings and implement future projects. With the tradition of utilising straw as building material in Ethiopia, the material is well-known and can easily be procured locally, and non-professional labour can support in the construction process.

Although rice straw can be used in construction in various ways, the reason why it is not being widely used is mainly due to lack of people's awareness. In the past 30 years, straw as a building method has been rediscovered and has become more and more popular across the world. As straw is a waste material, straw construction and insulation has relatively low initial investment, operation and maintenance costs compared to conventional building methods (Sertyesilisik, Yilmaz, Sertyesilisik, 2021). This potential advantage of the straw houses can contribute to the environmental, social and economic sustainability as well as to the affordability of housing.

3.3 Compressed earth blocks

Compressed earth blocks (CEB) or rammed earth could be suitable for non-loadbearing walls in the City Block Project and replace solid non-loadbearing block walls. Rammed earth, as with most types of earthen construction, is relatively stronger in compression than it is in bending and shear. Therefore, unreinforced rammed earth should generally only be used for structural elements subject to primarily compressive loads, mainly vertical walls and to a lesser extent, columns. Rammed earth can be built non-stabilised or stabilised, where the main difference lies in the use of cement or lime additives in the latter to stabilize the soil, sand and gravel. It can further be distinguished between using small blocks (compressed earth blocks or adobes) implemented with a mortar to build masonry structures, and earth implemented in monolithic walls. With often more than 100+ years lifetime, CEB or rammed earth buildings have a very high durability as the materials barely deteriorate (Hall and Swaney, 2012).

- With a compressive strength similar to hollow concrete blockwork, around 1-4 N/mm^2, unfired clay bricks are expected to perform favourably in most building applications where fired bricks are currently being used for masonry wall construction (BRE, 2011).
- Rammed earth constructions can be highly sustainable as it has a high thermal mass and only a 40th of the carbon footprint of concrete.
- The local abundance of clay and soil can help making countries and regions independent of international imports.
- Raw earth can be used, together with different types of reinforcements, to create safe, earthquake-resistant and thermally efficient buildings.

3.3.1 Sustainability opportunities

Unfired adobe bricks are perceived as eco-friendly and energy-efficient construction materials that can achieve great carbon savings. While hollow concrete blocks emit around 180 kg CO_2eq/m^3, unfired earth bricks emit only 93.6 kg CO_2eq/m^3 and rammed earth 9.3 kg CO_2eq/m^3 (CINARK, n.d.). The values show the significant impact clay-based materials could have on the City Block Project when replacing non-load-bearing block walls.

These values depend on raw material extraction, additives, manual manufacturing (casting), and delivery of material to the building site. Additives especially can have a significant influence on the CO_2e impact. For bricks or rammed earth walls with a proportion of 5-10% of lime or cement, the CO_2e emissions will be significantly higher as it is estimated that per 1kg of cement produced, 0.5-0.9kg of CO_2e emissions are evolved (Fayomi et al. 2019)

At end-of-life, clay elements in buildings can be disassembled using manual tools such as axes. Depending on whether additives such as cement or lime were used, the bricks can degrade back into nature as soil (Dabaieh et al., 2020). With cement as an additive, it is not possible to recycle the building material. In this case, it is often possible to reuse the bricks if they can be recovered whole and if no finishing was done.

3.3.2 Employment opportunities

The renewed attention paid to raw earth construction in recent decades is linked to its undoubted sustainability, cost-effectiveness, and low embodied energy, but to date raw earth buildings are limited by the lack of a technical reference standard. Raw earth materials have a short value chain as soil can be obtained locally and, in some cases, directly at site. Soil is then sieved, mixed and rammed or precast into compressed earth blocks. Since the processing does not require a lot of technical skill, it can be practiced by the local workforce, creating employment. It should be noted that raw earth construction requires good knowledge and understanding of soil types to obtain the appropriate soil mixture. Building with raw earth does not require specialised manpower, which allows anyone with access to simple tools to build a house. During seasons with high rainfall, rammed earth walls need additional protection or shelter against rain when constructed which can impact the duration of construction. The drying time of rammed earth depends on the moisture content, humidity and stabilisers and is cured for a minimum of 28 days when cement is used as a stabiliser (Gupta, 2014).

A barrier to the use of clay as construction material is that it is perceived as a low-class material and it is often strived-for other materials that reflect status. One of the major challenges is therefore to enable local population to use the soil material, which is an available material, competitive in terms of price with concrete and providing unequalled thermal comfort. As soil is a natural material, rammed earth is comparable to conventional masonry. However, the availability of local soil and transport costs can make a big difference to the cost. There are also economies of scale; bigger works have smaller set-up costs.

3.4 Other materials

3.4.1 Use of recycled or recyclable materials

There are several studies demonstrating the use of recycled and reused building materials significantly mitigating the energy consumptions and CO_2e emissions in buildings. The reduction of CO_2e emissions through recycling and reusing materials always depends on the dismantling, processing and transport of such materials.

The results from studies on using recycled materials for the construction show that there are considerable environmental benefits to be derived especially from the use of reused clay bricks instead of new bricks. The embodied carbon for recycled bricks can be as low as 5 kg CO_2eq/m^3 (compared to new fired clay bricks with 530 kg CO_2eq/m^3) (CINARK, n.d.).

Recycling concrete on the other hand requires virgin materials and is thought not to be significant in terms of GHG emission mitigation. This is mainly due to the lower structural performance of recycled materials, which needs to be compensated for by using additional reinforcements consisting of cement in most cases. The main source of carbon emissions in concrete is in cement production. The cement in concrete cannot be viably separated and reused or recycled into new cement and thus carbon reductions cannot be achieved by recycling concrete (CSI, 2009).

3.4.2 Design implications for conventional materials

Although sustainable building materials as an alternative or supplementary option to conventional materials are gaining more interest from architects, designers, developers, and planners, there is not one single material that can address sustainability issues alone. The importance of transitioning towards a more sustainable building sector lies in choosing sustainable options depending on their suitability for the project type, local or regional availability, climate mitigation potential, and circularity. For some applications, there is still a lack of sustainable alternatives. In these cases, conventional materials should be integrated following the circular economy principles to minimise materials and waste. Conventional materials that cannot be sourced responsibly and sustainably should be planned in following the circular design principles, to:

- Minimise the quantities of materials used;
- Design for reusability / recoverability / longevity / adaptability / flexibility;
- Design out construction, demolition, excavation, industrial waste arising;
- Design for an end-of-life strategy.

With wastage of materials in the Ethiopian construction industry being more than twice as much as in developed countries, prefabrication builds an effective strategy for preventing or minimising construction wastes. This approach can significantly lower the embodied energy and CO_2e emissions of buildings compared to the traditional in situ concrete (Taffese and Abegaz, 2019). Hence, utilisation of prefabrication materials is one of the highly recommended strategies to mitigate the embodied energy and the associated CO_2e emissions.

Further, we should consider what happens to the scheme at the end of its life. By taking on board the aspirations, ideas, and commitments set out above, the applicant is moving towards a scheme that breaks down barriers to ultimate disassembly, and which gives greater consideration to the value of the materials used. Thorough records and models will be kept, and these will be developed in the detailed design and construction stages so that they might act as a guide for the repurposing or disassembly and recovery of the layers and elements of the scheme. This will allow the future custodians to prolong the life of the building and maintain the value of materials it contains.

4. Recommendations

Building on the findings from the previous sections and material assessment, this section includes recommendations of suitable building materials for the context of the City Block Project in Addis Ababa and general recommendations for sourcing materials.

4.1 Material selection

The importance of transitioning towards a more sustainable building sector lies in choosing sustainable options depending on their suitability. While materials such as SCM replacements in concrete have a high compressive strength and can be used for load-bearing applications, materials such as straw bales are more suited for low-rise buildings or partition walls. As not all sustainable materials can fulfil the requirements for the building types, a mix of conventional materials and sustainable materials is recommended. Sustainable alternative materials should be integrated into the development based on their specific areas of application, such as the insulation factor and compressive or tensile strength. An appropriate mix from sustainable materials can contribute significantly to the CO_2e emission reduction.

Appropriate material selection plays a crucial role in reducing the embodied energy and other environmental impacts of a building. For the City Block Project in Addis Ababa, it is recommended to look further into raw earth materials and straw bale construction as well as concrete elements containing SCMs and to develop feasibility studies for the appropriate use of each material.

4.2 Sustainable sourcing

Building materials such as straw or clay are not automatically good either as raw materials or as a processed building material. Even with a renewable raw material, a differentiated view is essential to obtain a holistic, sustainable result. This applies especially to the regional use of materials. For instance, although straw can be a sustainable choice for a building, it can only be truly sustainable when sourced locally and from sustainable agriculture. Sourcing sustainable materials also should not create adverse effects on local employment or lead to environmentally harmful agriculture practices when demands are rising. Local value chains of all sourced materials should therefore be considered before building. Sustainable sourcing further includes incorporating local knowledge into material selection and design of the development, to make use of local and established or traditional techniques.

4.3 Circular design

In the context of sustainable construction, it is important to mention circular economy principles to not only use better materials but to contribute to the transition from a take-make-dispose economy towards reducing and reusing materials and designing for adaptability. Incorporating reuse elements and materials that have been recovered from the existing site, or from another site, into the new development can deliver carbon savings and helps saving on the cost of procuring new materials. As the materials for the Perimeter Block cannot be replaced completely by sustainable and sustainably sourced materials, it is important to design the overall development following the principles of circular economy. Materials should further be thought to their end-of-life so that elements can be disassembled and reused where viable or recycled or composted. A further aim should be to minimise conventional materials through material efficiencies, modular building or the prefabrication of elements.

4.4 Data collection

To date, there is a lack of detailed data on material use, material densities and climate impacts resulting from building materials in Ethiopia and many other countries. The lack of information on the embodied energy and CO_2e emissions of different types of building materials is a big challenge for architects to design buildings with low environmental impact. Even though not all materials can be sourced sustainably or designed for composting or reuse, it is important to contribute to data collection. Creating an embodied energy and CO_2e emissions database for locally produced building materials would be one of the potential strategies to reduce energy consumption and CO_2e emissions of buildings in Ethiopia in the future.

4.5 Challenges and bottlenecks towards implementation

Barriers to the implementation of sustainable construction materials are usually divided into categories such as regulatory, financial, technical, organisational, value chain and consumer barriers. These do not stand alone but in mutual relationships between providers, users, the product and related services, which leads to sets of nested barriers. In Ethiopia, main barriers include the perception of industrialised materials such as concrete blockwork as modern and reliable building materials and methods. Organic materials such as clay and straw are often perceived as inferior to steel and concrete.

The promotion through the construction industry and standardisation of conventional materials such as concrete has an influence of on the availability of alternative materials and the standardisation, codes and regulations of alternative technologies. For example, the promotion of the use of coal fly ash by the industry puts renewable raw materials in direct competition with them in which they are often not cost-competitive. More flexible building codes related to sustainable materials would make the implementation of these materials easier and could create opportunities for SMEs to produce alternative materials or use alternative technologies.

References

Ahlfeldt, G.M., Pietrostefani, E. (2019). The economic effects of density: a synthesis. Journal of Urban Economics, 111. pp. 93-107. ISSN 0094-1190.

BRE (2011). Unfired Clay Masonry. An introduction to low-impact building materials. IP 16/11. URL: https://www.bre.co.uk/filelibrary/pdf/projects/low_impact_materials/IP16_11.pdf (last accessed 29.09.2021)

Bredenoord, J., Lindert, P. V. and Smets, P. (2014) Introduction: Governance, Sustainability and Affordability of Low-Income Housing. In: Bredenoord, J., Lindert, P. V. and Smets, P. ed., Affordable Housing in the Urban Global South: Seeking Sustainable Solutions. Abingdon, Oxon ; New York, NY: Routledge, pp. 2–14.

CAHF – Centre for Affordable Housing Finance in Africa (2020). Benchmarking of construction and materials costs for new high-density, mixed-use, mixed-income housing and urban development projects for inner Addis Ababa. DRAFT.

CINARK – Centre for Industrialised Architecture, The Royal Danish Academy – Architecture, Design, Conservation (2021). Materialpyramiden. URL: https://www.materialepyramiden.dk/ (last accessed 29.09.2021)

CSI - The Cement Sustainability Initiative (2009). Recycling Concrete. World Business Council for Sustainable Development. URL: https://docs.wbcsd.org/2009/07/CSI-RecyclingConcrete-FullReport.pdf (last accessed 29.09.2021)

Dabaieh, M., Heinonen, J., El-Mahdy, D., Hassan, D.M. (2020). A comparative study of life cycle carbon emissions and embodied energy between sun-dried bricks and fired clay bricks. Journal of Cleaner Production 275 (2020) 122998.

Fayomi, G.U., Mini, S.E., Fayomi, O.S.I. (2019). Perspectives on environmental CO_2 emission and energy factor in Cement Industry. IOP Conf. Ser.: Earth Environ. Sci. 331 012035

Gan, Y., Liang, C., Chai, Q., Lemke, R., Campbell, C.A., Zenter, R. (2014). Improving farming practices reduces the carbon footprint of spring wheat production. Nature Communications, doi: 10.1038/ncomms6012

Gill, M. and Bhide, A. (2012) Densification through Vertical Resettlement as a Tool for Sustainable Urban Development [Online]. In: 6th Urban Research and Knowledge Symposium. Barcelona, 2012. URL : http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1369969101352/Gill-et-al.pdf

Gupta, R. (2014). Characterizing material properties of cement-stabilized rammed earth to construct sustainable insulated walls. Case Studies in Construction Materials. Volume 1, 2014, Pages 60-68. https://doi.org/10.1016/j.cscm.2014.04.002

Hall, M.R., Swaney, W. (2012). European modern earth construction. In: Modern Earth Buildings, 2012.

Hammond, G.P., Jones, C.I., (2008). Embodied energy and carbon in construction materials, Proc. Inst. Civ. Eng.: Energy 161 (2) (2008) 87–98.

Hjort, B. Widén, K. (2015). Introduction of sustainable low-cost housing in Ethiopia – an innovation diffusion perspective. Procedia Economics and Finance 21 (2015) 454 – 460.

He, J. Kawasaki, S. Achal, V. (2020). The Utilization of Agricultural Waste as Agro-Cement in Concrete: A Review. Sustainability 2020, 12, 6971; doi:10.3390/su12176971

Imbabi, M.S., Carrigan, C., McKenna, S. (2013). Trends and developments in green cement and concrete technology. International Journal of Sustainable Built Environment. Gulf Organisation for Research and Development. http://dx.doi.org/10.1016/j.ijsbe.2013.05.001

International Finance Corporation (IFC) (2017). Report India Construction Materials. Database of Embodied Energy and Global Warming Potential.

Abebaw, L. Vadivu, P.M. (2020) Combined Effect of Ambo Stone as Coarse Aggregate and Fly Ash as Cement on Mechanical Properties of Concrete. Journal of Engineering and Applied Sciences. Volume 15, Issue 15, 2020. 2977-2989.

NRMC - National Ready Mixed Concrete Association (2008). Concrete CO_2 Fact Sheet. URL: https://www.greenconcrete.info/downloads/11_ConcreteCO2.pdf

Martirena, F. and Monzó, J. (2018). Vegetable ashes as supplementary cementitious materials. Cement. Concrete. Res. 2018, 114, 57–64

MoARD - Ministry of Agriculture and Rural Development Ethiopia (2010). National Rice Research and Development Strategy for Ethiopia. URL: https://www.riceforafrica.net/downloads/NRDS/Ethiopia_En.pdf

Patel, S.B. (2007) Urban Layouts, Densities and the Quality of Urban Life. Trialog, 3 (94), pp. 45–50.

Patel, S. and Mandhyan, R. (2014) Impoverishment Assessment of Slum Dwellers after Off-site and On-Site Resettlement: A Case of Indore. Commonwealth Journal of Local Governance [Online], (15). URL: http://epress-dev.lib.uts.edu.au/journals/index.php/cjlg/article/view/4065

Patel, S., Sliuzas, R. and Mathur, N. (2015) The Risk of Impoverishment in Urban Development-Induced Displacement and Resettlement in Ahmedabad. Environment and Urbanization, 27 (1) April, pp. 231–256.

Paul, S.C., Mbewe, P.B.K., Kong, S.Y., Šavija, B. (2019). Agricultural Solid Waste as Source of Supplementary Cementitious Materials in Developing Countries. Materials 2019, 12, 1112. doi:10.3390/ma12071112

Re-Alliance (2021). Nepal's first straw bale house. URL: https://www.re-alliance.org/nepal-strawbale

RIBA - Royal Institute of British Architects (2021). Built for the environment. Addressing the climate and biodiversity emergency with a fair and sustainable built environment.

Sertyesilisik, E., Yilmaz, S., Sertyesilisik, B. (2021). Political Economy of Straw Houses: Traditional and Contemporary Way of Enhancing Sustainability of the Buildings. Journal of Sustainable Architecture and Civil Engineering. Doi:10.5755/j01.sace.28.1.27711

Suttie, J. M. (2000). Hay and Straw Conservation – For Small-Scale Farming and Pastoral Conditions. FAO Plant Production.

Taffese, W.Z., Abegaz, K.A. (2019). Embodied Energy and CO_2 Emissions of Widely Used Building Materials: The Ethiopian Context. Buildings 2019, 9, 136; doi:10.3390.

Woldemichael, S. (2020). Teff Straw Ash as Partial Cement Replacement Material.

Zhang, Y., et al. (2021). Treatment of municipal solid waste incineration fly ash: State-of-the-art technologies and future perspectives. Journal of Hazardous Materials 411 (2021).

Addis Ababa Urban Age Task Force Reports

Theme 1 | Urban Housing and Retrofitting

Policy Brief 1 | *The Addis Ababa City Block: a high-density, mixed-use and inclusive housing solution for the urban core*

Technical Report 1.1 | *The Addis Ababa City Block: inclusion and livelihood though the horizontal-above-vertical concept*, by Elias Yitbarek Alemayehu

Technical Report 1.2 | *Finding Housing Affordability: cost estimates and affordability paths for the Addis Ababa City Block,* by Jacus Pienaar

Technical Report 1.3 | *Sustainable Building Materials: exploring green construction options for new housing in Addis Ababa*, by Hannah Langmaack, Peter Scheibstock and Thomas Kraubitz (Buro Happold)

Theme 2 | Transport and Mobility Services

Policy Brief 2 | *Beyond Car Growth: digital van service as alternative to private car use in Addis Ababa*

Technical Report 2.1 | *Digital Van Service Demand: gauging interest in mobility alternatives among current and aspiring car owners in Addis Ababa*, by Philipp Rode, Bethany Mickleburgh, Jennifer Chan and Rebecca Flynn

Technical Report 2.2 | *Digital Van Service for Addis Ababa: understanding the transport landscape and the potential for digital bus aggregation in Ethiopia's capital* by Chris Kost and Gashaw Aberra (Institute for Transportation and Development Policy (ITDP))

Theme 3 | Green and Blue Infrastructure

Policy Brief 3 | *Working with Nature: next generation green and blue infrastructure for Addis Ababa*

Technical Report 3.1 | *Green and Blue Infrastructure in Addis Ababa: a review of challenges and response strategies*, by Hailu Worku

Technical Report 3.2 | *The Social Functions of Green and Blue Infrastructure: international case studies and insights for Addis Ababa*, by Santiago del Hierro, David Jácome and Tigist Kassahun Temesgen

Theme 4 | Urban Governance and Planning

Policy Brief 4 | *Urban Governance and Strategic Planning: how Addis Ababa could benefit from human-centred, inclusive design, participatory pilot projects and improved data management*

Technical Report 4.1 | *Participatory City Making: polycentric governance and human-centred, inclusive urban design,* by Meinolf Spiekermann and Marc Steinlin

Technical Report 4.2 | *Urban Knowledge Management: solutions for the Addis Ababa City Administration*, by Bersisa Berri

Technical Report 4.3 | *International Building Exhibitions (IBA): an approach to innovative city making in Addis Ababa* by Efrem A. Tesfaunegn, Anka Derichs and Michael von der Mühlen

Technical Report 4.4 | *Addis Ababa Spatial Compendium: mapping and urban analytics for Ethiopia's capital*, by Alexandra Gomes and Philipp Rode (LSE Cities)

Addis Ababa Urban Age Task Force

Founding Partners

The Task Force is a partnership between the Addis Ababa City Administration Plan & Development Commission (AAPDCo), LSE Cities at the London School of Economics and Political Science, the Alfred Herrhausen Gesellschaft, and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Members

Dereje Fekadu (Co-Chair), Commissioner, Plan and Development Commission (2018-2020), Special Chief of Staff, Mayor's Office, Addis Ababa City Administration, Addis Ababa, Ethiopia

Philipp Rode (Co-Chair), Executive Director, LSE Cities and Urban Age, LSE, London, UK

Elias Yitbarek Alemayehu, Architect and Associate Professor, EiABC, Addis Ababa University, Addis Ababa, Ethiopia

Elleni Ashebir, Cities and Urban Mobility Manager, Ross Centre for Sustainable Cities, WRI Africa, Addis Ababa, Ethiopia

Ricky Burdett, Director, LSE Cities and Urban Age, LSE, London, UK

Anka Derichs, Senior Strategic Urban Development Advisor, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany

Timnit Eshetu, CEO, Construction Enterprise, Addis Ababa City Administration (2019-2021), Addis Ababa, Ethiopia

Brett Herron, Former Member of the Mayoral Committee: Transport and Urban Development, Cape Town, South Africa

Olusola Ikuforiji, Environmental Specialist, African Development Bank, Abidjan, Côte d'Ivoire

Clarisse Linke, Country Director, Brazil, Institute for Transportation and Development Policy (ITDP), Rio de Janeiro, Brazil

Elisabeth Mansfeld, Cities Project Area, Alfred Herrhausen Gesellschaft, Berlin, Germany

Michael von der Muehlen, Former State Secretary and Participant of International Building Exhibition (IBA) "Emscher Park", Dortmund, Germany

Jennifer Semakula Musisi, First City Leader in Residence, Bloomberg Harvard City Leadership Initiative, Harvard Kennedy School, Cambridge, USA, Executive Director, Kampala Capital City Authority (2011-2018), Kampala, Uganda

Henk Ovink, Special Envoy for International Water Affairs, Kingdom of the Netherlands, and Sherpa to the High Level Panel on Water, United Nations, The Hague, Netherlands

Kecia Rust, Executive Director and Founder, Centre for Affordable Housing Finance in Africa, Johannesburg, South Africa

Semere Jelalu Shafi, Deputy General Director, Addis Ababa City Traffic Management Agency, Addis Ababa City Government, Addis Ababa, Ethiopia

Jagan Shah, Senior Infrastructure Adviser, Department for International Development (DFID), British High Commission, New Delhi, India

Marc Steinlin, Managing Director, Complex(c)ity Ltd., Helsinki, Finland and Basel, Switzerland

Zeleke Teferi, Department Head, Catchment Management and Water Quality Control, Addis Ababa Water & Sewerage Authority, Addis Ababa, Ethiopia

Cecilia Vaca Jones, Executive Director, Bernard van Leer Foundation, The Hague, Netherlands and Quito, Ecuador

Hailu Worku, Chair of Environmental Planning and Landscape Design and Deputy Scientific Director of EiABC, Addis Ababa University, Addis Ababa, Ethiopia

Governing Board

Dereje Fekadu (Co-Chair), Commissioner, Plan and Development Commission (2018-2020), Special Chief of Staff, Mayor's Office, Addis Ababa City Administration, Addis Ababa, Ethiopia

Anna Herrhausen (Co-Chair), Executive Director, Alfred Herrhausen Gesellschaft, Berlin, Germany

Ricky Burdett, Director, LSE Cities and Urban Age, LSE, London, UK

Anka Derichs, Senior Strategic Urban Development Advisor, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany

Timnit Eshetu, CEO, Construction Enterprise, Addis Ababa City Administration, Addis Ababa, Ethiopia

Philipp Rode, Executive Director, LSE Cities and Urban Age, LSE, London, UK

Partner Co-ordinators

Emily Cruz, Outreach Manager, LSE Cities, London, UK

Anka Derichs, Senior Strategic Urban Development Advisor, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany

Elisabeth Mansfeld, Cities Project Area, Alfred Herrhausen Gesellschaft, Berlin, Germany

Moges Tadesse, Chief Resilience Officer, Addis Ababa City Resilience Project Office, Addis Ababa, Ethiopia

An initiative by

URBAN AGE

Urban Age

The Urban Age Programme, jointly organised with and supported by the Alfred Herrhausen Gesellschaft, is an international investigation of the spatial and social dynamics of cities. The programme consists of conferences, research initiatives, task forces and publications. Since 2005, 17 conferences have been held in rapidly urbanising regions in Africa and Asia, as well as in mature urban regions in the Americas and Europe.

urbanage.LSECities.net
@UrbanAge

Addis Ababa Plan Commission

Addis Ababa City Plan and Development Commission is committed and fully dedicated to preparing research-based city-wide short, medium and long term strategic development plans (both socio-economic and spatial) in order to transform the city to one among the middle-income cities in the world; create a liveable city for the citizen; and make Addis Ababa the best destination for investment in Africa. The commission is accountable to promote urban economy and jobs; deliver urban renewal and housing for citizens; improve urban environment and quality of life; and support policy decisions that will register accelerated, sustainable and equitable economic growth and a climate resilient green economy.

The Alfred Herrhausen Gesellschaft

The Alfred Herrhausen Gesellschaft promotes a free and open society and its cohesion. Democracy, the social market economy and sustainability are the foundations of such a society. Our work is based on the values of Alfred Herrhausen: on freedom and responsibility, on competition and compassion. Alfred Herrhausen thought and acted with the aim of crossing and overcoming boundaries. In his memory, the Alfred Herrhausen Gesellschaft creates platforms for discussions to enrich relevant discourses during selected events, and in publications and other media.

alfred-herrhausen-gesellschaft.de
@AHG_Berlin

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

As a service provider in the field of international cooperation for sustainable development and international education work, GIZ is dedicated to shaping a future worth living around the world. GIZ has more than 50 years of experience in a wide variety of areas, including economic development and employment promotion, energy and the environment, and peace and security. We work with businesses, civil society actors and research institutions, fostering successful interaction between development policy and other policy fields and areas of activity. Our main commissioning party is the German Federal Ministry for Economic Cooperation and Development (BMZ).

GIZ.de
@giz_gmbh

LSE Cities

LSE Cities is an international centre at the London School of Economics and Political Science that carries out research, conferences, graduate and executive education and outreach activities in London and abroad. It studies how people and cities interact in a rapidly urbanising world, focusing on how the physical form and design of cities impacts on society, culture and the environment. Extending LSE's century-old commitment to the understanding of urban society, LSE Cities investigates how complex urban systems are responding to the pressures of growth, change and globalisation with new infrastructures of design and governance that both complement and threaten social and environmental equity.

LSE.ac.uk/cities
@LSECities

Addis Ababa City Government Plan & Development Commission | The London School of Economics and Political Science | LSE Cities | Alfred Herrhausen Gesellschaft | Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH